

DFM Analyses User Guide

Release NPI11.0

May 2019

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Chapter 1

Design for Manufacture Analysis

The entry level Design for Manufacture Analyses (DFMA) configuration includes the most common analyses related to fabrication and assembly. DFM Analysis is best implemented to verify a design in an incremental manner leading to a final DFM verification that incorporates manufacturing optimization into the PCB design process.

Catching DFM issues at the design stage is critical because at each successive stage of the production process, the cost of rectifying a problem increases significantly over the previous stage. Design for Manufacture Analyses works seamlessly with your EDA system to take you to the location of the manufacturing issue within your design tool.

DFM Analysis provides limited functionality that is sufficient for most customers. It differs from the full-function analysis solution in these respects:

- DFMA is a single user system. It does not require user logins and it benefits from a simple, straightforward installation.
- DFMA does not require sophisticated customization tools. It does not support scripting, user-defined attributes, or attribute assignment tools.
- DFMA does not require access to VPL, and does not include the BOM Manager.
- DFMA comes with a predefined set of checklists and ERF models. Complex features like ERF sub-models are not supported.
- DFMA benefits from streamlined checklist management. An easy to use checklist editor is sufficient.
- DFMA has a simplified result review process. By default only critical results of critical severity are reported. The Management Risk Assessment (MRA) result viewer is replaced by a simpler Result Viewer. The number of results is smaller, because only the most common DFM checks are performed. See “[DFMA Result Viewer](#)” on page 247.

Fabrication Analysis actions locate potential product model problems during bare board fabrication. Each action covers a specific aspect of board fabrication. This includes copper layers (signal, power and ground), support layers (solder mask and silk screen) and drill layers.

Assembly Analysis analyses locate potential manufacturability problems during board assembly and testability issues.

These are the benefits of performing thorough DFM analysis:

- Estimation of cost can be derived from the results of the analysis.

- Manufacturing defects can be identified and corrected prior to tool creation.
- Design parameters can be extracted to provide input for planning, down to which machines should be used for production.
- Rework considerations can be plugged into the design early on in the process.

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Category Format

In this document, each result category is described in a table of information.

Analysis Category	The ERF range name that defines the results for the category; determines the red, green, yellow classifications.
Measurement Shape	<ul style="list-style-type: none">• Point displayed as an X.• Line skeleton• Line displayed in full width, such as line summary or sliver.• Circle• Square• Arc• Bounding box that envelopes contours, such as a box to indicate a covered pinhole.
Measurement Value	<p>A number expressing the value of the measurement.</p> <ul style="list-style-type: none">• Distance• Percent• Area• Angle• Line width• Pitch• 3D distance• Ring
Measurement IDs	The type of features involved in the measurement. The Results Viewer displays types, sizes and symbols of features involved in the measurement. See “ DFMA Result Viewer ” on page 247.
Layers Displayed	The relevant layers displayed.
Graphic	A picture representing a typical measurement.
Purpose	The reason the category is needed.
Function	The measurements reported by the category.
ERF Parameters ERF Variables	The ERF parameters and variables that affect this category.
Limitations	Any restrictions, or lack thereof, of the results of this category.

Analysis Constraints

Constraints are reference values used to indicate the threshold at which a measurement becomes a critical violation. This table provides a list of categories and the constraints that govern the results they report, arranged by analysis type. In each case, the constraint defines a critical result.

See “[Modifying Analysis Constraints](#)” on page 22.

Drill Analysis Constraints

Table 1-1. Categories and their Constraints - Drill Analysis

Constraint Prompt	Affected Category	Category (internal name)
Mounting Hole Size	Mounting Holes	mount_holes
NPTH Size	NPTH Summary	npth
PTH Size	PTH Summary Plated Slot Summary	pth slot_pt
Tooling Hole Size	Tooling Holes	tooling_holes
VIA Size	Via Summary	via
no constraint required	Duplicate Holes Missing Holes No Thermal Touching Holes	duph missh no_thermal touchh

Signal Analysis Constraints

Table 1-2. Categories and their Constraints - Signal Layer Analysis

Constraint Prompt	Affected Category	Category (internal name)
Feature Spacing	Pad to Pad Pad to Circuit Circuit to Circuit Pads Lines Shaved Lines Arcs Shaved Arcs Line Neckdown Text Text Touches Copper Sliver Short Sliver Spacing Length Same Net Spacing CAD Self Spacing Conductor Width	p2p p2c c2c pad line shaved_line arc shaved_arc neckdown text text_touch_copper sliver short_sliver spacing_length self_spacing cad_self_spacing conductor_width
Hole Registration	PTH Registration NPTH Registration Via Registration	reg npth_reg via_reg
Hole to Feature Spacing	NPTH to Pad NPTH to Circuit PTH to Copper Via to Copper Tooling Hole to Exposed Copper PTH to Copper Same Net	npth2p npth2c pth2c via2c thole2exp_copper pth2c_same_net
Plated Hole AR	PTH (Comp) Annular Ring Via Annular Ring Blind Via Annular Ring Buried Via Annular Ring	pth_ar via_ar blind_via_ar buried_via_ar

Table 1-2. Categories and their Constraints - Signal Layer Analysis (cont.)

Constraint Prompt	Affected Category	Category (internal name)
Via Spacing	Via to Via Exposed Via to Exposed Via Exposed Via to Exposed Copper	via2via exvia2exvia exvia2exc
no constraint required	NPTH Annular ring SMD Pads Stubs Text to Text	npth_ar smd_pad stub text2text

Power and Ground Analysis Constraints

Table 1-3. Categories and their Constraints - Power and Ground Analysis

Constraint Prompt	Affected Category	Category (internal name)
Copper Spacing	Slivers Short Slivers Plane Spacing Segmentation	sliver short_sliver plane_spacing segmentation_lines
Hole Clearance	PTH Contains Clearance Via Contains Clearance NPTH Contains Clearance	pth_cont_clr via_cont_clr npth_cont_c
Hole Registration	PTH Registration NPTH Registration Via Registration	pth_reg npth_reg via_reg
Non-plated Hole Spacing	NPTH to Copper NPTH to Plane	npth2c npth2p
Plated Hole AR	PTH Annular Ring	pth2t
Plated Hole Spacing	PTH to Copper PTH to Plane Via to Copper Via to Plane	pth2c pth2p via2c via2p
no constraint required	Missing CU for Via	miss_cu

Solder Mask Analysis Constraints

Table 1-4. Categories and their Constraints - Solder Mask Analysis

Constraint Prompt	Affected Category	Category (internal name)
Gasket Size	SMD Pad Gasket Undrilled Pad Gasket PTH Pad Gasket Via Pad Gasket	neg_ar_smd neg_ar_ndrl_pad neg_ar_pth_pad neg_ar_via_pad
Hole Pad AR	Via Pad Annular Ring PTH Pad Annular Ring NPTH Pad Annular Ring	ar_via_pad ar_pth_pad ar_npth_pad
Plated Hole	PTH Annular Ring Via Annular Ring	ar_pth ar_via
PTH Gasket Size	PTH Gasket	neg_ar_pth
SMD Pad AR	Via Gasket SMD Annular Ring Undrilled Pad Annular Ring Pad Annular Ring	neg_ar_via ar_smd ar_ndrl_pad ar_pad
SM Feature Spacing	Coverage SM Sliver SM Short Sliver Pad to Pad Spacing Pad to Non-Pad Spacing Non-Pad to Non-Pad Spacing	coverage sliver short_sliver pad_to_pad pad_to_non non_to_non
no constraint required	Extra SM -Missing Copper Missing NPTH Clearance Missing PTH Clearance Missing SMD Clearance Missing Testpoint Clearance Missing Undrilled Pad Clearance Missing VIA Clearance NPTH Touches Mask	ext_sm_copper_miss npth_miss pth_miss smd_miss tp_miss ndrl_miss via_miss npth2m

Silk Screen Analysis Constraints

Table 1-5. Categories and their Constraints - Silk Screen Analysis

Constraint Prompt	Affected Category	Category (internal name)
Line Width	Line Width String Line Width	ss_line str_line_width
NPTH Spacing	NPTH Pads Clearance NPTH Clearance	ss2pad_npth ss2npth
PTH Spacing	PTH Pads Clearance PTH Clearance	ss2pad_pth ss2pth
SMD Spacing	SMD Clearance Undrilled Pads Clearance	ss2pad_smd ss2pad_undrl
VIA Spacing	Via Pads Clearance Via Clearance	ss2pad_via ss2via

Component Analysis Constraints

Table 1-6. Categories and their Constraints - Component Analysis

Constraint Prompt	Affected Category	Category (internal name)
no constraint required	Comp. Under Component Comp. Overlap	c_under_c comp_overlap

Testpoint Analysis Constraints

Table 1-7. Categories and their Constraints - Testpoint Analysis

Constraint Prompt	Affected Category	Category (internal name)
Exposed Copper Spacing	Testpoint to Exposed Copper	tp2c
Testpoint to Testpoint	Testpoint to Testpoint	tp2tp tp2tp;<PkgType> tp2tp;<PkgTypeA><PkgTypeB>

Solder Paste Analysis Constraints

Table 1-8. Categories and their Constraints - Solder Paste Analysis

Constraint Prompt	Affected Category	Category (internal name)
no constraint required	SMD Pad Without Solderpaste Solderpaste Not on SMD	smd_without_sp sp_non_smd

Internal Attribute Names

Step, job, component, feature, and net attributes used in fabrication analysis and assembly analysis have internal names (which might be found in legacy data) and display names.

The system truncates strings containing more than 64 characters for the purpose of analysis. A warning message appears in the log:

“Feature <feature_number> in layer <layer_name>: value of attribute <attribute_name> was truncated.”

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Fabrication Analysis

These attributes are used in fabrication analysis.

Internal Attribute Name	Display Name	Entity Type
.copper_weight	Copper Weight (oz)	Layer
.drill	Drill Type	Feature
.hatch	Hatch	Feature
.hatch_border	Hatch Border	Feature
.layer_dielectric	Thickness of Dielectric Below Layer	Layer
.nomenclature	Copper Text	Feature
.smd	SMD Pad	Feature
.string	Copper Text String	Feature
.test_point	ICT Test Point	Feature

Assembly Analysis

These attributes are used in assembly analysis.

Internal Attribute Name	Display Name	Entity Type
.drill	Drill Type	Feature
.nomenclature	Copper Text	Feature

Internal Attribute Name	Display Name	Entity Type
.pad_usage	Pad Usage	Feature
.pad_usage = g_fiducial	Pad Usage=g_fiducial	Feature
.smd	SMD Pad	Feature
.string	Copper Text String	Feature
.tear_drop	Tear Drop Feature	Feature
.test_point	ICT Test Point	Feature

System

The system uses these attributes for defining the product.

Internal Attribute Name	Display Name	Entity Type
.all_eda_layers	All EDA Layers	Step
.artwork	Feature Source	Feature
.comp_variant_list	Component Variant List	Component; Package
.data_source	Data Source	Job; Step
.dielectric_constant	Dielectric Constant (ER)	Layer
.eda_layers	All EDA Layers	Layer
.geometry	Geometry	Feature
.n_electric	Non Electrical Feature	Feature
.string_angle	String Angle	Feature
.string_justification	String Justification	Feature
.string_mirrored	String Mirror	Feature
.variant_list	Jog Variant List	Job

Performing DFM Analysis

DFM Analysis is performed by running a setup process and an analysis process.

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Setting DFM Analysis Preferences for PADS Layout

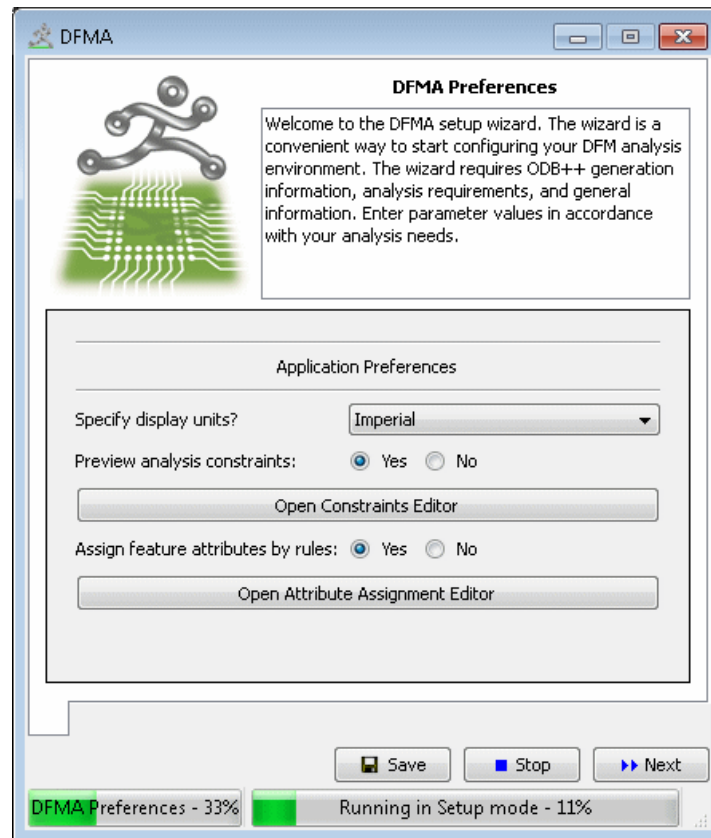
Use the DFM Analysis wizard to specify the units of measure in which to view results, to edit default constraints used to set violation thresholds, and to construct rules for assigning attributes to features of the design during translation.

The next time you open the DFM Analysis wizard, options display as you set them. The constraint values list should display in the units of measure you chose, and the measurements in the Result Viewer should also display in the units you chose. See “[DFMA Result Viewer](#)” on page 247.

Procedure

1. In your PADS Layout application, select **Tools > DFM Analyses > Setup**.

The DFM Analysis wizard opens:



2. In Specify display units? select Imperial or Metric.

This controls the units in which to display constraint values in the wizard, and analysis measurements in the Result Viewer. See “[DFMA Result Viewer](#)” on page 247.

3. To view or modify the constraints, set Preview analysis constraints = Yes, and click the **Open Constraints Editor** bar. See “[Modifying Analysis Constraints](#)” on page 22.
4. To create attribute rules, set Assign feature attributes by rules = Yes, and click the Open Attribute Assignment Editor bar. See “[Creating Feature Attribute Rules](#)” on page 25.
5. Click **Next**.

A message box opens stating that your setup values have been saved.

6. Click **Next** again to exit the application.

Modifying Analysis Constraints

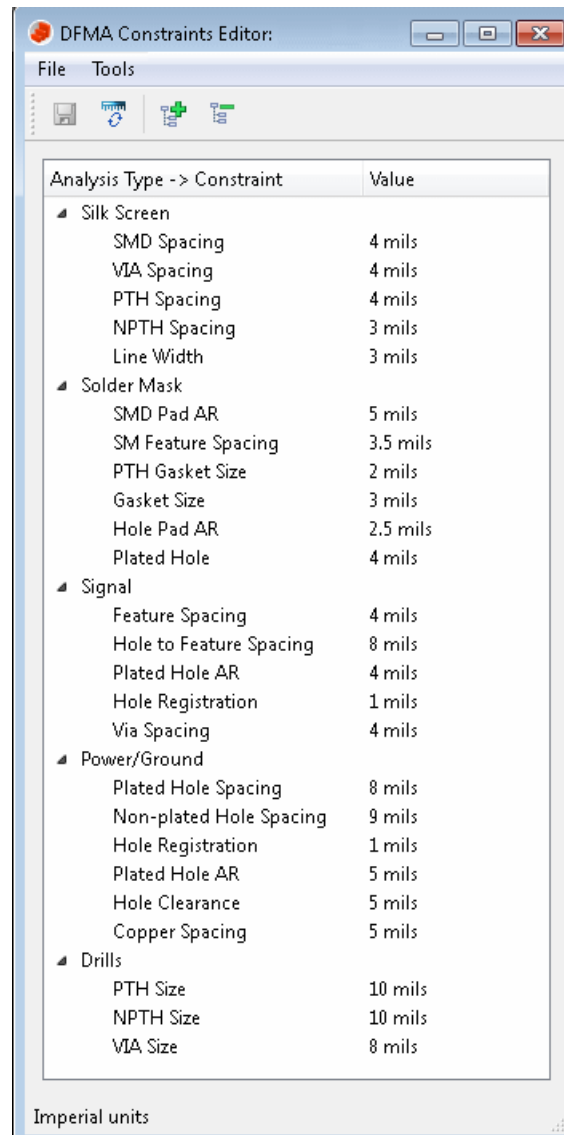
DFM Analysis reports results that violate constraint values. Constraints specify the threshold at which a measurement becomes a critical violation. You can use a system default set of constraints, or customized constraints stored with the product or saved as an external file.

For a list of constraints and the categories they affect, see “[Analysis Constraints](#)” on page 14.

Procedure

1. Open the DFMA wizard as described in “[Setting DFM Analysis Preferences for PADS Layout](#)” on page 21.
2. In the DFMA wizard, set Preview analysis constraints = Yes, and click the **Open Constraints Editor** bar.

The Constraints Editor opens displaying the constraints whose values can be modified:



The Constraints Editor does not display categories reporting go/no-go type violations. For example, Missing Holes, NPTH Annular ring, Missing VIA Clearance, SMD pads without Solderpaste.

3. Use the File menu options as needed:

File Option	Explanation
Load	Opens the Select ERF constraint file path dialog box. Navigate to the location of the constraint file, and select it.
Save	Saves the modified constraint file in the current location. The default file of the system is not affected.
Save as	Saves the modified constraint file at a location of the user's choice.
Close	Closes the Constraint Editor.

4. Use the Tools menu options as needed:

Tools Option	Explanation
Restore Design Defaults	Restores system default values for all constraints.
Switch Units	Switches the display units of constraints between imperial and metric
Expand All	Expands the constraints tree to display all analysis types and their constraint value.
Collapse All	Collapses the constraints tree to display only the analysis types.

5. To modify a constraint value, double-click the numerical value and enter a different value. Placing the cursor over the selected value displays a tooltip stating the valid range for the constraint.
6. If you want to save the values for future DFMA runs, select **File > Save** to save the modified constraints.

You do not have to save modifications to affect the current DFMA run. The constraint file found with the project is always used for running the analysis.

Saving customized constraints does not overwrite system values. If saved, they are always saved at the current location with the project. If not saved, they are saved with the project when you close the application or move to another window.

Alternatively, use the Save as option to save the modified file at a location of your choice.

7. To use a constraint file other than the default system file, select **File > Load** and access the stored file. It replaces the file in the project.
8. To restore the default system file, select **Tools > Restore Design Defaults**.

Creating Feature Attribute Rules

You can set rules to be used for assigning attributes to features when the design is imported. The Attribute Assignment Editor uses the file *attribute_assignment.xml*, found in the folder containing the *DFM4PADS* executable.

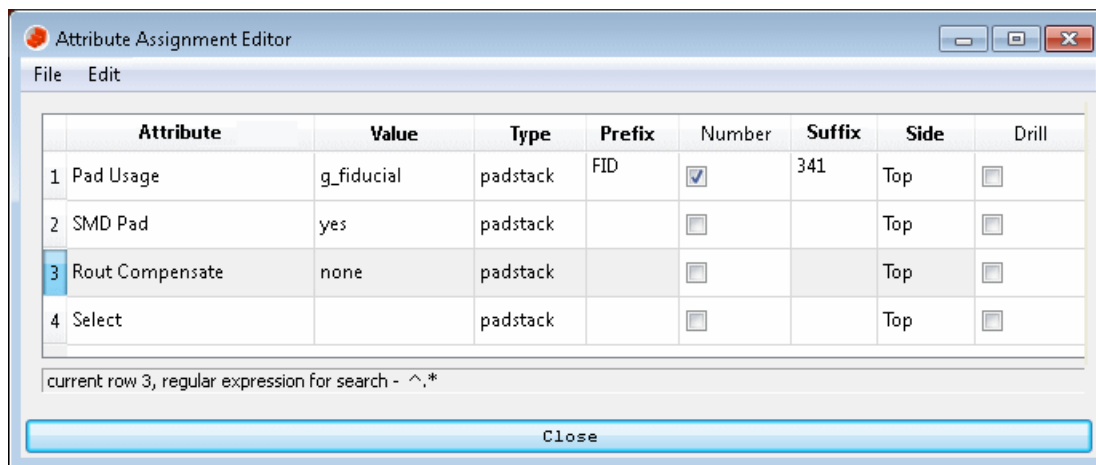
If you want to save your attribute definitions, and not have them overwritten the next time you use the Attribute Assignment Editor, give the file a different name or save it in a different location.

For a list of the attributes available for DFM analysis, see “[Internal Attribute Names](#)” on page 19.

Procedure

1. If you have an existing attribute file that you want to edit, copy the file to the file named *attribute_assignment.xml* in the folder containing the *DFM4PADS* executable.
2. Open the DFMA wizard as described in “[Setting DFM Analysis Preferences for PADS Layout](#)” on page 21.
3. In the DFMA wizard, set Assign features attributes by rules = Yes, and click the **Open Attribute Assignment Editor** bar.

The Attribute Assignment Editor opens.



The values stored in *attribute_assignment.xml* display in the relevant drop-down lists.

4. Use the menu options as needed:

- The **File** menu options are:

File Option	Explanation
New	Clears the grid.
Reread	Reads in the values from the <i>attribute_assignment.xml</i> file, overwriting the information currently displayed in the grid.

File Option	Explanation
Save	Saves the displayed assignments to file <i>attribute_assignment.xml</i> ; the path is displayed in the status line.
Close	Closes the Attribute Assignment Editor.

- The **Edit** menu options are:

Edit Option	Explanation
Copy	Copies the values of Value, Type, Prefix, Number, Suffix, Side, Drill from the selected row.
Cut	Cuts the selected line.
Paste	Pastes the values of Value, Type, Prefix, Number, Suffix, Side, Drill to the selected row.
Delete	Deletes the selected row.
Add row	Adds a row at the bottom of the grid.

- For a selected row, these are the right-click menu options:

Right-Click Option	Explanation
Copy	Copies the information in the selected row.
Cut	Cuts the information from the selected row.
Paste	to current — Pastes the copied or cut values of Value, Type, Prefix, Number, Suffix, Side, Drill to the selected row. at end — Adds the copied or cut row to the end of the grid.
Delete	Deletes the selected rows.
Insert new row	Inserts a new row with default values to one of these positions: before current, at end.
Insert copied row	Inserts the copied or cut row above the selected row.

5. For each attribute to be assigned to features, specify the following:

Column	Explanation
Attribute	Select the attribute to be set.
Value	Select the value to be set for the attribute.
Type	The type of feature for which to set the attribute: padstack or refdes.
Prefix	The attribute will be set for features with this prefix.
Number	Indicates whether the attribute should be assigned only for a feature with a number in the regular expression.

Column	Explanation
Suffix	The attribute will be set for features with this suffix.
Side	The attribute will be set for features on this side: Top or Bottom or Both.
Drill	The attribute will be set only on drill layers.

6. Save the file, and close the editor.

If you have entered incorrect values, a warning displays. You will not be able to save the file until you correct the errors.

7. If necessary, rename the *attribute_assignment.xml* file or save it in a different location so that it is not overwritten the next time you edit attributes.

Running DFM Analysis

After setting and saving parameters and preferences in the DFM Analysis wizard, you can run the DFM analysis process. The analysis is run using either system or user-modified constraints to determine a threshold for each analysis type, and reports only critical violations.

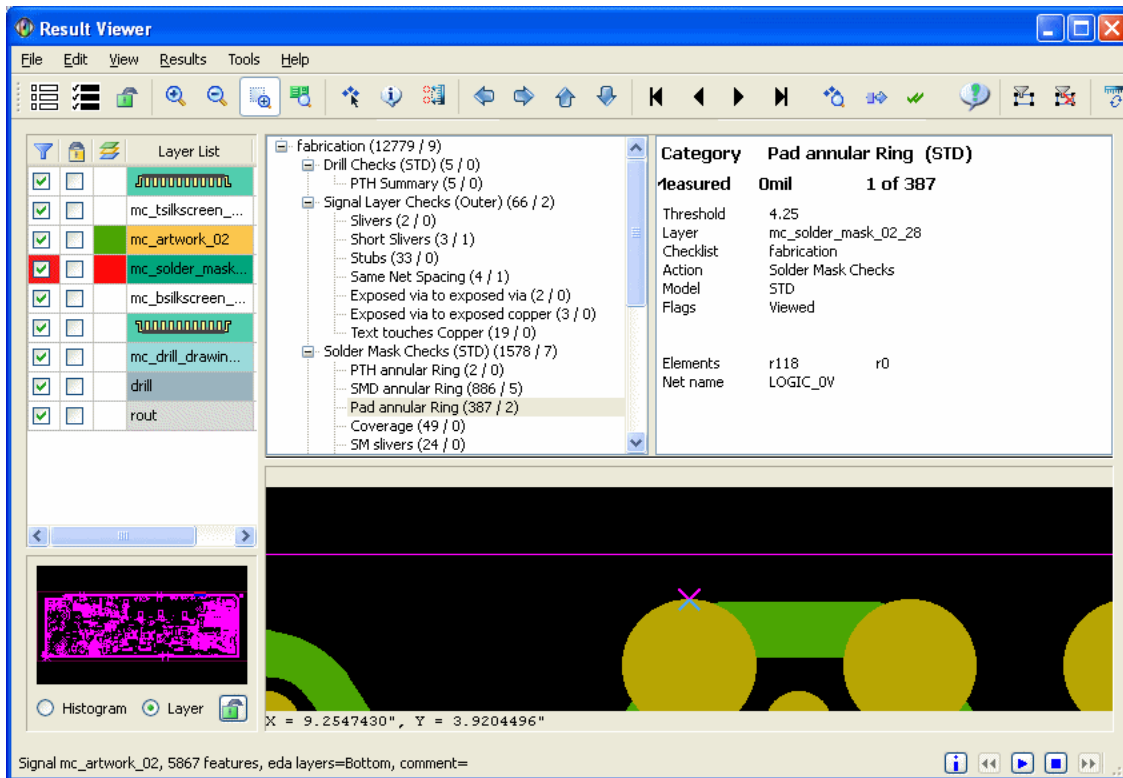
Procedure

1. In the PADS Layout, select **Tools > DFM Analyses > Start Analysis**.

The constraint values list opens with a wizard message prompting to review or edit analysis constraint values.

2. Review or edit constraints as in “[Modifying Analysis Constraints](#)” on page 22, and click in the wizard message box to continue.

DFM analysis is performed on the project, and the Result Viewer opens with another wizard message prompting to review the DFM results. See “[DFMA Result Viewer](#)” on page 247.



Terminology

Conventions, abbreviations and acronyms are used in descriptions of the analyses.

Term	Explanation
NFP	Non-functional pad.
NPTH	Non-plated through hole.
PTH	Plated through hole (component hole).
Via	Via drill.
Text	A feature of type text or a line, arc, or pad tagged with the feature attribute Copper Text.
Circuit	A line, arc or surface used to facilitate the flow of electricity.

Term	Explanation
r0	Null feature ID. In many analysis categories there are two associated features, such as two pads in the pad to pad spacing category. Sometimes, when a drill annular ring is measured, there are two features, namely the pad and the drill. But there may be cases where there is an annular ring measurement between a drill and a drawn surface. In that case there is no pad to refer to; the ID will be an r0 null feature.
RM	Reliability Margin. The RM is defined in the ERF variables list at the end of each Action chapter.
DRA	Design Registration Allowance. The DRA for a category is the margin between the minimum measurement in the category and the RM. The DRA for a board is the minimum of all DRAs for categories for which a DRA is defined.
Plated Hole	This term is used to refer to PTHs and vias only.

Chapter 2

Fabrication Analysis - Drill Checks

The Drill Checks action is a read-only action that finds potential manufacturability defects in drill layers (through, buried and blind via layers) and generate statistics on drill layers. The action is intended to operate only on drill layers. It uses the drill layer, the top and bottom layers of its drilled stack and any power and ground layers in the stack.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Drill Checks

Several drill checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Hole Size — Provides a list of all PTHs, NPTHs, and vias, as well as NPTHs that need pilot drills.

Hole Separation — Reports duplicate holes, touching holes and close holes.

Missing Holes — Reports missing drills for non-SMD pads.

Thermal Connection — Reports the absence of thermals for through-hole pin drills and calculates the total copper area of thermal connections through all negative power and grand and mixed layers.

PCB Aspect Ratio — Reports the relationship between board thickness and drilled hole diameters for the smallest through hole and vias (standard, blind and buried) in the tested drill layer.

Attributes Used in Drill Checks

Attributes assigned to features, layers, or the board in the product model control the analysis.

Feature Attributes

Table 2-1. Drill Checks Feature Attributes

Name	Description
Drill Type	The feature attribute Drill Type is attached to all drill holes on the drill layers. It defines the type of drill and is used extensively in fabrication.
Pad Usage	The feature attribute Pad Usage is attached to pads on outer signal layers. It value can be one of the following: toeprint via g_fiducial l_fiducial tooling_hole
SMD Pad	This feature attribute should be attached to outer layer pads which are lands for SMD components. It is set by the 'Set SMD Attribute' Cleanup Action.
Tooling Hole	This feature attribute is attached to drill features to indicate that they are tooling holes.

Layer Attributes

Table 2-2. Drill Checks Layer Attributes

Name	Description
Copper Weight (oz)	The weight in ounces of one square inch of copper (default=1oz)

Table 2-2. Drill Checks Layer Attributes (cont.)

Name	Description
Thickness of Dielectric Below Layer	The thickness of the insulating layer of laminate between copper layers (default=0.0001in.)

Board Attributes

Table 2-3. Drill Checks Board Attributes

Name	Description
Thickness	The thickness of the printed circuit board

Thermal Connection

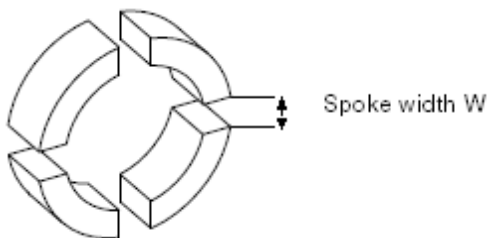
Through hole pins with too many thermals or too much copper area in the thermal connections associated with them create poor solder joints.

The No Thermal category detects drills lacking thermals and, according to their size, report the total copper area associated with them.

The measurement value is calculated as <number of thermal spokes> * <width of spokes> * <layer thickness> (as found in the layer attribute .copper_weight * 1.35 [the thickness of 1 ounce of copper]).

If you work in metric units, multiply the number obtained for layer thickness by the translation factor 25.4.

The width of a spoke is measured from one side to the opposite side of the spoke gap. Measurements are cumulative.



Identified thermals are symbols of 3, 4, or 5 spokes. Thermals of more than five spokes, unsymmetrical thermals, or drawn thermals are not always recognized and are reported to category 'No Thermal'.

PCB Aspect Ratio

Aspect ratio describes the relationship between drill span and drilled hole diameter. It is important because if holes are too small for a given span, they cannot be successfully plated. The ratio is usually given in the form 8:1, that is, drill span is eight times the drilled hole diameter.

Boards stored in ODB++ already contain the required information in various attributes (Thickness, Copper Weight and Thickness of Material) and individual drill tables.

Drill Checks report the aspect ratio for the smallest through hole and vias (standard, blind and buried) on a drill layer. Each category reports the aspect ratio calculated as $\frac{\text{<drill_span>}}{(\text{<hole_size>} + \text{const})}$.

- **<drill_span>** — As determined by `v_aspect_ratio_calc_drill_span`, is the value of board attribute Thickness (recommended where all drills are through hole and standard vias) or the calculation of the drill span obtained from the layer attributes Copper Weight and Thickness of Material (recommended where blind and buried vias are present and these attributes have been accurately defined).

For regular via drills, the span is considered as piercing all copper layers—a drill span of 3 layers pierces layer 1, 2 and 3. For vias of type laser or photo, the span is to the last layer, but does not pierce it.

- **<hole_size>** — The size of the smallest plated through hole or via in the layer (diameter for circular pads or diagonal of the bounding box for non-circular pads). Plated slots are ignored. Whether to use finished or unfinished drill diameter is determined by ERF variable `v_aspect_ratio_by_finished_size`.
- **const** — The correction constant determined by ERF variable `v_pcb_aspect_ratio_correction`.

If `v_aspect_ratio_calc_drill_span = 0` and attribute Thickness does not exist, or its value is zero or a negative number, a very large value (10000) is reported to the relevant categories to indicate a critical problem. One of these messages is printed to the log:

- Job attribute <Thickness> does not exist. (Unreliable results in Aspect Ratio categories.)
- Illegal value for job attribute <Thickness> (0.000000). (Unreliable results in Aspect Ratio categories.)

Categories in Drill Checks

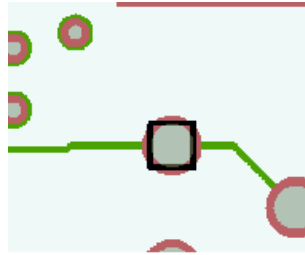
Several drill checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Table 2-4. Result Categories for Drill Checks

Category	Description
PTH Summary (Hole Size)	Reports the size of all PTH holes in the layer with attribute Drill Type = PTH.
NPTH Summary	Reports the size of all NPTH holes in the layer with attribute Drill Type = NPTH.
Via Summary (Hole Size)	Reports the size of all via holes in the layer with attribute Drill Type = Via.
Plated Slot Summary (Hole Size)	Reports the size of all plated slots in layer with attribute Drill Type = PTH.
Tooling Holes (Hole Size)	Reports all drill features with attribute Tooling Hole, and inserts each as a measurement.
Mounting Holes (Hole Size)	Reports all drill features with attribute Mounting Hole, and inserts each as a measurement.
Duplicate Holes (Hole Separation)	Reports holes whose centers are closer than duph_tolerance.
Touching Holes (Hole Separation)	Reports touching holes whose centers are further apart than ERF variable duph_tolerance.
Close Holes (Hole Separation)	Reports non-touching holes closer than close_hole_dist.
Missing Holes (Missing Holes)	Reports pads in the top and bottom layers of the drilled stack of the inspected drill layer where the appropriate conditions apply.
No Thermal (Thermal Connection)	Reports drills connected to a large plane (at least ten times larger than the drill) without an interceding thermal on negative and positive Power and Ground or mixed layers. Surfaces bearing the .tear_drop attribute are ignored.
TH Aspect Ratio (PCB Aspect Ratio)	Reports an aspect ratio for the smallest plated through hole in the layer, calculated as: <drill_span> / (<hole_size> + const).


PTH Summary (Hole Size)

Reports the size of all PTH holes in the layer with attribute Drill Type = PTH.

Analysis Category	<Area>:pth
Measurement Shape	Square
Measurement Entity	Pad (representing a PTH)
Layers Displayed	Drill layer
Graphic	
Purpose	The process of reviewing sizes of plated through holes used for components is necessary to determine that the holes are not smaller than accepted fabrication and assembly tolerances.
Function	Reports the size of all PTH holes in the layer with attribute Drill Type = PTH. Requires setting of the attribute by direct EDA input.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	PTH Size
Limitations	


NPTH Summary

Reports the size of all NPTH holes in the layer with attribute Drill Type = NPTH.

