

Virtuoso FinFET Support Overview

**Product Version ICADVM20.1
October 2020**

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Printed in the United States of America.

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Preface

Virtuoso® Layout Suite incorporates full support for the use of optimized 16nm native SKILL® process design kits (PDKs). This enables innovative FinFET custom design flows by supporting FinFET-based devices and rules at every design stage, together with a robust set of productivity-enhancing Virtuoso capabilities for leading custom and analog design.

This document summarizes the new capabilities added to Virtuoso layout tools to enable the structured FinFET custom placement using module generators (modgens); complex auto-alignment, device snapping, and abutment of FinFET-based devices; advanced rule support for layout automation; and sophisticated fluid guard ring generation.

Important

This document is not intended as a comprehensive FinFET user guide. It provides information on the enhancements made to various Virtuoso products to support FinFET-based design and includes links to more detailed information in the documentation of the specific products involved.

This user guide is aimed at developers and designers of integrated circuits and assumes that you are familiar with:

- The Virtuoso design environment and application infrastructure mechanisms designed to support consistent operations between all Cadence® tools.
- The applications used to design and develop integrated circuits in the Virtuoso design environment, notably, the Virtuoso Layout Suite.
- The Virtuoso design environment technology file.

This preface contains the following topics:

- [Scope](#)
- [Licensing Requirements](#)
- [Related Documentation](#)
- [Additional Learning Resources](#)
- [Customer Support](#)
- [Feedback about Documentation](#)

- [Typographic and Syntax Conventions](#)

Scope

The functionality described in this guide can be used only in ICADVM18.1 advanced nodes and advanced methodologies releases.

Licensing Requirements

For information on advanced node licensing in the Virtuoso design environment, see [*License Requirements for Advanced Node Features*](#) in [*Virtuoso Software Licensing and Configuration User Guide*](#).

Related Documentation

What's New and KPNS

- [*Virtuoso Width Spacing Patterns What's New*](#)
- [*Virtuoso Width Spacing Patterns Known Problems and Solutions*](#)

Installation, Environment, and Infrastructure

- [*Cadence Installation Guide*](#).
- [*Virtuoso Design Environment User Guide*](#)
- [*Virtuoso Design Environment SKILL Reference*](#)
- [*Cadence Application Infrastructure User Guide*](#)

Technology Information

- [*Virtuoso Technology Data User Guide*](#)
- [*Virtuoso Technology Data ASCII Files Reference*](#)
- [*Virtuoso Technology Data Constraint Reference*](#)
- [*Virtuoso Technology Data SKILL Reference*](#)

- [*Virtuoso Design Environment SKILL Reference*](#)

Virtuoso Tools

- [*Virtuoso Layout Viewer User Guide*](#)
- [*Virtuoso Layout Suite XL: Basic Editing User Guide*](#)
- [*Virtuoso Layout Suite XL: Connectivity Driven Editing Guide*](#)
- [*Virtuoso Layout Suite EXL Reference*](#)
- [*Virtuoso Simulation Driven Interactive Routing User Guide*](#)
- [*Virtuoso Width Spacing Patterns User Guide*](#)
- [*Virtuoso Layout Suite SKILL Reference*](#)

Additional Learning Resources

Video Library

The [Video Library](#) on the Cadence Online Support website provides a comprehensive list of videos on various Cadence products.

To view a list of videos related to a specific product, you can use the *Filter Results* feature available in the pane on the left. For example, click the *Virtuoso Layout Suite* product link to view a list of videos available for the product.

You can also save your product preferences in the Product Selection form, which opens when you click the *Edit* icon located next to *My Products*.

Virtuoso Videos Book

You can access certain videos directly from Cadence Help. To learn more about this feature and to access the list of available videos, see [Virtuoso Videos](#).

Rapid Adoption Kits

Cadence provides a number of [Rapid Adoption Kits](#) that demonstrate how to use Virtuoso applications in your design flows. These kits contain design databases and instructions on how to run the design flow.

