

# **Virtuoso Photonics Solution Guide**

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# Preface

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This document describes how to use the Cadence® Virtuoso® Photonics Solution. Virtuoso Photonics Solution is a photo-electronic co-design, co-simulation methodology supported in Cadence® Virtuoso® Layout Suite EXL (Layout EXL) that enables designers to design for hybrid systems in familiar Virtuoso environment.

This document is aimed at developers and designers of Photonic Integrated Circuits (PIC) and assumes that you are familiar with:

- The Virtuoso design environment and application infrastructure mechanisms supporting consistent operations between all Cadence tools.
- The applications for designing and developing integrated circuits in the Virtuoso design environment, notably the Cadence® Virtuoso® Schematic Editor, Cadence® Virtuoso® Analog Design Environment, and the Cadence® Virtuoso® Layout Suite XL (Layout XL) layout editor.
- Virtuoso technology data.
- Component description format (CDF), which lets you create and describe components for use with Layout XL.

This preface contains the following topics:

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

## Scope

Unless otherwise noted, the functionality described in this guide can be used in the ICADVM18.1 release.

## Licensing Requirements

To use the Virtuoso Photonics Solution, you must have access to the following design environment capabilities:

- **Virtuoso Release:** ICADVM18.1 ISR8 (or later)

For information about licensing in the Virtuoso design environment, see [\*Virtuoso Software Licensing and Configuration Guide\*](#).

- **Virtuoso Layout Suite Application:** Cadence® Virtuoso® Layout Suite EXL (Layout EXL)

For information about the Layout EXL editor, see [\*Virtuoso Layout Suite EXL Reference\*](#).

## Related Documentation

This document does not contain information about all the functions and commands enabled in Layout EXL. Many of the features available in Layout EXL and Layout XL are described in the dedicated user guides. Where this is the case, you will find specific references to the documents that contain the most detailed information.

For information on the SKILL® functions supported to enable the Virtuoso Photonics Solution, see [\*Virtuoso Design Environment SKILL Reference\*](#).

For information on any of the basic layout creation and editing commands supported in Layout XL, see:

- [\*Virtuoso Layout Suite XL: Basic Editing User Guide\*](#)
- [\*Virtuoso Layout Suite XL: Connectivity Driven Editing User Guide\*](#)

For information on any commands supported in Layout EXL, see [\*Virtuoso Layout Suite EXL Reference\*](#).



## **What's New and KPNS**

- [Virtuoso Photonics Solution What's New](#)
- [Virtuoso Photonics Solution 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](#) and the [Virtuoso Technology Data ASCII Files Reference](#)
- [Virtuoso Technology Data SKILL Reference](#)
- [Virtuoso Technology Data Constraints Reference](#)

## **Virtuoso Tools**

- [Virtuoso Layout Viewer User Guide](#)
- [Virtuoso Layout Suite XL: Basic Editing User Guide](#)
- [Virtuoso Layout Suite XL: Connectivity Driven Editing](#)
- [Virtuoso Layout Suite EXL Reference](#)
- [Virtuoso Concurrent Layout User Guide](#)
- [Virtuoso Multi-Patterning Technology User Guide](#)
- [Virtuoso Placer User Guide](#)
- [Virtuoso Simulation Driven Interactive Routing User Guide](#)
- [Virtuoso Width Spacing Patterns User Guide](#)
- [Virtuoso RF Solution Guide](#)

- [\*Virtuoso Electromagnetic Solver Assistant User Guide\*](#)

## **Relative Object Design and Inherited Connections**

- [\*Virtuoso Relative Object Design User Guide\*](#)
- [\*Virtuoso Schematic Editor User Guide\*](#)

## **Additional Learning Resources**

### **Video Library**

The [Video Library](#) on the Cadence Support portal 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 that 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 on Virtuoso Layout Suite XL:

- [\*Virtuoso Connectivity-Driven Layout Transition\*](#)
- [\*Virtuoso Layout Pro: T3 Basic Commands \(XL\)\*](#)
- [\*Virtuoso Layout Pro: T4 Advanced Commands \(XL\)\*](#)

### ■ Virtuoso Layout for Advanced Nodes

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

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 Support portal [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.
<code>text</code>	Indicates text that you must type exactly 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 <b>must</b> choose one.
[ ]	Encloses an optional argument or a list of choices separated by vertical bars, from which you <b>may</b> choose one.
[ ?argName <i>t_arg</i> ]	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.