Analysis Category	<Area>:npth
Measurement Shape	Square representing NPTH
Measurement Entity	Pad (representing an NPTH)
Layers Displayed	Drill layer
Graphic	
Purpose	The process of reviewing non-plated through holes is necessary to find which holes are used, their location and their minimum and maximum sizes.
Function	Reports the size of all NPTH holes in the layer with attribute Drill Type=NPTH. Requires setting of the attribute by direct EDA input.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	NPTH Size
Limitations	


Via Summary (Hole Size)

Reports the size of all via holes in the layer with attribute Drill Type = Via.

Analysis Category	<Area>:via
Measurement Shape	Circle
Measurement Entity	Pad (representing a via)
Layers Displayed	Drill layer
Graphic	
Purpose	Reviewing sizes of via holes is necessary to determine that the holes are not smaller than the accepted fabrication tolerances.
Function	Reports the size of all via holes in the layer with attribute Drill Type = Via. Requires setting of the attribute by direct EDA input.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	Via Size
Limitations	

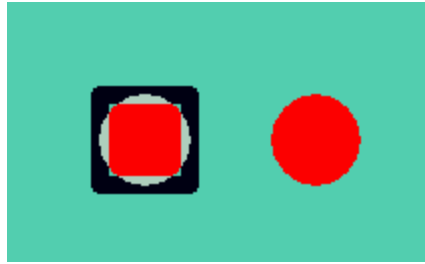
Plated Slot Summary (Hole Size)

Reports the size of all plated slots in layer with attribute Drill Type = PTH.

Analysis Category	<Area>:slot_pt
Measurement Shape	Shape
Measurement Entity	Slot
Layers Displayed	Drill layer
Graphic	
Function	Reports the size of all plated slots in layer with attribute Drill Type = PTH. Requires setting of the attribute by direct EDA input.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	PTH Size
Limitations	


Tooling Holes (Hole Size)

Reports all drill features with attribute Tooling Hole, and inserts each as a measurement.

Internal ERF Name	<Area>:tooling_holes
Measurement Shape	Circle
Measurement Entity	Pad (representing a tooling hole)
Layers Displayed	Drill layer
Graphic	
Purpose	Tooling holes are non-plated through holes on a board, used in the manufacturing process to align it during various processes such as autorout, ATE, and IFX Functional Tests.
Function	Reports all drill features with attribute Tooling Hole, and inserts each as a measurement. This category provides an ASCII summary of all tooling hole sizes in the layer.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	Tooling Hole Size
Limitations	

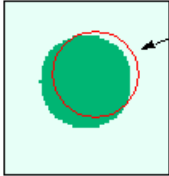
Mounting Holes (Hole Size)

Reports all drill features with attribute Mounting Hole, and inserts each as a measurement.

Analysis Category	<Area>:mount_holes
Measurement Shape	Circle
Measurement Entity	Pad (representing a mounting hole)
Layers Displayed	Drill layer
Graphic	
Purpose	Mounting holes are a pattern of holes on a PCB used to attach the PCB to another object. The object may be another board, chassis, or sheet metal. If tolerances are suitable, mounting holes may also serve as tooling locations for assembly and test operations.
Function	Reports all drill features with attribute Mounting Hole, and inserts each as a measurement. It provides an ASCII summary of all mounting hole sizes in the layer.
ERF Parameters	pp_drill_layer
ERF Variables	
Constraint	Mounting Holes (Hole Size)
Limitations	

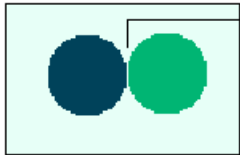
Duplicate Holes (Hole Separation)

Reports holes whose centers are closer than duph_tolerance.

Analysis Category	<Area>:duph
Measurement Shape	Shape representing drill
Measurement Entity	Two pads (representing any drill)
Layers Displayed	Drill layer
Graphic	
Purpose	Duplicate holes (holes with same size and location) serve no purpose. They just lengthen the drilling process and incur wear and tear on the drill bit. Clicking on duplicate holes causes the pile-up menu to appear. Select the hole you want from the list. Placing the cursor over the name in the list highlights the feature.
Function	Reports holes whose centers are closer than duph_tolerance. Measurements are shapes representing the drill with the smallest index in layer.
ERF Parameters	pp_drill_layer
ERF Variables	duph_tolerance
Limitations	

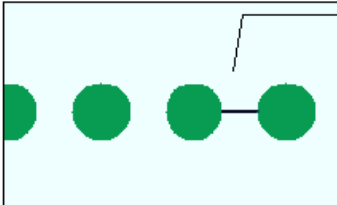
Touching Holes (Hole Separation)

Reports touching holes whose centers are further apart than ERF variable dugh_tolerance.

Analysis Category	<Area>:touchh
Measurement Shape	Segment
Measurement Entity	Two pads (representing any drill)
Layers Displayed	Drill layer
Graphic	 <p>Touching holes - drills touching each other, whose centers are further apart than dugh_tolerance.</p>
Purpose	Holes that touch each other can cause the creation of irregular shapes with acute corners susceptible to breakage.
Function	Reports touching holes whose centers are further apart than ERF variable dugh_tolerance. Measurement is a segment representing the inter-center distance of the holes.
ERF Parameters	pp_drill_layer
ERF Variables	dugh_tolerance
Limitations	


Close Holes (Hole Separation)

Reports non-touching holes closer than close_hole_dist.

Analysis Category	<Area>:closeh
Measurement Shape	Segment
Measurement Entity	Two pads (representing drill diameters)
Layers Displayed	Drill layer
Graphic	
Purpose	Holes which are too close may create a tiny inter-hole strip which is liable to break during processing.
Function	Reports non-touching holes closer than close_hole_dist. Measurements are shapes representing distance segments.
ERF Parameters	pp_drill_layer
ERF Variables	close_hole_dist
Limitations	


Missing Holes (Missing Holes)

Reports pads in the top and bottom layers of the drilled stack of the inspected drill layer where the appropriate conditions apply.

Analysis Category	<Area>:missh
Measurement Shape	Point
Measurement Entity	Pad
Layers Displayed	Top and bottom outer layers
Graphic	
Purpose	This category serves as a warning. Sometimes a hole is omitted by a mistake, then two pads will be located on both sides of a stack without a connecting hole.
Function	<p>Reports pads in the top and bottom layers of the drilled stack of the inspected drill layer where all of the following apply:</p> <ul style="list-style-type: none">• No drill touches the top pad.• Both pads are non SMD.• The distance between the pad centers is no more than duph_tolerance. <p>Measurement is a point at the center of the top pad.</p> <p>If a fiducial is found in one of the outer layers, a missing hole violation is not reported.</p>
ERF Parameters	pp_drill_layer
ERF Variables	duph_tolerance
Limitations	

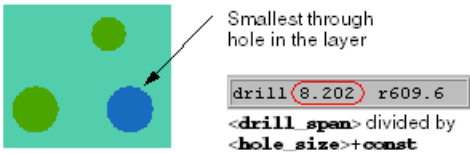
No Thermal (Thermal Connection)

Reports drills connected to a large plane (at least ten times larger than the drill) without an interceding thermal on negative and positive Power and Ground or mixed layers. Surfaces bearing the .tear_drop attribute are ignored.

Analysis Category	<Area>:no_thermal;<pin_type>
Measurement Shape	Drill shape
Measurement Entity	Drill shape
Layers Displayed	Drill layer Copper layer
Graphic	
Purpose	Through-hole pins connected directly to a plane without a thermal may cause an improper solder joint due to heat dissipation.
Function	Reports drills connected to a large plane (at least ten times larger than the drill) without an interceding thermal on negative and positive Power and Ground or mixed layers. Surfaces bearing the .tear_drop attribute are ignored.
ERF Parameters	pp_drill_layer
ERF Variables	min_pad_to_report_thermal min_trace_to_report_thermal max_thermal_dist v_polarity_for_thermal_check
Limitations	

TH Aspect Ratio (PCB Aspect Ratio)

Reports an aspect ratio for the smallest plated through hole in the layer, calculated as:
 $\text{<drill_span> / (<hole_size> + const)}$.

Internal ERF Name	th_aspect_ratio
Measurement Shape	Smallest TH drill in the layer
Measurement ID	Pad (representing a drill), drill size, drill span
Measurement Value	Ratio (floating point number)
Layers Displayed	Drill layer
Graphic	
Purpose	Aspect ratio is a fabrication term used to describe the relationship between drill span and the drilled hole diameter. Holes that are too small for their length cannot be successfully plated.
Function	<p>Reports an aspect ratio for the smallest plated through hole in the layer, calculated as: $\text{<drill_span> / (<hole_size> + const)}$</p> <ul style="list-style-type: none"> • <drill_span> — determined by ERF variable v_pcb_aspect_ratio_correction. • <hole_size> — Size of the smallest plated through hole in the layer (diameter for circular pads or diagonal of the bounding box for non-circular pads). Plated slots are ignored. • const — Correction constant determined by ERF variable v_pcb_aspect_ratio_correction. <p>If v_aspect_ratio_calc_drill_span = 0 and attribute Thickness does not exist, or its value is zero or a negative number, a very large value (10000) is reported to the relevant categories to indicate a critical problem. A message is printed to the log.</p>
ERF Parameters	pp_drill_layer
ERF Variables	v_pcb_aspect_ratio_correction v_aspect_ratio_by_finished_size v_aspect_ratio_calc_drill_span
Limitations	

ERF Parameters for Drill Checks

Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Drill Layer	pp_drill_layer	Defines the layer to be affected by the action.	All categories
Test List	pp_tests	Defines the tests to be run. See “Tests Performed in Drill Checks” on page 31.	All categories

ERF Variables for Drill Checks

Variables set in the ERF file control the analysis.

ERF Variable	Description	Categories Affected
close_hole_dist	Maximum search radius for 'Hole Separation' tests. (default = 24 mils) Close Holes — When non-touching holes are closer than this variable.	Close Holes
duph_tolerance	Defines the relationship between holes and pads. (default = 0.5) They are defined as: Duplicate Holes — Two holes whose centers are closer than this value. Touching Holes — Two holes whose centers are further apart than this value, but touch. Missing Holes — Two pads in top and bottom layers where all these apply: <ul style="list-style-type: none"> • The distance between pad centers is no more than this value. • No drill touches the top pad. • Both pads are non SMD. 	Duplicate Holes Touching Holes Missing Holes
max_thermal_dist	Distance within which to check for a thermal. If no thermal is found, results are reported to 'No Thermal'.	No Thermal
min_pad_to_report_thermal	Minimum diameter of thermal pads to report on inner layers if the thermal has only one or two spoke gaps. Relates only to positive layers. (default=200mil)	No Thermal
min_trace_to_report_thermal	Minimum trace width (cumulative) to report thermals of either one or two spoke gaps on inner layers. Relates only to positive layers. (default=200mil)	No Thermal

ERF Variable	Description	Categories Affected
v_aspect_ratio_calc_drill_span	<p>Controls whether drill span is taken from the job attribute Thickness or calculated using the layer attributes .copper_weight and Thickness of Dielectric Below Layer.</p> <p>0 — Drill Span taken from attribute Thickness. (default) Recommended where all drills are through hole and standard vias.</p> <p>1 — Drill span calculated using attributes .copper_weight and Thickness of Dielectric Below Layer. Recommended where blind and buried vias are present and these attributes have been accurately defined.</p>	TH Aspect Ratio
v_aspect_ratio_by_finished_size	<p>Controls the size taken from the drill tool manager for drill diameter, finished or unfinished.</p> <p>0 — Use drill size (drill diameter before plating).</p> <p>1 — Use finished drill size (drill diameter after plating). (default)</p>	TH Aspect Ratio
v_pcb_aspect_ratio_correction	<p>The constant used in calculating the aspect ratio. (default=0)</p>	TH Aspect Ratio
v_polarity_for_thermal_check	<p>Controls the layers to be affected by the Thermal Connection checks.</p> <p>All — All layers. (default)</p> <p>Negative — Negative layers only.</p> <p>Positive — Positive layers only.</p>	No Thermal

Chapter 3

Fabrication Analysis - Signal Layer Checks

The Signal Layer action is a read-only action that finds potential manufacturability defects in signal and mixed layers, and generate statistics. The action can operate on any layer, but is mainly intended for signal layers. It uses the layer itself and any NC (drill or rout) layer which pierces it.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Signal Layer Checks

Several signal checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Spacing — Reports spacing violations between pads, circuits and nets, and between text to text. Also reports shorts and spacing between different CAD nets and close distances between non-touching features on the same CAD or Layer nets.

Drill — Reports distance violations between NPTHs, PTHs, Vias, and pads, circuits, annular rings and copper. Also reports missing pads.

Size — Reports sizes of pads, shaved lines, text, line neckdowns, arcs and shaved arcs.

Sliver — Reports on slivers between lines and pads or between pads and pads. Slivers between two features with the Copper Text attribute are ignored. However, a sliver between a text feature and a functional pad are reported. See “[Sliver and Short Sliver Categories \(Signal Layer Checks\)](#)” on page 56.

Stubs — Reports unconnected line endpoints.

SMD — Lists SMD pads, reports on pitch of SMD pads, and identifies SMD packages.

Bottleneck — Reports thin copper surfaces which could break during assembly.

Exposure — reports distances between exposed vias to exposed vias, toeprints, or copper on outer layers.

Attributes Used in Signal Layer Checks

Attributes assigned to features and components in the product model control the analysis.

Feature Attributes

Table 3-1. Signal Layer Checks Feature Attributes

Name	Description
Copper Balancing	This attribute is attached to features which are added during a pattern fill operation, either manually or through the Copper Balance DFM action. If a line or arc has this attribute attached, then it will not be reported in the line histogram display.
Copper Feature Ignore	Copper features bearing this attribute are ignored in analysis actions. (Presently implemented only for Rout Test.)
Copper Text	This attribute defines a feature as a nomenclature legend feature. The attribute affects the fabrication analysis by directing spacing checks between such features into a new category (Text to text).
Drill Type	This attribute is attached to hole features in drill layers. It defines the type of drill and is used extensively during fabrication analysis.
Pad Usage	The feature attribute Pad Usage is attached to pads on outer signal layers. It value can be one of the following: toeprint via g_fiducial l_fiducial tooling_hole
SMD Pad	This feature attribute should be attached to outer layer pads which are lands for SMD components. It is set by the 'Set SMD Attribute' Cleanup Action.

Component Attributes

Table 3-2. Signal Layer Checks Component Attributes

Name	Description
Ignore Graphically/ Output	This attribute is attached to a component to be ignored during DFM actions.

Table 3-2. Signal Layer Checks Component Attributes (cont.)

Name	Description
Required Toeprint Spacing	This attribute is specifically attached to components for reporting in the Toeprint to Toeprint category. It defines the maximum spacing within which to report pad to pad spacing measurements. Range: 1-500 Units: inch or mm

DFM Analysis Compatibility for Signal Layer Checks

To maintain compatibility between legacy products and DFM Analysis, ERF variables used with earlier products are mapped to the appropriate DFM Analysis ERF variables.

Earlier Products	DFM Analysis
ignore_isolated_pad = yes	miss_pad_for_isolated_hole = 0
ignore_isolated_pad = no	miss_pad_for_isolated_hole = 1
diff_net_local_spacing	v_slivers_check_diff_nets
dist2sliver_ratio	v_dist2sliver_ratio
min_sliver_len	v_min_sliver_len

Annular Ring Measurement

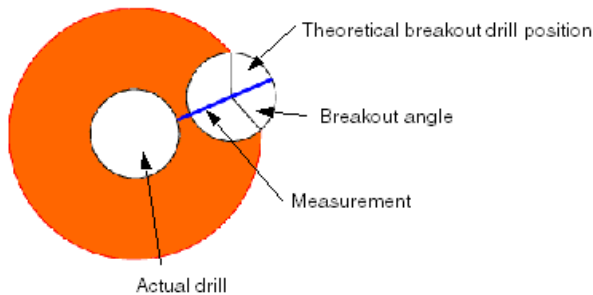
The calculation of annular ring measurements depend on whether breakouts are allowed by the designer.

The normal procedure requires two values:

- RM_AR, Reliability Margin for Annular Ring as received from the customer (the implementation of the RM_AR does not allow the specification of a breakout).
- DRA, Design Registration Allowance is generated by the analysis (the maximum misregistration permitted by a design while still meeting all other requirements).

For example, if the minimum annular ring width = 4, RM_AR = 1, then DRA=4-1=3.

If the user specifies that the RM should allow a breakout (RM_AR=0), the measurement will be extended to the outer perimeter of the drill hole in the position of a theoretical breakout, as in the following figure:

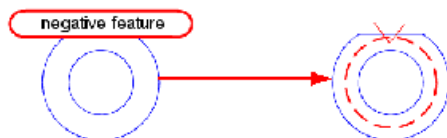


The breakout angle is defined in the ERF parameter via_breakout_angle or pth_breakout_angle. The range is 0-180, where 0 means no breakout is allowed.

When you do specify a breakout, RM_AR must be specified as zero, and the system will automatically calculate an extended Annular Ring measurement based on the size of the AR and drill. The AR size that is reported is larger than the actual AR size by an amount that depends on the AR and drill sizes (see example below).

The system assumes a drill that is centered within the AR and an AR that is a circle. If the AR is any other shape the system will construct a circle from this shape and plan the breakout on the constructed circular AR. The following figure clarifies this:

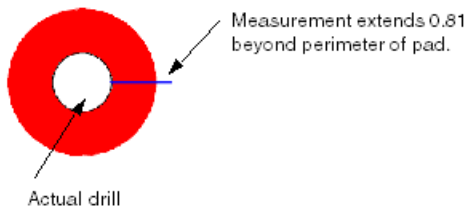
When a negative feature shaves an AR pad, the system assumes a hold circle and positions the breakout according to this assumption.



When the feature is rectangular, the system also assumes a circular AR and positions the breakout accordingly.



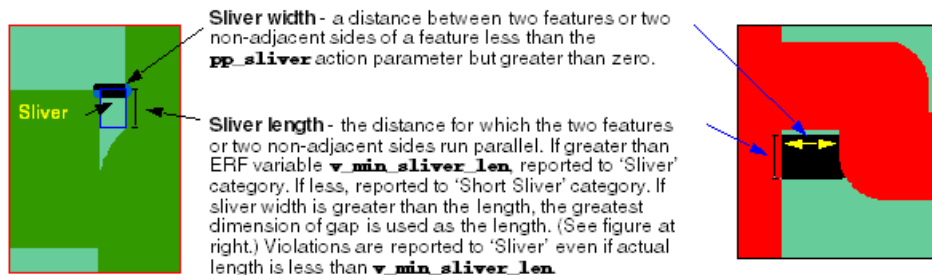
This example describes an annular ring with a 90° breakout angle. Outer radius = 20, Inner radius = 10. The annular ring width = 5. In this case, since RM=0, the minimum annular ring = 5.81 and $DRA = 5.81 - 0 = 5.81$.



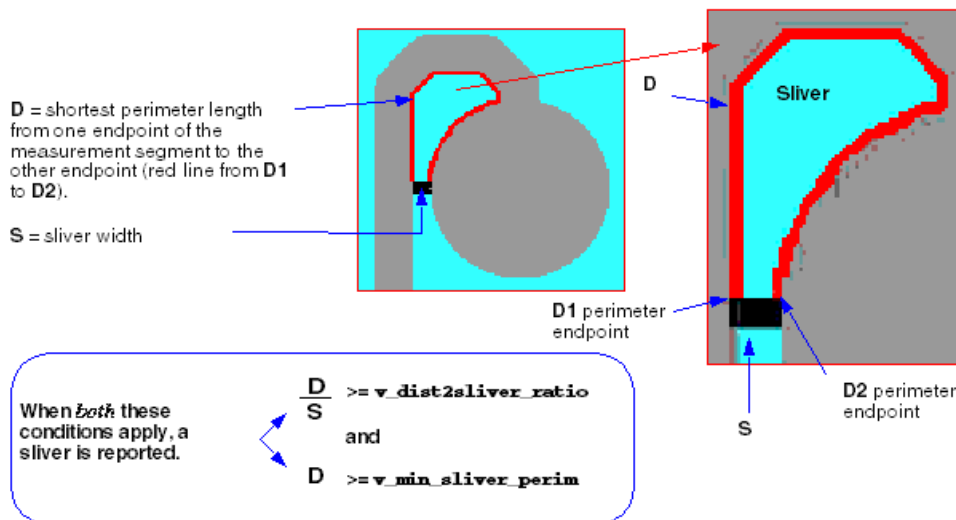
Sliver and Short Sliver Categories (Signal Layer Checks)

These two categories deal with slivers, narrow strips of copper between two features or between non-adjacent sides of the same feature. It is important to detect slivers which could break off during the manufacturing process and cause shorts. In detecting slivers, length, width and shortest perimeter length are measured.

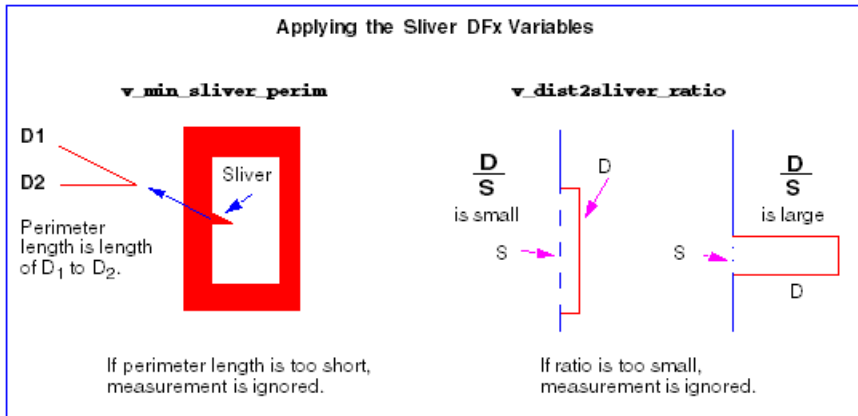
These categories do not detect acute angles. To detect acute angles as slivers, set ERF parameter `pp_sliver` = 12 mils or more (this may also cause additional reports of non-critical violations).



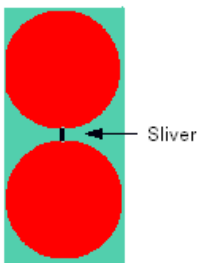
Measurements are distance segments between two connected features (features on the same net) or two non-adjacent sides of one feature.



Applying the Sliver DfX Variables

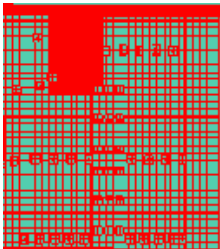


When the two features are not connected (not on the same net), v_dist2sliver_ratio and v_min_sliver_perim become irrelevant.



Slivers found on hatched areas (a plane filled with lines instead of solid copper, where each line in the area has the attribute Hatch Feature) are reported only if ERF variable replace_crosshatch_by_surface=by_attr. (Default value = yes).

However, if the surface is filled with at least fifty lines of the same width, it is accepted as a hatched area even if the lines do not bear the Hatch Feature attribute and ERF variable replace_crosshatch_by_surface=no.



Categories in Signal Layer Checks

Several signal checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Spacing measurements are reported when they are within the search radius (the value of ERF parameter pp_spacing).

Table 3-3. Result Categories for Signal Layer Checks

Category	Description
Via to Via (Spacing)	Reports via pad to via pad measurements less than pp_spacing.
Pad to Pad (Spacing)	Reports electrically unconnected pads (in the same layer) closer than pp_spacing.
Pad to Circuit (Spacing)	Reports unconnected pads and circuit elements closer than pp_spacing in the same layer.
Circuit to Circuit (Spacing)	Reports unconnected circuit elements closer than pp_spacing in the same layer.
Text to Text (Spacing)	Reports text features closer than pp_spacing.
Text Touches Copper (Spacing)	Reports text features touching copper features.
Spacing Length (Spacing)	Reports parallel lines closer than pp_spacing belonging to different layer nets.
Same Net Spacing (Spacing)	Reports non-touching, non-text features closer than pp_spacing belonging to the same layer net.
CAD Self Spacing (Spacing)	Reports non-touching features closer than pp_spacing belonging to the same CAD net.
NPTH to Pad (Drill)	Reports other net NPTHs and pads closer than pp_d2c in accordance with group_drill_to_copper.
NPTH to Circuit (Drill)	Reports other net NPTHs and circuits closer than pp_d2c in accordance with group_drill_to_copper.
PTH to Copper (Drill)	Reports plated holes of different nets in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
PTH to Copper Same Net (Drill)	Reports plated holes of the same net in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
PTH Registration (Drill)	Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg.

Table 3-3. Result Categories for Signal Layer Checks (cont.)

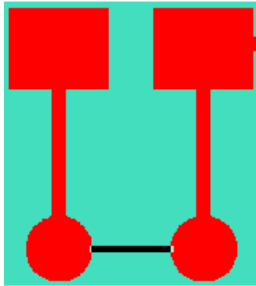
Category	Description
NPTH Registration (Drill)	Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg.
NPTH Annular Ring (Drill)	Reports the shortest distance between drill and laminate for NPTHs embedded in copper if closer than pp_d2c.
PTH Annular Ring (Drill)	Reports the shortest distance between drill and laminate for PTHs (or vias) embedded in copper if closer than pp_d2c.
PTH (Comp) Annular Ring (Drill)	Reports the shortest distance between drill and laminate for PTHs embedded in copper if closer than pp_d2c.
Blind Via Annular Ring (Drill)	Reports the shortest distance between drill and laminate for blind vias embedded in copper if closer than pp_d2c.
Buried Via Annular Ring (Drill)	Reports the shortest distance between drill and laminate for buried vias embedded in copper if closer than pp_d2c.
Via to Copper (Drill)	Reports other net, via holes closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
Tooling Hole to Exposed Copper (Drill)	Reports all tooling holes closer than pp_d2c to exposed copper on an outer layer.
Pads (Size)	Provides a summary of all pads in a signal layer. Measurements are pad shapes. (circle, square or contour).
Lines (Size)	Reports width of lines representing conductor traces in signal layers.
Shaved Line (Size)	Reports lines touched by negative shaves, NPTHs, or non-plated rout features.
Text (Size)	Reports all lines tagged by the Copper Text system attribute.
Line Neckdown (Size)	Reports lines that are joined so that the width at the narrowest point is less than nominal line width.
Arc (Size)	Reports arc features thinner than max_line_width with neither Copper Text nor Copper Balancing attributes.
Shaved Arc (Size)	Reports arc features shaved by negative features, NPTHs or non-plated rout features.
Conductor Width (Size)	Reports lines with neckdowns.
Sliver (Sliver) (Signal Layer)	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero.

Table 3-3. Result Categories for Signal Layer Checks (cont.)

Category	Description
Short Sliver (Sliver) (Signal Layer)	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero.
Stubs (Stubs)	Reports line endpoints that do not touch any other feature.
SMD Pads (SMD)	Reports pads tagged with feature attribute SMD Pad.
Exposed Via to Exposed Via (Exposure)	Reports distances less than pp_e_spacing between the edges of the exposed copper of two uncapped vias, while ignoring pads of the same net that are fully embedded in copper. Classified by the process.
Exposed Via to Exposed Copper (Exposure)	Reports the distance between the edge of the exposed copper of an uncapped via and the exposed copper on the outer signal layers only, when closer than pp_e_spacing. Does not report spacing between pads of the same net that are fully embedded in copper. Classified by process. The reported exposed via and exposed copper surface do not touch.

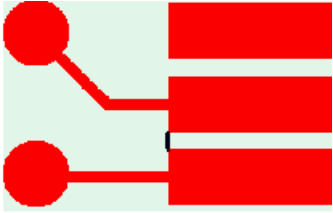
Via to Via (Spacing)

Reports via pad to via pad measurements less than pp_spacing.

Internal ERF Name	<Area>:via2via
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	Pad1; Pad2
Layers Displayed	Signal layer
Graphic	
Purpose	To apply spacing restrictions to via pads.
Function	<p>Reports via pad to via pad measurements less than pp_spacing. Does not report measurements involving features with attribute Copper Feature Ignore.</p> <p>Via, in this instance, refers to a via hole with attribute Drill Type = Via.</p> <p>If the job was created directly from a CAD database, extra functionality is provided. A measurement between pads of the same CAD net, even if unconnected in the same layer, are placed in the 'CAD Self Spacing' category rather than the 'Via to Via' category.</p>
ERF Parameters	pp_spacing pp_layer
ERF Variables	classify_pad2pad = yes
Constraint	Via Spacing
Limitations	

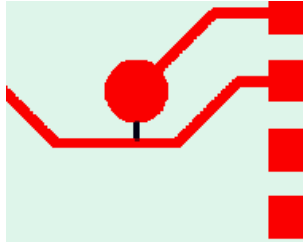
Pad to Pad (Spacing)

Reports electrically unconnected pads (in the same layer) closer than pp_spacing.

Internal ERF Name	<Area>p2p
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	Pad1; Pad2
Layers Displayed	Signal layer
Graphic	
Purpose	Close pads may bridge during imaging, etching, plating or soldering, and result in a direct short.
Function	<p>Reports electrically unconnected pads (in the same layer) closer than pp_spacing. Measurements are segments, provided they only touch copper at its end points.</p> <p>If classify_pad2pad=yes, the measurements reported are only between pads that are both non-drilled and non-SMD. If no, all measurements are reported here.</p> <p>Does not report measurements involving features with attribute Copper Feature Ignore.</p> <p>If the job was created directly from a CAD database, extra functionality is provided. A measurement between pads of the same CAD net, even if unconnected in the same layer, are placed in the 'CAD Self Spacing' category rather than the 'Pad to Pad' category.</p>
ERF Parameters	pp_layer pp_spacing
ERF Variables	classify_pad2pad
Constraint	Feature Spacing
Limitations	

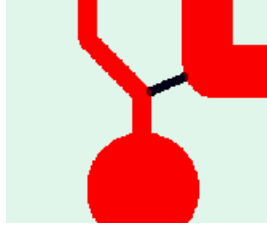
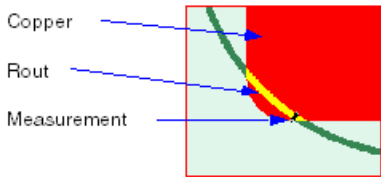
Pad to Circuit (Spacing)

Reports unconnected pads and circuit elements closer than pp_spacing in the same layer.

Internal ERF Name	<Area>p2c
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	Pad; Circuit
Layers Displayed	Signal layer
Graphic	
Purpose	A pad and a circuit too close may bridge during imaging, etching, plating or soldering, and result in a direct short.
Function	<p>Reports unconnected pads and circuit elements closer than pp_spacing in the same layer. Measurements are segments, provided they only touch copper at its end points. Does not report measurements involving features with attribute Copper Feature Ignore.</p> <p>If the job was created directly from a CAD database, extra functionality is provided. A measurement between pads, even if unconnected, and circuits of the same CAD net in the same layer are placed in the 'CAD Self Spacing' category rather than in the 'Pad to Circuit' category.</p>
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_surface_spacing_separately
Constraint	Feature Spacing
Limitations	


Circuit to Circuit (Spacing)

Reports unconnected circuit elements closer than pp_spacing in the same layer.

Internal ERF Name	<Area>:c2c
Measurement Shape	Segment
Measurement Value	Spacing
Measurement ID	Circuit1; Circuit2
Layers Displayed	Signal layer
Graphic	
Purpose	Close circuits may bridge during imaging, etching, plating or soldering, and result in a direct short.
Function	<p>Reports unconnected circuit elements closer than pp_spacing in the same layer. Measurements are segments, provided they only touch copper at its end points. Does not report measurements involving features with attribute Copper Feature Ignore.</p> <p>Jobs created directly from a CAD database, contain extra functionality. A measurement between two circuits of the same CAD net, even if unconnected in the same layer, are reported to 'CAD Self Spacing' rather than 'Circuit to Circuit'.</p> <p>Violations occurring when rout features or non-plated holes cross copper features are also reported to this category. Make sure the respective layers (rout and npth drill) are displayed. Otherwise, measurements seem to be embedded within a copper feature. Activating the relevant layer reveals that the copper feature has been cut into two very close</p> <div style="text-align: center;">  <p>Copper</p> <p>Rout</p> <p>Measurement</p> </div> <p>surfaces.</p>
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_surface_spacing_separately
Constraint	Feature Spacing
Limitations	


Text to Text (Spacing)

Reports text features closer than pp_spacing.

Internal ERF Name	<Area>:text2text
Measurement Shape	Segment
Measurement Value	Spacing
Measurement ID	Text1; Text2
Layers Displayed	Signal layer
Graphic	
Purpose	Copper marked as text on a layer may create spacing violations. Since these are typically non-critical, they are channelled to a special category.
Function	Text features are either features of type text, or lines, arc, or pads tagged with attribute Copper Text. Reports text features closer than pp_spacing. Does not report measurements involving features with attribute Copper Feature Ignore.
ERF Parameters	pp_layer pp_spacing
Limitations	

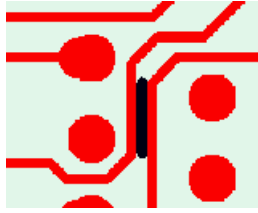


Text Touches Copper (Spacing)

Reports text features touching copper features.

Internal ERF Name	<Area>:text_touch_copper
Measurement Shape	Shape
Measurement Value	Size
Measurement ID	Text feature
Layers Displayed	Signal layer
Graphic	
Purpose	Copper marked as text on a layer should be isolated from conducting features to avoid shorts.
Function	Reports text features (text, or lines, arc, or pads tagged with attribute Copper Text) touching copper features. Does not report measurements involving features with attribute Copper Feature Ignore.
ERF Parameters	pp_layer
ERF Variables	
Constraint	Text Touches Copper
Limitations	

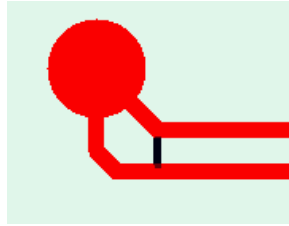
Spacing Length (Spacing)

Reports parallel lines closer than pp_spacing belonging to different layer nets.

Internal ERF Name	<Area>:spacing_length
Measurement Shape	Line
Measurement Value	Distance
Measurement ID	Circuit1; Circuit2
Layers Displayed	Signal layer
Graphic	
Purpose	This category provides a report on cumulative lengths of parallel spacing in a layer. The results can be used for forecasting yields and planning.
Function	<p>Reports parallel lines closer than pp_spacing belonging to different layer nets. Also measures the overlap of lines (line to line) greater than min_line_len (see figure below).</p> <p>Measurements are lines representing the parallel spacing and overlap. Measurements are reported when both of the following conditions are</p> <div><p>AND</p></div> <p>met:</p> <p>Does not report measurements involving features with attribute Copper Feature Ignore.</p>
ERF Parameters	pp_layer pp_spacing
ERF Variables	spacing_length_measure = yes spacing_resolution min_line_len
Constraint	Feature Spacing
Limitations	In rare cases where one of the lines touches another feature in the layer, the action does not report the cumulative lengths of parallel spacing.

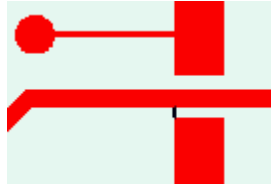
Same Net Spacing (Spacing)

Reports non-touching, non-text features closer than pp_spacing belonging to the same layer net.