In addition, Cadence offers the following training courses that are relevant to Virtuoso Width Spacing Patterns:

- [Virtuoso Layout for Advanced Nodes](#)
- [Virtuoso Connectivity-Driven Layout Transition](#)

Cadence also offers the following training courses on the SKILL programming language, which you can use to customize, extend, and automate your design environment:

- [SKILL Language Programming Introduction](#)
- [SKILL Language Programming](#)
- [Advanced SKILL Language Programming](#)

To explore the full range of training courses provided by Cadence in your region, visit [Cadence Training](#) or write to training_enroll@cadence.com.

Note: The links in this section open in a separate web browser window when clicked in Cadence Help.

Help and Support Facilities

Virtuoso offers several built-in features to let you access help and support directly from the software.

- The Virtuoso *Help* menu provides consistent help system access across Virtuoso tools and applications. The standard Virtuoso *Help* menu lets you access the most useful help and support resources from the Cadence support and corporate websites directly from the CIW or any Virtuoso application.
- The Virtuoso Welcome Page is a self-help launch pad offering access to a host of useful knowledge resources, including quick links to content available within the Virtuoso installation as well as to other popular online content.

The Welcome Page is displayed by default when you open Cadence Help in standalone mode from a Virtuoso installation. You can also access it at any time by selecting *Help – Virtuoso Documentation Library* from any application window, or by clicking the

Home button on the Cadence Help toolbar (provided you have not set a custom home page).

For more information, see Getting Help in *Virtuoso Design Environment User Guide*.

Customer Support

For assistance with Cadence products:

- **Contact Cadence Customer Support**

Cadence is committed to keeping your design teams productive by providing answers to technical questions and to any queries about the latest software updates and training needs. For more information, visit <https://www.cadence.com/support>.

- **Log on to Cadence Online Support**

Customers with a maintenance contract with Cadence can obtain the latest information about various tools at <https://support.cadence.com>.

Feedback about Documentation

You can contact Cadence Customer Support to open a service request if you:

- Find erroneous information in a product manual
- Cannot find in a product manual the information you are looking for
- Face an issue while accessing documentation by using Cadence Help

You can also submit feedback by using the following methods:

- In the Cadence Help window, click the *Feedback* button and follow instructions.
- On the Cadence Online Support Product Manuals page, select the required product and submit your feedback by using the *Provide Feedback* box.

Typographic and Syntax Conventions

The following typographic and syntax conventions are used in this manual.

<i>text</i>	Indicates names of manuals, menu commands, buttons, and fields.
text	Indicates text that you must type as presented. Typically used to denote command, function, routine, or argument names that must be typed literally.
<i>z_argument</i>	Indicates text that you must replace with an appropriate argument value. The prefix (in this example, <i>z_</i>) indicates the data type the argument can accept and must not be typed.
	Separates a choice of options.
{ }	Encloses a list of choices, separated by vertical bars, from which you must choose one.
[]	Encloses an optional argument or a list of choices separated by vertical bars, from which you may choose one.
[?argName t_arg]	Denotes a <i>key argument</i> . The question mark and argument name must be typed as they appear in the syntax and must be followed by the required value for that argument.
...	Indicates that you can repeat the previous argument.
	Used with brackets to indicate that you can specify zero or more arguments.
	Used without brackets to indicate that you must specify at least one argument.
, ...	Indicates that multiple arguments must be separated by commas.
=>	Indicates the values returned by a Cadence® SKILL® language function.
/	Separates the values that can be returned by a Cadence SKILL language function.

If a command-line or SKILL expression is too long to fit within the paragraph margins of this document, the remainder of the expression is moved to the next line and indented. In code excerpts, a backslash (\) indicates that the current line continues on to the next line.

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At advanced process nodes, CMOS technology is moving away from planar field-effect transistors (FETs) towards more advanced device structures that offer reduced leakage and better control over short channel effects. This has led to the development of multi-gate FETs also known as tri-gate FETs or FinFETs.

FinFETs use long, narrow fins fabricated on top of the substrate and surrounded by the gate on three sides. The fin pitch is typically the same for all devices and fins are surrounded by a fin boundary shape. The devices also come with new design rule checks that are required to ensure that device are correctly and legally placed.

This document provides an overview of the enhancements made to Virtuoso layout editing tools in order to support FinFET-based design. These include:

- Updates to the **technology file definitions** to let you define snap patterns for each layer-purpose pair on which FinFET devices will be placed. These snap patterns help ensure that placement constraints are honored when FinFET devices are created or edited either manually or automatically in the layout canvas.