# **Virtuoso Photonics Solution Guide**

## **Preface**

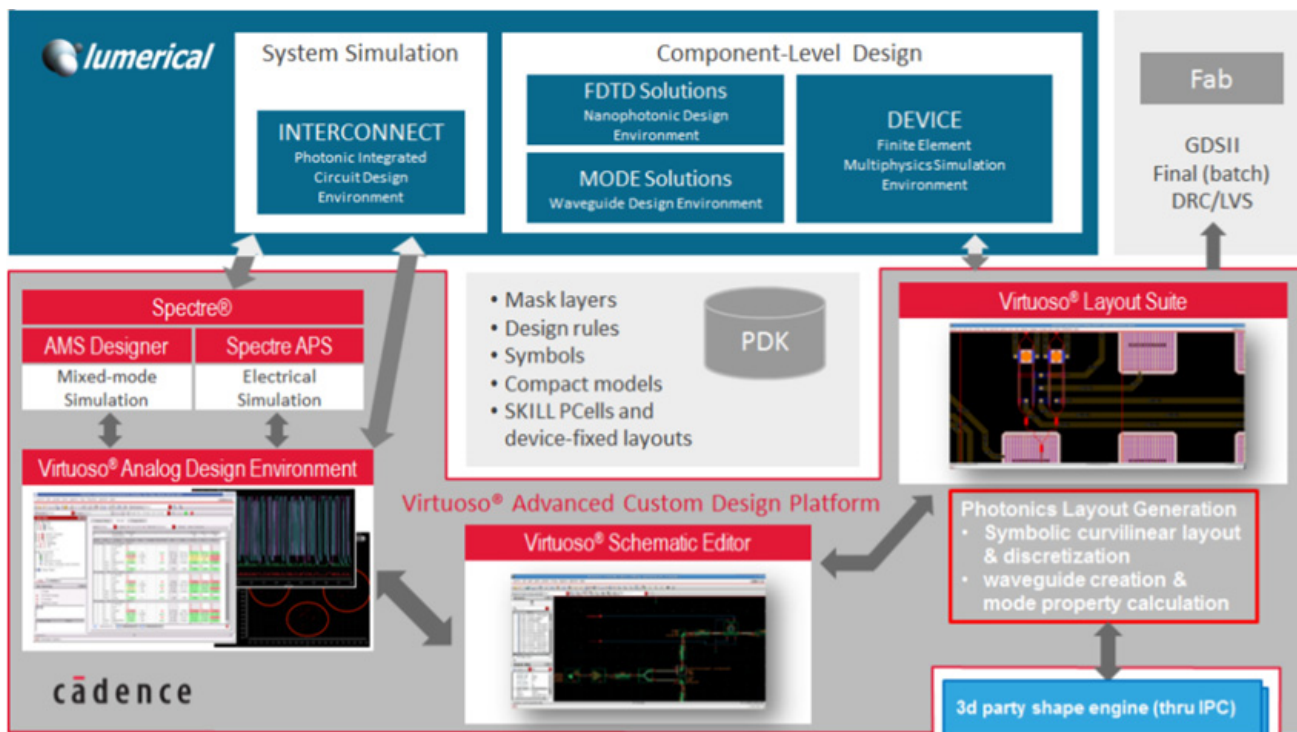
---

# Introduction to the EPDA Framework

Photonics, the science and technology of generating, controlling, and detecting light, is quickly moving into mainstream electronic designs. This is particularly true for communications hardware, where bandwidth demands are so high that only Photonic Integrated Circuits (PICs) offer a viable solution. Other key application areas include data centers, antenna and RF systems, biophotonics, and environmental sensing systems.