Internal ERF Name	<Area>:self_spacing
Measurement Shape	Segment
Measurement Value	Distance
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Purpose	Spacing (p2p, p2c, c2c) is measured only between features of different layer nets. There is a need to find spacing violations between features of the same net when this spacing is small and can potentially cause slivers.
Function	Reports non-touching, non-text features closer than pp_spacing belonging to the same layer net. Measurements are segments representing the distance. Does not report measurements involving features with attribute Copper Feature Ignore. To retain compatibility with prior software versions, this category is reported in the Results Viewer under 'Same Net Spacing'.
ERF Parameters	pp_layer pp_spacing
ERF Variables	large_net_min self_spacing = yes
Constraint	Feature Spacing
Limitations	Due to performance considerations, nets considered drawn surfaces (that contain more features than specified in large_net_min) are not tested for 'Same Net Spacing' violations. Measurements are located arbitrarily between the contours of two parallel features. If the location happens to be over copper, that violation is not reported.

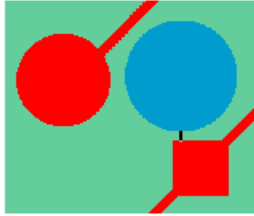
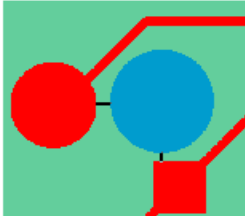
CAD Self Spacing (Spacing)

Reports non-touching features closer than pp_spacing belonging to the same CAD net.

Internal ERF Name	<Area>:cad_self_spacing
Measurement Shape	Segment
Measurement Value	Distance
Measurement ID	Feature1; Feature2
Layers Displayed	Signal layer
Graphic	
Purpose	There can be instances where close features are located in different layer nets but still belong to the same CAD net (for example, two ground pads or planes connected through other layers). When the system 'knows' the CAD nets, it channels these spacing violations to this category instead of the p2p, p2c or c2c categories. This avoids creating false alarms since CAD Self Spacing violations are not normally an issue.
Function	Reports non-touching features closer than pp_spacing belonging to the same CAD net. Measurements are segments representing the distance, if they only touch copper at their end-points. Does not report measurements involving features with attribute Copper Feature Ignore.
ERF Parameters	pp_layer pp_spacing
ERF Variables	
Constraint	Feature Spacing
Limitations	Layer data must be input directly from a CAD database.

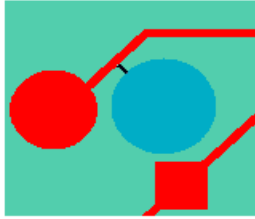
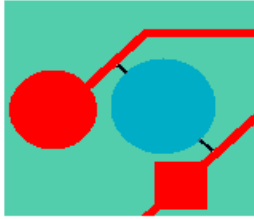
NPTH to Pad (Drill)

Reports other net NPTHs and pads closer than pp_d2c in accordance with group_drill_to_copper.

Internal ERF Name	<Area>npth2p
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	NPTH; Pad
Layers Displayed	Signal layer Drill layer which pierces it
Graphic	<div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p>group drill to copper = 1 Employ Grouping</p> </div> <div style="text-align: center;">  <p>group drill to copper = 0 Don't Employ Grouping</p> </div> </div>
Purpose	When an NPTH is too close to a pad, drill machine inaccuracy may cause the NPTH to 'bite' the pad and damage it.
Function	Reports other net NPTHs and pads closer than pp_d2c in accordance with group_drill_to_copper.
ERF Parameters	pp_layer pp_d2c
ERF Variables	group_drill_to_copper
Constraint	Hole to Feature Spacing
Limitations	

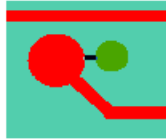

NPTH to Circuit (Drill)

Reports other net NPTHs and circuits closer than pp_d2c in accordance with group_drill_to_copper.

Analysis Category	<Area>:npth2c
Measurement Shape	Segment
Measurement Value	Spacing
Measurement ID	NPTH; Circuit
Layers Displayed	Signal layer Drill layer which pierces it
Graphic	<div>  <p>group_drill_to_copper = 1 Employ Grouping</p> </div> <div>  <p>group_drill_to_copper = 0 Don't Employ Grouping</p> </div>
Purpose	When an NPTH is too close to a circuit, drill machine inaccuracy may cause it to 'bite' the circuit and damage it.
Function	Reports other net NPTHs and circuits closer than pp_d2c in accordance with group_drill_to_copper.
ERF Parameters	pp_layer pp_d2c
ERF Variables	group_drill_to_copper v_surface_spacing_separately
Constraint	Hole to Feature Spacing
Limitations	Copper text is considered as a circuit.



PTH to Copper (Drill)

Reports plated holes of different nets in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.

Internal ERF Name	<Area>:pth2c
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	PTH; Feature
Layers Displayed	Signal layer Drill layer which pierces it
Graphic	<div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p>group_drill_to_copper = 1 Employ Grouping</p> </div> <div style="text-align: center;">  <p>group_drill_to_copper = 0 Don't Employ Grouping</p> </div> </div>
Purpose	To detect holes too close to other net copper.
Function	Reports plated holes of different nets in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
ERF Parameters	pp_layer pp_d2c
ERF Variables	group_drill_to_copper classify_via2c v_split_pth2c_report
Constraint	Hole to Feature Spacing
Limitations	

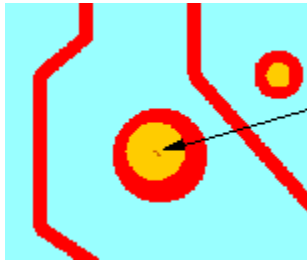
PTH to Copper Same Net (Drill)

Reports plated holes of the same net in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.

Internal ERF Name	<Area>:pth2c_same_net
Measurement Shape	Spacing segment
Measurement Value	Spacing
Measurement ID	PTH; Feature
Layers Displayed	<ul style="list-style-type: none"> • Signal layer • Drill layer which pierces it
Graphic	<div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p>group_drill_to_copper = 1 Employ Grouping</p> </div> <div style="text-align: center;">  <p>group_drill_to_copper = 0 Don't Employ Grouping</p> </div> </div>
Purpose	To detect holes too close to copper where there is no pad around the hole (on internal layers).
Function	Reports plated holes of the same net in the same layer closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
ERF Parameters	pp_layer pp_d2c
ERF Variables	group_drill_to_copper classify_via2c v_split_pth2c_report = yes
Constraint	Hole to Feature Spacing
Limitations	

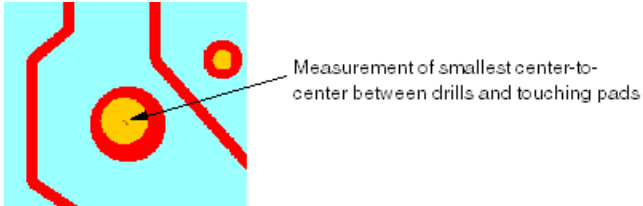
PTH Registration (Drill)

Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg.

Internal ERF Name	<Area>:reg
Measurement Shape	Segment
Measurement Value	Distance
Measurement ID	Hole; Feature
Layers Displayed	<ul style="list-style-type: none">• Signal layer• Drill layer which pierces it
Graphic	
Purpose	Typically, a hole should be in the middle of a pad. Any deviation may indicate inaccuracy in the input files or a CAD system error.
Function	Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg. Measurements are segments representing distance.
ERF Parameters	pp_layer
ERF Variables	reg_allowance max_reg
Constraint	Hole Registration
Limitations	If the distance between the centers is larger than max_reg, then the features are considered offset on purpose and large registration errors may be missed. Vias drilled in SMD lands may be intentionally offset.

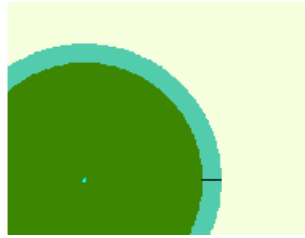
NPTH Registration (Drill)

Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg.

Internal ERF Name	<Area>npth_reg
Measurement Shape	Segment
Measurement Value	Distance
Measurement ID	Hole; Feature
Layers Displayed	Signal layer Drill layer which pierces it
Graphic	
Purpose	Typically, a hole should be in the middle of a pad. Any deviation may indicate inaccuracy in the input files or a CAD system error.
Function	Reports the smallest center-to-center distance between drills and touching pads, if larger than reg_allowance and smaller than max_reg. Measurements are segments representing distance.
ERF Parameters	pp_layer
ERF Variables	reg_allowance max_reg
Constraint	Hole Registration
Limitations	If the distance between the centers is larger than max_reg, then the features are considered offset on purpose and large registration errors may be missed. Vias drilled in SMD lands may be intentionally offset.


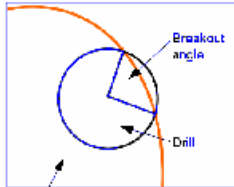
NPTH Annular Ring (Drill)

Reports the shortest distance between drill and laminate for NPTHs embedded in copper if closer than pp_d2c.

Internal ERF Name	<Area>:npth_ar
Measurement Shape	Segment
Measurement Value	Ring
Measurement ID	NPTH; Feature (or r0)
Layers Displayed	Signal layer Drill layer that pierces it
Graphic	
Purpose	
Function	Reports the shortest distance between drill and laminate for NPTHs embedded in copper if closer than pp_d2c. Measurements are segments representing distance between the NPTH and nearest laminate.
ERF Parameters	pp_layer pp_d2c
ERF Variables	limited_npth_check
Limitations	<p>If there is any copper in the NPTH, then a zero annular ring measurement is reported. This may be considered by some to be a false alarm.</p> <p>Where NPTH AR is composed of more than one feature (such as in drawn surfaces), the measurement entity will be r0.</p>

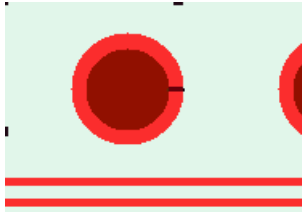
PTH Annular Ring (Drill)

Reports the shortest distance between drill and laminate for PTHs (or vias) embedded in copper if closer than pp_d2c.

Analysis Category	<Area>:ar
Measurement Shape	Spacing segment
Measurement Value	Ring
Measurement ID	PTH (or via); Feature (or r0)*
Layers Displayed	Signal layer Drill layer which pierces it
Graphic	
Purpose	When an annular ring around a plated through hole is too small, the hole may shift during drilling and cause insufficient plating later.
Function	<p>Reports the shortest distance between drill and laminate for PTHs (or vias) embedded in copper if closer than pp_d2c. The measurement takes into account both negative and positive data. Measurements are segments representing the shortest distance from drill to laminate. Breakouts are enabled by specifying a breakout</p>  <p>angle.</p> <p>For further details see Annular Ring Measurement.). Where PTH AR is composed of more than one feature (as in drawn surfaces), the measurement entity will be r0.</p>
ERF Parameters	pp_layer pp_d2c
ERF Variables	pth_breakout_angle classify_pad_ar = no
Limitations	

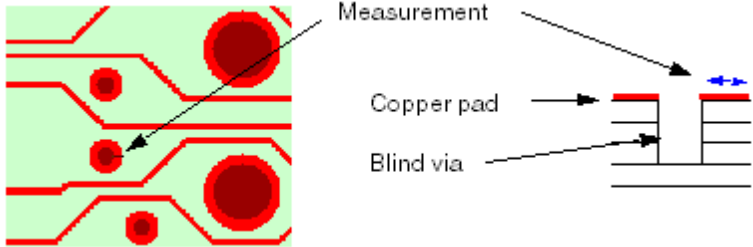
PTH (Comp) Annular Ring (Drill)

Reports the shortest distance between drill and laminate for PTHs embedded in copper if closer than pp_d2c.

Internal ERF Name	<Area>:pth_ar
Measurement Shape	Segment
Measurement Value	Ring
Measurement ID	PTH; Feature (or r0)
Layers Displayed	Signal layer
Graphic	
Function	Reports the shortest distance between drill and laminate for PTHs embedded in copper if closer than pp_d2c. Takes into account both negative and positive data. Measurements are segments representing the shortest distance from drill to laminate.
ERF Parameters	pp_layer pp_d2c
ERF Variables	pth_breakout_angle classify_pad_ar = yes
Constraint	Plated Hole AR
Limitations	Where PTH AR is composed of more than one feature (such as in drawn surfaces), the measurement entity will be r0.

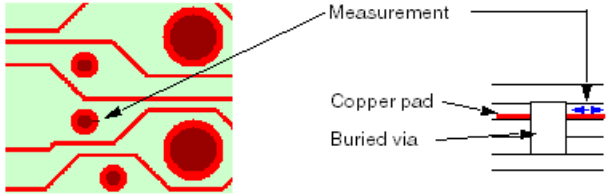
Blind Via Annular Ring (Drill)

Reports the shortest distance between drill and laminate for blind vias embedded in copper if closer than pp_d2c.

Internal ERF Name	<Area>:blind_via_ar
Measurement Shape	Segment
Measurement Value	Ring
Measurement ID	Via; Feature (or r0)
Layers Displayed	Signal layer
Graphic	
Function	Reports the shortest distance between drill and laminate for blind vias embedded in copper if closer than pp_d2c. Takes into account both negative and positive data. Measurements are segments representing the shortest distance from drill to laminate.
ERF Parameters	pp_layer pp_d2c
ERF Variables	via_breakout_angle classify_pad_ar = yes v_report_via_by_type = yes
Constraint	Plated Hole AR
Limitations	Where PTH AR is composed of more than one feature (such as in drawn surfaces), the measurement entity will be r0.

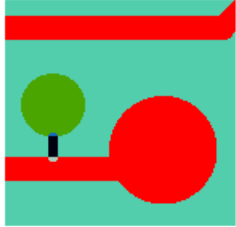
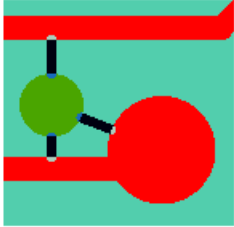
Buried Via Annular Ring (Drill)

Reports the shortest distance between drill and laminate for buried vias embedded in copper if closer than pp_d2c.

Internal ERF Name	<Area>:buried_via_ar
Measurement Shape	Segment
Measurement Value	Ring
Measurement ID	Via; Feature (or r0)
Layers Displayed	Signal layer
Graphic	
Function	Reports the shortest distance between drill and laminate for buried vias embedded in copper if closer than pp_d2c. Takes into account both negative and positive data. Measurements are segments representing the shortest distance from drill to laminate.
ERF Parameters	pp_layer pp_d2c
ERF Variables	via_breakout_angle classify_pad_ar = yes v_report_via_by_type = yes
Constraint	Plated Hole AR
Limitations	Where PTH AR is composed of more than one feature (such as in drawn surfaces), the measurement entity will be r0.


Via to Copper (Drill)

Reports other net, via holes closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.

Internal ERF Name	<Area>:via2c
Measurement Shape	Segment
Measurement Value	Via; Feature (or r0)
Measurement ID	Via; Feature
Layers Displayed	<ul style="list-style-type: none"> • Signal layer • Drill layer which pierces it
Graphic	<div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p><code>group_drill_to_copper = 1</code> Employ Grouping</p> </div> <div style="text-align: center;">  <p><code>group_drill_to_copper = 0</code> Don't Employ Grouping</p> </div> </div>
Function	Reports other net, via holes closer than pp_d2c to any copper (circuit, pad or text) in accordance with group_drill_to_copper.
ERF Parameters	pp_layer pp_d2c
ERF Variables	group_drill_to_copper classify_via2c = 1
Constraint	Hole to Feature Spacing
Limitations	

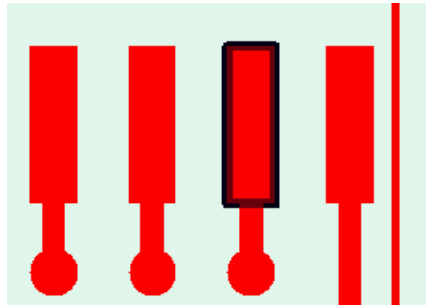
Tooling Hole to Exposed Copper (Drill)

Reports all tooling holes closer than pp_d2c to exposed copper on an outer layer.

Analysis Category	<Area>:thole2exp_copper
Measurement Shape	Distance segment
Measurement Value	Spacing
Measurement ID	Hole; Feature
Layers Displayed	Signal layer Drill layer Correspondent solder mask layer (if exists)
Graphic	
Function	Reports all tooling holes closer than pp_d2c to exposed copper on an outer layer. All copper shapes in the signal layer are considered “exposed” if a correspondent solder mask layer does not exist.
ERF Parameters	pp_layer pp_d2c
ERF Variables	
Constraint	Hole to Feature Spacing
Limitations	


Pads (Size)

Provides a summary of all pads in a signal layer. Measurements are pad shapes. (circle, square or contour).

Internal ERF Name	<Area>:pad
Measurement Shape	Shape
Measurement Value	Size
Measurement ID	Feature
Layers Displayed	Signal layer
Graphic	
Function	Provides a summary of all pads in a signal layer. Measurements are pad shapes. (circle, square or contour). A histogram depicts a range of pads sizes.
ERF Parameters	pp_layer
ERF Variables	
Constraint	Feature Spacing
Limitations	

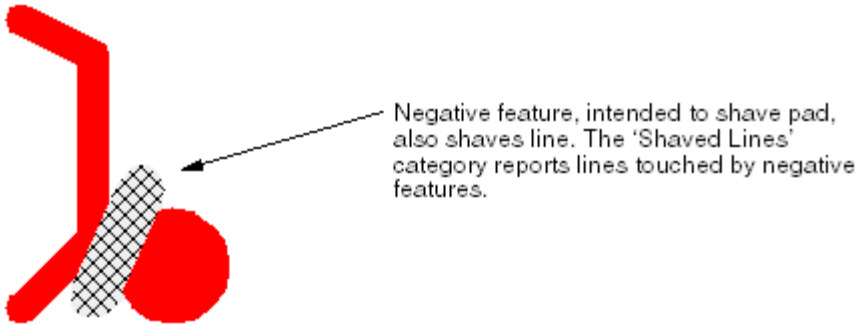
Lines (Size)

Reports width of lines representing conductor traces in signal layers.

Analysis Category	<Area>:line
Measurement Shape	Line
Measurement Value	Size
Measurement ID	Feature
Layers Displayed	Signal layer
Graphic	
Function	<p>Reports width of lines representing conductor traces in signal layers. Lines with attribute Copper Balancing or Copper Text are not reported. If a line is drawn (represented by two touching lines running beside each other), the compound width of the drawn line is reported.</p> <p>Lines are reported if both of these conditions are met:</p> <ul style="list-style-type: none">• Line is narrower than max_line_width.• One of these conditions is met:<ul style="list-style-type: none">• Line is longer than min_line_len.• Length to width ratio is greater than len2width_ratio. <p>If a line is partially covered by another feature, only the uncovered part is measured.</p> <p>‘Lines’ is intended to report Active when the ‘Size’ test is selected.</p>
ERF Parameters	pp_layer
ERF Variables	min_line_len max_line_width len2width_ratio report_lines_with_arcs = yes
Constraint	Feature Spacing
Limitations	


Shaved Line (Size)

Reports lines touched by negative shaves, NPTHs, or non-plated rout features.

Internal ERF Name	<Area>:shaved_line
Measurement Shape	Line
Measurement Value	Symbol representing the line
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Function	Reports lines touched by negative shaves, NPTHs, or non-plated rout features. Such lines may be potential conductor width violations. Measurements are the original lines.
ERF Parameters	pp_layer
ERF Variables	report_lines_with_arcs = yes
Constraint	Feature Spacing
Limitations	These lines are displayed but not measured.


Text (Size)

Reports all lines tagged by the Copper Text system attribute.

Internal ERF Name	<Area>:text
Measurement Shape	Line
Measurement Value	Width
Measurement ID	Feature
Layers Displayed	Signal layer
Graphic	
Function	Reports all lines tagged by the Copper Text system attribute. The user can gauge the widths of lines used to draw text.
ERF Parameters	pp_layer
ERF Variables	
Constraint	Feature Spacing
Limitations	

Line Neckdown (Size)

Reports lines that are joined so that the width at the narrowest point is less than nominal line width.

Internal ERF Name	<Area>:neckdown
Measurement Shape	Segment
Measurement Value	Size
Measurement ID	Line
Layers Displayed	Signal layer
Graphic	
Purpose	A line neckdown can be a dangerous defect. The indentation of copper at the connection point may become an acid trap and cause over etching of the copper. This forms a nick and a potential cut.
Function	Reports lines that are joined so that the width at the narrowest point is less than nominal line width. Measurements are segments representing the minimal line width.
ERF Parameters	pp_layer
ERF Variables	max_line_width
Constraint	Feature Spacing

Limitations

Neckdowns are not reported if the difference between the wider section and the narrower section is less than 0.5 mil.

Neckdowns are always reported, except when `max_line_width` is less than 1000my (default value is 12mil=304.8my), if the difference is greater than 0.6mil. See Fig. A.


Differences between 0.5mil and 0.6mil are sometimes reported (0.1mil accuracy).

If the wider section is greater than `max_line_width`, the line is replaced by a virtual line of the same coordinates with width equal to `max_line_width`. The narrower part is reported if less than $[\text{max_line_width} - 0.6\text{mil}]$. See Fig.



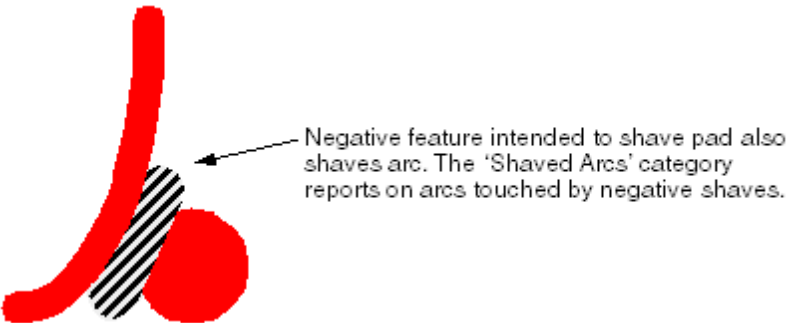
Arc (Size)

Reports arc features thinner than max_line_width with neither Copper Text nor Copper Balancing attributes.

Internal ERF Name	<Area>:arc
Measurement Shape	Arcs
Measurement Value	Size
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Function	Reports arc features thinner than max_line_width with neither Copper Text nor Copper Balancing attributes. Measurements are arcs whose center sections do not touch other features.
ERF Parameters	pp_layer
ERF Variables	max_line_width - maximum width for lines. report_lines_with_arcs = no
Constraint	Feature Spacing
Limitations	

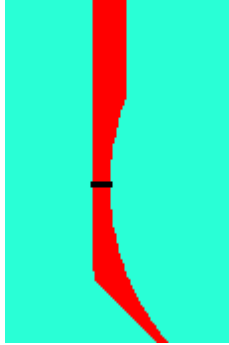
Shaved Arc (Size)

Reports arc features shaved by negative features, NPTHs or non-plated rout features.

Internal ERF Name	<Area>:shaved_arc
Measurement Shape	Bounding box
Measurement Value	Symbol representing the arc
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Function	Reports arc features shaved by negative features, NPTHs or non-plated rout features.
ERF Parameters	pp_layer
ERF Variables	report_lines_with_arcs = no
Constraint	Feature Spacing
Limitations	


Conductor Width (Size)

Reports lines with neckdowns.

Internal ERF Name	<Area>:conductor_width
Measurement Shape	Segment representing width at thinnest point
Measurement Value	Width
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Function	Reports lines with neckdowns.
ERF Parameters	pp_layer
ERF Variables	v_conductor_width_full_check
Constraint	Feature Spacing
Limitations	


Sliver (Sliver) (Signal Layer)

Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero.

Internal ERF Name	<Area>:sliver
Measurement Shape	Segment
Measurement Value	Size
Measurement ID	Feature representing the sliver line
Layers Displayed	Signal layer
Graphic	
Purpose	A laminate sliver can cause material to detach during photo-imaging processes in fabrication. Floating pieces can cause defects and shorts which reduce yield.
Function	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero. A sliver is defined by v_dist2sliver_ratio and v_min_sliver_perim. See “ Sliver and Short Sliver Categories (Signal Layer Checks) ” on page 56.
ERF Parameters	pp_layer pp_sliver
ERF Variables	v_sliver_algorithm_mode = 1 v_dist2sliver_ratio v_min_sliver_perim large_net_min v_slivers_check_diff_net = yes replace_crosshatch_by_surface v_min_sliver_len
Constraint	Feature Spacing
Related Category	Short Sliver (Sliver)

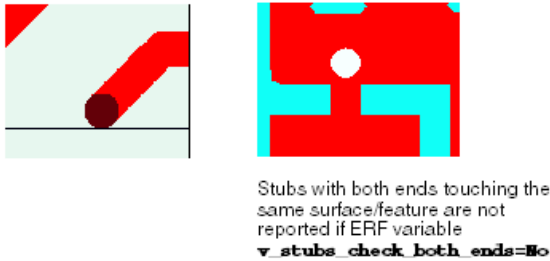
Short Sliver (Sliver) (Signal Layer)

Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero.

Internal ERF Name	<Area>:short_sliver
Measurement Shape	Segment
Measurement Value	Size
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Purpose	A laminate sliver may cause material to detach during photo-imaging processes in fabrication. The floating piece can cause defects and shorts which reduce yield.
Function	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers), that have width less than pp_sliver, and non-zero. See “ Sliver and Short Sliver Categories (Signal Layer Checks) ” on page 56.
ERF Parameters	pp_layer pp_sliver
ERF Variables	v_sliver_algorithm_mode = 1 v_dist2sliver_ratio v_min_sliver_perim large_net_min v_slivers_check_diff_net replace_crosshatch_by_surface v_min_sliver_len
Constraint	Feature Spacing
Related Category	Sliver (Sliver)

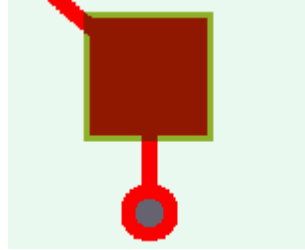
Stubs (Stubs)

Reports line endpoints that do not touch any other feature.

Internal ERF Name	<Area>:stub
Measurement Shape	Endpoint
Measurement Value	Shape
Measurement ID	Feature representing the open dimensions (r8)
Layers Displayed	Signal layer
Graphic	 <p>Stubs with both ends touching the same surface/feature are not reported if ERF variable <code>v_stubs_check_both_ends=No</code></p>
Purpose	In some cases, stubs indicate an error in the design. Normally, lines end with pads, or are drilled by component holes or vias (wide ground conductors).
Function	<p>Reports line endpoints that do not touch any other feature. Measurements are shapes representing the endpoints (for example, a circle for a round, capped line).</p> <p>When two identical lines lie on top of each other, the endpoints touch each other. This is reported if the end points do not touch other features. Drilled line endpoints are not inserted as measurements.</p>
ERF Parameters	pp_layer
ERF Variables	v_stubs_check_both_ends v_terminated_stub
Limitations	<ul style="list-style-type: none"> Features tagged with attribute Copper Balancing are not tested for 'Stubs' so as to improve performance. The endpoints of lines that are shaved (touching successive negative features) are not inserted as measurements. When two circuit lines coincide, a false alarm may be reported at the end of the wider line.


SMD Pads (SMD)

Reports pads tagged with feature attribute SMD Pad.

Internal ERF Name	<Area>;smd_pad
Measurement Shape	Pad
Measurement Value	Shape representing the pad
Measurement ID	None
Layers Displayed	Signal layer
Graphic	
Purpose	Provides a review of all identified SMD pads used in the design. It can be used as a measure of the difficulty in producing the job.
Function	Reports pads tagged with feature attribute SMD Pad. Measurements are shapes of SMD pads (circle, square or bounding box).
ERF Parameters	pp_layer
ERF Variables	
Limitations	


Exposed Via to Exposed Via (Exposure)

Reports distances less than pp_e_spacing between the edges of the exposed copper of two uncapped vias, while ignoring pads of the same net that are fully embedded in copper. Classified by the process.

Internal ERF Name	<Area>:exvia2exvia
Measurement Shape	Segment
Measurement ID	Vias
Layers Displayed	Top or Bottom signal Solder mask layers
Graphic	
Purpose	Vias (pads) should be kept distant from each other to prevent solder bridging during the assembly process.
Function	Reports distances less than pp_e_spacing between the edges of the exposed copper of two uncapped vias, while ignoring pads of the same net that are fully embedded in copper. Classified by the process.
ERF Parameters	pp_layer pp_e_spacing
ERF Variables	v_tp_exvia_as_via
Constraint	Via Spacing
Limitations	

Exposed Via to Exposed Copper (Exposure)

Reports the distance between the edge of the exposed copper of an uncapped via and the exposed copper on the outer signal layers only, when closer than pp_e_spacing. Does not report spacing between pads of the same net that are fully embedded in copper. Classified by process. The reported exposed via and exposed copper surface do not touch.

Internal ERF Name	<Area>:exvia2exc
Measurement Shape	Segment
Measurement ID	Via and copper surface
Layers Displayed	Top or Bottom signal Solder mask layers
Graphic	
Function	Reports the distance between the edge of the exposed copper of an uncapped via and the exposed copper on the outer signal layers only, when closer than pp_e_spacing. Does not report spacing between pads of the same net that are fully embedded in copper. Classified by process. The reported exposed via and exposed copper surface do not touch.
ERF Parameters	pp_layer pp_e_spacing
ERF Variables	v_tp_exvia_as_via
Constraint	Via Spacing
Limitations	

ERF Parameters for Signal Layer Checks

Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Layer	pp_layer	Defines the layer to be affected by the action.	All categories
Spacing	pp_spacing	Defines search radius to use when looking for closely spaced features.	Via to Via Pad to Pad Pad to Circuit Circuit to Circuit Text to Text Same Net Spacing
Drill to Cu	pp_d2c	Defines the search radius for copper features too close to drills, and also determines the maximum annular ring value to be reported.	NPTH to Pad NPTH to Circuit PTH to Copper PTH Annular Ring NPTH Annular ring PTH (Comp) Annular Ring Via Annular Ring Tooling Hole to Exposed Copper
Sliver Min	pp_sliver	Maximum sliver width to be reported in the sliver category.	Sliver Short Sliver
Exposure Spacing	pp_e_spacing	Maximum spacing between exposed copper features.	Exposed Via to Exposed Via Exposed Via to Exposed Copper
Tests List	pp_tests	Defines the tests to be run. See “Tests Performed in Signal Layer Checks” on page 52.	All categories

ERF Variables for Signal Layer Checks

Variables set in the ERF file control the analysis.

ERF Variable	Description	Categories Affected
classify_pad_ar	<p>Determines how via or PTH measurements are reported.</p> <p>yes — Classify AR measurement according to via or PTH in ‘Via Annular Ring’ or ‘PTH (Comp) Annular Ring’. (default)</p> <p>no — Report all via or PTH measurements in ‘PTH Annular Ring’.</p>	<p>PTH Annular Ring</p> <p>PTH (Comp) Annular Ring</p> <p>Blind Via Annular Ring</p> <p>Buried Via Annular Ring</p>
classify_pad2pad	<p>no — All measurements reported to ‘Pad to Pad’ category. (default)</p> <p>yes — Distributes measurements to the following categories, depending on pad type:</p> <ul style="list-style-type: none"> • ‘Toeprint to Toeprint’ — when both pads belong to the same component with attribute Required Toeprint Spacing. • ‘SMD to SMD’ — When both pads are SMD pads. • ‘Via to Via’ — When both pads are pierced by a via drill. • ‘PTH to PTH’ — When both pads are pierced by a non-via drill. • ‘Pad to Pad’ — All other pads. 	<p>Via to Via</p> <p>Pad to Pad</p>
classify_via2c	<p>0 — Do not distinguish between via and PTH measurements to copper. Report both in ‘PTH to Copper’. (default)</p> <p>1 — Distinguish between via and PTH holes. Report measurements in ‘Via to Copper’ or ‘PTH to Copper’.</p>	<p>PTH to Copper</p> <p>PTH to Copper Same Net</p> <p>Via to Copper</p>

ERF Variable	Description	Categories Affected
group_drill_to_copper	<p>Determines whether to report only the closest violation or all violations.</p> <p>1 — For each drill (NPTH, PTH, or via) only the closest spacing violation is reported to its respective category. If there are both pad and circuit spacing violates with NPTHs, only the closest is reported in its respective category (either 'NPTH to Pad' or 'NPTH to Circuit'). The category of the other violation does not appear. (default)</p> <p>0 — All spacing violations are reported, each to its respective category.</p>	<p>NPTH to Pad</p> <p>NPTH to Circuit</p> <p>PTH to Copper</p> <p>PTH to Copper</p> <p>Same Net</p> <p>Via to Copper</p>
large_net_min	Nets with more than large_net_min features are ignored in 'Same Net Spacing', 'Sliver' and 'Short Sliver' categories.	<p>Same Net</p> <p>Spacing</p> <p>Sliver</p> <p>Short Sliver</p>
len2width_ratio	Minimum ratio of length to width of a line to be inserted in the 'Lines' category.	Lines
limited_npth_check	<p>Determines whether NPTH annular ring values larger than pp_d2c are reported.</p> <p>yes — Only distances less than pp_d2c are reported. (default)</p> <p>no — All values reported.</p>	NPTH Annular Ring
max_bottleneck_width	Maximum bottleneck width for 'Conductor Width' and 'Copper Bottleneck'.	Conductor Width
max_line_width	Maximum line width in 'Lines' category.	<p>Lines</p> <p>Line Neckdown</p> <p>Arc</p>
max_reg	Maximum offset to be considered a registration error. A center to center distance of a drill and pad larger than this value, is not reported.	<p>PTH Registration</p> <p>NPTH</p> <p>Registration</p>
min_line_len	Minimum line length in 'Lines' category. Also the minimum overlap between lines to report in parallel spacing.	<p>Lines</p> <p>Spacing</p>
pth_breakout_angle	Defines maximum angle allowed for breakout of drill from PTH pad.	<p>PTH Annular Ring</p> <p>PTH (Comp)</p> <p>Annular Ring</p>

ERF Variable	Description	Categories Affected
reg_allowance	A distance between pad center and drill center greater than this value is considered misregistered.	PTH Registration NPTH Registration
replace_crosshatch_by_surface	Determines how slivers are reported. yes — Do not report slivers found on hatched area. (default) (Gerber) no — Report slivers found on hatched area. by attr — Do not report slivers found on features with a hatch attribute. (EDA)	Sliver Short Sliver
report_lines_with_arcs	Determines how lines with arcs are reported. yes — Arc sizes are reported to 'Lines' or 'Shaved Line'. (default) no — Arc sizes are reported in 'Arcs' or 'Shaved Arcs'.	Lines Shaved Line Arc Shaved Arc
rm_d2c	Reliability margin for all drill to copper measurements other than annular ring. Used in the calculation of the DRA attributes.	Affects the reporting of result attributes for drill categories
self_spacing	Determines whether self-spacing measurements are taken. yes — Self-spacing measurements are taken. (default) no — Self-spacing measurements are not taken.	Same Net Spacing (Spacing) Same Net Spacing (Bottleneck)
spacing_length_measure	Determines whether parallel spacing measurements are taken. yes — Parallel spacing measurements are taken. (default) no — Measurements are not taken.	Spacing Length
spacing_resolution	Determines the resolution for parallel spacing report. (1mil = default)	Spacing Length

ERF Variable	Description	Categories Affected
v_bottleneck_algorithm_mode	<p>Defines which of two algorithms is used to determine bottleneck violations.</p> <p>0 — Use original algorithm where results are reported to ‘Conductor Width’ (Bottleneck) and ‘Same Net Spacing’ (Bottleneck). (slow)</p> <p>1 — Use improved algorithm where results are reported to ‘Copper Bottleneck’ (Bottleneck). (default) (fast)</p> <p>2 — Results are the same as with 1, but the process is slower. (Remains in the system to insure backward compatibility.)</p>	<p>Conductor Width (Bottleneck)</p> <p>Same Net Spacing (Bottleneck)</p>
v_conductor_width_full_check	<p>Determines how conductor width is checked.</p> <p>no — Conductor width is not checked if a line or arc is touched by more than a certain, threshold, number of negative shapes (neckdowns). The result is better performance. (default)</p> <p>yes — Conductor width is checked, no matter the number of negative shapes. Therefore, there is a degradation in performance.</p>	Conductor Width
v_dist2sliver_ratio	<p>Minimal ratio for the distance between measurement segment endpoints along the net and the width of the sliver.</p> <p>See “DFM Analysis Compatibility for Signal Layer Checks” on page 54</p>	Sliver Short Sliver
v_min_sliver_len	<p>Slivers shorter than this value are reported as ‘Short Sliver’. All others are reported in ‘Sliver’. Maximum possible value is 100 mils.</p> <p>See “DFM Analysis Compatibility for Signal Layer Checks” on page 54</p>	Sliver Short Sliver
v_min_sliver_perim	<p>Defines the minimal distance between the measurement segment endpoints along the net. (For a description of perimeter, see “Sliver and Short Sliver Categories (Signal Layer Checks)” on page 56).</p>	Sliver Short Sliver

ERF Variable	Description	Categories Affected
v_report_via_by_type	<p>Determines whether via annular ring violations are reported to 'Via Annular Ring' or to individual categories according to via type.</p> <p>no — Report all via annular ring violations to 'Via Annular Ring'. (default)</p> <p>yes — Report via annular ring violations according to type: regular, blind or buried.</p>	<p>Blind Via Annular Ring</p> <p>Buried Via Annular Ring</p>
v_sliver_algorithm_mode	<p>Defines which of two algorithms is used to determine sliver violations.</p> <p>0 — Use original algorithm where results are reported to the 'Sliver' category. (slow)</p> <p>1 — Use improved algorithm where results are reported to either the 'Sliver' or 'Short Sliver' category. (fast) (default)</p> <p>2 — Results are the same as with 1, but the process is slower. (Remains in the system to insure backward compatibility.)</p>	<p>Sliver</p> <p>Short Sliver</p>
v_slivers_check_diff_nets	<p>no — Do not report slivers detected between unconnected features (on different nets). (default)</p> <p>yes — Report slivers detected between unconnected features, and distances between close nets.</p> <p>See “DFM Analysis Compatibility for Signal Layer Checks” on page 54</p>	<p>Short Sliver</p>
v_split_pth2c_report	<p>Determines whether to report results from the same CAD net in this category along with those of different CAD nets or to 'PTH to Copper Same Net'.</p> <p>no - report all results to this category. (default)</p> <p>yes - report same CAD net results to 'PTH to Copper Same Net'.</p>	<p>PTH to Copper</p> <p>PTH to Copper Same Net</p>
v_stubs_check_both_ends	<p>yes — Lines and arcs with both ends touching the same surface or feature are reported as stubs. (default)</p> <p>no — Ignore stubs touching the same surface or feature.</p>	<p>Stubs</p>

ERF Variable	Description	Categories Affected
v_surface_spacing_separately	<p>Determines whether measurements to surfaces are reported as circuits or into their own categories.</p> <p>no — Report surfaces as circuits to categories ‘Circuit to Circuit’, ‘Pad to Circuit’ and ‘NPTH to Circuit’. (default)</p> <p>yes — Report measurements to surfaces to ‘Surface to Surface’, ‘Pad to Surface’, ‘Circuit to Surface’ and ‘NPTH to Surface.’</p>	<p>Pad to Circuit</p> <p>NPTH to Circuit</p>
v_terminated_stub	<p>Determines whether lines with small pads at their endpoints are reported as stubs.</p> <p>0 — Do not report such lines as a stub.</p> <p>1 — Report lines with a pad smaller than the line endpoint (and having the same x and y coordinate) as a stub. (default)</p> <p>2 — Report lines with a pad smaller than or equal to the line endpoint as a stub.</p>	<p>Stubs</p>
v_tp_exvia_as_via	<p>Determines whether an exposed via with attribute ICT Test Point is considered a via (reported in ‘Exposed Via to Exposed Via’) or a copper pad (reported in ‘Exposed to Exposed’).</p> <p>no — Consider via pad with attribute ICT Test Point a copper pad. (default)</p> <p>yes — Consider via pad with attribute ICT Test Point a via.</p>	<p>Exposed Via to Exposed Via</p> <p>Exposed Via to Exposed Copper</p>
via_breakout_angle	<p>Defines maximum angle allowed for breakout of drill from via pad.</p>	<p>PTH Annular Ring</p> <p>Blind Via Annular Ring</p> <p>Buried Via Annular Ring</p>

Chapter 4

Fabrication Analysis - Power and Ground Checks

The Power and Ground Checks action is a read-only action that finds potential manufacturability defects in power and ground and mixed layers. It uses different algorithms to diagnose negative and positive power and ground layers.