For more information, see [Technology File Requirements for FinFET-based Design](#).

- Updates to **Virtuoso Layout Suite L** (Layout L) to let you display the fin grids in the layout canvas, as well as automatically snap shapes and design objects to these grids when they are created or moved around the canvas.

For more information on these features, see [FinFET Support in Layout L](#).

- Updates to **Virtuoso Layout Suite XL** (Layout XL) to preserve any snap patterns during layout generation; to generate a place and route boundary that is correctly sized in relation to the fin grid; to automatically snap FinFET devices to the fin grid when generating devices in the layout canvas; and fold FinFET devices based on a specified number of fins rather than the transistor width used to fold conventional devices.

For more information, see [FinFET Support in Layout XL](#).

- Updates to the **Virtuoso Module Generator** feature to snap modgens to the top-level snap pattern shape and to let you specify the number of fins required for dummy devices.

For more information, see [FinFET Support in Modgens](#).

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- Updates to the layout editor **design rule driven (DRD) editing** feature, which now supports the generation and placement of FinFET devices based on FinFET-specific spacing, width, and enclosure rules.

For more information, see [FinFET Support in DRD Editing](#).

Technology File Requirements for FinFET-based Design

This section summarizes the technology file definitions required to support snap patterns in your design, along with the public SKILL functions provided to create and locate snap pattern definitions in your technology files.

- Layer Definition Requirements
- Snap Pattern Definition Requirements
- Snap Pattern SKILL Functions

Layer Definition Requirements

You must update your layer definitions to define a purpose for each fin boundary type you require. The purpose you define

- Must have parent purpose "annotation"
- Must be a user-defined purpose; you cannot specify a Virtuoso system-reserved purpose

You do this in the `techPurposes` section of the technology file. For example:

```
layerDefinitions(  
  techPurposes(  
    (fb      1001 fb      'parent "annotation")  
    (fbdummy 1002 fbd    'parent "annotation")  
    (polygrid 1003 pg    'parent "annotation")  
  ) ;techPurposes  
) ;layerDefinitions
```

When the purpose is defined, you can reference it in the snap pattern definition.

Snap Pattern Definition Requirements

You define snap patterns in the `layerRules` section of the technology file. A snap pattern definition lets you store and access the attributes for snap pattern shapes on a specific fin boundary LPP.

The `snapPatternDef` syntax is as follows:

```
layerRules(  
  snapPatternDefs(  
    (name (tx_layer tx_purpose)  
      'step          g_step  
      'stepDirection {"horizontal" | "vertical"}  
      ['type         {"local" | "global"} ]  
    )  
  )  
)
```