To address the challenges of designing PICs, Cadence® has developed an integrated Electronic-Photonic Design Automation (EPDA) environment in collaboration with Lumerical®.

## EPDA for Photonics Integrated Circuits



Built on the Cadence® Virtuoso® custom IC Design platform, the EPDA environment supports both the monolithic and hybrid design approaches. In monolithic approach, a single chip carries both traditional electronic and photonic design elements. In hybrid approach, a 3D-IC stack is used with a traditional electronics chip on top of a photonics chip, providing schematic and layout-driven design flows that support:

- Photonic schematic capture in the Cadence® Virtuoso® Schematic Editor.
- Photonic circuit simulation in the Cadence® Virtuoso® Analog Design Environment, using Lumerical® INTERCONNECT®, a dedicated PIC simulation engine.
- Photonic layout implementation in the Cadence® Virtuoso® Layout Suite environment.
  - Schematic-driven layout, using the same golden schematic as the one used for simulation.
  - Complex photonic Pcells and advanced photonic layout generators using the Cadence® SKILL® scripting language.
  - Backannotation of device and compounded waveguide parameters to schematic for layout-accurate optical re-simulation.
- Photonic component parameter and model generation for custom-defined components.
- Co-design of the electronic and photonic components for hybrid systems.

## About the CurvyCore Technology

To support the development of complex curvilinear shapes for photonic designs, which are based on complicated mathematical equations, Cadence natively supports the CurvyCore® technology in Virtuoso® Layout Suite EXL. Integration of the CurvyCore technology in the Virtuoso custom IC design platform makes it possible for designers to work on complex technologies and designs in a familiar design environment. In addition, the collaboration makes it possible for designers to factor in both the electronic- and opto-electronic effects into the design much earlier in the cycle and put together a full electronic-photonic solution within the same design environment. For more information on the CurvyCore technology and how integration in Virtuoso makes it advantageous for a photonics designer, see [CurvyCore](#).

## Setting Environment Variables

Environment variables control the Photonics design environment. For a list of all the environment variables supported by the Virtuoso Photonics Solution and the default and supported values of these environment variables, see [List of Photonics Solution Environment Variables](#).



There are two ways in which you can set environment variables:

- To set an environment variable that is applied every time you invoke the Virtuoso Photonics design environment, add the setting to your `.cdsenv` or `.cdsinit` file. For more information, see [Setting Environment Variables in a .cdsenv or .cdsinit File](#).
- To set an environment variable that is applied for the duration of the current session, use the `envSetVal()` command in the CIW. For more information, see [Setting Environment Variables in the CIW](#).

## Setting Environment Variables in a .cdsenv or .cdsinit File

To have your environment variables set automatically when you start the Virtuoso Photonics design environment, do one of the following:

- Include the environment variables in the `.cdsenv` file in your home directory; for example,

```
layoutXL phoAbutNonPcells boolean t
```

- Include an `envSetVal()` command in your `.cdsinit` file

```
envSetVal("layoutXL" "phoAbutNonPcells" 'boolean t)
```

For more information on the `.cdsenv` and `.cdsinit` files, see [Environment Variables in the Virtuoso Layout Suite XL: Basic Editing User Guide](#).

## Setting Environment Variables in the CIW

If you use any environment variable values consistently and do not want to set these values each time you use a command, you can set the variables to the value you normally use in the CIW and it will remain valid for the duration of the current session.

To set environment variables for a single session, do one of the following.

- Include `envSetVal()` in any other Cadence® SKILL® file you load.
- Type `envSetVal()` in the CIW.