For an explanation of how to run this analysis, see [“Performing DFM Analysis”](#) on page 21.

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Tests Performed in Power and Ground Checks

Several power and ground checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

- **Drill** — Reports distance violations between NPTHs, PTHs, or Vias to plane, copper, clearances and annular rings.
- **Sliver** — Reports slivers in negative and positive layers. See “[Sliver and Short Sliver Categories \(Power and Ground\)](#)” on page 107.
- **Thermal** — Reports spoke (tie) widths and reduction of connectivity of thermal pads.

These categories apply only to negative layers and to proper thermal pads (pads with “th...” names). The categories detect thermal ties either completely broken or chipped by adjacent clearances and thermals.

The categories report the spoke (tie) width and the percentage of overall reduction in thermal pad electrical connectivity. If a thermal has four 10-mil ties, of which two are completely broken, there is a 50% reduction in thermal connectivity.

- **Plane Spacing** — Reports spacing between features of different planes.

Attributes Used in Power and Ground Checks

Attributes assigned to features and layers in the product model control the analysis.

Feature Attributes

Table 4-1. Power and Ground Checks Feature Attributes

Name	Description
Drill Type	This attribute is attached to hole features in drill layers. It defines the type of drill and is used extensively during fabrication analysis.

Layer Attributes

Table 4-2. Power and Ground Checks Layer Attributes

Name	Description
Layer Class	This attribute is used to differentiate between layers. It enables you to set different ERF ranges for power layers than for ground layers.

DFM Analysis Compatibility for Power and Ground Checks

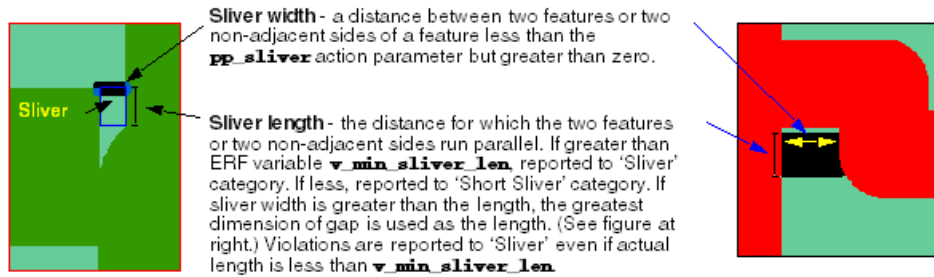
To maintain compatibility between legacy products and DFM Analysis, ERF variables used with earlier products are mapped to the appropriate DFM Analysis ERF variables.

Earlier Products	DFM Analysis
max_net_size	v_max_net_size
dist2sliver_ratio	v_dist2sliver_ratio
min_sliver_len	v_min_sliver_len

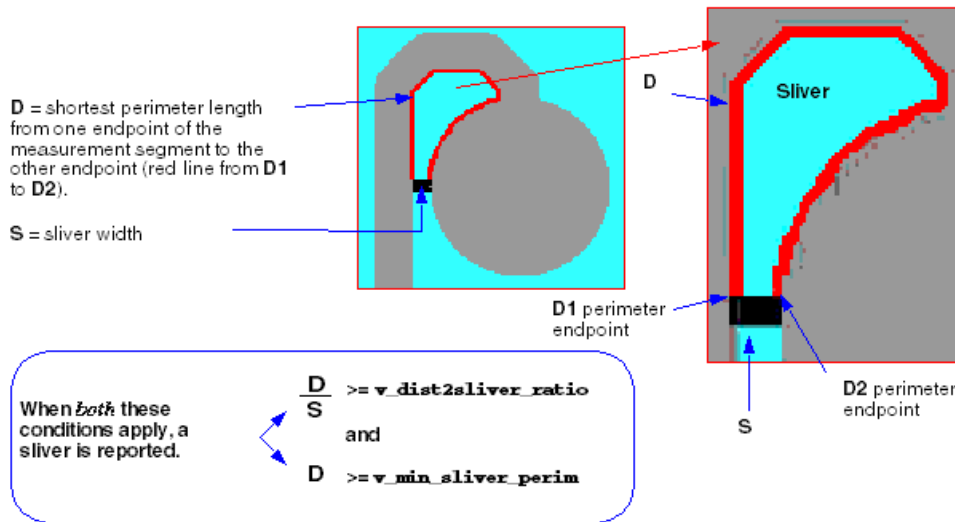
Sliver and Short Sliver Categories (Power and Ground)

These two categories deal with slivers, narrow strips of copper between two features or between non-adjacent sides of the same feature. It is important to detect slivers which could break off during the manufacturing process and cause shorts. In detecting slivers, length, width and shortest perimeter length are measured.

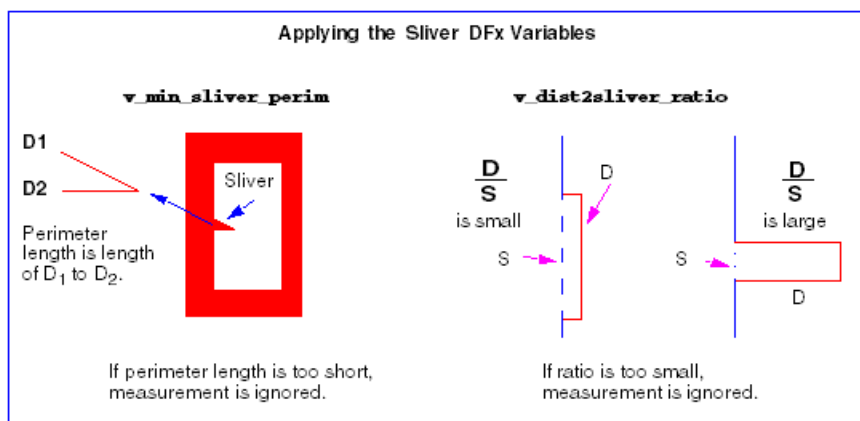
These categories do not detect acute angles. To detect acute angles as slivers, set ERF parameter pp_sliver = 12 mils or more (this may also cause additional reports of non-critical violations).



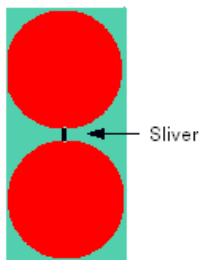
Measurements are distance segments between two connected features (features on the same net) or two non-adjacent sides of one feature.



Applying the Sliver DfX Variables

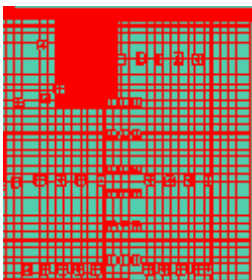


When the two features are not connected (not on the same net), **v_dist2sliver_ratio** and **v_min_sliver_perim** become irrelevant.



Slivers found on hatched areas (a plane filled with lines instead of solid copper, where each line in the area has the attribute Hatch Feature) are reported only if ERF variable `replace_crosshatch_by_surface=by_attr`. (Default value = yes).

However, if the surface is filled with at least fifty lines of the same width, it is accepted as a hatched area even if the lines do not bear the Hatch Feature attribute and ERF variable `replace_crosshatch_by_surface=no`.



Categories in Power and Ground Checks

Several power and ground checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

All measurements are from edge to edge of copper, drill or clearance unless stated otherwise.

Table 4-3. Result Categories for Power and Ground Checks

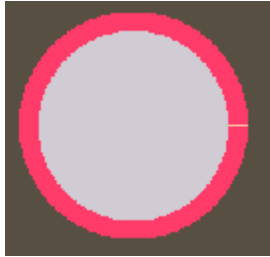
Category	Description
NPTH to Copper (Drill)	Reports NPTHs closer than pp_d2c or touching copper.
PTH Annular Ring (Drill)	Reports the shortest distance between drill and laminate for PTHs embedded in copper if less than pp_d2c.
PTH to Copper (Drill)	Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c.
Via to Copper (Drill)	Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c.
PTH Contains Clearance (Drill)	Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded.
Via Contains Clearance (Drill)	Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded.
PTH to Plane (Drill)	Reports drills (embedded in copper) closer than pp_d2c to other net copper.
Via to Plane (Drill)	Reports drills (embedded in copper) closer than pp_d2c to other net copper.
NPTH to Plane (Drill)	Reports NPTHs closer than pp_d2c to other net copper.
NPTH Contains Copper (Drill)	Reports NPTHs containing copper on positive layers only.
Missing Cu for Vias (Drill)	Reports via holes not completely surrounded by copper in the drill layer with layer attribute Vias Need CU.
PTH Registration (Drill)	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.
NPTH Registration (Drill)	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.

Table 4-3. Result Categories for Power and Ground Checks (cont.)

Category	Description
Via Registration (Drill)	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.
Sliver (Sliver) (Power and Ground)	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case), whose width is less than pp_sliver, and non-zero.
Short Sliver (Sliver) (Power and Ground)	Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case).
Spoke Width (Thermal)	Reports thermal spoke (tie) widths in negative layers with flashed pads that are less than their defined widths.
Thermal Connect Reduction (Thermal)	Reports all incidents of thermal connectivity reduction in negative layers where thermal pads are flashed.
Plane Spacing (Plane Spacing)	Reports features in a positive or negative layer closer than pp_pln_spacing belonging to different plane nets if the measurement segment touches copper only at its endpoints.
Segmentation Lines (Plane Spacing)	Reports widths of actual laminate (spacing width) occupied by lines in negative layers only (lines in negative plane layers represent spacing), less than pp_pln_spacing.

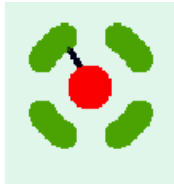
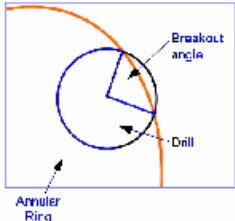
NPTH to Copper (Drill)

Reports NPTHs closer than pp_d2c or touching copper.

Internal ERF Name	<Area>npth2c
Measurement Shape	Segment
Measurement ID	Drill and clearance (in negative layer) or none (in positive layer)
Layers Displayed	Power and ground layer Drill layer piercing it
Graphic	
Purpose	A non-plated through hole should be kept away from copper surfaces since it is used for mounting and tooling by metal objects.
Function	Reports NPTHs closer than pp_d2c or touching copper. In negative power and ground layers, a violation is an NPTH whose clearance is not large enough. In positive power and ground layers, a violation is an NPTH too close to copper features.
ERF Parameters	pp_d2c
ERF Variables	take_npth_range
Constraint	Non-plated Hole Spacing
Limitations	

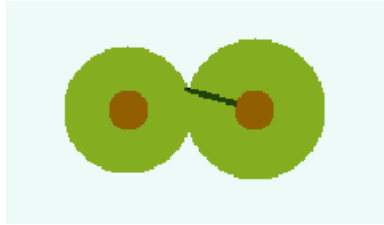
PTH Annular Ring (Drill)

Reports the shortest distance between drill and laminate for PTHs embedded in copper if less than pp_d2c.

Internal ERF Name	<Area>:pth2t (from pth to thermal)
Measurement Shape	Segment
Measurement ID	In negative power and ground layer, Entity = thermal pad, or Entity = clearance if clearance encroaches on drill. In positive power and ground layer, there is no Entity.
Layers Displayed	Power and ground layer Drill layer piercing it
Graphic	
Purpose	A hole connected to copper must have a sufficiently large annular ring of copper. If not, shifts of the drill and the imaging process cause the drill to lack sufficient contact.
Function	<p>Reports the shortest distance between drill and laminate for PTHs embedded in copper if less than pp_d2c. Breakouts are allowed by specifying a breakout angle between 0 - 180 where 0 = no breakout.</p>  <p>In most cases these drills are drilled through thermal pads; the annular ring indicates the quality of the connection. With negative power and ground layers, the associated entity from the power and ground layer is a thermal pad. See “Annular Ring Measurement” on page 54.</p>
ERF Parameters	pp_d2c
ERF Variables	classify_via2t pth_breakout_angle
Constraint	Plated Hole AR
Limitations	In positive power and ground layers, no associated copper features are reported.

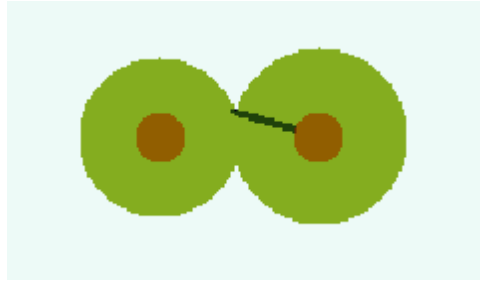
PTH to Copper (Drill)

Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c.

Internal ERF Name	<Area>:pth2c
Measurement Shape	Segment
Measurement ID	Drill, thermal or close clearance (negative layer); nothing (positive layer)
Layers Displayed	Power and ground layer Drill layer piercing it
Graphic	
Purpose	A hole to be isolated from power or ground planes must be kept apart from copper. The required distance is typically larger than regular spacing due to the higher than usual current.
Function	Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c. This category also indicates the spacing of the hole from the copper or its laminate annular ring. Normally, it shows how well holes are embedded in laminate.
ERF Parameters	pp_d2c
ERF Variables	classify_via2c
Constraint	Plated Hole Spacing
Limitations	In positive power and ground layers, no associated copper feature is reported.

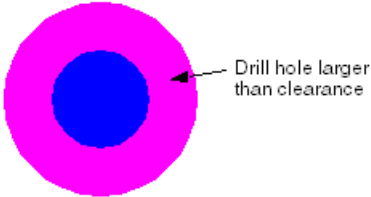
Via to Copper (Drill)

Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c.

Internal ERF Name	<Area>:via2c
Measurement Shape	Segment
Measurement ID	Drill and thermal or close clearance (negative layer); none (positive layer)
Layers Displayed	Power and ground layer Drill layer piercing it
Graphic	
Purpose	A hole to be isolated from power or ground planes must be kept apart from copper. The required distance is typically larger than regular spacing due to the higher than usual current.
Function	Reports other net drills embedded in laminate if the distance from the edge of the drill to the nearest copper is less than pp_d2c.
ERF Parameters	pp_d2c
ERF Variables	classify_via2c = 1
Constraint	Plated Hole Spacing
Limitations	In positive power and ground layers, no associated copper feature is reported.

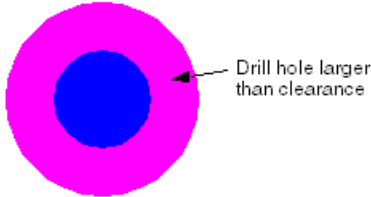
PTH Contains Clearance (Drill)

Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded.

Internal ERF Name	<Area>:pth_cont_clr
Measurement Shape	Segment
Measurement ID	Drill
Layers Displayed	Power and ground (or mixed) layer Layer piercing it
Graphic	
Function	Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded. Measurements are segments representing the smallest distance between drill and clearance outlines.
ERF Parameters	
ERF Variables	classify_via_cont_clr
Constraint	Hole Clearance
Limitations	

Via Contains Clearance (Drill)

Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded.

Internal ERF Name	<Area>:via_cont_clr
Measurement Shape	Segment
Measurement ID	Drill
Layers Displayed	Power and ground (or mixed) layer Layer piercing it
Graphic	
Function	Reports drills containing clearances on negative layers only. If clearance size is close to drill size, drill connectivity is degraded. Measurements are segments representing the smallest distance between drill and clearance outlines.
ERF Parameters	
ERF Variables	classify_via_cont_clr = 1
Constraint	Hole Clearance
Limitations	

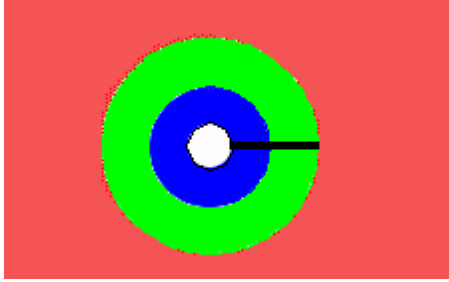
PTH to Plane (Drill)

Reports drills (embedded in copper) closer than pp_d2c to other net copper.

Internal ERF Name	<Area>:pth2p
Measurement Shape	Segment
Measurement ID	Drill
Layers Displayed	Power and ground (or mixed) layer Drill layer piercing it
Graphic	
Function	Reports drills (embedded in copper) closer than pp_d2c to other net copper. Measurements are segments representing the distance between plane and hole edge.
ERF Parameters	pp_d2c
ERF Variables	classify_via2p
Constraint	Plated Hole Spacing
Limitations	This category applies only to positive power and ground layers.

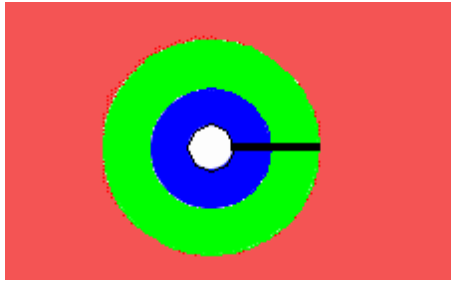
Via to Plane (Drill)

Reports drills (embedded in copper) closer than pp_d2c to other net copper.

Internal ERF Name	<Area>:via2p
Measurement Shape	Segment
Measurement ID	Drill
Layers Displayed	Power and ground (or mixed) layer Drill layer piercing it
Graphic	
Function	Reports drills (embedded in copper) closer than pp_d2c to other net copper. Measurements are segments representing the distance between plane and hole edge.
ERF Parameters	pp_d2c
ERF Variables	classify_via2p = 1
Constraint	Plated Hole Spacing
Limitations	This category applies only to positive power and ground layers.


NPTH to Plane (Drill)

Reports NPTHs closer than pp_d2c to other net copper.

Internal ERF Name	<Area>npth2p
Measurement Shape	Segment
Measurement ID	NPTH
Layers Displayed	<ul style="list-style-type: none">• Power and ground (or mixed) layer• Drill layer piercing it
Graphic	
Function	Reports NPTHs closer than pp_d2c to other net copper. Measurements are segments representing the distance between plane and hole edge.
ERF Parameters	pp_d2c
ERF Variables	take_npth_range
Constraint	Non-plated Hole Spacing
Limitations	

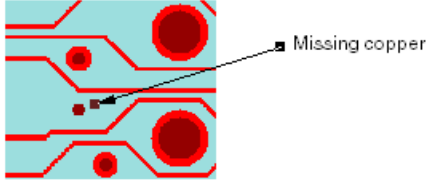
NPTH Contains Copper (Drill)

Reports NPTHs containing copper on positive layers only.

Internal ERF Name	<Area>npth_cont_c
Measurement Shape	Segment
Measurement ID	Drill
Layers Displayed	<ul style="list-style-type: none"> • Power and ground layer • Layer piercing it
Graphic	
Purpose	Having copper inside non-plated through holes serves no purpose and inflicts unnecessary wear and tear on the drill bit.
Function	Reports NPTHs containing copper on positive layers only.
ERF Parameters	
ERF Variables	
Constraint	Hole Clearance
Limitations	

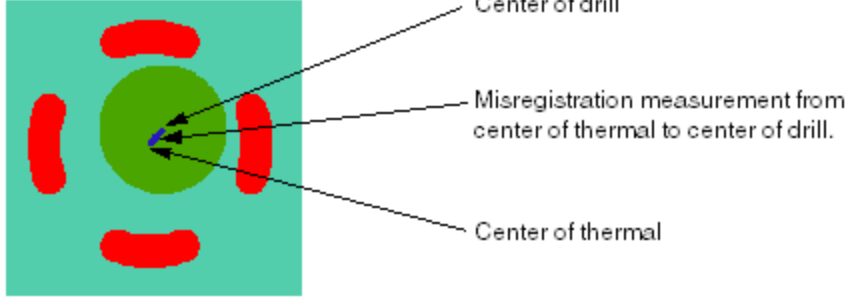
Missing Cu for Vias (Drill)

Reports via holes not completely surrounded by copper in the drill layer with layer attribute Vias Need CU.

Internal ERF Name	<Area>:miss_cu
Measurement Shape	Circle
Measurement ID	Vias
Layers Displayed	Power and ground layer Drill layer which pierces it
Graphic	
Purpose	To determine if a via drill is completely surrounded by copper in power and ground layers.
Function	Reports via holes not completely surrounded by copper in the drill layer with layer attribute Vias Need CU. Measurements are circles representing the via.
ERF Parameters	
ERF Variables	
Limitations	

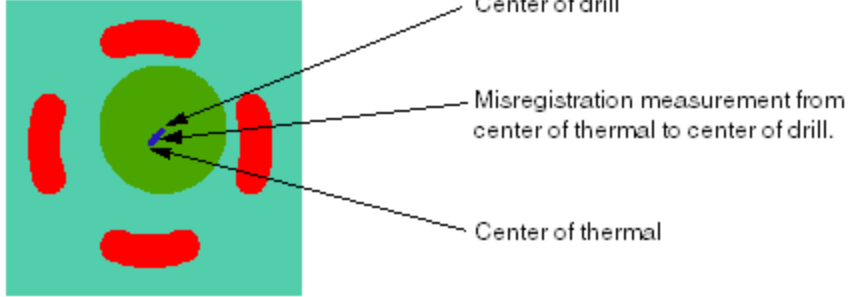
PTH Registration (Drill)

Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.

Internal ERF Name	<Area>:pth_reg
Measurement Shape	Segment
Measurement ID	Drill; Pad
Layers Displayed	<ul style="list-style-type: none">• Power and ground layer• Drill layer which pierces it
Graphic	
Purpose	Typically, a hole should be in the middle of a pad. Any deviation may indicate inaccuracy in the input files or a CAD system error.
Function	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg. Measurements are segments representing distance.
ERF Parameters	
ERF Variables	reg_allowance max_reg
Limitations	If the distance between the centers is larger than max_reg, then the features are considered offset on purpose and large registration errors may be missed.

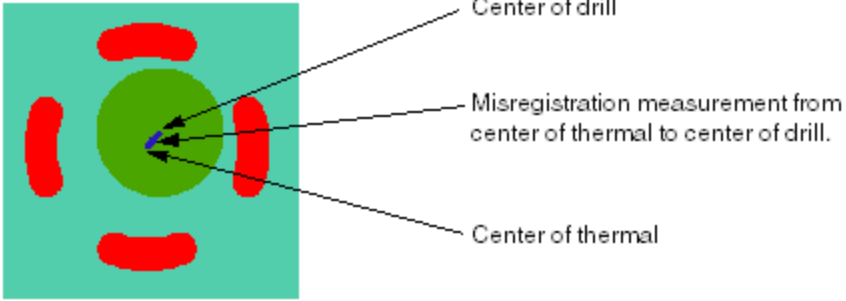
NPTH Registration (Drill)

Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.

Internal ERF Name	<Area>npth_reg
Measurement Shape	Segment
Measurement ID	Drill; Pad
Layers Displayed	<ul style="list-style-type: none"> • Power and ground layer • Drill layer which pierces it
Graphic	
Purpose	Typically, a hole should be in the middle of a pad. Any deviation may indicate inaccuracy in the input files or a CAD system error.
Function	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg. Measurements are segments representing distance.
ERF Parameters	
ERF Variables	reg_allowance max_reg
Constraint	Hole Registration
Limitations	If the distance between the centers is larger than max_reg, then the features are considered offset on purpose and large registration errors may be missed.

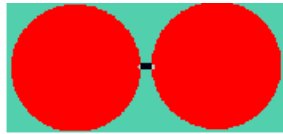
Via Registration (Drill)

Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg.

Internal ERF Name	<Area>:via_reg
Measurement Shape	Segment
Measurement ID	Drill; Pad
Layers Displayed	<ul style="list-style-type: none">• Signal layer• Drill layer which pierces it
Graphic	
Purpose	Typically, a hole should be in the middle of a pad. Any deviation may indicate inaccuracy in the input files or a CAD system error.
Function	Reports the center-to-center distance between drills and touching pads, if larger reg_allowance and smaller than max_reg. Measurements are segments representing distance.
ERF Parameters	
ERF Variables	reg_allowance max_reg
Constraint	Hole Registration
Limitations	If the distance between the centers is larger than max_reg, then the features are considered offset on purpose and large registration errors may be missed.


Sliver (Sliver) (Power and Ground)

Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case), whose width is less than pp_sliver, and non-zero.

Internal ERF Name	<Area>:sliver
Measurement Shape	Segment
Measurement ID	None
Layers Displayed	Power and ground layer
Graphic	
Purpose	A copper sliver can cause material to detach during photo-imaging processes in fabrication. Floating pieces can cause defects and shorts which reduce yield.
Function	Both ‘Silver’ and ‘Short Sliver’ report slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case). A violation is reported if silver width is less than pp_sliver, and non-zero. A sliver is defined by v_dist2sliver_ratio and v_min_sliver_perim. See “ Sliver and Short Sliver Categories (Power and Ground) ” on page 107. v_slivers_check_diff_net used in ‘Sliver’ (Signal Layers Checks), is irrelevant here.
ERF Parameters	pp_sliver
ERF Variables	v_sliver_algorithm_mode v_dist2sliver_ratio v_min_sliver_perim v_max_net_size replace_crosshatch_by_surface v_min_sliver_len
Constraint	Copper Spacing
Related Category	Short Sliver (Sliver)


Short Sliver (Sliver) (Power and Ground)

Reports slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case).

Internal ERF Name	<Area>:short_sliver
Measurement Shape	Segment
Measurement ID	None
Layers Displayed	Power and ground layer
Graphic	
Purpose	A copper sliver can cause material to detach during photo-imaging processes in fabrication. Floating pieces cause defects and shorts which reduce yield.
Function	Both ‘Silvers’ and ‘Short Sliver’ report slivers, either between two copper areas (positive layer) or two clearance areas (negative layers) (usual case). See “ Sliver and Short Sliver Categories (Power and Ground) ” on page 107. v_slivers_check_diff_net used in ‘Sliver’ (Signal Layers Checks), is irrelevant here.
ERF Parameters	pp_sliver
ERF Variables	v_sliver_algorithm_mode = 1 v_dist2sliver_ratio v_min_sliver_perim v_max_net_size replace_crosshatch_by_surface v_min_sliver_len
Constraint	Copper Spacing
Related Category	Sliver (Sliver)


Spoke Width (Thermal)

Reports thermal spoke (tie) widths in negative layers with flashed pads that are less than their defined widths.

Internal ERF Name	<Area>:spoke_width
Measurement Shape	Segment
Measurement ID	None
Layers Displayed	Power and ground (or mixed) layer
Graphic	
Function	<p>Reports thermal spoke (tie) widths in negative layers with flashed pads that are less than their defined widths. Measurements are segments describing the spoke width at its narrowest point.</p> <p>The definition of a thermal pad includes the 'tie width'. ('Spoke gap' in DFM Analysis.)</p>
ERF Parameters	
ERF Variables	thermal_shrink_outer
Limitations	

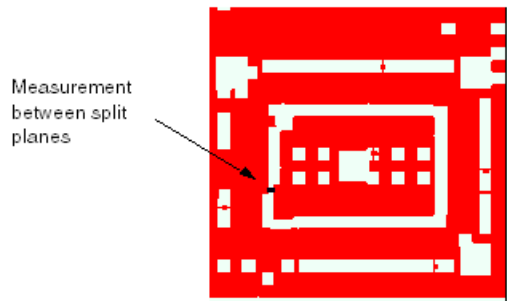
Thermal Connect Reduction (Thermal)

Reports all incidents of thermal connectivity reduction in negative layers where thermal pads are flashed.

Internal ERF Name	<Area>:thermal_percent_red
Measurement Shape	Bounding box around thermal
Measurement ID	None
Layers Displayed	Power and ground (or mixed) layer
Graphic	
Purpose	If the drill located inside the thermal has insufficient electrical connectivity to the surrounding plane, it may not provide the required functionality, especially in high speed designs.
Function	<p>Reports all incidents of thermal connectivity reduction in negative layers where thermal pads are flashed. Measurement is expressed as a percentage.</p> <p>The overall electrical connectivity of a thermal pad is the sum of its defined spoke widths. The actual connectivity is the sum of actual spoke widths. The percentage reduction is calculated according to this</p> <p>formula: $\frac{[\text{Defined Connectivity}] - [\text{Actual Connectivity}]}{[\text{Actual Connectivity}]}$</p>
ERF Parameters	
ERF Variables	thermal_shrink_outer
Limitations	

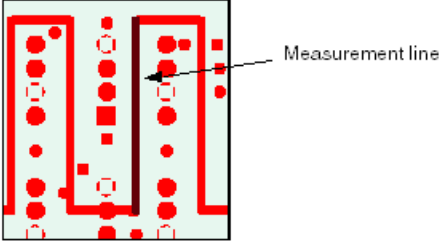
Plane Spacing (Plane Spacing)

Reports features in a positive or negative layer closer than pp_pln_spacing belonging to different plane nets if the measurement segment touches copper only at its endpoints.

Internal ERF Name	<Area>:plane_spacing
Measurement Shape	Segment
Measurement ID	Any two features
Layers Displayed	Power and ground (or mixed) layer
Graphic	
Purpose	When spacing between planes is compromised, shorts can occur between different voltage levels or between power and ground, resulting in non-functional boards.
Function	Reports features in a positive or negative layer closer than pp_pln_spacing belonging to different plane nets if the measurement segment touches copper only at its endpoints. If measurement segment touches copper at any point other than its endpoints, it is not reported.
ERF Parameters	pp_pln_spacing
ERF Variables	max_nfp_net_size
Constraint	Copper Spacing
Limitations	Drawn planes close to each other can produce a large number of measurements. Measurements are not filtered by their proximity to each other.

Segmentation Lines (Plane Spacing)

Reports widths of actual laminate (spacing width) occupied by lines in negative layers only (lines in negative plane layers represent spacing), less than pp_pln_spacing.

Internal ERF Name	<Area>:segmentation_lines
Measurement Shape	Line
Measurement ID	Line
Layers Displayed	Power and ground (or mixed) layer
Graphic	
Function	<p>Reports widths of actual laminate (spacing width) occupied by lines in negative layers only (lines in negative plane layers represent spacing), less than pp_pln_spacing. This width may be larger than line width if spacing is drawn using partially overlapping parallel lines.</p> <p>Measurements are line shapes representing spacing width.</p>
ERF Parameters	pp_pln_spacing
ERF Variables	min_line_len len2width_ratio
Constraint	Copper Spacing
Limitations	The measured lines may not always represent split planes but also cutouts or text.