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```
        ['offset'          g_offset]
        ['snappingLayers'  (l_snappingLayers)]
        ['trackWidth'      g_trackWidth]
    )
) ;snapPatternsDefs
) ;layerRules
```

The attributes defined in a snap pattern definition are listed below. For more detailed syntax information and examples of snap pattern definitions, see [snapPatternDefs](#) in the *Virtuoso Technology Data ASCII Files Reference*.

- Name, which must be unique
- Layer-purpose pair, which provides the link between the snap pattern definition in the technology file and the snap pattern shapes drawn in the design
- Step, which specifies the spacing between snap pattern tracks
- Step direction, which specifies the direction in which to create the snap pattern tracks, either horizontal (grid step is applied left to right) or vertical (grid step is applied from bottom to top)
- Type, which can be `local` or `global`
When snapping a shape to a snap pattern grid, snap pattern shapes whose snap pattern definition is of type `local` have higher priority than those of type `global`
- Offset, which specifies the distance of the first snap pattern track from the lower (for vertical direction) or left (for horizontal direction) edge of the shape bounding box
- Snapping layers; shapes on these layers snap to the snap pattern tracks. Each snapping layer has the following attributes:
 - Purposes; shapes on the snapping layer with one of these snapping purposes snap to this snap pattern shape
 - Enclosures, which specify a list of enclosures of a snapping shape beyond a grid line in the snap pattern direction
- Track width, which specifies the width of the physical shape that each track represents

With the snap pattern definition loaded for the design, you can draw a fin boundary in the layout canvas, and when you move parameterized cells, vias, shapes, or instances over this fin boundary, the layout editor automatically snaps the objects to the defined fin grid. For more information, see [Snapping Objects to Local Snap Pattern Shapes](#).

Snap Pattern SKILL Functions

You can use the following public SKILL functions to create and find snap pattern definitions in your technology files:

- techCreateSnapPatternDef lets you create a snap pattern definition in the current technology file
- techFindSnapPatternDefByLP lets you find a snap pattern definition based on its layer purpose pair
- techFindSnapPatternDefByName lets you find a snap pattern definition by name

FinFET Support in Layout L

This section summarizes the enhancements made to Layout L to support FinFET devices in your design. These include mechanisms to let you display the snap pattern grid in the layout canvas; to specify that design objects are to be automatically snapped to that grid; and to quickly place objects manually without zooming in to the canvas.

Layout L can now:

- Display fins, fin boundaries, and snap patterns in the layout canvas and specify that objects are automatically snapped to the snap pattern grid. See [Snapping Objects to Local Snap Pattern Shapes](#) for more information.
- Snap objects to a global snap pattern grid. See [Snapping Objects to the Global Snap Pattern Grid](#) for more information.
- Display snap patterns in the Palette assistant. See [Controlling the Display of the Snap Pattern in the Palette](#) for more information.
- Use Abstract Mode placement to improve performance when placing large blocks. See [Modes for Object Placement](#) for more information.

You customize the Create Guard Ring form to support advanced node design methodologies. For more information, see:

- [Customizing the Create Guard Ring Form](#)

Snapping Objects to Local Snap Pattern Shapes

Layout L has been enhanced to let you display fin grids in the layout canvas and automatically snap design objects to these grids when the object is moved over the fin boundary LPP. For more information, see the following topics in the *Virtuoso Layout Suite L User Guide*.

- [Snapping Objects to Snap Patterns](#)
- [Placing Objects Inside the Fin Boundary](#)
- [Controlling the Display of Snap Patterns](#)
- [Turning On Snap Pattern Snapping](#)
- [Snapping Objects](#)
- [Snapping Objects and Shapes In Groups](#)

Snapping Objects to the Global Snap Pattern Grid

The layout editor can now display a uniform fin grid called a global snap pattern grid that extend over the entire design window. You can use the global grid to

- Snap local fin boundaries by adding the fin boundary LPP to the list of `snappingLayers` for the global snap pattern definition
- Snap *Active* shapes by adding the *Active* LPP to the list of `snappingLayers` for the global snap pattern definition

You create a global snap pattern grid by specifying the value `global` in the `type` constraint of the snap pattern definition, as shown below:

```
snapPatternDefs(  
  (GFG ("CellBoundary" "global")  
    'offset      0.024  
    'step        0.048  
    'type        "global"  
    ...  
  )  
)
```

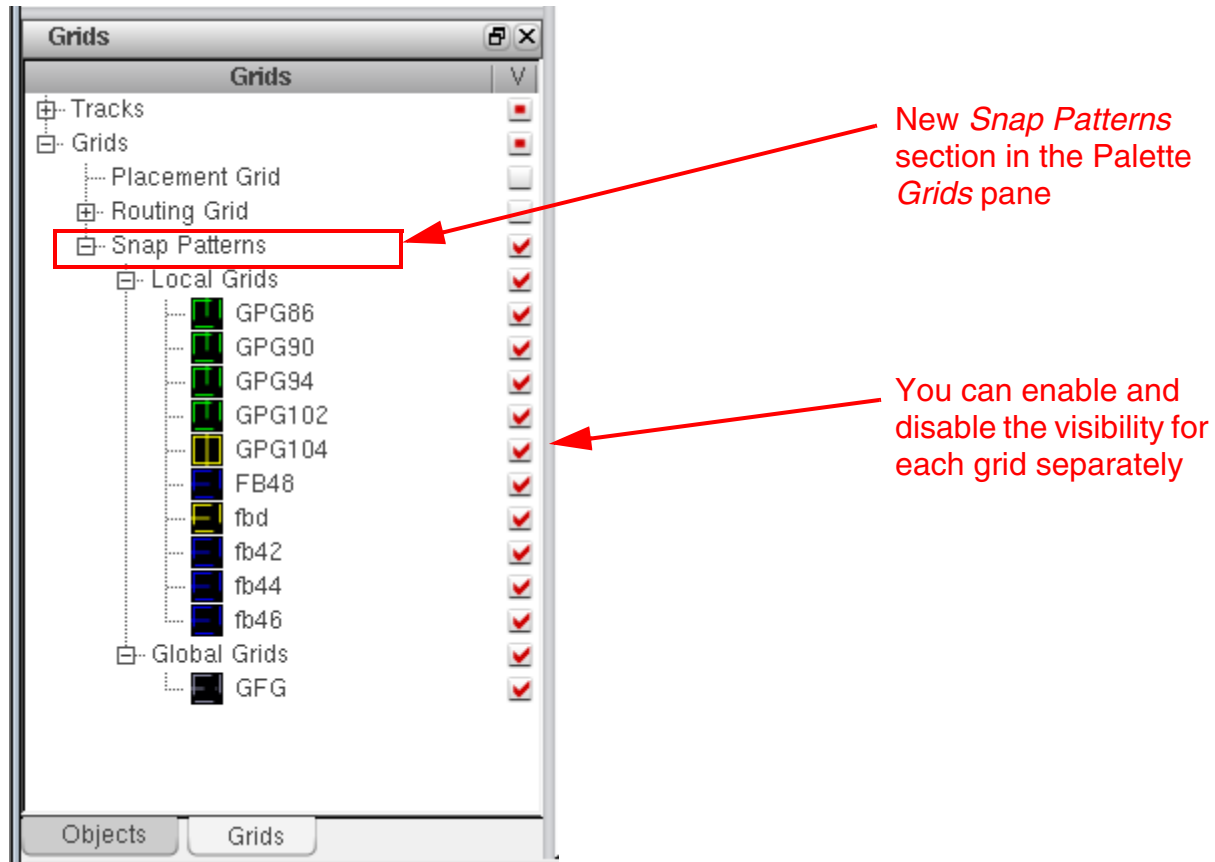
You activate the global grid either through a constraint (`snapGridVertical` or `snapGridHorizontal`) or by drawing a corresponding snap pattern shape in the canvas.

For more information, see:

- [Controlling the Display of Global Grid](#)
- [Anchoring the Global Grid](#)

Controlling the Display of the Snap Pattern in the Palette

You control the visibility of local and global snap pattern grids on the Grids panel of the Palette assistant.



The grid drawing style is controlled through the *Snap Pattern Display* field in the Display Options form.

For more information, see [Controlling the Display of Snap Patterns](#).

Modes for Object Placement

For small FinFET devices, placement is performed by searching the instance master for fin grids. If no fin grids are found, the snapping shapes are searched. This functionality is referred to as *Detail Mode Placement*.

When placing large blocks it is not feasible to search through instance masters and snapping shapes. Instead, Cadence recommends that you use *Abstract Mode Placement*, which allows fast placement of large layout blocks. In Abstract Mode, an instance snaps to a global

snap pattern grid using either its snap boundary or PR boundary, or – if neither is found – the instance origin axis. For more information, see [Abstract Mode Placement](#).

There may also be situations where neither Detail Mode or Abstract Mode are appropriate; for example, when the design has a third-party IP block laid out using a different methodology. In these cases, you can use the *Manual Mode Placement Override* to manually specify the placement mode or offset on a per instance or per master basis. You do this by setting the `leSnapPatternSnapping` property on either the instance or the master concerned. For more information, see [Manual Mode Placement Override](#).

SKILL Function for Fin Grid Snapping

A new `leGetSnapToSPTTransform` SKILL function has been added to compute how far and in which direction an object must be moved to align it with the grid. It can be used in conjunction with existing SKILL commands used to move objects, such as `dbMoveFig`, and helps ensure that objects are placed legally after the move is complete.

Customizing the Create Guard Ring Form

When working at advanced node and advanced nodes methodologies, some system-defined GUI components available on the Create Guard Ring form might not be applicable. In such circumstances, you can customize the Create Guard Ring form to display user-defined widgets that let you use fluid guard rings for your specific design needs. Virtuoso provides some triggers and SKILL API functions specifically designed for this purpose. For more information, see [Customizing the Create Guard Ring Form](#) in the *Virtuoso Fluid Guard Ring User Guide*.

FinFET Support in Layout XL

This section summarizes the enhancements made to Layout XL to support FinFET devices in your design. These include the provision of new `NFIN` and `PFIN` component type attributes in CPH and the LAM file and the enhancement of the folding engine to support folding of FinFET devices. There is also support for snapping during the generation and editing of FinFET devices in the layout canvas and for generating a constraint-driven PR boundary.

Component Type Definition for FinFET Devices

For FinFET devices to be recognized by layout generation commands such as *Generate All From Source* and for these devices to support operations such as chaining and folding, they must be assigned to an appropriate component type—`PFIN` or `NFIN`. You define these component types and assign devices to them using either:

- The *Configure Physical Hierarchy* command. See [Component Types Mode](#) for more information.
- The library and attributes mapping (LAM) file. See [LAM File Component Type Section](#) for more information.

Generating a Constraint-Driven PR Boundary

The *Generate All From Source* and *Update Components And Nets* commands now generate a PR boundary with dimensions based on a new [allowedPRBoundaryDimensions](#) constraint, which ensures that the PR boundary is legal for use in FinFET-based designs.

The constraint has the following syntax:

```
spacings (
    (allowedPRBoundaryDimensions
        ['vertical' | 'horizontal']
        ['stepSize g_step'] (g_ranges)
    )
);spacings
```

The `allowedPRBoundaryDimensions` constraint can be applied separately for the horizontal and vertical directions to cover all the dimensions of a PR boundary.

Preserving Snap Patterns and Generating Devices

Generate All From Source now features an option to preserve any *Snap Patterns* already defined in the layout view. See [Preserving Snap Patterns during Layout Generation](#) for more information.

Layout XL now also correctly snaps FinFET devices to the fin grid defined for the design in the following scenarios:

- When placing FinFET devices in your layout using the *Generate Selected From Source* command in *Group As In Schematic* mode, the generated devices are automatically snapped to the fin grid.
- When moving a chain of abutted devices in the layout canvas, all the devices in the chain are snapped together (i.e., the snapping does not break any existing chains).

Folding FinFET Devices

Folding lets you divide an individual device or a chain of devices into two or more layout instances with terminals connected in parallel to the same nets. The aim is to change the aspect ratio of the devices in your design while retaining the original orientation and design intent of the device that was folded.

To enable folding for FinFET devices, the devices in question must have their component classes correctly defined as either `NFIN` or `PFIN` as described above. See [Component Types Mode](#) for more information.

Additionally, the *Number of fins* parameter or the *Width parameter* must be set in the folding form. For more information, see [Folding a Transistor](#) in the *Virtuoso Layout Suite XL User Guide*.

FinFET Support in Modgens

The Module Generator feature has also been enhanced to support FinFET-based design.

Snapping Modgens

Because the layout editor has been enhanced to automatically snap the parameterized cells in modgens to the snap pattern, the entire modgen block is also snapped to the top-level snap pattern shape.

Additionally, the Modgen Dummy Options form now includes an option to specify the number of fins for dummy devices. For more information, see [Defining Dummy Device Properties](#) in the *Module Generator User Guide*.

FinFET Support in DRD Editing

Design rule driven editing now supports the creation and placement of FinFET devices that adhere to FinFET-specific spacing, width, and enclosure rules:

- Use the `allowedSpacingRanges` constraint to define legal spacing rules in the form of ranges and discrete values. See [Defining Discrete Spacing Rules](#).
- Use the `minSpacing` constraint with derived layers to define the minimum spacings between fin boundaries. See [Defining Minimum Spacing Rules](#).
- Use the `allowedWidthRanges` constraint to define directional legal width rules in the form of ranges and discrete values. See [Defining Directional and Discrete Width Rules](#).
- Use the `allowedPRBoundaryDimensions` and `minPRBoundaryInteriorHalo` constraints to define directional legal spacing and width rules for PR boundaries. See [Defining Directional and Discrete P&R Boundary Rules](#).
- Use the `minOppExtension` constraint to define directional and discrete enclosure rules for overlapping shapes on two different layers. See [Defining Directional and Discrete Opposite Extension Rules](#).

For more information on these features, see [DRD Support for FinFET Devices](#) in the *Virtuoso Design Rule Driven Editing User Guide*.

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