For example, to set the `phoAbutNonPcells` variable, type the following in the CIW or include it in a setup file.

```
envSetVal("layoutXL" "phoAbutNonPcells" 'boolean t)
```

To determine the current value of any environment variable, type the following in the CIW.

```
envGetVal("layoutXL" "phoAbutNonPcells)
```

## Virtuoso Photonics Solution Guide

### Introduction to the EPDA Framework

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**Note:** Use the appropriate tool partition for the environment variable you want to set or look up the value for. For information about the tool partition—`layoutXL`, `graphic`, or `schematic`—associated with a specific environment variable supported for the Virtuoso Photonics Solution, see the related environment variable [documentation](#).

#### ***Related Information***

- [Virtuoso Layout Suite XL: Basic Editing User Guide](#)
- [Virtuoso Layout Suite XL: Constraint Aware Editing User Guide](#)
- [Virtuoso Design Environment SKILL Reference](#)
- [Virtuoso Layout Suite SKILL Reference](#)

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## Using EPDA in the Virtuoso Environment

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The unified Electronics-Photonics Design Environment (EPDA) framework is built upon the Virtuoso® Design Framework, leveraging the three core applications of the design framework—Virtuoso® Schematic Editor, Virtuoso® Analog Design Environment, and Virtuoso® Layout Suite. To enable a true co-simulation methodology within the Virtuoso platform, the EPDA framework supports optical signal simulation in Cadence® Virtuoso® Analog Design Environment using the Lumerical® Interconnect Photonic Integrated Circuit (PIC) simulator. For more information about the Lumerical PIC simulator, visit the [Lumerical](#) website.

The key advantage of using the EPDA framework for running the Virtuoso® Photonics® Solution is that Virtuoso supports the integration and implementation of optical signals largely in the same way as that for electrical signals. This makes it easy for both existing and new users to use Virtuoso for creating their electro-optical designs.

### Specifying Technology Information

To enable the generation and update of optical pins, you can update the technology file to define an additional constraint group—`virtuosoDefaultOpticalPinSetup`.

If specified, the `virtuosoDefaultOpticalPinSetup` constraint group defines the optical layers to use for generating and updating the optical pins. You can use the `opticalPinSetup` environment variable to specify the name of the constraint group to use for optical pin generation.

**Note:** You can also define the `virtuosoDefaultElectricalPinSetup` constraint group to specify the electrical layers to use for generating and updating electrical pins. To control the constraint group to use for electrical pin generation, use the `electricalPinSetup` environment variable.

If the `virtuosoDefaultOpticalPinSetup` or the `virtuosoDefaultElectricalPinSetup` constraint group is not defined, Virtuoso uses the `validLayers` defined in the default Layout EXL constraint group—`virtuosoDefaultSetup`—for pin generation.

## Launching Virtuoso in Photonics Mode

Depending on whether or not you already have the Virtuoso licenses available, you can launch Photonics using one of the following licensing options:

- Launching the Virtuoso Photonics Option
- Launching the Virtuoso Photonics Platform

**Note:** Virtuoso Photonics Solution, irrespective of the license you choose, is supported only in Layout EXL.

### Launching the Virtuoso Photonics Option

If you already have access to the Virtuoso design environment, you can invoke the additional Photonics capabilities supported in Virtuoso by using the Virtuoso Photonics Option (VPO) license.

To check out the Virtuoso Photonics Option license, set the following shell environment variables:

```
setenv Virtuoso_Photonics_Option t
setenv Virtuoso_MultiTech t
```

### Launching the Virtuoso Photonics Platform

If you do not already have a dedicated license to access the Virtuoso design environment, you can check out a single, platform-level license called the Virtuoso Photonics Platform (VPP). This license enables all the Virtuoso design environment capabilities required for running the Photonics solution in addition to enabling the Virtuoso Photonics Solution.