ERF Parameters for Power and Ground Checks

Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Layer	pp_layer	Defines layer to be affected by the action.	All categories
Drill to Copper	pp_d2c	The maximum search radius for all drill related measurements to copper.	NPTH to Copper PTH Annular Ring PTH to Copper Via to Copper PTH to Plane Via to Plane NPTH to Plane
Minimal Sliver	pp_sliver	The minimum allowable sliver width. A sliver that is narrower than this value is reported.	Sliver Short Sliver
Plane Spacing	pp_pln_spacing	The maximum distance for split plane spacing measurements.	Plane Spacing Segmentation Lines
Test List	pp_tests	Defines the tests to be run. See “ Tests Performed in Power and Ground Checks ” on page 106.	All categories

ERF Variables for Power and Ground Checks

Variables set in the ERF file control the analysis.

ERF Variable	Description	Categories Affected
classify_via_cont_clear	Defines how PTHs or vias containing clearances are reported. 0 - report both PTHs or vias in 'PTH Contains Clearance'. (default) 1 - report PTHs in 'PTH Contains Clearance' and vias in 'Via Contains Clearance'.	PTH Contains Clearance Via Contains Clearance
classify_via2c	Defines how PTH or via to copper measurements are reported. 0 - report both PTHs or vias in 'PTH to Copper'. (default) 1 - report PTHs in 'PTH to Copper' and vias in 'Via to Copper'.	PTH to Copper Via to Copper
classify_via2p	Defines how PTH or via to plane measurements are reported. 0 - report both PTHs or vias in 'PTH to Plane'. (default) 1 - report PTHs in 'PTH to Plane' and vias in 'Via to Plane'.	PTH to Plane Via to Plane
classify_via2t	Defines how PTH or via to annular ring measurements are reported. 0 - report both PTHs or vias in 'PTH to Annular Ring'. (default) 1 - report PTHs in 'PTH Annular Ring' and vias in 'Via Annular Ring'.	PTH Annular Ring
len2width_ratio	Minimum ratio of length to width for the 'Segmentation Lines' category.	Segmentation Lines
max_nfp_net_size	Defines the limits (length and width of a bounding box) of a copper net in positive power and ground layers. Nets with limits less than this value are considered NFP nets, except for one pad nets which are always considered NFP, regardless of size. Spacing measurements between two NFP nets or an NFP net and a plane net are reported to 'NFP Spacing (pos)'. Spacing measurements between two plane nets are reported to 'Plane Spacing'.	Plane Spacing

ERF Variable	Description	Categories Affected
max_reg	Maximum offset considered a registration error. If the center-to-center distance of drill and pad is larger than this value, a registration error is <i>not</i> reported.	PTH Registration NPTH Registration Via Registration
min_line_len	Minimum line length in 'Segmentation Lines' category. Also the minimum overlap between lines to report in parallel spacing.	Segmentation Lines
pth_breakout_angle	0 - 180 degrees Defines maximum angle allowed for breakout of drill from PTH pad. To block breakout of PTH to thermal pad set pth_breakout_angle=0.	PTH Annular Ring
reg_allowance	A distance between pad center and drill center greater than this value is considered misregistered.	PTH Registration NPTH Registration Via Registration
replace_crosshatch_by_surface	Determines how slivers are reported on hatched area. yes - do not report slivers found on hatched area. (default) (Gerber) no - report slivers found on hatched area. by attr - only report slivers bearing a hatch attribute. (EDA)	Sliver Short Sliver
take_npth_range	Defines whether the maximal distance for NPTHs to copper is taken from pp_d2c or from the npth2c. parameter 0 - use value of pp_d2c. (default) 1 - use value of npth2c range.	NPTH to Copper NPTH to Plane
thermal_shrink_outer	The amount to shrink the diameter of the outer thermal shape without causing a spoke reduction violation, when clearance barely intrudes upon the outer perimeter of a thermal. This is accomplished by taking a shape equal to the outer shape of the thermal, shrinking it by the value of thermal_shrink_outer and checking the spoke widths and thermal reduction along the outline of this shape.	Spoke Width Thermal Connect Reduction

ERF Variable	Description	Categories Affected
v_dist2sliver_ratio	Minimal ratio for the distance between measurement segment endpoints along the net and the width of the sliver. See “ DFM Analysis Compatibility for Power and Ground Checks ” on page 107.	Sliver Short Sliver
v_max_net_size	Nets with more than v_max_net_size features are ignored. See “ DFM Analysis Compatibility for Power and Ground Checks ” on page 107.	Sliver Short Sliver
v_min_sliver_len	Slivers shorter than this value are reported as ‘Short Sliver’. All others are reported in ‘Sliver’. Maximum possible value is 100 mils. See “ DFM Analysis Compatibility for Power and Ground Checks ” on page 107.	Sliver Short Sliver
v_min_sliver_perim	Defines the minimal distance between the measurement segment endpoints along the net. (For a description of perimeter, see “ Sliver and Short Sliver Categories (Power and Ground) ” on page 107).	Sliver
v_sliver_algorithm_mode	Defines which of three algorithms is used to determine sliver violations. 0 - use original algorithm where results are reported to the ‘Sliver’ category. (slow) 1 - use improved algorithm where results are reported to either the ‘Sliver’ or ‘Short Sliver’ category. (fast) (default) 2 - results are the same as with 1 , but the process is slower. (Remains in the system to insure backward compatibility.)	Sliver Short Sliver

Chapter 5

Fabrication Analysis - Solder Mask Checks

Solder Mask Checks is a read-only check of solder mask layers for potential manufacturability defects. Its findings are collected in categories. Solder mask layers are always assumed to be negative; all positive features describe clearances or the absence of solder mask.

This action also checks if solder paste has been deposited on all SMD pads. See “[Missing SMD Clearance \(Missing\)](#)” on page 165.

The action operates on a single solder mask layer per side (single top, single bottom) at a time. If more than one layer is selected, the action will not analyze any layers.

This action also checks solder paste layers to detect SMDs without paste, and compares the negative annular ring (gasket) of the SMD pad with the paste pad.

This action relates to a solder mask layer, and the drill and external copper layers associated with it.

If there is no solder mask CAM document defined, PADS Layout creates a solder mask document when DFMA is opened from within PADS Layout. This newly created document includes a 10-mil oversize added to the solder mask clearance.

If there is an existing solder mask document, and it specifies the oversize, DFMA uses that value.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Solder Mask Checks

Several solder mask checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

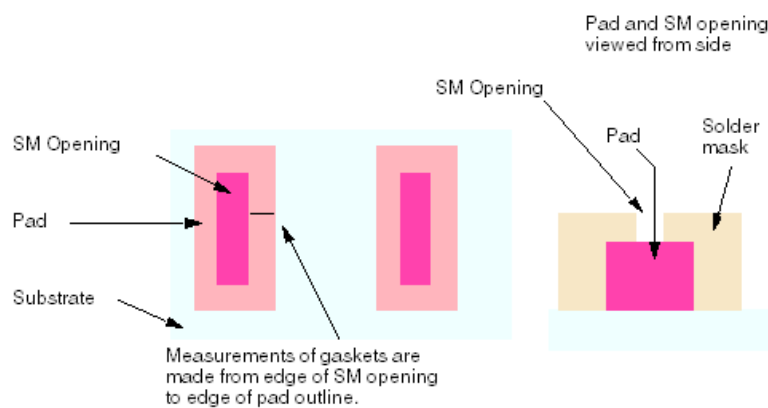
- **Drill** — Reports close distances to solder mask openings of PTH or NPTH annular rings, and where NPTH touches mask.
- **Pads** — Reports close distances to solder mask openings of all pads, including undrilled pads. It also reports on gaskets.
 - **Pad Annular Ring Categories** — These categories report pad annular ring results. Some can be used to classify the Pad Annular Ring measurement according to the pad type: PTH Pads, NPTH Pads, Via Pads and Non-Drilled Pads. This option is activated by setting ERF variable `classify_pad_ar = 1`.

Annular ring categories do not report a pad (or drill) completely covered by solder mask. Zero annular ring might be reported if a solder mask clearance and a pad drill overlap, but neither includes the other.

- **Gasket Categories** — These categories reports on measurements of gasket annular rings. Gaskets are overlapping sections of solder mask onto board features, such as pads. This makes the solder mask opening smaller than the pad.

The system measures this by assuming a negative annular ring, that is an annular ring that dips into the pad rather than extends beyond it. To indicate to the system that you want to activate the ‘gasket’ categories (that is, consider negative annular rings), set the ERF variable `categorize_negative_ar` to 1 (active). When `categorize_negative_ar` is set to 0 (inactive), the system globally assigns a zero value to all negative annular rings and they are reported to “[Pad Annular Ring \(Pads\)](#)” on page 153.

This example illustrates a gasket:



- **Coverage** — reports lines too close to clearances (that is, not adequately covered).
- **Sliver** — Reports slivers between solder mask clearances. See “[Sliver and Short Sliver Categories \(SM\)](#)” on page 140
- **Missing** — reports missing clearances.
- **Spacing** — reports close spaces between clearances (wider than sliver).
- **Extra** — reports solder mask features that do not intersect with copper.

Attributes Used in Solder Mask Checks

Attributes assigned to features in the product model control the analysis.

Feature Attributes

Table 5-1. Solder Mask Checks Feature Attributes

Attribute	Description
Drill Type	This attribute is attached to hole features in drill layers. It defines the type of the drill and is used extensively during fabrication analysis.

Table 5-1. Solder Mask Checks Feature Attributes (cont.)

Attribute	Description
SMD Pad	This attribute is attached to outer layer pads which are lands for SMD components. It is set by the 'Set SMD Attribute' Cleanup Action.

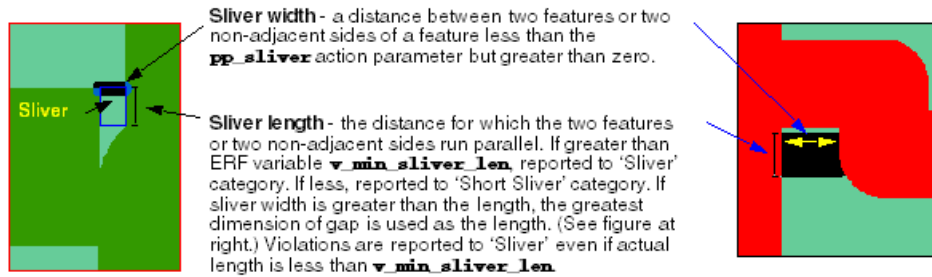
DFM Analysis Compatibility for Solder Mask Checks

To maintain compatibility between legacy products and DFM Analysis, ERF variables used with earlier products are mapped to the appropriate DFM Analysis ERF variables.

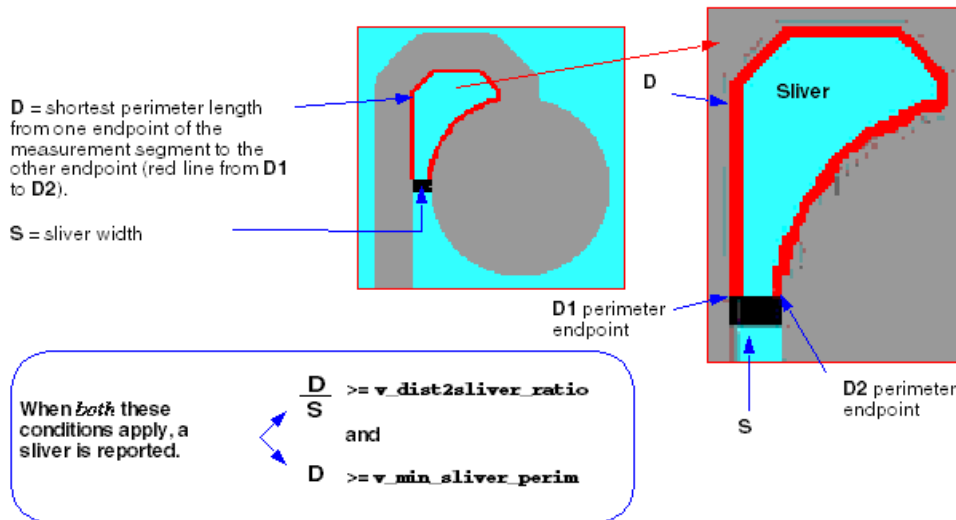
Earlier Products	DFM Analysis
cover_check_same_net = 0 cover_check_same_net = 1	cover_ignore_same_net = 1 cover_ignore_same_net = 0
dist2sliver_ratio	v_dist2sliver_ratio
min_sliver_len	v_min_sliver_len
classify_pad_ar=2	classify_pad_ar=1

Sliver and Short Sliver Categories (SM)

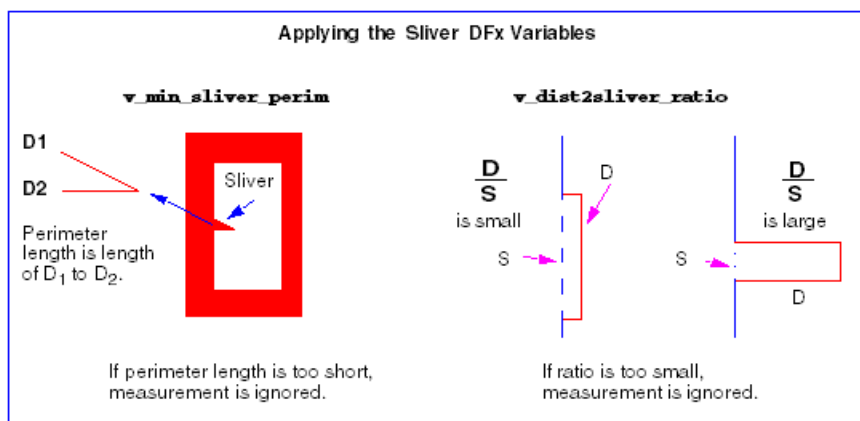
These categories deal with slivers, narrow strips of copper between two features or between non-adjacent sides of the same feature. It is important to detect slivers which could break off during the manufacturing process and cause shorts. In detecting slivers, length, width and shortest perimeter length are measured.



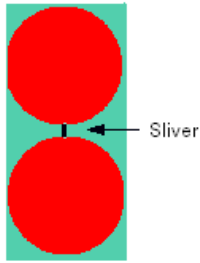
Measurements are distance segments between two connected features (features on the same net) or two non-adjacent sides of one feature.



Applying the Sliver Dfx Variables:

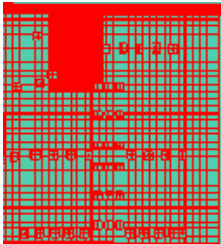


When the two features are not connected (not on the same net), **v_dist2sliver_ratio** and **v_min_sliver_perim** become irrelevant.



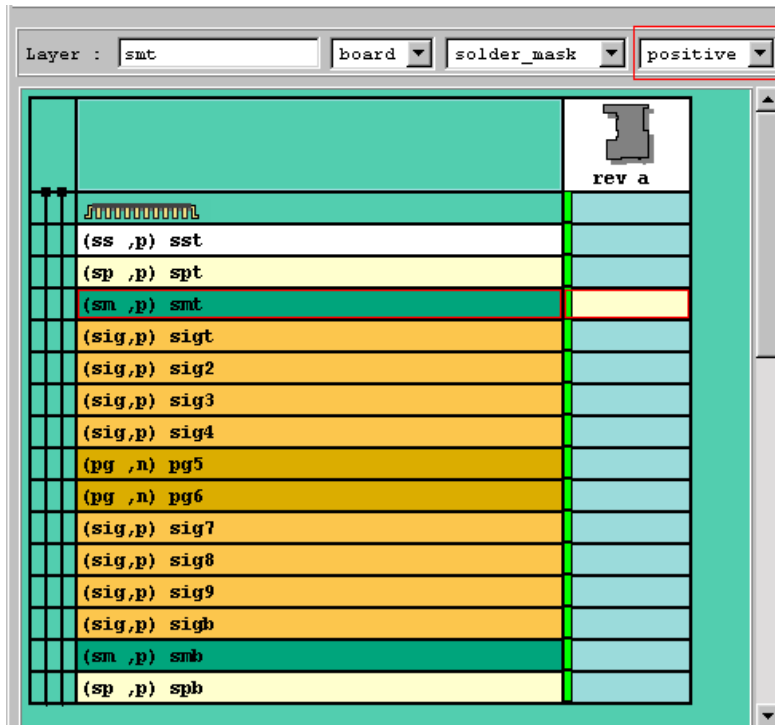
Slivers found on hatched areas (a plane filled with lines instead of solid copper, where each line in the area has the attribute Hatch Feature) are reported only if ERF variable `replace_crosshatch_by_surface=by_attr`. (Default value = yes).

However, if the surface is filled with at least fifty lines of the same width, it is accepted as a hatched area even if the lines do not bear the Hatch Feature attribute and ERF variable `replace_crosshatch_by_surface=no`.



Polarity for Solder Mask Layers

Features on a positive layer are considered copper. Features on a negative layer are considered clearances. This is true for every layer except the solder mask layer. Though solder mask is defined as positive, the system considers it negative and its features are considered clearances. Therefore, the solder mask layer should be set to positive in the job matrix. If defined as negative, it may result in incorrect results and long analysis.



Categories in Solder Mask Checks

Several solder mask checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

The ERF parameter pp_layer affects all categories, and is not repeated in the category fact sheets.

These are the result categories, with the Test in parentheses.

Table 5-2. Result Categories for Solder Mask Checks

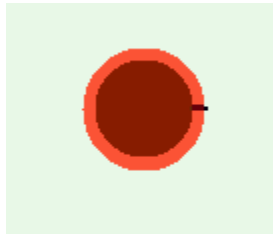
Category	Description
PTH Annular Ring (Drill)	Reports distances less than pp_ar between PTHs and solder mask in negative layers.
NPTH Annular Ring (Drill)	Reports distances less than pp_ar between NPTHs and solder mask in negative layers.
Via Annular Ring (Drill)	Reports distances less than pp_ar between vias and solder mask in negative layers.
NPTH Touches Mask (Drill)	Reports NPTHs not contained in a solder mask clearance (have non-negative annular ring of clearance) or with no clearance at all.
PTH Gasket (Drill)	Reports all SM to PTH gaskets (negative AR) narrower than pp_ar.
Via Gasket (Drill)	Reports all SM to via gaskets (negative AR) narrower than pp_ar.
SMD Annular Ring (Pads)	Reports distances less than pp_ar between SMD pads with attribute SMD Pad and solder mask.
Pad Annular Ring (Pads)	Reports non-SMD pad to solder mask distances less than pp_ar.
PTH Pad Annular Ring (Pads)	Reports PTH pad to solder mask distances less than pp_ar.
NPTH Pad Annular Ring (Pads)	Reports NPTH pad to solder mask distances less than pp_ar.
Via Pad Annular Ring (Pads)	Reports via pad to solder mask distances less than pp_ar.
SMD Pad Gasket (Pads)	Reports SMD pad gaskets narrower than pp_ar.
PTH Pad Gasket (Pads)	Reports PTH pad gaskets narrower than pp_ar.
NPTH Pad Gasket (Pads)	Reports NPTH pad gaskets narrower than pp_ar.
Via Pad Gasket (Pads)	Reports via pad gaskets narrower than pp_ar.

Table 5-2. Result Categories for Solder Mask Checks (cont.)

Category	Description
Undrilled Pad Gasket (Pads)	Reports via pad gaskets narrower than pp_ar.
Coverage (Coverage)	Reports traces (or any other circuit features) closer than pp_coverage or touching a solder mask clearance that exposes a pad belonging to another net.
SM Sliver (Sliver)	Reports slivers between two solder mask clearances, if silver width is less than pp_sliver, and non-zero.
SM Short Sliver (Sliver)	Reports slivers between two solder mask clearances if silver width is less than pp_sliver, and non-zero.
Missing SMD Clearance (Missing)	Reports SMD pads that neither include, nor are included, in any solder mask clearances.
Missing Undrilled Pad Clearance (Missing)	Reports undrilled pads that neither include, nor are included, in any solder mask clearances.
Missing NPTH Clearance (Missing)	Reports NPTHs that do not touch any solder mask clearances.
Missing PTH Clearance (Missing)	Reports PTHs that do not touch any solder mask clearances.
Missing Via Clearance (Missing)	Reports vias that do not touch any solder mask clearances.
Missing Testpoint Clearance (Missing)	Reports testpoint pads that neither include, nor are included, in any solder mask clearance.
Pad to Pad Spacing (Spacing)	Reports distances between pads in solder mask layers closer than pp_spacing.
Pad to Non-Pad Spacing (Spacing)	Reports distances between pads and non-pads in solder mask layers closer than pp_spacing.
Non-Pad to Non-Pad (Spacing)	Reports distances between non-pad features in solder mask layers closer than pp_spacing.
Extra SM - Missing Copper (Extra)	Reports solder mask features which do not intersect with copper.

PTH Annular Ring (Drill)

Reports distances less than pp_ar between PTHs and solder mask in negative layers.

Internal ERF Name	<Area>:ar_pth
Measurement Shape	Segment
Measurement ID	Pad (representing the PTH)
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Drill layer
Graphic	
Purpose	The area in and around a plated through hole should be clear of mask, enabling the solder wave to completely fill the hole around the component pin.
Function	Reports distances less than pp_ar between PTHs and solder mask in negative layers. Measurements are segments corresponding to the minimal distance between drill and clearance outline.
ERF Parameters	pp_ar
ERF Variables	
Constraint	Plated Hole AR
Limitations	

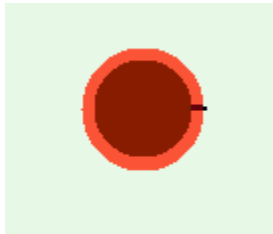
NPTH Annular Ring (Drill)

Reports distances less than pp_ar between NPTHs and solder mask in negative layers.

Internal ERF Name	<Area>:ar_npth
Measurement Shape	Segment
Measurement ID	Pad (representing the NPTH)
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Drill layer
Graphic	
Function	<p>Reports distances less than pp_ar between NPTHs and solder mask in negative layers. Measurements are segments corresponding to the minimal distance between drill and clearance outline.</p> <p>NPTH drills are assumed to be drilled through a solder mask opening and require a large clearance.</p>
ERF Parameters	pp_ar
ERF Variables	
Limitations	

Via Annular Ring (Drill)

Reports distances less than pp_ar between vias and solder mask in negative layers.

Internal ERF Name	<Area>:ar_via
Measurement Shape	Segment
Measurement ID	Pad (representing the via)
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Drill layer
Graphic	
Purpose	The area in and around a via should be clear of mask, enabling the solder wave to completely fill the hole around the component pin.
Function	Reports distances less than pp_ar between vias and solder mask in negative layers. Measurements are segments corresponding to the minimal distance between drill and clearance outline.
ERF Parameters	pp_ar
ERF Variables	
Constraint	Plated Hole
Limitations	

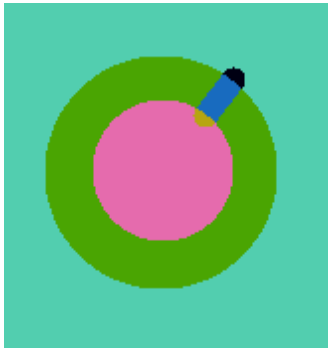
NPTH Touches Mask (Drill)

Reports NPTHs not contained in a solder mask clearance (have non-negative annular ring of clearance) or with no clearance at all.

Internal ERF Name	<Area>npth2m
Measurement Shape	Zero length segment at drill center
Measurement ID	Pad (representing an NPTH)
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Drill layer
Graphic	
Function	Reports NPTHs not contained in a solder mask clearance (have non-negative annular ring of clearance) or with no clearance at all. At these locations the NPTH touches the solder mask.
ERF Parameters	
ERF Variables	
Limitations	

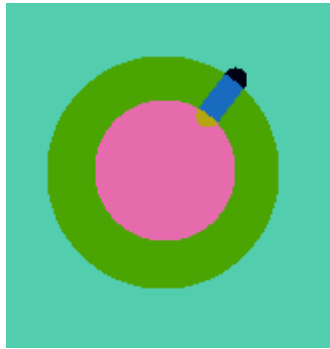
PTH Gasket (Drill)

Reports all SM to PTH gaskets (negative AR) narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_pth
Measurement Shape	Segment
Measurement ID	Solder mask clearance; Drill
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Drill layer
Graphic	
Purpose	To identify PTH drills whose SM gaskets are too narrow.
Function	Reports all SM to PTH gaskets (negative AR) narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	
Constraint	PTH Gasket Size
Limitations	

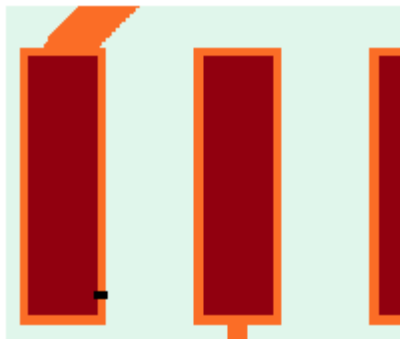
Via Gasket (Drill)

Reports all SM to via gaskets (negative AR) narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_via
Measurement Shape	Segment
Measurement ID	Solder mask clearance; Drill
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Drill layer
Graphic	
Purpose	To identify via drills whose SM gaskets are too narrow.
Function	Reports all SM to via gaskets (negative AR) narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	
Constraint	PTH Gasket Size
Limitations	

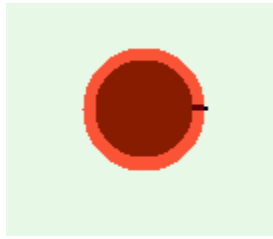
SMD Annular Ring (Pads)

Reports distances less than pp_ar between SMD pads with attribute SMD Pad and solder mask.

Internal ERF Name	<Area>:ar_smd
Measurement Shape	Segment
Measurement ID	Pad (representing the SMD); Pad (for clearance)
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• External copper layer
Graphic	
Purpose	SMD pads must be free of mask but typically with a smaller annular ring than plated through hole pads. This is why they have their own category.
Function	Reports distances less than pp_ar between SMD pads with attribute SMD Pad and solder mask. Measurements are segments corresponding to the minimal distance between SMD pad and clearance outline.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 0
Constraint	SMD Pad AR
Limitations	<p>If the clearance is drawn, the clearance entity will be r0 because no single feature corresponds to the clearance.</p> <p>Solder mask gaskets (clearance smaller than the pad) are reported as zero annular ring. For actual “negative” annular ring values for gaskets, categorize_negative_ar must be set to 1. Then gaskets are reported in this category.</p>

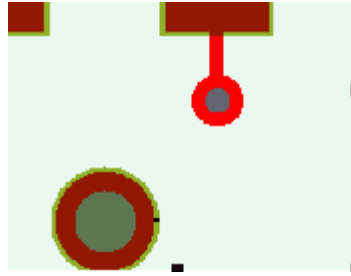
Pad Annular Ring (Pads)

Reports non-SMD pad to solder mask distances less than pp_ar.

Internal ERF Name	<Area>:ar_pad
Measurement Shape	Segment
Measurement ID	Pad (representing the SMD); Pad (for clearance)
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • External copper layer
Graphic	
Function	Reports non-SMD pad to solder mask distances less than pp_ar. Measurements are segments corresponding to the minimal distance between pad and clearance outline.
ERF Parameters	pp_ar
ERF Variables	classify_pad_ar = 0
Constraint	SMD Pad AR
Limitations	

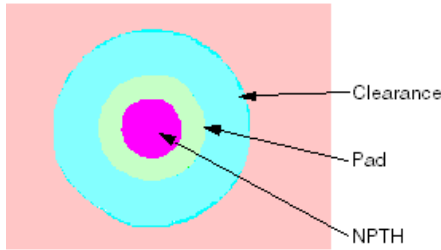
PTH Pad Annular Ring (Pads)

Reports PTH pad to solder mask distances less than pp_ar.

Internal ERF Name	<Area>:ar_pth_pad
Measurement Shape	Segment
Measurement ID	Two pads (one representing the pad; the other, the clearance)
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• External copper layer
Graphic	
Function	Reports PTH pad to solder mask distances less than pp_ar. Measurements are segments corresponding to the minimal distance between pad and clearance outline.
ERF Parameters	pp_ar
ERF Variables	classify_pad_ar = 1
Constraint	Hole Pad AR
Limitations	

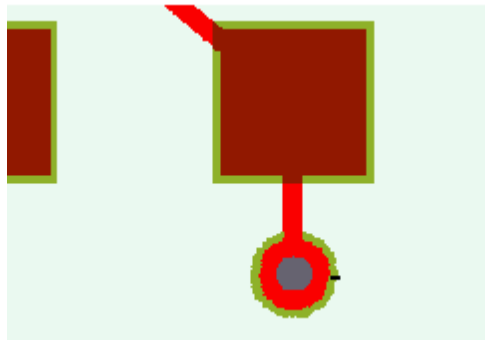
NPTH Pad Annular Ring (Pads)

Reports NPTH pad to solder mask distances less than pp_ar.

Internal ERF Name	<Area>:ar_npth_pad
Measurement Shape	Segment
Measurement ID	Two pads (one representing the pad; the other, the clearance)
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • External copper layer
Graphic	
Function	Reports NPTH pad to solder mask distances less than pp_ar. Measurements are segments corresponding to the minimal distance between pad and clearance outline.
ERF Parameters	pp_ar
ERF Variables	classify_pad_ar = 1
Constraint	Hole Pad AR
Limitations	

Via Pad Annular Ring (Pads)

Reports via pad to solder mask distances less than pp_ar.

Internal ERF Name	<Area>:ar_via_pad
Measurement Shape	Segment
Measurement ID	Two pads (one representing the pad; the other, the clearance)
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• External copper layer
Graphic	
Function	Reports via pad to solder mask distances less than pp_ar. Measurements are segments corresponding to the minimal distance between pad and clearance outline.
ERF Parameters	pp_ar
ERF Variables	classify_pad_ar = 1
Constraint	Hole Pad AR
Limitations	

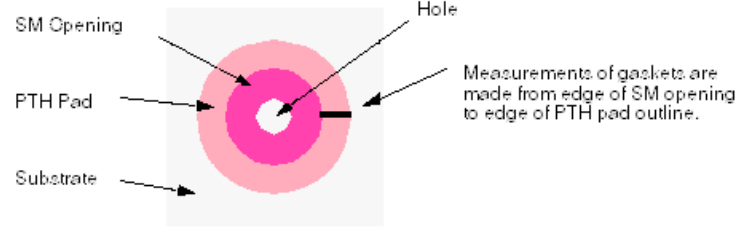
SMD Pad Gasket (Pads)

Reports SMD pad gaskets narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_smd
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none"> • External copper layer • Solder mask layers
Graphic	<p>SM Opening</p> <p>SMD Pad</p> <p>Substrate</p> <p>Measurements of gaskets are made from edge of SM opening to edge of SMD pad outline.</p>
Function	Reports SMD pad gaskets narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 1
Constraint	Gasket Size
Limitations	

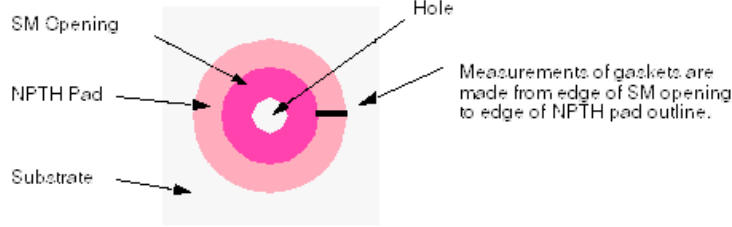
PTH Pad Gasket (Pads)

Reports PTH pad gaskets narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_pth_pad
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none">• External copper• Solder mask layers
Graphic	 <p>The diagram illustrates a cross-section of a PTH pad gasket. It shows a central white circle labeled 'Hole', surrounded by a pink ring labeled 'PTH Pad'. This is further enclosed by a light gray ring labeled 'SM Opening' (Solder Mask Opening). The outermost layer is a light gray square labeled 'Substrate'. A text box on the right states: 'Measurements of gaskets are made from edge of SM opening to edge of PTH pad outline.'</p>
Function	Reports PTH pad gaskets narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 1
Constraint	Gasket Size
Limitations	

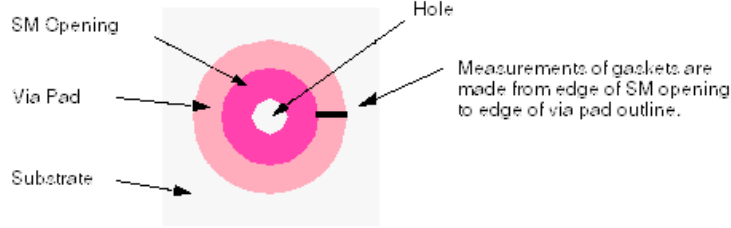
NPTH Pad Gasket (Pads)

Reports NPTH pad gaskets narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_npth_pad
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none"> • External copper • Solder mask layers
Graphic	 <p>The diagram illustrates a cross-section of a printed circuit board (PCB) showing a Non-Plated Through Hole (NPTH) pad. It features a central white circle labeled 'Hole', surrounded by a pink ring labeled 'NPTH Pad'. This pad is enclosed within a larger, light gray square labeled 'SM Opening' (Solder Mask Opening). The entire assembly is on a light gray background labeled 'Substrate'. A text box with an arrow pointing to the gap between the NPTH pad and the SM opening contains the text: 'Measurements of gaskets are made from edge of SM opening to edge of NPTH pad outline.'</p>
Function	Reports NPTH pad gaskets narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 1
Limitations	

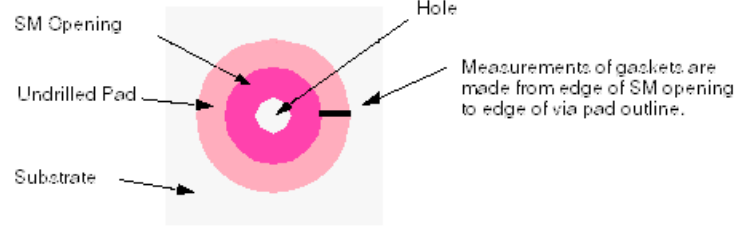
Via Pad Gasket (Pads)

Reports via pad gaskets narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_via_pad
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none">• External copper• Solder mask layers
Graphic	 <p>The diagram illustrates a cross-section of a via pad gasket. It shows a central 'Hole' surrounded by a 'Via Pad' (a pink ring). This is further enclosed by a 'SM Opening' (a larger pink ring). The entire structure is on a 'Substrate' (grey background). A note indicates that measurements of gaskets are made from the edge of the SM opening to the edge of the via pad outline.</p>
Function	Reports via pad gaskets narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 1
Constraint	Gasket Size
Limitations	

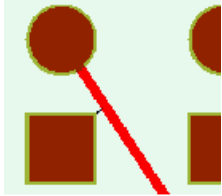
Undrilled Pad Gasket (Pads)

Reports via pad gaskets narrower than pp_ar.

Internal ERF Name	<Area>:neg_ar_ndrl_pad
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none"> • External copper • Solder mask layers
Graphic	 <p>Diagram illustrating the Undrilled Pad Gasket (Pads) measurement. The diagram shows a cross-section of a via pad with concentric layers: a central hole, an inner copper pad, an outer solder mask opening, and the substrate. Labels indicate the SM Opening, Undrilled Pad, Hole, and Substrate. A note states: "Measurements of gaskets are made from edge of SM opening to edge of via pad outline."</p>
Function	Reports via pad gaskets narrower than pp_ar.
ERF Parameters	pp_ar
ERF Variables	categorize_negative_ar = 1
Limitations	

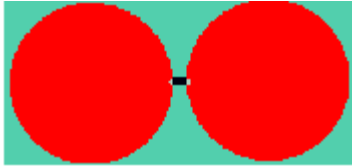
Coverage (Coverage)

Reports traces (or any other circuit features) closer than pp_coverage or touching a solder mask clearance that exposes a pad belonging to another net.

Internal ERF Name	<Area>:coverage
Measurement Shape	Segment
Measurement ID	Spacing; Clearance
Layers Displayed	<ul style="list-style-type: none"> • Solder mask • External copper layer
Graphic	
Purpose	Lines which pass close to a pad must be fully covered by mask to avoid solder bridging between line and pad during the assembly process.
Function	<p>Reports traces (or any other circuit features) closer than pp_coverage or touching a solder mask clearance that exposes a pad belonging to another net.</p> <p>Typically, each clearance has a signal intersecting it, a trace that touches exposed copper. If it does not connect to an inner pad, it is considered a violation.</p> <p>Unexposed copper, too close to a SM clearance with no exposed copper within, is always reported in this category.</p>
ERF Parameters	pp_coverage
ERF Variables	cover_dist_to_cu cover_ignore_same_net cover_ignore_intersection cover_special_check v_report_proximity
Constraint	SM Feature Spacing
Limitations	To avoid false alarms near SMD picture frame openings and drawn areas, a filter is applied. If the distance to the other net exposed copper is greater than 1.5 times pp_coverage, the measurement is filtered. This causes coverage violations in oversized clearances to go unreported.

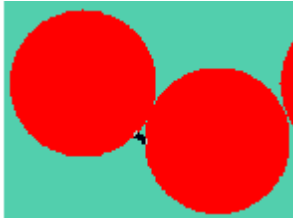
SM Sliver (Sliver)

Reports slivers between two solder mask clearances, if silver width is less than pp_sliver, and non-zero.

Internal ERF Name	<Area>:sliver
Measurement Shape	Segment
Measurement ID	None
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer
Graphic	
Purpose	Tiny solder mask slivers can detach during processing and cause a short or damage.
Function	Both the 'Sliver' and 'Short Sliver' categories report slivers between two solder mask clearances. A violation is reported if silver width is less than pp_sliver, and non-zero. v_dist2sliver_ratio and v_min_sliver_perim define slivers. See “Sliver and Short Sliver Categories (SM)” on page 140. v_slivers_check_diff_net used in 'Sliver' (Signal Layers Checks), is irrelevant here.
ERF Parameters	pp_sliver
ERF Variables	v_sliver_algorithm_mode v_dist2sliver_ratio v_min_sliver_perim v_max_net_size replace_crosshatch_by_surface v_min_sliver_len
Constraint	SM Feature Spacing
Related Category	SM Short Sliver (Sliver)

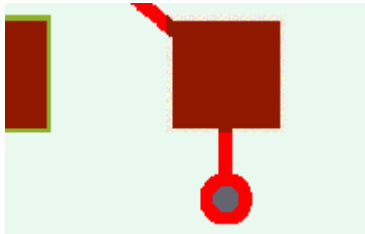
SM Short Sliver (Sliver)

Reports slivers between two solder mask clearances if silver width is less than pp_sliver, and non-zero.

Internal ERF Name	<Area>:short_sliver
Measurement Shape	Segment
Measurement ID	None
Layers Displayed	<ul style="list-style-type: none"> Solder mask layer
Graphic	
Purpose	Tiny solder mask slivers can detach during processing and cause a short or damage.
Function	<p>Both the 'Sliver' and 'Short Sliver' categories report slivers between two solder mask clearances. A violation is reported if silver width is less than pp_sliver, and non-zero. v_dist2sliver_ratio and v_min_sliver_perim define slivers. See "Sliver and Short Sliver Categories (SM)" on page 140 for a detailed explanation.</p> <p>v_slivers_check_diff_net used in 'Sliver' (Signal Layers Checks), is irrelevant here.</p>
ERF Parameters	pp_sliver
ERF Variables	v_sliver_algorithm_mode = 1 v_dist2sliver_ratio v_min_sliver_perim v_max_net_size replace_crosshatch_by_surface v_min_sliver_len
Constraint	SM Feature Spacing
Related Category	SM Sliver (Sliver)

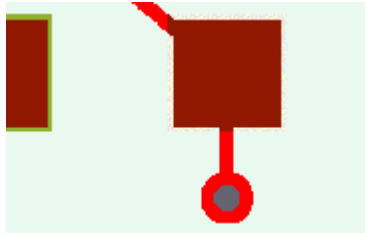
Missing SMD Clearance (Missing)

Reports SMD pads that neither include, nor are included, in any solder mask clearances.

Internal ERF Name	<Area>smd_miss
Measurement Shape	Square
Measurement ID	Pad
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Matching external copper layer
Graphic	
Function	Reports SMD pads that neither include, nor are included, in any solder mask clearances. At such locations the SMD pad is covered by solder mask. Measurements are squares or bounding boxes (representing SMD pads).
ERF Parameters	
ERF Variables	
Limitations	


Missing Undrilled Pad Clearance (Missing)

Reports undrilled pads that neither include, nor are included, in any solder mask clearances.

Internal ERF Name	<Area>:ndrl_miss
Measurement Shape	Square
Measurement ID	Pad
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Matching external copper layer
Graphic	
Function	<p>Reports undrilled pads that neither include, nor are included, in any solder mask clearances. At such locations, the undrilled pad is covered by solder mask. Measurements are squares or bounding boxes (representing undrilled pads).</p> <p>This category is also useful for checking the existence of solder paste for each SMD pad in the solder paste layer.</p>
ERF Parameters	
ERF Variables	
Limitations	


Missing NPTH Clearance (Missing)

Reports NPTHs that do not touch any solder mask clearances.

Internal ERF Name	<Area>npth_miss
Measurement Shape	Circle
Measurement ID	Pad
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Matching external copper layer
Graphic	
Function	Reports NPTHs that do not touch any solder mask clearances. At such locations, the NPTH is covered by solder mask. Measurements are circles representing NPTHs.
ERF Parameters	
ERF Variables	v_report_only_one_side_sm
Limitations	If an NPTH touches a solder mask clearance even at a single point, it is reported as zero annular ring rather than as a missing NPTH clearance.


Missing PTH Clearance (Missing)

Reports PTHs that do not touch any solder mask clearances.

Internal ERF Name	<Area>:pth_miss
Measurement Shape	Circle
Measurement ID	Pad
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Matching drill layer
Graphic	
Function	Reports PTHs that do not touch any solder mask clearances. At such locations, the PTH is covered by solder mask. Measurements are forms representing PTHs.
ERF Parameters	
ERF Variables	v_report_only_one_side_sm
Limitations	If a PTH touches a solder mask clearance even at a single point, it is reported as zero annular ring rather than as a missing PTH clearance.

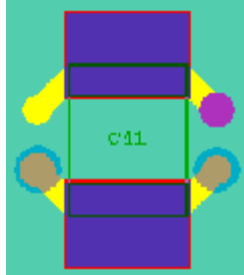
Missing Via Clearance (Missing)

Reports vias that do not touch any solder mask clearances.

Internal ERF Name	<Area>:via_miss
Measurement Shape	Circle
Measurement ID	Pad
Layers Displayed	<ul style="list-style-type: none"> • Solder mask layer • Matching drill layer
Graphic	
Function	<p>Reports vias that do not touch any solder mask clearances. At such locations, the via is covered by solder mask.</p> <p>This category is normally disabled through the default setting of ignore_miss_via to 1. The reasoning is that vias are supposed to be covered by solder mask. For cases where vias are supposed to be exposed, the check can be activated by setting ignore_miss_via = 0.</p>
ERF Parameters	
ERF Variables	v_report_only_one_side_sm ignore_miss_via = 0
Limitations	If a via touches a solder mask clearance even at a single point, it is reported as zero annular ring rather than as a missing via clearance.

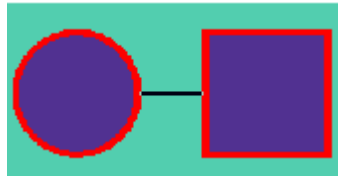
Missing Testpoint Clearance (Missing)

Reports testpoint pads that neither include, nor are included, in any solder mask clearance.

Internal ERF Name	<Area>:tp_miss
Measurement Shape	Pad (or its bounding box)
Measurement Value	Pad size
Measurement ID	
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Matching drill layer
Graphic	
Purpose	Testpoint pads require solder mask clearances so that the testing probe comes in contact with the copper pad.
Function	Reports testpoint pads that neither include, nor are included, in any solder mask clearance.
ERF Parameters	
ERF Variables	full_tp_exposure
Limitations	

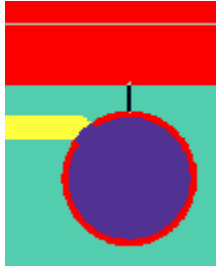
Pad to Pad Spacing (Spacing)

Reports distances between pads in solder mask layers closer than pp_spacing.

Internal ERF Name	<Area>:pad_to_pad
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none"> Solder mask layer
Graphic	
Function	Reports distances between pads in solder mask layers closer than pp_spacing.
ERF Parameters	pp_spacing
ERF Variables	
Constraint	SM Feature Spacing
Limitations	


Pad to Non-Pad Spacing (Spacing)

Reports distances between pads and non-pads in solder mask layers closer than pp_spacing.

Internal ERF Name	<Area>:pad_to_non
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer
Graphic	
Function	<p>Reports distances between pads and non-pads in solder mask layers closer than pp_spacing.</p> <p>In the figure above, the distance is between a pad opening over a signal layer pad and a line clearance over a rout.</p>
ERF Parameters	pp_spacing
ERF Variables	
Constraint	SM Feature Spacing
Limitations	

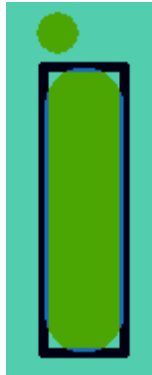
Non-Pad to Non-Pad (Spacing)

Reports distances between non-pad features in solder mask layers closer than pp_spacing.

Internal ERF Name	<Area>:non_to_non
Measurement Shape	Segment
Measurement ID	Two pads
Layers Displayed	<ul style="list-style-type: none"> Solder mask layer
Graphic	
Function	Reports distances between non-pad features in solder mask layers closer than pp_spacing.
ERF Parameters	pp_spacing
ERF Variables	
Constraint	SM Feature Spacing
Limitations	

Extra SM - Missing Copper (Extra)

Reports solder mask features which do not intersect with copper.

Internal ERF Name	<Area>:ext_sm_copper_miss
Measurement Shape	Solder mask pad
Measurement Value	Solder mask pad size
Measurement ID	
Layers Displayed	<ul style="list-style-type: none">• Solder mask layer• Signal layer
Graphic	
Purpose	Solder mask pads which do not intersect with copper may indicate faulty design.
Function	Reports solder mask features which do not intersect with copper.
ERF Parameters	
ERF Variables	
Limitations	

ERF Parameters for Solder Mask Checks

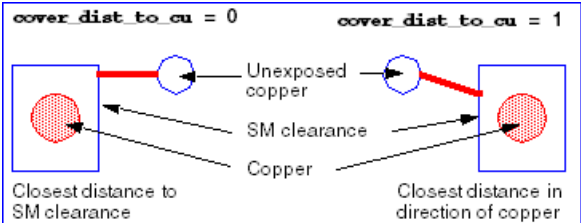
Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Layer	pp_layer	Defines layers to be affected by the action.	All categories
SM A.R.	pp_ar	Maximum distance from annular rings to solder mask.	PTH Annular Ring NPTH Annular Ring Via Annular Ring PTH Gasket Via Gasket SMD Annular Ring Pad Annular Ring PTH Pad Annular Ring NPTH Pad Annular Ring Via Pad Annular Ring SMD Pad Gasket PTH Pad Gasket NPTH Pad Gasket Via Pad Gasket Undrilled Pad Gasket
Spacing Min	pp_spacing	Defines search radius to use when looking for closely spaced features.	Pad to Pad Spacing Pad to Non-Pad Spacing Non-Pad to Non-Pad Spacing
SM Coverage	pp_coverage	Maximum distance between circuit features and solder mask.	Coverage
Sliver Min	pp_sliver	The minimum allowable sliver width. A sliver that is narrower than this value is reported.	SM Sliver SM Short Sliver

Screen Name	Parameter	Description	Categories Affected
Tests List	pp_tests	Defines the tests to be run. See “ Tests Performed in Solder Mask Checks ” on page 138.	All categories

ERF Variables for Solder Mask Checks

Variables set in the ERF file control the analysis.

ERF Variable	Description	Categories Affected
categorize_negative_ar	<p>Determines whether SM negative annular rings are reported.</p> <p>0 — Report SM negative annular rings (gaskets) as r0. (default)</p> <p>1 — Report measurement of SM negative annular rings.</p>	<p>SMD Annular Ring</p> <p>SMD Pad Gasket</p> <p>PTH Pad Gasket</p> <p>NPTH Pad Gasket</p> <p>Via Pad Gasket</p> <p>Undrilled Pad Gasket</p>
classify_pad_ar	<p>Determines whether SM pad annular ring measurements are classified according to type.</p> <p>0 — Report all SM pad annular ring measurements in 'Pad Annular Ring'. (default)</p> <p>1 — Report SM pad annular ring according to type. (PTH, NPTH, via, undrilled)</p> <p>2 — Maintains compatibility between earlier products and DFM Analysis by mapping to 1.</p> <p>See “DFM Analysis Compatibility for Solder Mask Checks” on page 140.</p>	<p>Pad Annular Ring</p> <p>PTH Pad Annular Ring</p> <p>NPTH Pad Annular Ring</p> <p>Via Pad Annular Ring</p>
cover_dist_to_cu	<p>Controls whether a measurement from non-exposed copper is the closest distance to the solder mask clearance or the closest distance to the SM clearance in the direction of the exposed copper within it:</p> <p>1 — Report distance from non-exposed copper to SM clearance in the direction of the exposed copper. (default)</p> <p>0 — Report closest distance from non-exposed copper to solder mask clearance.</p> 	<p>Coverage</p>

ERF Variable	Description	Categories Affected
cover_ignore_intersection	<p>Determines whether features intersecting SM clearances are reported.</p> <p>0 — Report features intersecting SM clearances. (default)</p> <p>1 — Do not report features intersecting SM clearances.</p> <p>If a copper feature is not entirely within an SM clearance, the system checks for a pad partly within and with its center inside. If found, it and its intersecting traces are ignored.</p>	Coverage
cover_ignore_same_net	<p>Determines whether copper features of the same net within the SM clearance are ignored.</p> <p>0 — Report copper features of the same net. (default)</p> <p>1 — Ignore copper features of the same net.</p> <p>See “DFM Analysis Compatibility for Solder Mask Checks” on page 140.</p>	Coverage
cover_special_check	<p>Determines whether a special check of nets intersecting with a SM clearance twice are checked in the ‘Coverage’ category.</p> <p>0 — If a signal net has a pad covered completely by SM clearance, ignore intersections between its features and the clearance. (default)</p> <p>1 — Check for more than one intersection in solder mask clearance where the first is legal (a signal trace connected directly to the covered pad) and report all others as a violation.</p> <p>Note: A check requires considerable processing time.</p>	Coverage
full_tp_exposure	<p>Determines which types of testpoints should be considered exposed by solder mask clearance.</p> <p>0 — Does not report testpoint pads that are included or include a solder mask clearance. (default)</p> <p>1 — Does not report testpoint pads that are fully included in a solder mask clearance.</p>	Missing Testpoint Clearance

ERF Variable	Description	Categories Affected
ignore_miss_via	Determines whether missing vias are reported. 1 — Do not report missing vias. (default) 0 — Report missing vias.	Missing Via Clearance
replace_crosshatch_by_surface	yes — Do not report slivers found on hatched area. (default) (Gerber) no — Report slivers found on hatched area. by attr — Do not report slivers found on features with a hatch attribute. (EDA)	SM Sliver SM Short Sliver
v_dist2sliver_ratio	Minimal ratio for the distance between measurement segment endpoints along the net and the width of the sliver. See “ DFM Analysis Compatibility for Solder Mask Checks ” on page 140.	SM Sliver SM Short Sliver
v_max_net_size	Nets with more than v_max_net_size features are ignored. See “ DFM Analysis Compatibility for Solder Mask Checks ” on page 140.	SM Sliver SM Short Sliver
v_min_sliver_len	Slivers shorter than this value are reported as ‘Short Sliver’. All others are reported in ‘Sliver’. Maximum possible value is 100 mils. See “ DFM Analysis Compatibility for Solder Mask Checks ” on page 140.	SM Sliver SM Short Sliver
v_min_sliver_perim	Defines the minimal distance between the measurement segment endpoints along the net. (For a description of perimeter, see “ SM Short Sliver (Sliver) ” on page 164).	SM Sliver SM Short Sliver
v_report_only_one_side_sm	Determines how drills that do not touch a solder mask clearance are reported. no — Report all locations that do not touch any solder mask clearances. (default) yes — Report only those locations that do not touch solder mask clearances on one side only.	Missing NPTH Clearance Missing PTH Clearance Missing Via Clearance

ERF Variable	Description	Categories Affected
v_report_proximity	<p>Defines the size of area for reporting solder mask coverage violations. Only one violation between a clearance and signal layer net is reported. (Default=20 mil; minimum value=5mil. If a value less than the minimum is entered, 5 mil is used.)</p> <p>Example: If v_report_proximity = 10, from all the 'same net' violations within a square of 10x10, only one is reported.</p>	Coverage
v_sliver_algorithm_mode	<p>Defines which of two algorithms is used to determine sliver violations.</p> <p>0 — Use original algorithm where results are reported to the 'Sliver' category. (slow)</p> <p>1 — Use improved algorithm where results are reported to either the 'Sliver' or 'Short Sliver' category. (fast) (default)</p> <p>2 — Results are the same as with 1, but the process is slower. (Remains in the system to insure backward compatibility.)</p>	<p>SM Sliver</p> <p>SM Short Sliver</p>

Chapter 6

Fabrication Analysis - Silk Screen Checks

The Silk Screen Checks action is a read-only action intended to find potential manufacturing defects in silk screen layers, and generate statistics.

The check operates only on silk screen layers because it relies on the job matrix to find the related external copper, solder mask and drill layers against which to check. It uses the associated solder mask, external copper and drill layers to test against.

For an explanation of how to run this analysis, see [“Performing DFM Analysis”](#) on page 21.

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Tests Performed in Silk Screen Checks

Several silk screen checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

SM Clearance — reports close distances between silk screen features and solder mask clearances.

SMD Clearance — reports close distances between silk screen features and SMD pads.

Pad Clearance — reports close distances between silk screen features and pads.

Hole Clearance — reports close distances between silk screen features and drills.

Line Width — reports line width violations and length to width ratio violations.

String Properties — reports the height, width and rotation of text on the silk screen.

Attributes Used in Silk Screen Checks

Attributes assigned to features in the product model control the analysis.

Feature Attributes

Table 6-1. Silk Screen Checks Feature Attributes

Name	Description
Copper Feature Ignore	Copper features bearing this attribute are ignored in analysis actions. (Presently implemented only for Rout Test.)
Drill Type	This attribute is attached to hole features in drill layers. It defines the type of drill and is used extensively during fabrication analysis.
SMD Pad	This attribute should be attached to outer layer pads which are lands for SMD components. It is set by the 'Set SMD Attribute' Cleanup Action.
Copper Balancing	This attribute is attached to features which are added during a pattern fill operation, either manually or through the Copper Balance DFM action.
String Angle	For text features, the value of this attribute is the original (in the input file) rotation angle of the text string of which this feature is a part. This attribute is assigned to translated jobs of formats: Cadence Allegro BRD or APD, Mentor Graphics Board Station, Mentor Graphics PADS.
Copper Text	This attribute defines a feature as a nomenclature legend. It affects the fabrication analysis by directing spacing checks between such features into a new category (Text to Text).

Grouping of Silk Screen Results

Silk screen features are composed of a number of other features (lines and arcs). Measurements, by default, are reported for each and every one of the features within the distance specified by ERF parameter pp_spacing. This can result in many unnecessary measurements, depending upon what an operator is checking. The ERF variable v_results_grouping allows grouping silk

screen features. Only one measurement from each close string (dependent upon attribute String Value) or from the closest string only can be reported. The differences are illustrated below:



v_results_grouping=0
All measurements are reported from each segment of a silk screen feature closer than **pp_spacing**.



v_results_grouping=1
One measurement is reported from each silk screen string closer than **pp_spacing**.



v_results_grouping=2
Only the closest silk screen feature, closer than **pp_spacing**, is reported.
Note: If the non-silk screen feature (smd, sm, drill, etc.) is larger than 200 mil, mode 1 is used.

Limitations in Silk Screen Checks

Silk Screen Analysis, run on a single-sided board, with silk screening on the bottom bare laminate, will exit without checking.

Categories in Silk Screen Checks

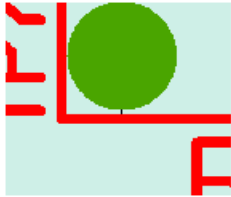
Several silk screen checks analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Table 6-2. Result Categories for Silk Screen Checks

Category	Description
SM Clearance (SM Clearance)	Reports distances less than pp_spacing between silk screen features and solder mask clearances.
SMD Clearance (SMD Clearance)	Reports distances less than pp_spacing between silk screen features and SMD pads.
PTH Pads Clearance (Pad Clearance)	Reports distances less than pp_spacing between silk screen features and PTH pads.
Via Pads Clearance (Pad Clearance)	Reports distances less than pp_spacing between silk screen features and PTH pads.
NPTH Pads Clearance (Pad Clearance)	Reports distances less than pp_spacing between silk screen features and NPTH pads.
Undrilled Pads Clearance (Pad Clearance)	Reports distances less than pp_spacing between silk screen features and undrilled pads (possibly fiducials or testpoints).
NPTH Clearance (Hole Clearance)	Reports distances less than pp_spacing between NPTHs and silk screen features.
PTH Clearance (Hole Clearance)	Reports distances less than pp_spacing between PTHs and silk screen features.
Via Clearance (Hole Clearance)	Reports distances less than pp_spacing between vias and silk screen features.
Line Widths (Line Width)	Reports width of lines in silk screen layers.
String Line Width (String Properties)	Reports the width and length of string lines in the silk screen layers.


SM Clearance (SM Clearance)

Reports distances less than pp_spacing between silk screen features and solder mask clearances.

Internal ERF Name	<Area>:ss2sm
Measurement Shape	Segment
Measurement ID	Any SM feature
Layers Displayed	Silk screen layer Solder mask layer of the same side (top or bottom)
Graphic	 <p>With <code>v_report_include_sm_as_zero=0</code> only incidences of too close or intersecting features are reported.</p>
Purpose	Silk screen should only be printed on masked areas and not inside clearance areas. Due to the inaccuracy of the silk screen process, a certain safety distance should be retained.
Function	Reports distances less than pp_spacing between silk screen features and solder mask clearances.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_report_include_sm_as_zero v_results_grouping v_report_only_string_feature
Limitations	

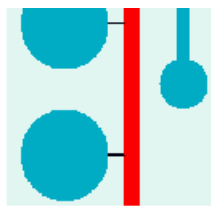
SMD Clearance (SMD Clearance)

Reports distances less than pp_spacing between silk screen features and SMD pads.

Internal ERF Name	<Area>:ss2pad_smd
Measurement Shape	Segment
Measurement ID	Silk screen feature; SMD pad of the matching external layer
Layers Displayed	Silk screen layer Matching external copper layer
Graphic	
Purpose	Silk screen should never be applied on pads since this adversely affects the soldering process.
Function	Reports distances less than pp_spacing between silk screen features and SMD pads. If an SMD pad is reported here, it is not reported in 'Undrilled Pads Clearance'.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_report_only_string_feature
Constraint	SMD Spacing
Limitations	

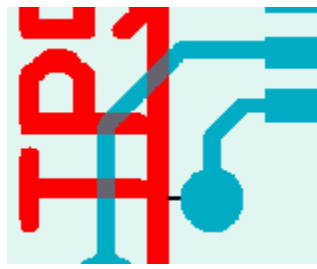
PTH Pads Clearance (Pad Clearance)

Reports distances less than pp_spacing between silk screen features and PTH pads.

Internal ERF Name	<Area>:ss2pad_pth
Measurement Shape	Segment
Measurement ID	Silk screen feature; Pad
Layers Displayed	Silk screen layer Matching external copper layer
Graphic	
Purpose	Silk screen should never be applied on pads since this adversely affects the soldering process.
Function	Reports distances less than pp_spacing between silk screen features and PTH pads.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	PTH Spacing
Limitations	

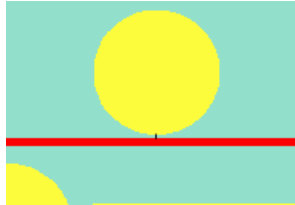
Via Pads Clearance (Pad Clearance)

Reports distances less than pp_spacing between silk screen features and PTH pads.

Internal ERF Name	<Area>:ss2pad_via
Measurement Shape	Segment
Measurement ID	Silk screen feature; Pad
Layers Displayed	Silk screen layer Matching external copper layer
Graphic	
Purpose	Silk screen should never be applied on pads since this adversely affects the soldering process.
Function	Reports distances less than pp_spacing between silk screen features and via pads.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	Via Spacing
Limitations	

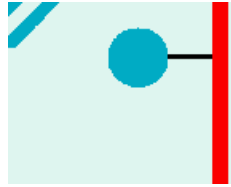
NPTH Pads Clearance (Pad Clearance)

Reports distances less than pp_spacing between silk screen features and NPTH pads.

Internal ERF Name	<Area>:ss2pad_npth
Measurement Shape	Segment
Measurement ID	Silk screen feature; Pad
Layers Displayed	Silk screen layer Matching external copper layer
Graphic	
Purpose	Silk screen should never be applied on pads since this adversely affects the soldering process.
Function	Reports distances less than pp_spacing between silk screen features and NPTH pads.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	NPTH Spacing
Limitations	

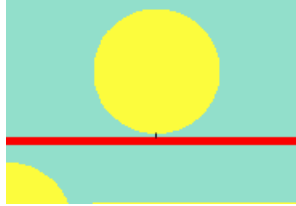
Undrilled Pads Clearance (Pad Clearance)

Reports distances less than pp_spacing between silk screen features and undrilled pads (possibly fiducials or testpoints).

Internal ERF Name	<Area>:ss2pad_undrl
Measurement Shape	Segment
Measurement ID	Silk screen feature; Pad
Layers Displayed	Silk screen layer Matching external copper layer
Graphic	
Function	Reports distances less than pp_spacing between silk screen features and undrilled pads (possibly fiducials or testpoints). Note: If an SMD pad is reported in 'SMD Clearance', it is not reported here.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	SMD Spacing
Limitations	

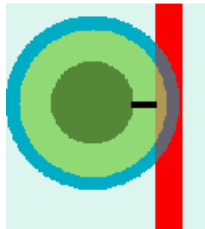
NPTH Clearance (Hole Clearance)

Reports distances less than pp_spacing between NPTHs and silk screen features.

Internal ERF Name	<Area>:ss2npth
Measurement Shape	Segment
Measurement ID	Silk screen feature; Pad
Layers Displayed	Silk screen layer Matching drill layer Solder Mask layer
Graphic	
Purpose	Silk screen should never be applied on holes since it will be unreadable and adversely affects the assembly process.
Function	Reports distances less than pp_spacing between NPTHs and silk screen features.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	NPTH Spacing
Limitations	

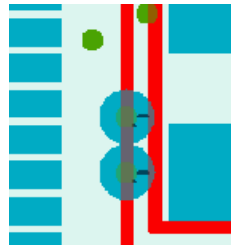
PTH Clearance (Hole Clearance)

Reports distances less than pp_spacing between PTHs and silk screen features.

Internal ERF Name	<Area>:ss2pth
Measurement Shape	Segment
Measurement ID	Silk screen feature; Drill
Layers Displayed	Silk screen layer Matching drill layer Solder Mask layer
Graphic	
Purpose	Silk screen should never be applied on holes since it will be unreadable and adversely affects the assembly process.
Function	Reports distances less than pp_spacing between PTHs and silk screen features.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	PTH Spacing
Limitations	

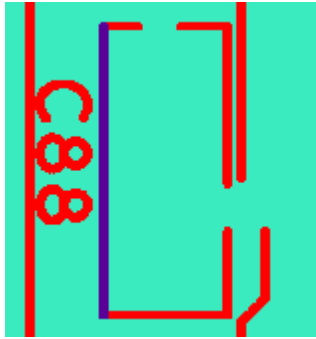
Via Clearance (Hole Clearance)

Reports distances less than pp_spacing between vias and silk screen features.

Internal ERF Name	<Area>:ss2via
Measurement Shape	Segment
Measurement ID	Silk screen feature; Drill
Layers Displayed	Silk screen layer Matching drill layer Solder mask layer
Graphic	
Purpose	Silk screen should never be applied on holes since it will be unreadable and adversely affects the assembly process.
Function	Reports distances less than pp_spacing between vias and silk screen features.
ERF Parameters	pp_layer pp_spacing
ERF Variables	v_results_grouping v_hole_clearance_consider_sm v_report_only_string_feature
Constraint	Via Spacing
Limitations	


Line Widths (Line Width)

Reports width of lines in silk screen layers.

Internal ERF Name	<Area>:ss_line
Measurement Shape	Line
Measurement ID	Silk screen feature
Layers Displayed	Silk screen layer
Graphic	
Purpose	To report line widths matching specifications.
Function	Reports width of lines in silk screen layers. If a line is drawn (represented by two touching lines running along each other), the compound width of the drawn line is reported. Lines with the attributes Copper Balancing and Copper Text are not reported.
ERF Parameters	pp_layer pp_spacing
ERF Variables	min_line_len max_line_width len2width_ratio v_one_width_report_per_letter
Constraint	Line Width
Limitations	

String Line Width (String Properties)

Reports the width and length of string lines in the silk screen layers.

Internal ERF Name	<Area>:str_line_width
Measurement Shape	Line
Measurement Value	Line width; Line length
Measurement ID	Silk screen feature; String value
Layers Displayed	Silk screen layer
Graphic	
Purpose	The information given by the silk screen text is used for assembling the board. If this information is not clear, it could cause mistakes.
Function	Reports the width and length of string lines in the silk screen layers. Lines with attribute Copper Balancing or lacking attribute String Value or Copper Text are not reported.
ERF Parameters	pp_layer
ERF Variables	
Constraint	Line Width
Limitations	

ERF Parameters for Silk Screen Checks

Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Layer	pp_layer	Defines layer to be affected by the action.	All categories
Spacing	pp_spacing	Defines search radius to use when looking for closely spaced features.	All categories
Test List	pp_tests	Defines the tests to be run. See “ Tests Performed in Silk Screen Checks ” on page 181.	All categories

ERF Variables for Silk Screen Checks

Variables set in the ERF file control the analysis.

ERF Variable	Description	Categories Affected
len2width_ratio	Minimum ratio of length to width for the 'Line Widths' category.	Line Widths
max_line_width	Maximum line width of lines in the 'Line Widths' category	Line Widths
min_line_len	Minimum line length of lines in the 'Line Widths' category, also minimum overlap between lines to report in parallel spacing	Line Widths
v_hole_clearance_consider_sm	Determines whether to report only drills within SM clearances too close to silk screen features or all drills, even those without SM clearances. yes — Report spacing violations only if SM clearance is present. (default) no — Report all spacing violations.	PTH Pad Clearance Via Pad Clearance NPTH Pad Clearance Undrilled Pad Clearance NPTH Clearance PTH Clearance Via Clearance
v_one_width_report_per_letter	Determines how line width of silk screen features is reported. no — Report line width for each individual feature yes — Report the line width of one feature of a group of connected features (as in a letter or number)	Line Widths
v_report_include_s_m_as_zero	Determines whether to report silk screen features completely covered or included in solder mask features. 0 — (default) Do not report silk screen features completely covered or included in solder mask features. 1 — Report such features as a segment of zero length.	SM Clearance

ERF Variable	Description	Categories Affected
v_report_only_string_feature	<p>Determines which silk screen features are reported.</p> <p>no — Reports all silk screen features. (default)</p> <p>yes — Reports only silk screen features with the attribute String Value.</p>	<p>SM Clearance</p> <p>SMD Clearance</p> <p>All Pad Clearance categories</p> <p>All Hole Clearance categories</p>
v_results_grouping	<p>Determines how silk screen results are reported.</p> <p>0 — (default) no grouping of silk screen results is performed and each measurement between a silk screen feature and another feature is reported individually.</p> <p>1 — Silk screen results are grouped according to the same String Value attribute, and only one measurement is reported between the grouped features and other features.</p> <p>2 — Silk screen results are grouped and the measurement between the group and another feature is the shortest measurement possible.</p> <p>If the non-silk screen feature (smd, sm, drill, etc.) is larger than 200 mil, mode 1 is used.</p> <p>See “Grouping of Silk Screen Results” on page 182 for an illustration.</p>	<p>SM Clearance</p> <p>SMD Clearance</p> <p>All Pad Clearance categories</p> <p>All Hole Clearance categories</p>

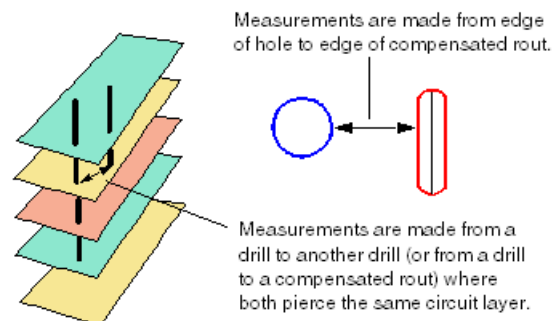
Chapter 7

Fabrication Analysis - Board-Drill Checks

Board-Drill is a read-only action intended to find potential manufacturability defects in drill and compensated rout layers. It generates measurements between drills and compensated rout paths piercing the same circuit layer. Measurements are taken between drills, from drills to rout features, but not between rout features. The Board-Drill action extends the functions available in the Drill Checks action.

The system uses a dynamic algorithm that adapts to user-selection and provides maximum performance. It assumes that all features on a rout layer are rout features, even though some features may have non-rout attributes. However, with drill layers, measurements are performed in accordance with assigned feature attributes.

The rout paths used in this section are compensated. Measurements are made from edge of hole to edge of compensated rout feature. Measurements are made between drills and routs that pierce the same circuit layer.



This section provides a description of each of the pairs of feature measurements in the Board-Drill-Check action screen. The sequence of the listing starts with Row #1 and ends in Row #3, with the measurement made between a feature selected in the left-hand column (First El.) and a feature in the right-hand column (Second Element).

When measurements are made between drill features, they can be made between features on the same layer (when Single is activated) or on different layers (when Cross is activated). When measurements are made between drill features and rout features they are, of necessity, made on different layers (drill and rout).

In all categories, the maximum distance reported is the highest value in the green range of the relevant category. If, for example, red = 4, yellow = 8, and green = 12, the maximum in this range is 12. This means that vias that are further apart than 12 mils will not be reported.

For an explanation of how to run this analysis, see [“Performing DFM Analysis”](#) on page 21.

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Attributes Used in Board-Drill Checks

Attributes assigned to features in the product model control the analysis.

Feature Attributes

Table 7-1. Board-Drill Checks Feature Attributes

Name	Description
Drill Type	This attribute is attached to hole features in drill layers. It defines the type of drill and is used extensively during fabrication analysis.

Categories in Board-Drill Checks

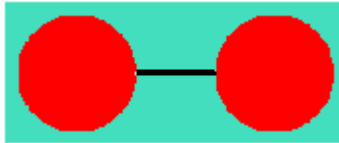
Several board drill checks analysis tests are run. For each test performed, results might be reported to the result categories available for that test.

Table 7-2. Result Categories for Board Drill Checks

Category	Description
Via to Via	Reports distances between the edges of two vias.
Via to PTH	Reports distances between the edges of vias and PTHs.
Via to NPTH	Reports distances between the edges of vias and NPTHs.
Via to Rout	Reports distances between the edges of vias and compensated rout features.
PTH to PTH	Reports distances between the edges of PTHs.
PTH to NPTH	Reports distances between the edges of PTHs and NPTHs.
PTH to Rout	Reports distances between the edges of PTHs and compensated rout features.
NPTH to NPTH	Reports distances between the edges of NPTHs
NPTH to Rout	Reports distances between the edges of NPTHs and compensated rout features.


Via to Via

Reports distances between the edges of two vias.

Analysis Category	<Area>:VIA2VIA
Measurement Shape	Distance between vias
Measurement ID	Pads (representing a via)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of two vias, if less than the upper limit of the VIA2VIA green severity range.
ERF Parameters	pp_1_element = Via pp_2_element = Via
Limitations	


Via to PTH

Reports distances between the edges of vias and PTHs.

Analysis Category	<Area>:VIA2PTH
Measurement Shape	Distance between via and PTH
Measurement ID	Pads (representing a via and PTH)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of vias and PTHs, if less than the upper limit of the VIA2PTH green severity range.
ERF Parameters	pp_1_element = Via pp_2_element = PTH
Limitations	

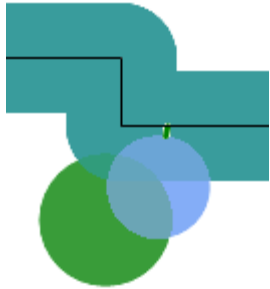
Via to NPTH

Reports distances between the edges of vias and NPTHs.

Analysis Category	<Area>:VIA2NPTH
Measurement Shape	Distance between via and NPTH
Measurement ID	Pads (representing a via and NPTH)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of vias and NPTHs, if less than the upper limit of the VIA2NPTH green severity range.
ERF Parameters	pp_1_element = Via pp_2_element = NPTH
ERF Variables	
Limitations	

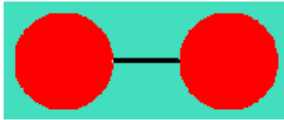
Via to Rout

Reports distances between the edges of vias and compensated rout features.

Analysis Category	<Area>:VIA2ROUT
Measurement Shape	Distance between via and rout
Measurement ID	Pads (representing a via and compensated rout feature)
Layers Displayed	The drill and rout layers on which the elements are located
Graphic	
Function	Reports distances between the edges of vias and compensated rout features, if less than the upper limit of the VIA2ROUT green severity range.
ERF Parameters	pp_1_element = Via pp_2_element = Rout
Limitations	

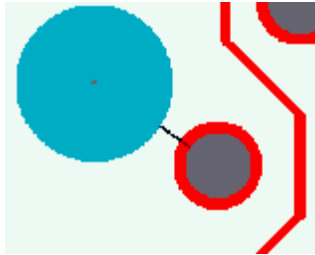
PTH to PTH

Reports distances between the edges of PTHs.

Analysis Category	<Area>:PTH2PTH
Measurement Shape	Distance from PTH to PTH
Measurement ID	Pad (representing a PTH)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of PTHs, if less than the upper limit of the PTH2PTH green severity range.
ERF Parameters	pp_3_element = PTH pp_4_element = PTH
Limitations	

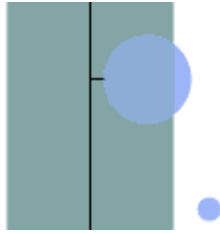
PTH to NPTH

Reports distances between the edges of PTHs and NPTHs.

Analysis Category	<Area>:PTH2NPTH
Measurement Shape	Distance from PTH to NPTH
Measurement ID	Pads (representing a PTH and an NPTH)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of PTHs and NPTHs, if less than the upper limit of the PTH2NPTH green severity range.
ERF Parameters	pp_3_element = PTH pp_4_element = NPTH
Limitations	

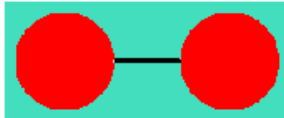
PTH to Rout

Reports distances between the edges of PTHs and compensated rout features.

Analysis Category	<Area>:PTH2ROUT
Measurement Shape	Distance from PTH to rout
Measurement ID	Pads (representing an NPTH and a compensated rout feature)
Layers Displayed	The drill and rout layers on which the elements are located
Graphic	
Function	Reports distances between the edges of PTHs and compensated rout features, if less than the upper limit of the PTH2ROUT green severity range.
ERF Parameters	pp_3_element = PTH pp_4_element = Rout
ERF Variables	
Limitations	

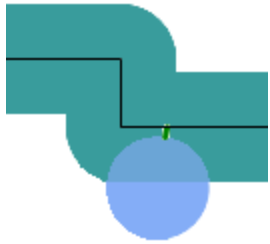
NPTH to NPTH

Reports distances between the edges of NPTHs

Analysis Category	<Area>:NPTH2NPTH
Measurement Shape	Distance between NPTHs
Measurement ID	Pad (representing an NPTH)
Layers Displayed	The drill layers on which the elements are located
Graphic	
Function	Reports distances between the edges of NPTHs, if less than the upper limit of the NPTH2NPTH green severity range.
ERF Parameters	pp_5_element = NPTH pp_6_element = NPTH
ERF Variables	
Limitations	

NPTH to Rout

Reports distances between the edges of NPTHs and compensated rout features.

Analysis Category	<Area>:NPTH2ROUT
Measurement Shape	Distance between NPTH and rout
Measurement ID	Pads (representing an NPTH and a rout feature)
Layers Displayed	The drill and rout layers on which the elements are located.
Graphic	
Function	Reports distances between the edges of NPTHs and compensated rout features, if less than the upper limit of the NPTH2ROUT green severity range.
ERF Parameters	pp_5_element = NPTH pp_6_element = Rout
ERF Variables	
Limitations	

ERF Parameters for Silk Screen Checks

Parameters set in the ERF file control the analysis.

Screen Name	Parameter	Description	Categories Affected
Operation Modes	pp_operation_modes	Single — Filters report by drills of same layer only. Cross — Filters report by drills of different layers only. (Both can be set.)	All categories
Check	pp_layers_all	Board — The options selected in Operation Modes (Single or Cross or both) are applied to the entire board. Affected — The options selected in Operation Modes (Single or Cross or both) are applied to the layers of pp_input_layers only.	All categories
Layer	pp_input_layer	The layer on which to run the check. Ignored when pp_layer_all=Board.	All categories
First El Type: Via	pp_1_element	Controls whether a measurement is made from a via. (yes or no)	Via to Via Via to PTH Via to NPTH Via to Rout
First El Type: PTH	pp_3_element	Controls whether a measurement is made from a plated thru-hole. (yes or no)	PTH to PTH PTH to NPTH PTH to Rout
First El Type: NPTH	pp_5_element	Controls whether a measurement is made from a non-plated thru-hole. (yes or no)	NPTH to NPTH NPTH to Rout NPTH to Rout_%

Screen Name	Parameter	Description	Categories Affected
Second Element Type (for First-El.-Type = Via)	pp_2_element	If pp_1_element is selected, one or more entities to which to measure from a via: <ul style="list-style-type: none"> • Via • PTH • NPTH • Rout 	Via to Via Via to PTH Via to NPTH Via to Rout
Second Element Type (for First-El.-Type = PTH)	pp_4_element	If pp_3_element is selected, one or more entities to which to measure from a plated thru-hole: <ul style="list-style-type: none"> • PTH • NPTH • Rout 	PTH to PTH PTH to NPTH PTH to Rout
Second Element Type (for First-El.-Type = NPTH)	pp_6_element	If pp_5_element is selected, one or more entities to which to measure from a non-plated thru-hole: <ul style="list-style-type: none"> • NPTH • Rout • Rout_% 	NPTH to NPTH NPTH to Rout NPTH to Rout_%

ERF Variables for Silk Screen Checks

There are no variables set in the ERF files for this analysis.

Chapter 8

Assembly Analysis - Component Analysis

The Component Analysis is a read-only action intended to check component placement relative to other components or to drill and rout features. It operates on the top or bottom layers, and refers to the corresponding component layer.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Component Analysis

Several component analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Summary — Reports the pitch, height and rotation of all components on the board.

Attributes Used in Component Analysis

Attributes assigned to components in the product model control the analysis.

Component Attributes

Table 8-1. Component Analysis Component Attributes

Name	Description
Ignore Graphically/Output	Components with this attribute are ignored in analyses.

Component Outline

In measuring distances between features and components, the component outline can be defined in several ways: as component body (ignoring pins), as component body and pins, or as component body and the external toeprints in a corresponding outer layer (the copper layer on the components side).

In fiducial analysis, component analysis, and testpoint analysis, where spacing to components is measured, ERF parameter Component Outline (pp_comp_outline) defines the component outline as either Body, Envelope or T-envelope.

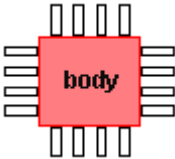
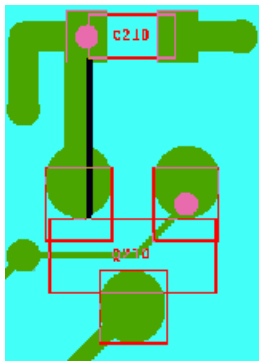
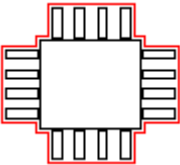
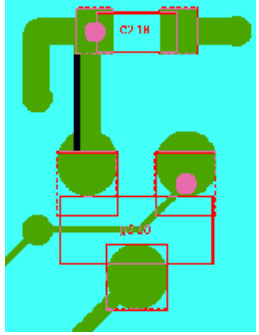
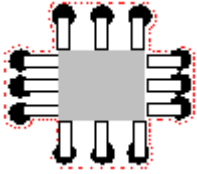
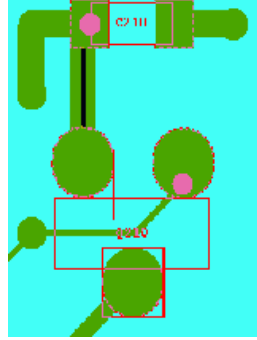
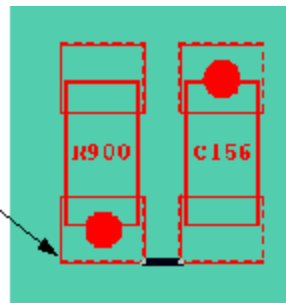
Diagram	Component Outline	Explanation	c2c Measurement Example
	Body	Measures the distance between a feature and component body (regardless of pins or toeprints).	
	Envelope	Measures the distance between a feature and an “envelope” (a shrink-fit polygon) surrounding the component and its pins. (Default)	

Diagram	Component Outline	Explanation	c2c Measurement Example
	T-Envelope	Measures the distance between a feature and an envelope surrounding the component and its toeprints in an outer layer.	

By choosing either Envelope or T-envelope in the Controls dialog box, a dotted line will appear around the external pins or toeprints of a component, making envelope measurement more obvious. This is the recommended method for viewing spacing measurements in envelope and T-envelope mode.

c2c Measurement

Component Outline set to Envelope in the Controls popup causes a dotted line to appear around the pin in the figure at the right.



Configuration parameter `edt_t_envelope_mode` can be used to control the T-envelope when the solder mask is smaller than the pad.

Dynamic Categories

Some categories are divided into multiple classifications according to the process area in which the measurement is applied, or the type of component involved in the measurement, or the component side used in the measurement.

For example, the Comp. Spacing category (c2c) appears as several sub-classifications:

smt:c2c;soic_sot_nn — This category includes measurements that are in the SMT process area, between the narrow side of soic components (the first ‘n’) and the narrow side of sot components (the second ‘n’).

fs_smt:c2c;tsop_tsop_wn — This category includes measurements that are in the overlap area between FS and SMT process areas (or that start in one and end in the other), between the wide side of a tsop component and the narrow side of another tsop component.

In the documentation, this sort of classification is indicated by entries such as this:

Full internal name: <Area>c2c;<PkgTypeA>_<PkgTypeB>_<CompSide><CompSide>

- <Area> — The process area name.
- <PkgType> — The types of components involved. See “[Classification by Component Type](#)” on page 220.
- <CompSide><CompSide> — The sides of the components that the measurement touches: w or n. If only one component is involved, there will be only one <CompSide> (if, for example, the other feature measured is a rout feature, where specifying its narrow or wide side is irrelevant). See “[Classification by Component Side](#)” on page 222.

A single wildcard asterisk (*) can be used alone in ERF models to represent the <Area>, the <PkgType>, or the <CompSide><CompSide> fields, to indicate that all measurements are to be classified by this entry. A wildcard character along with other characters to form a string is not allowed.

- This usage of wildcards is legal: *:c2c;tsop_tsop_*
It indicates component spacing in all process areas, between two tsop components regardless of the side involved.
- This usage of wildcards is NOT legal: *:c2c;*conn_tsop_*
This is not allowed because the string *conn is an illegal use of the single wildcard character rule.

Ranges can use exact name specification or wildcards. The wildcard character asterisk (*) is used to indicate all measurements in areas of not otherwise defined ranges.

- **SMT:c2c;1210_soj_nn=50, 50, 50.1** — This category reports measurements in the SMT area, between the narrow side of one component and the narrow side of the other.
- ***:c2c;1210_*_nn=50, 50, 50.1** — This category reports measurements in all process areas, between two components, regardless of the side involved.

Ranges with two entity types must be ordered alphabetically.

- **Correct** — *:c2c;axial_sot_*
- **Incorrect** — *:c2c;sot_axial_*

Range order in the ERF affects the order of matching.

- This order yields exact results, because results of process area SMT between 1210 and soj are reported to the first category, and the second category reports results that do not fall into the first category, but are measured between the narrow sides of 1210 and any other type of component.

```
SMT:c2c;1210_soj_nn=50,50,50.1
*:c2c;1210_*_nn=100,100,100.1
```

- This order results in no results being reported to the second category, because the more general category will already have reported those results.

```
*:c2c;1210_*_nn=100,100,100.1
SMT:c2c;1210_soj_nn=50,50,50.1
```

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Classification by Process Area

A process area indicates the manufacturing process used for assembly of components in a particular area. Process areas can be created for every component of a specific type or mount type, or having a specific attribute, or found within a specific area of a DFx layer.

The process area name is derived from a special layer, whose name is found in the ERF variable process_map_layer_top or process_map_layer_bot. This layer includes the shapes of process areas, with the attribute DFx Area Name containing the name.

Sometimes an area name is composed of a number of process area names. If the combination is longer than allowed by a specific action—typically 64 characters—the combination is replaced by the system-defined name multiple_areas. If the ERF model does not contain a range for a

dynamic category like this, all results are reported in blue severity. To see the results, set configuration parameter `chk_ignore_blue_sev = no`.

Classification by Component Type

There are two built-in component classification attributes: Type 2 and Type 1. Alternatively, you can create a user attribute named `comp_type` to contain the component classification, or you can use any other attribute and point to this attribute in the ERF variable `v_sub_cat_default`.

An algorithm is followed to decide which attribute contains the component type:

- **v_sub_cat_default** — This ERF variable can be assigned strings that are identical to any component attribute name. It is used in all Assembly Analysis actions. If left empty (default), the system searches for the user attribute `_comp_type`.
- **_comp_type** — If this user attribute is not defined, the system searches for at least one component in the product model with attribute Type 2.
- **Type 2** — If found for at least one component in the product model, attribute Type 1 is ignored. If not found, the system searches for Type 1.
- **Type 1** — Used if found in product models where no component has attribute Type 2 or where `v_sub_cat_default` is set to Type 1.

The system checks `_comp_type` first. If not defined, the selected component is checked against Type 2. If not found, it is checked against Type 1.

Example of User-Defined Component Type Classification

You can use the ERF variable `v_sub_cat_default` to specify a component type classification for each analysis.

This example illustrates how to run these analyses:

- Run Component analysis by Type 1
- Run Padstack analysis by Mount Type
- Run Testpoint analysis by `_height_class` (a user attribute)

The ERFs are as in the examples:

ERF Model	Example
Component ERF model	v_sub_cat_default = Type 1 ... SMT:c2c;bga_qfp_nn = 50 60 100 ...
Padstack ERF model	v_sub_cat_default = Mount Type ... SMT:toep2toep;smt_smt_nn = 30 40 100 ...
Testpoint ERF model	v_sub_cat_default = _height_class ... FS:tp2toep;H1_H2_nn = 60 70 100 ...

Classifying Results by a User Defined Component Attribute

Any component measurement can be customized by substituting a user defined component attribute for the category default. The results will be classified in dynamic categories in accordance with the user attribute.

For example, you can report different distances for testpoint to component measurements, depending on component height:

- Components of low height must be distance D1 from the testpoint.
- Components of medium height must be distance D2 from the testpoint.
- Components of tall height must be distance D3 from the testpoint.

Procedure

1. In the user attribute file, define an attribute that will be assigned to each component.

For example, define a user attribute `_comp_height` with possible values of low, medium and tall, by adding these lines:

```
OPTION {
  NAME = _comp_height
  ENTITY = COMPONENT
  OPTIONS = low;medium;tall
}
```

2. Set the ERF variable `v_sub_cat_default` to point to the user attribute, in *testpoint.erf*.

For example, set `v_sub_cat_default = _comp_height`.

3. Set the ranges for the dynamic categories, in the ERF model:

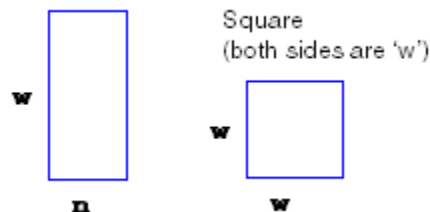
For example, set these ranges:

```
*:tp2comp;low_*=D3, <value>, <value>
*:tp2comp;medium_*=D2, <value>, <value>
*:tp2comp:tall_*=D1, <value>, <value>
*:tp2comp;*_*=<value>, <value>, <value>
```

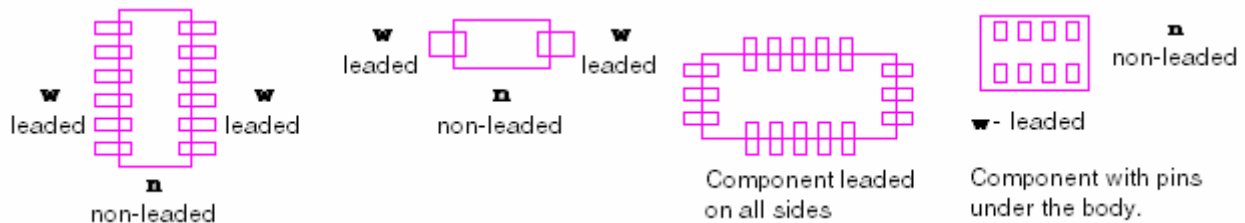
Classification by Component Side

Depending on the value of ERF variable `v_classify_by_leaded_side`, results can be classified either by whether the side of the component involved in the measurement is narrow or wide, or by whether the side has leads.

If `v_classify_by_leaded_sides = 0`, a side classification of `n` or `w` indicates whether the side of the component involved in the measurement is the narrow side (`n`) or the wide side (`w`).



If `v_classify_by_leaded_sides = 1`, a side classification of `n` or `w` indicates whether the side of the component involved in the measurement is the non-leaded side (`n`) or the lead side (`w`).



Components can be leaded on all sides. Whether component pins extend from the body or are covered by it does not change leaded or non-leaded classification.

Consider this line in the ERF: `SMT:c2c;tab_qfp_nn = 4 6 8`

- If `v_classify_by_leaded_sides = 0`, the red value for narrow side to narrow side is 4.
- If `v_classify_by_leaded_sides = 1`, the red value for unleaded side to unleaded side is 4.

Categories in Component Analysis

Several component analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Measurements are made from edge of component to edge of feature, unless otherwise indicated.

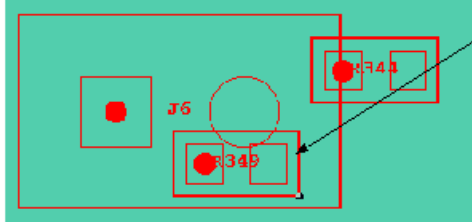
Components with the Ignore During Spacing Analysis attribute are not reported in categories involving spacing as well as all categories in the Silk Screen test.

Table 8-2. Result Categories for Component Analysis

Category	Description
Comp. Under Component (Spacing)	Reports components partially or totally under other components.
Comp. Overlap (Spacing)	Reports components that overlap other components.

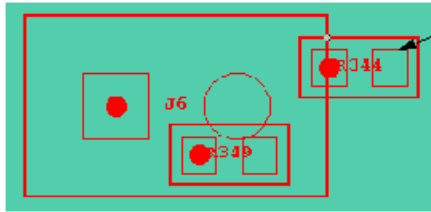
Comp. Under Component (Spacing)

Reports components partially or totally under other components.

Analysis Category	<Area>:c_under_c;<PkgTypeA>_<PkgTypeB>_<CompSide><CompSide>
Measurement Shape	Segment
Measurement Value	Percent (area of overlap or area of smaller component)
Measurement IDs	Two components
Layers Displayed	Component layer Outer layer on component side, if pp_comp_outline=T-envelope.
Graphic	 <p>Component R349 is under component J6.</p>
Purpose	Not all component overlap is illegal. (SMT components can be placed under through hole components in some situations.)
Function	Reports components partially or totally under other components. Measurement value is reported in percent; that is, less than 100% is partial overlap, 100% is total overlap. Does not report components with attribute Ignore During Spacing Analysis.
ERF Parameters	pp_comp_outline pp_ignore_comps_with_ignore_attr
ERF Variables	v_split_c2c = yes
Limitations	

Comp. Overlap (Spacing)

Reports components that overlap other components.

Analysis Category	<Area>:comp_overlap;<PkgTypeA>_<PkgTypeB>_<CompSide><CompSide>
Measurement Shape	Overlap segment
Measurement Value	Overlap distance
Measurement IDs	Component names
Layers Displayed	Component layer Outer layer on component side, if pp_comp_outline = T-envelope.
Graphic	 <p>Component R344 is partially under component J6</p>
Purpose	Not all component overlap is illegal.
Function	<p>Reports components that overlap other components. The overlap distance indicates how far a component should be moved to avoid overlapping.</p> <p>For each two components that overlap, but are not completely covered one by the other, report the greatest extent of overlapping. Does not report components with attribute Ignore During Spacing Analysis.</p>
ERF Parameters	pp_comp_outline pp_ignore_comps_with_ignore_attr pp_c_spacing
ERF Variables	v_split_c2c = report_overlap
Limitations	

ERF Parameters for Component Analysis

Parameters set in the ERF file control the analysis.

Name	Parameter	Description	Categories Affected
Side	pp_side	Determines the side on which tests are performed: top, bottom or both.	All categories
Component Spacing	pp_c_spacing	Maximal distance to detect between components	All categories
Component Outline	pp_comp_outline	The type of component outline to use: body — The body only. envelope — A polygon around body + pins. T-envelope — A polygon around body + toeprints in outer layer. See “ Component Outline ” on page 216 for an explanation of component outline types.	All categories
Ignore comps. with .comp_ignore	pp_ignore_comps_with_ignore_attr	Determines whether to ignore components with attribute Ignore Graphically/Output. no — Include these components in the analysis. (default) yes — Ignore these components. (Assigned to components not placed on the board when printed.)	All categories

ERF Variables for Component Analysis

Variables set in the ERF file control the analysis.

Variable	Description	Categories Affected
v_split_c2c	Controls how overlapping components are reported. yes — Reports overlapping measurements in category Comp. Under Component as a percent (area of overlap or area of smaller component). report_overlap — Reports partially overlapping components to category 'Comp. Overlap'. Completely overlapping components are reported to 'Comp. Under Component'.	Comp. Under Component Comp. Overlap
v_sub_cat_default	Controls the attribute used in component classification. Empty — If left empty, the system searches for User Type, if at least one package has a user type designation. Otherwise, it searches for Package Type. If not found, no classification according to component type is performed. (default) Package Type — Component classification types assigned prior to import. User Type — User-defined component classification types assigned prior to import. String — A string identical to the name of the attribute to be used for component assignment. Mount Type — The mount type used by the component. [Possible values: SMT; THMT; PRESSFIT or Other]	All categories classified by component type

Chapter 9

Assembly Analysis - Testpoint Analysis

Testpoint Analysis is a read-only action intended to detect issues related to testpoints—pads having an attribute designating them as testpoints. It addresses issues such as accessibility to testpoints by probes and coverage on the board. It operates on top or bottom layers, and refers to the corresponding component layer.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Testpoint Analysis

Several testpoint analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Spacing — Reports the spacing between testpoints.

Testpoints are designated by the feature attribute ICT Test Point, Test Point Potential or both as defined by ERF variable v_testpoint_attr.

If v_testpoint_attr = both, then all incidences of ICT Test Point and Test Point Potential are reported along with any incidences of both on the same feature. If two attributes of the same feature contradict one another, the value of Test Point Potential is used.

For example, if v_testpoint_attr = both and a pad has feature attribute ICT Test Point and Test Point Potential = not_potential_tp_manual, the not_potential_tp_manual is used and the pad is ignored during analysis.

Attributes Used in Testpoint Analysis

Attributes assigned to features in the product model control the analysis.

Feature Attributes

Table 9-1. Testpoint Analysis Feature Attributes

Name	Description
ICT Test Point	Features with this attribute are considered testpoints.
Copper Feature Ignore	Copper features bearing this attribute are ignored in analysis actions. (Presently implemented only for Rout Test.)
Test Point Potential	Features with this attribute are considered as testpoints in the analysis unless its value is not_potential_tp_manual. If so, it is ignored.

Categories in Testpoint Analysis

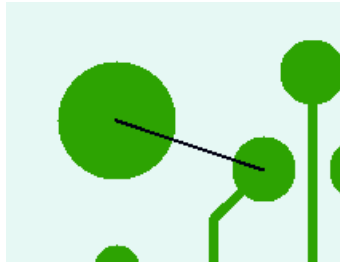
Several testpoint analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Table 9-2. Result Categories for Testpoint Analysis

Category	Description
Testpoint to Testpoint (Spacing)	Reports distances between testpoints that are less than pp_t_spacing.
Testpoint to Exposed Copper (Spacing)	Reports distances between testpoints and exposed copper pads or surfaces of the outer signal layer, less than pp_t_spacing.
Testpoint Density (Spacing)	Reports each area that contains more than a specified number of testpoints.

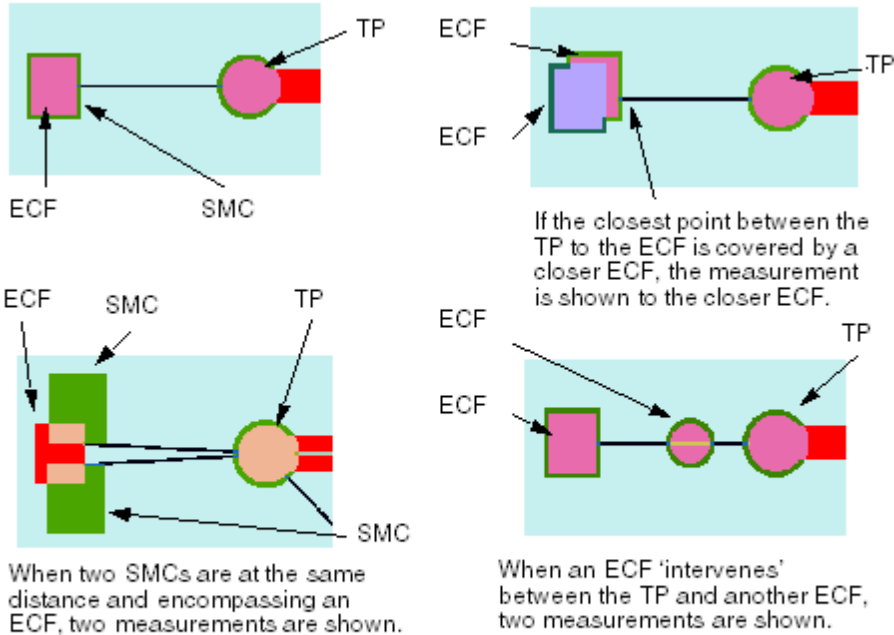
Testpoint to Testpoint (Spacing)

Reports distances between testpoints that are less than pp_t_spacing.

Analysis Category	tp2tp tp2tp;<PkgType> tp2tp;<PkgTypeA>_<PkgTypeB>
Measurement Shape	Segment
Measurement IDs	Two testpoint pads
Layers Displayed	Top or bottom signal layer. Corresponding solder mask layer if v_exposed_tp=1.
Graphic	
Purpose	Testpoints should be kept sufficiently apart in order to allow simultaneous probing without collision.
Function	Reports distances between testpoints that are less than pp_t_spacing for these cases: <ul style="list-style-type: none"> • None of the testpoints is a toeprint of a component (tp2tp) • One of the testpoints is a toeprint of a component (tp2tp;<PkgType>) • Both testpoints are toeprints of components (tp2tp;<PkgTypeA>_<PkgTypeB>) The distance is measured from pad center to pad center.
ERF Parameters	
ERF Variables	v_testpoint_attr v_tp2tp_by_side = no
Constraint	Testpoint to Testpoint
Change in Behavior	When one or two of the testpoints are also toeprints of a component, the result is classified by their comp_type. Therefore, this category can be classified by two, one or no comp_type, depending upon where they are situated.
Limitations	

Testpoint to Exposed Copper (Spacing)

Reports distances between testpoints and exposed copper pads or surfaces of the outer signal layer, less than pp_t_spacing.

Analysis Category	<Area>:tp2c
Measurement Shape	Segment
Measurement Value	Spacing
Measurement IDs	Testpoint; Feature
Layers Displayed	Top or bottom signal layer Corresponding solder mask layer
Graphic	 <p>If the closest point between the TP to the ECF is covered by a closer ECF, the measurement is shown to the closer ECF.</p> <p>When two SMCs are at the same distance and encompassing an ECF, two measurements are shown.</p> <p>When an ECF 'intervenes' between the TP and another ECF, two measurements are shown.</p> <p>Legend: TP - Testpoint ECF - Exposed Copper Feature SMC - Solder Mask Clearance</p>
Purpose	To assure testpoint probes do not touch and have sufficient clearance from exposed copper. Reports only copper pads which are neither via nor toeprint pads.
Function	Reports distances between testpoints and exposed copper pads or surfaces of the outer signal layer, less than pp_t_spacing.
ERF Parameters	pp_t_spacing

ERF Variables	v_exposed_tp v_tp2c_by_side = no v_ignore_tp2c_same_net v_report_same_net_spacing v_testpoint_attr
Constraint	Exposed Copper Spacing
Limitations	

Testpoint Density (Spacing)

Reports each area that contains more than a specified number of testpoints.

Analysis Category	<Area>:tp_density
Measurement Shape	Bounding box of a group of testpoints
Measurement Value	Number of testpoints within the bounding box
Measurement Entity	None
Layers Displayed	Signal layer
Graphic	
Purpose	Too many testpoint probes concentrated in a small area can cause pressure that could damage the board and crack solder joints.
Function	Reports each area that contains more than a specified number of testpoints.
ERF Parameters	
ERF Variables	v_tp_density_box_size v_tp_density_number
Limitations	

ERF Parameters for Testpoint Analysis

Parameters set in the ERF file control the analysis.

Name	Parameter	Description	Categories Affected
Side	pp_side	Determines the side on which tests are performed: top, bottom or both.	All categories
Testpoint Spacing	pp_t_spacing	Maximal spacing between testpoints	Testpoint to Testpoint Testpoint to Exposed Copper
Test List	pp_tests	Determines the tests performed on the layer. See “ Tests Performed in Testpoint Analysis ” on page 229.	All categories

ERF Variables for Testpoint Analysis

Variables set in the ERF file control the analysis.

Variable	Description	Categories Affected
process_map_layer_bot	Process map layer for bottom side of board	All categories classified by area
process_map_layer_top	Process map layer for top side of board	All categories classified by area
v_exposed_tp	The edge of a testpoint from which to measure. 1 — (default) Measures only from the exposed edge. 0 — Measures from the edge, whether exposed or not.	Testpoint to Testpoint Testpoint to Exposed Copper
v_ignore_tp2c_same_net	Controls whether violations between testpoints and exposed copper on the same net are reported. 0 — Reports all violations (default) 1 — Does not report violations between testpoints and exposed copper of the same net. This ERF variable remains to maintain backward compatibility. It is overridden by v_report_same_net_spacing.	Testpoint to Exposed Copper
v_report_same_net_spacing	Controls whether to report all testpoint to copper violations together or only those of different nets. yes — Report spacing violations between testpoints and copper features regardless of net. no — Only report spacing violations between testpoints and copper features of different nets. This variable, when set to no, takes precedence over v_ignore_tp2c_same_net.	Testpoint to Exposed Copper

Variable	Description	Categories Affected
v_sub_cat_default	<p>Indicates the attribute used in component classification.</p> <p>Empty — If left empty, the system searches for User Type, if at least one package has a user type designation. Otherwise, it searches for Package Type. If not found, no classification according to component type is performed. (default)</p> <p>Package Type — Component classification types assigned prior to import.</p> <p>User Type — User-defined component classification types assigned prior to import.</p> <p>String — Any string identical to the desired component attribute name.</p> <p>Mount Type — The mount type used by the component. [Possible values: SMT; THMT; PRESSFIT or Other]</p>	All categories classified by component type
v_testpoint_attr	<p>Determines the attribute used for testpoint designation of a pad.</p> <ul style="list-style-type: none"> • ICT Test Point — Accepted as a testpoint. • Test Point Potential — If its value is potential_tp_manually or potential_tp_by_analysis, accepted as a testpoint. • both — At least one of the above attributes is accepted as a testpoint. <p>A pad with contradictory attributes (ICT Test Point and Test Point Potential = not_potential_tp_manual) is not accepted as a testpoint.</p>	All categories
v_tp2c_by_side	<p>Determines whether all testpoint to exposed copper measurements are reported to 'Testpoint to Exposed Copper' or according to the side found.</p> <p>no — Reports all violations to 'Testpoint to Exposed Copper'.</p> <p>yes — Reports violations to 'Testpoint to Exposed Copper (Primary)' or 'Testpoint to Exposed Copper (Secondary)'.</p>	Testpoint to Exposed Copper

Variable	Description	Categories Affected
v_tp2tp_by_side	Determines how results are reported for measurements between testpoints. no — Reports all results to ‘Testpoint to Testpoint’ category. (default) yes — Reports results to ‘Testpoint to Testpoint (Primary)’ or ‘Testpoint to Testpoint (Secondary)’.	Testpoint to Testpoint
v_tp_density_box_size	Determines the length of a side for the square area containing the testpoints.	Testpoint Density
v_tp_density_number	Determines the number of testpoints within an area to be reported.	Testpoint Density

Chapter 10

Assembly Analysis - Solderpaste Analysis

Solderpaste Analysis is a read-only action that includes tests to verify correct placement of solderpaste on the board (solderpaste should be on all SMD pads and only there), and proper overlap between solderpaste and solder mask, between solderpaste and copper layers.

For an explanation of how to run this analysis, see “[Performing DFM Analysis](#)” on page 21.

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Tests Performed in Solderpaste Analysis

Several solderpaste analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

SMD — Reports solderpaste features that do not touch SMD pads (in outer signal layers), and SMD pads not covered at all with solderpaste.

Attributes Used in Solderpaste Analysis

Attributes assigned to features in the product model control the analysis.

Feature Attributes

Table 10-1. Solderpaste Analysis Feature Attributes

Name	Description
SMD Pad	Boolean attribute used to determine whether a pad is an SMD pad.
Copper Text	Boolean attribute. A solderpaste feature having this attribute is ignored in the Solderpaste Analysis.

Categories in Solderpaste Analysis

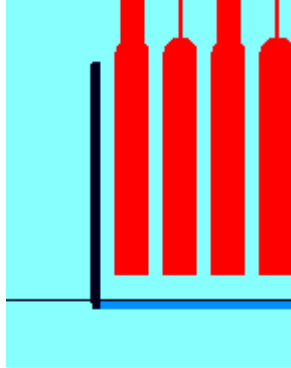
Several solderpaste analysis tests can be run. For each test performed, results might be reported to the result categories available for that test. In the result category descriptions in this document, the test name is indicated in parentheses after the category name.

Table 10-2. Result Categories for Solder Paste Analysis

Category	Description
Non-SMD Pads with Solderpaste (SMD)	Reports solderpaste features touching pads without attribute SMD Pad in the outer signal layer.
SMD Pad Without Solderpaste (SMD)	Reports SMD pads on the outer signal layer not covered, at least partially, with solderpaste.

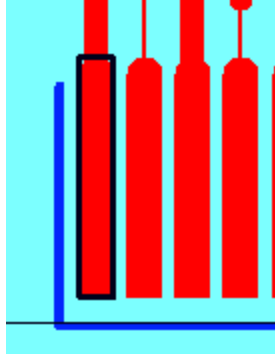
Non-SMD Pads with Solderpaste (SMD)

Reports solderpaste features touching pads without attribute SMD Pad in the outer signal layer.

Analysis Category	sp_non_smd;<PkgType>
Measurement Shape	Solderpaste feature
Measurement Value	Solderpaste feature bounding box
Measurement (ID)s	
Layers Displayed	Solderpaste layer Outer signal layer
Graphic	
Purpose	Solderpaste on non-SMD pads may result in shorts.
Function	Reports solderpaste features touching pads without attribute SMD Pad in the outer signal layer.
ERF Parameters	
ERF Variables	
Limitations	

SMD Pad Without Solderpaste (SMD)

Reports SMD pads on the outer signal layer not covered, at least partially, with solderpaste.

Analysis Category	smd_without_sp;<PkgType>
Measurement Shape	SMD pad
Measurement Value	SMD pad bounding box
Measurement (ID)s	
Layers Displayed	Solderpaste layer Outer signal layer
Graphic	
Purpose	Missing solderpaste may result in broken net connectivity.
Function	Reports SMD pads on the outer signal layer not covered, at least partially, with solderpaste.
ERF Parameters	
ERF Variables	v_ignore_gold_smd_without_sp
Limitations	

ERF Parameters for Solderpaste Analysis

Parameters set in the ERF file control the analysis.

Name	Parameter	Description	Categories Affected
Side	pp_side	Determines the side on which tests are performed: top, bottom or both.	All categories
Test List	pp_tests	Determines the tests performed on the layer. See “Tests Performed in Solderpaste Analysis” on page 241.	All categories

ERF Variables for Solderpaste Analysis

Variables set in the ERF file control the analysis.

Variable	Description	Categories Affected
v_ignore_gold_smd_without_sp	<p>Determines whether to report all SMD pads (with attribute SMD Pad) lacking solderpaste or ignore those with the attribute Plated Feature.</p> <p>no — Report all SMD pads without solderpaste. (default)</p> <p>yes — Ignore SMD pads with attribute Plated Feature lacking solderpaste.</p>	SMD Pad Without Solderpaste
v_sub_cat_default	<p>Determines the attribute used in component classification.</p> <p>Empty — If left empty, the system searches for User Type, if at least one package has a user type designation. Otherwise, it searches for Package Type. If not found, no classification according to component type is performed. (default)</p> <p>Package Type — Component classification types assigned prior to import.</p> <p>User Type — User-defined component classification types assigned prior to import</p> <p>String — Any string identical to the desired component attribute name.</p> <p>Mount Type — The mount type used by the component. [Possible values: SMT; THMT; PRESSFIT or Other]</p>	All categories classified by component type

Chapter 11

DFMA Result Viewer

The execution of analyses can present a user with thousands of analysis results. The Result Viewer enables the user to inspect results most likely to prevent the successful manufacture of a board.

For users of DFM Analyses, only violations are reported. A histogram of category results displays, along with a typical measurement and an explanation of the category's purpose. An overview highlights either the area of the design where a specific result is found, or a distribution map of all results on a layer.

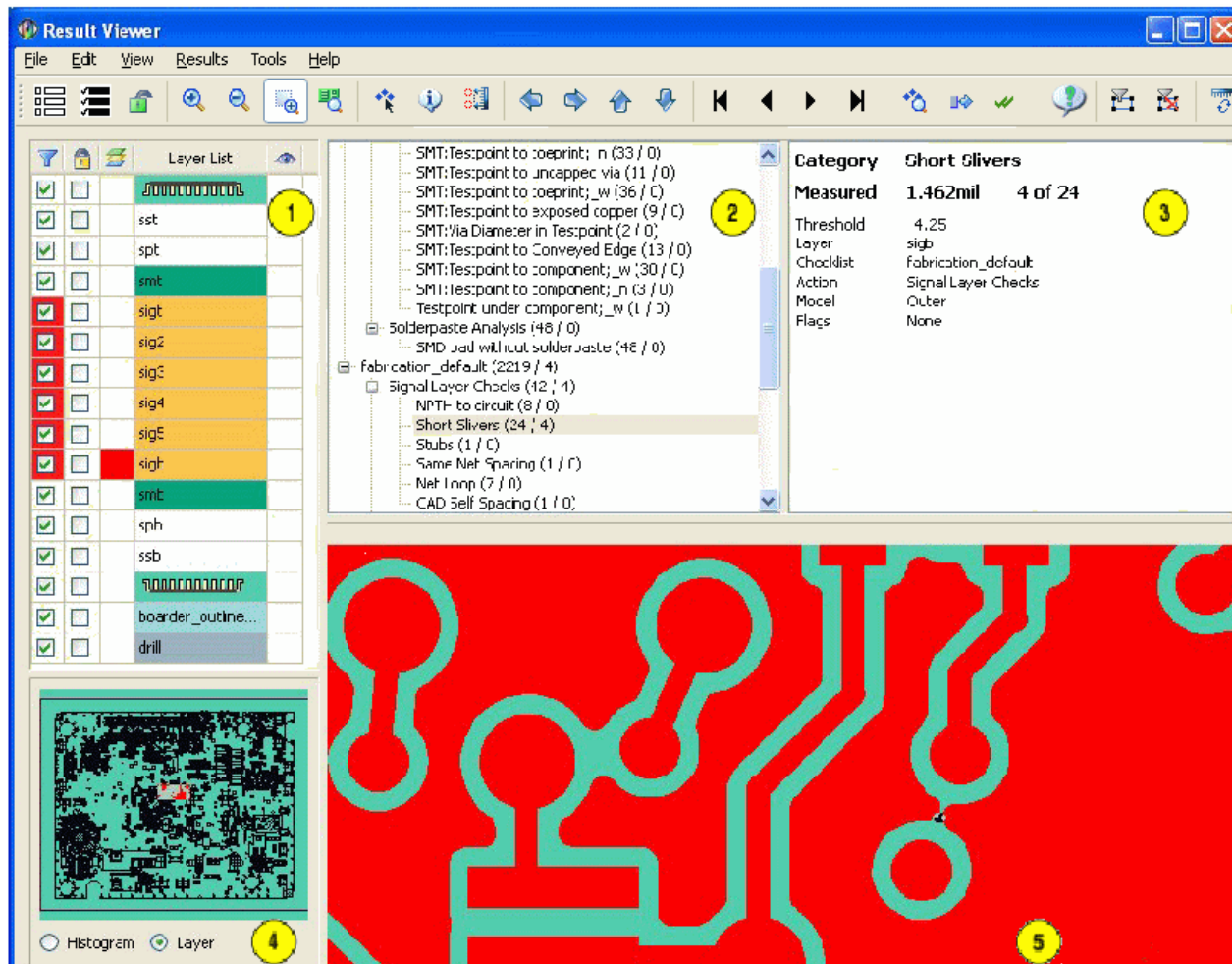
The graphic area displays the selected result. You can zoom in or out to examine a result or the area around it. You can filter to review results within a selected area only.

Moving between the Result Viewer and the EDA application where the design was created allows you to edit critical violations. Rerunning the analyses allows you to verify that the manufacturability of the product model is improving.

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Result Viewer Workspace

Running Design for Manufacture Analysis (DFMA) opens the Result Viewer workspace. All actions for reviewing analysis results can be performed from the Result Viewer workspace.



The numbered panes in the example contain this information:

Table 11-1. Panes of the Result Viewer Window

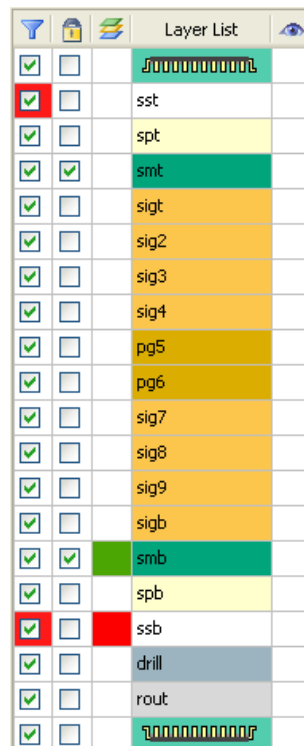
Result Viewer Pane	Explanation
Layer List	This pane displays a list of all layers in the design. It contains options for viewing layers and their contents: a filter, a locking mechanism, color guide, the name and type of the layer, and an indication of results viewed in the layer.
Result Categories Pane	This pane displays a list of results grouped by categories, and sorted according to severity.

Table 11-1. Panes of the Result Viewer Window (cont.)








Result Viewer Pane	Explanation
Details Pane	This pane can display a histogram of category results, the details of a selected result in the category, and the description of what the category reports. It displays a representative graphic of a typical measurement. If you select an individual result in the Result Categories pane, the Details pane displays measurement details.
Overview Pane	This pane displays an overview of the board. Click a category to see a distribution map of its results. If viewing an individual result, the features of its primary layer also display. The location of the measurement is highlighted.
Board View of the Result	This area of the workspace displays the selected measurement on the board. You can zoom in, and examine the actual features involved in the measurement and neighboring features in order to decide what action should be taken.

Layer List

This pane displays a list of all layers in the design. It contains options for viewing layers and their contents: a filter, a locking mechanism, color guide, the name and type of the layer, and an indication of results viewed in the layer.



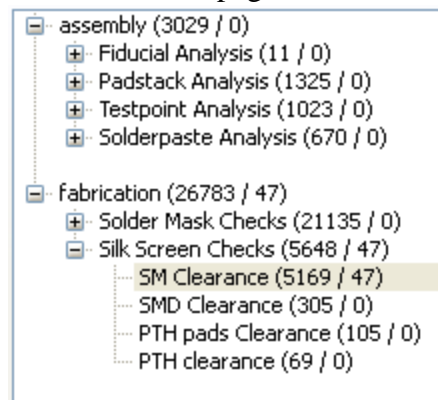
The **Layer List** represents the layers of the job.

Column	Explanation
	The layer filter is used to control the display of results. By default all results in all layers displayed. Clear the check box to remove the results of that layer from the result categories. A red border around the check mark indicates the presence of critical violations on the layer for the selected category. The default display is only violations. Result Viewer users have the option of viewing all results.
	A locked layer remains displayed.
	The layer color guide displays the color used for that layer in the graphic area, and controls its display. Click the color box or layer name to display or hide the features of that layer in the graphic area.
Layer List	A component layer is represented by this icon  . Other layers display their names.
	The viewed column indicates the proportion of results in the selected category already viewed on the layer. For example,  indicates only a quarter of the results have been viewed, and  indicates all results have been viewed.


Result Categories Pane

This pane displays a list of results grouped by categories, and sorted according to severity.

If features have an attribute identifying their padstack, or a symbol name, the user can view them by layer. See “[Result Viewer Tools](#)” on page 253.



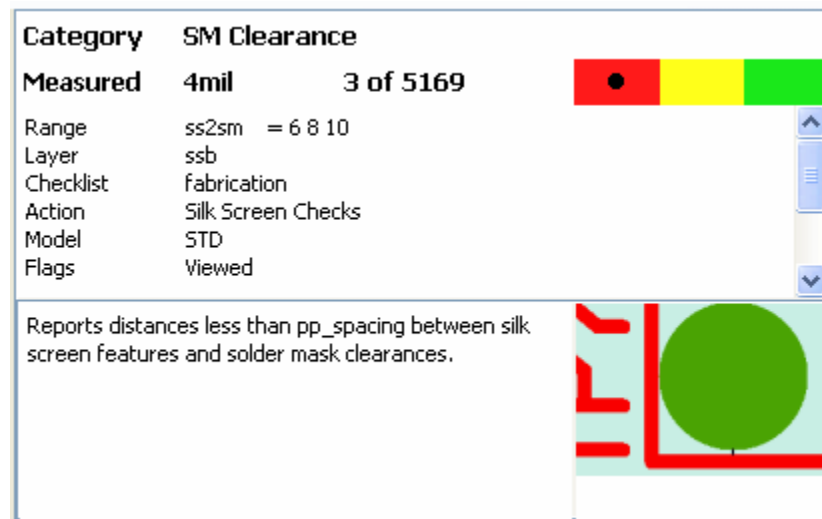
Note

 The names of result categories do not fully correlate to the names of constraints in the Constraints Editor. Analysis categories include both violations that are based on values set in the Constraints Editor, and go/no-go type violations, such as SMD pads without Solderpaste or Non-SMD pads with Solderpaste.

Details Pane

This pane can display a histogram of category results, the details of a selected result in the category, and the description of what the category reports. It displays a representative graphic of a typical measurement. If you select an individual result in the Result Categories pane, the Details pane displays measurement details.

The histogram displays when the user selects a category. Category and measurement details display when selecting a specific measurement. The function of the category and an illustration can display with either the histogram or category details, or can be hidden by selecting in the main menu **View > Toggle category description**.



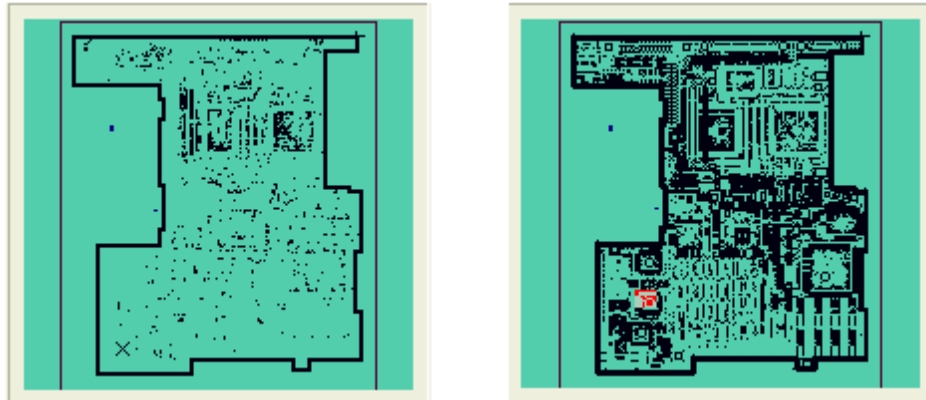
The measurement details include the category name, measurement value, index number of this measurement out of a total for the category, and its severity indicated by a dot in one of the severity bars, as well as the general details of range, layer, checklist, action, model and flags.

DFM Analysis users view only violations. The Threshold is displayed instead of the Range.

Overview Pane

This pane displays an overview of the board. Click a category to see a distribution map of its results. If viewing an individual result, the features of its primary layer also display. The location of the measurement is highlighted.

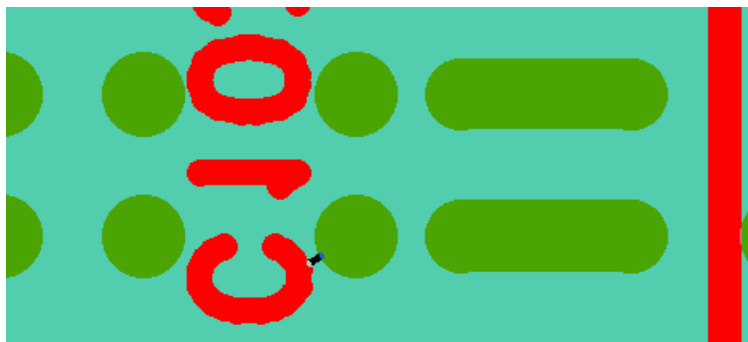
On the left is a distribution map of all results in the selected category. On the right, the area of the features and the selected measurement are highlighted.



Board View of the Result













This area of the workspace displays the selected measurement on the board. You can zoom in, and examine the actual features involved in the measurement and neighboring features in order to decide what action should be taken.









The right-click menu for the graphic area offers options for zooming, measuring, displaying, and selecting features.





Result Viewer Tools

The Result Viewer workspace contains tools for navigation, selection or deselection, reviewing results, and accessing related applications. All actions available on the toolbar can also be accessed using a menu option. Some menu options have no toolbar equivalent. There are right-click options that do not display in the toolbars or the menus.

Tool	Explanation
	Deselects all layers in the layer filter.
	Selects all layers in the layer filter.
	Removes all layer locks.
	Zooms the view of the graphic area in enlarging all features.
	Zooms the view of the graphic area out reducing all features.
	Zooms the view of the graphic area to the rectangle drawn with this tool.
	Zooms the view of the graphic area to home—to include the entire board.
	Selects a feature. Pressing Shift , and clicking other features causes the selection to be cumulative.
	Used to measure the distance between two features.
	Opens the Snap dialog box to determine how certain features—line, pad, filled surface, arc, text—snap to positions on the grid or to other features, and whether the grid is displayed and in what form. See Setting Grid and Snap Options .
	Pans the view of the graphic area left, right, up and down, respectively.
	Navigates from one result to another either sequentially, to the first in the category, or to the last in the category. (Clicking the next arrow at the end of a category, moves the view to the first result of the next category.)

Tool	Explanation
	Sets the zoom mode: Auto Zoom Pan Only No Zoom
	Synchronize with the current EDA program. Displays the same area of the board in the EDA program, as the measurement displayed in the Result Viewer. You can examine the problematic areas and perform DFM actions to rectify critical violations.
	Shows/hides the category description and typical measurement in Pane 3.
	Flags a single result of a specific category to be reported. For information on reports, see Flagging Results and Creating a Results Report .
	Flags all results of the selected node to be reported.
	Filters results of a rectangular selection.
	Clears the rectangular filter.
	Changes measurement display from inches to millimeters, or vice versa.
File > Exit	Closes the application.
Tools > Component Options	Opens the Component Display Options dialog box for setting how components display.
Expand All Collapse All	Right-click any action, entity, or property by which to displaying the results tree, and select one of these options to expand or collapse all results in the tree, not just those of the right-clicked node.

Tool	Explanation
<p>Toggle Feature Classification</p>	<p>You can view measurement results involving two, one or no features according to classification by the feature attribute Geometry or by their symbol name. Results are displayed by layer, with the first results being the most severe for that layer. Features having the feature attribute Geometry, containing the name of the padstack to which the feature belongs, are given preference. If the feature does not have the attribute Geometry, then its symbol name is used. If neither of these are found, the results display under None.</p> <p>Right-click any category, and choose Toggle Feature Classification.</p> <p>The results are sorted by layer, under padstack name, symbol name, or None. The histogram displays the results of the selected</p> <div data-bbox="581 674 1062 1115"> </div> <p>layer.</p>
	<p>Displays results singly or simultaneously when you use the navigation tools to move from one measurement to the next, or from one category to another.</p> <p>To view all results simultaneously, click the Show All</p> <div data-bbox="565 1293 919 1598"> </div> <p>tool.</p>
	<p>In Inches or Millimeters</p> <p>Click the Switch Units tool. The workspace dynamically updates all results and histograms.</p>

Grid and Snap Options

Grid and snap option tools enable greater accuracy when editing features.

Snap depends on these factors:

- The snap features chosen for snapping.
For example, if you deselect Arc, then features in the display will not snap to arcs.




- The snap mode: Grid, Center, Skeleton, Edge, Intersect, or Midpoint.
- The feature snap point, and distance to the nearest snap point.
- The snap layer, as designated with SA (snap advance).

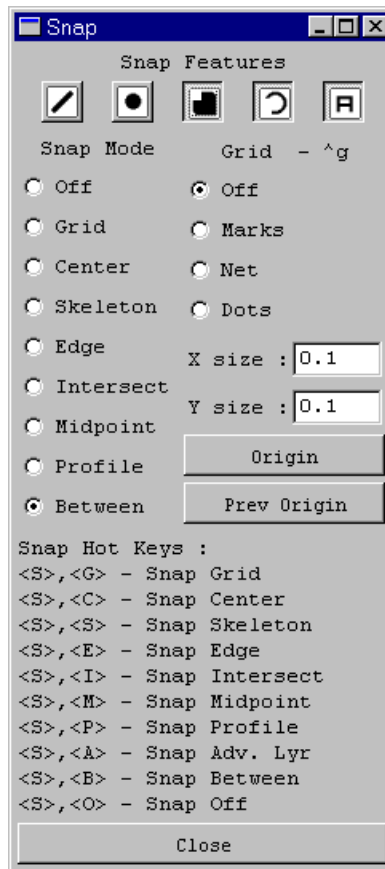
Setting Grid and Snap Options	256
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Setting Grid and Snap Options

The Snap functions enable you to determine how certain features—line, pad, filled surface, arc, text—snap to positions on the grid or to other features, and enables you to decide whether the grid is displayed as well as in what form.


The **Control Snapping** tool opens the Snap dialog box . Selecting a mode in the Snap dialog box causes the tool icon in the toolbar of the Result Viewer to change to the specific tool

in use. The Grid Mode options determine whether to display the grid or not; and if displayed, in what form. There are hot keys for each of the snap options.



Snap Mode options can be deactivated by clicking **Off**.

Tool	Use
	Grid — Snaps to grid intersection.
	Center — Snaps to center of pad (end of arc or line).
	Skeleton — Snaps to skeleton hairline in center of line or arc, or to center of pad.
	Edge — Snaps to closest edge of feature (also lines and arcs).
	Intersect — Snaps to intersection of lines or arcs.
	Midpoint — Snaps to midpoint of lines (not arcs) or center of pads and filled surfaces.
	Profile — Snaps to the closest point on the defined profile.

Tool	Use
	Between — Snaps to the center of an orthogonal (horizontal or vertical) line between two closest pads.

Procedure




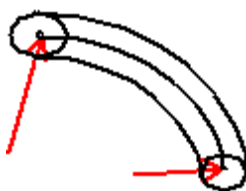
1. Clear the Off option under Grid, or press Ctrl-G.
2. Select one of the grid type options.
 - **Marks** — Grid is displayed in crosses at grid intersections
 - **Net** — Displays horizontal and vertical lines
 - **Dots** — Displays dots at grid intersections
3. In X size and Y size set the distances between grid intersections along the X/Y axes.




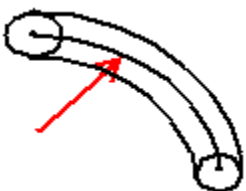
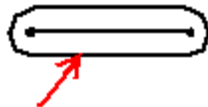



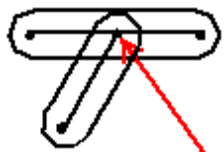

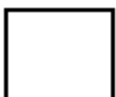
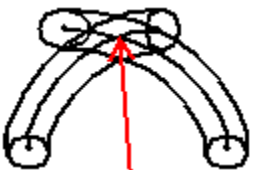




Locations of Snap Points

Snap points for features are points to which a snap action applies.

Feature	Snap Point
Grid	At grid intersections
Line	At line endpoints, edges, skeleton, or midpoint of skeleton
Pad	At their edges or centers
Surface (areas, polygons)	At their corners, edges or centers
Arc	At their endpoints, edges or skeletons
Text	To the beginning of the baseline

The snap points for a line, pad, surface, or arc depend on the mode (center, skeleton, edge, intersect, or midpoint):

Mode	Line	Pad	Surface	Arc
Center	 to ends	 to center	 to center	 to ends

Mode	Line	Pad	Surface	Arc
Skeleton	 to skeleton	 to center	 to center	 to skeleton
Edge	 to closest edge	 to closest edge	 to closest edge	 to closest edge
Intersect	 to intersect	 no snap	 no snap	 to intersect
Midpoint	 to midpoint	 to center	 to center	 no snap

Snap Hot Keys

This table describes the shortcut keys associated with the Snap function:

Table 11-2. Snap Shortcut Keys

Keys/Mouse button	Function
SG	Snap grid
SC	Snap center
SE	Snap skeleton
SA	Snap advance
SI	Snap intersect
SM	Snap midpoint
SP	Snap profile

Table 11-2. Snap Shortcut Keys (cont.)

Keys/Mouse button	Function
SO	Snap off
Ctrl+G	Grid on/off

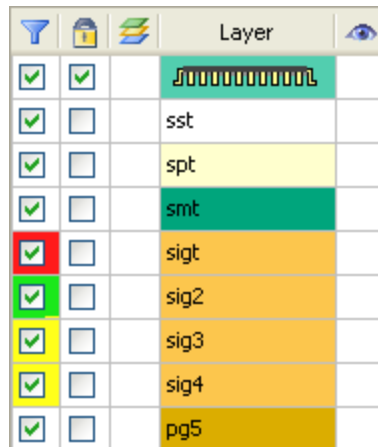
Filtering and Reporting Results

Results can be filtered by layers, area, or histogram bar. One of the most significant features of the Result Viewer is that no matter how results are filtered, they are then ordered to display the most severe measurements first. If any restriction is placed upon the number of results to display, it becomes effective only after the order and sort actions. The Result Viewer also enables you to print result reports for distribution or archiving.

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Filtering by Layer

The Filter column in the layer pane is the layer filter. By default, results of all layers are displayed. The color of the box around the check mark for a layer indicates the highest severity of results found in the layer for the selected category.






For example, to view results from only outer layers, remove the check mark from the inner signal layers—in the example that would be layers sig2, sig3, and sig4.

Procedure

1. If you want to display all but a few layers, click the tool **Select All Layers**  and then clear the check box in the filter column  for layers you do not want to display.
2. If you want to display only a few layers, click the tool **Deselect All Layers**  and then select the layers in the filter column  that you want to display.


Results

- As you view the results, they are automatically flagged as viewed.
- If you leave a group of results, without viewing all of them, the viewed column  indicates the proportion of results already viewed. For example,  indicates that a quarter of the results have been viewed, and  indicates that all results have been viewed.

Filtering by Board Area

You can view result measurements for a selected area of the board.

Procedure

1. To review only those measurements within a specific area of the board, click the **Select Area** filter. 
2. In the board overview, draw a rectangle around the area of the board from which to take results.

A blue rectangle displays in the overview around the area. Only results within the area are listed in the categories of the tree. (Fewer categories might display; and the total number of results for some categories is less.)

3. To remove the filter, click the **Clear Area** filter. 

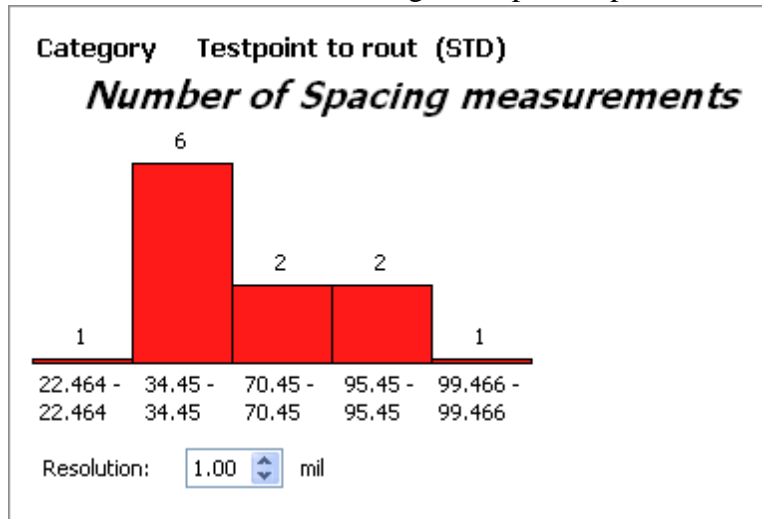
Filtering with a Histogram


You can display a histogram for any category. When you choose a category, the histogram displays all violations of the category. When you navigate to an individual measurement, a description of the category, specific measurement details, and a typical measurement display.

Procedure

1. To view a histogram of analysis category results, click a category in the selection pane.

A histogram of the measurements for the category opens in the histogram pane. The number of results in each bar of the histogram depends upon the user-defined resolution.



- Adjust the resolution, if necessary.
- To hide the category description and typical measurement, click .
- To filter with the histogram, select the bar of results to view. For example, only those of 34.45 mil.
- Click the **Next Result** button on the toolbar.

The first of the 6 results of 34.45 mil displays in the graphic area. The result details display instead of the histogram. The counter says this is the first of six results.


Category	Testpoint to rout (STD)	
Measured	34.45mil	1 of 6
Range	tp2r = 112.5 125 137.5	
Layer	sigb	
Checklist	analysis	
Action	Testpoint Analysis	
Model	STD	
Flags	Viewed	
Elements	r33	r125
Net name	/R5232GND	

After viewing all six results, clicking the **Next Result** button moves the view to the next category.

Flagging Results



You can flag results to be reported as you investigate the measurements of a category. You can flag individual results, all results of a category, or a group of results in a category. If a measurement already flagged for reporting has undergone changes, flagging it again overwrites the previous data with the new data.

Procedure

1. Select a category or entity in the tree for review.
2. Click the **Next Result**  button in the toolbar.

The first measurement displays in the graphic area, and details of the measurement display instead of the histogram for the category.


3. Assign the Report flag by doing one of the following:

If you want to report:	Do this:
A single result	With the measurement displaying in the graphic area, click the Report One button.  You can repeat this action for as many measurements as necessary.
All results of a category	1. Select the category in the tree. 2. Click the Report All button. 
A group of results	1. In the histogram for a category, right-click one of the bars. 2. In the popup menu that opens, choose Report.

Creating a Results Report

As you review results, you can choose measurements to be reported. When you finish your review, you can generate a report of these results.

Note

 Creating a results report requires a license. If the license is not available, features relating to reporting do not display.

Procedure

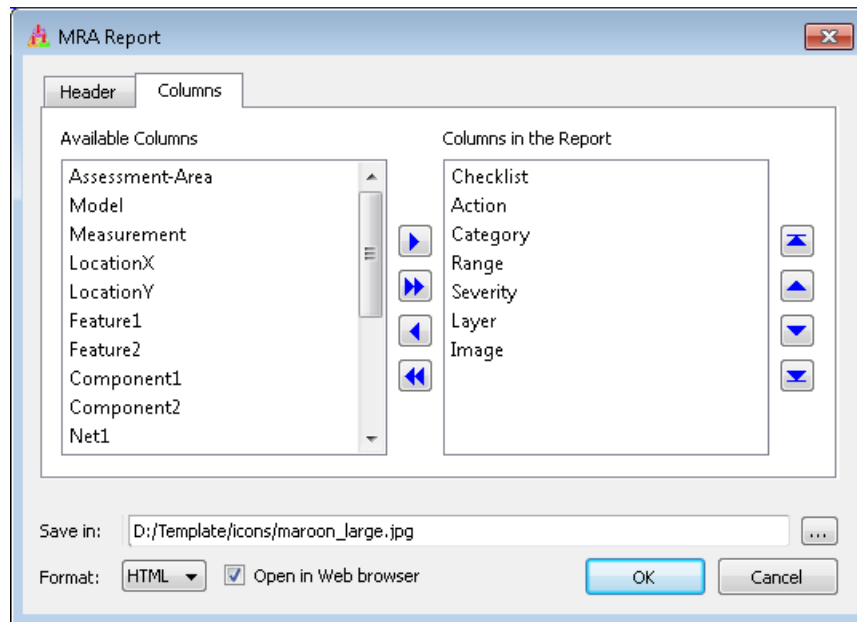
1. Make sure that all results you want to include are flagged for reporting. See “[Flagging Results](#)” on page 264.
2. Select **File > Save** to save the work performed on the job.

3. In the main menu, select **Tools > Generate Report**.

The MRA Report dialog box opens.

4. On the **Header** tab, enter a title, description, job description. (optional)
5. Mark Include top side view and Include bottom side view if you want an image of the board side(s) to display in the report.
6. If you want to place a company/department logo on the report, enter a path to the file. Logos must be in JPEG format only.
7. In Save in, enter the location where to save the report, or click the browse button, navigate to the location, and double-click it.
8. In **Format**, select either HTML or XML.
9. To open the report in your default browser after saving it, mark Open in Web browser.
10. Click the **Columns** tab.

The **Columns** tab opens.



11. Move the columns you want in the report from the Available Columns list to the Columns in the Report list either by double-clicking the name or using the navigation buttons between the columns.
12. When all required columns display on the right, use the navigation buttons on the right to move them up or down in the order you want them to display across the report.
13. Click **OK**.

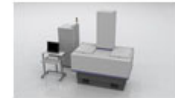
A report in either HTML or XML format is generated and stored at the specified location.

Examples

Figure 11-1. MRA Report in XML

```
<?xml version='1.0' encoding='UTF-8'?>
<Report>
  <ReportHeader>
    <Title text="Component Analysis" />
    <Description text="Lower Right Corner" />
    <Date date="Monday, November 18, 2015" />
    <Job description="Note the extreme density" stepName="rev_a"
jobName="demo_design_baruch" />
    <TopView
image="/9j/4AAQSkZJRgABAQEAYABgAAD/2wBDAAgGBgcGBQgHBwcJCQgKDBQNDAsLDI
```

Figure 11-2. MRA Report in HTML



Demo MRA Report

Job: dts.950102 **Step:** pcb

Wednesday, November 13, 2015

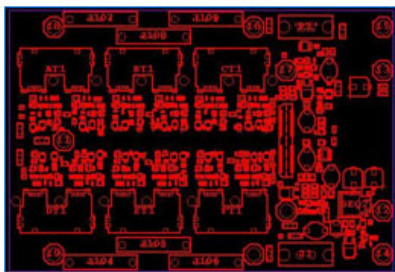
Description

Description text for this report.
Can be a few lines of text.

Job Description

Description of this job.
Can also be a few lines.

Top View



Bottom View



Category	Measurement	Layer	LocationX	LocationY	Feature1	Feature2	Comp1	Comp2	Net1	Net2	Image	Overview
Stubs	5 x 5mil	legend	3.2076891	3.5627118	r5							
Stubbed Via	20 x 20mil	drill	6.413	2.708								
Missing Holes	0mil	drill	1.2598425	6.2992126	r50							
Close Holes	9.939mil	drill	5.6141366	2.2350803	r110.236	r19.685				MC2		
Close Holes	9.939mil	drill	5.6141366	2.318463	r110.236	r19.685				MC2		
Close Holes	9.939mil	drill	4.4094853	4.881537	r110.236	r19.685				MC1		

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