To check out the Virtuoso Photonics Platform license, set the following shell environment variable:

```
setenv Virtuoso_Photonics_Platform t
```

### Verifying the Photonics License

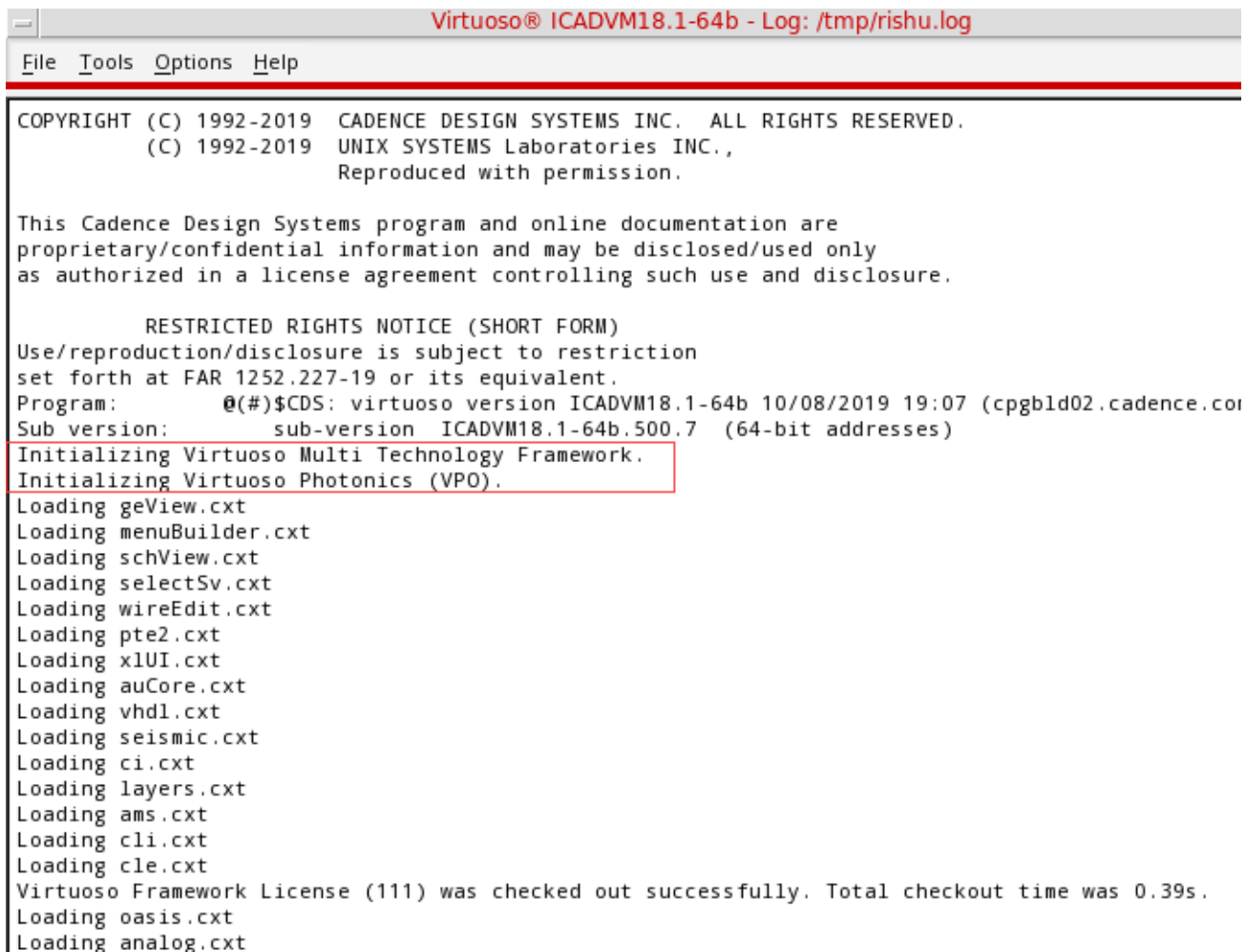
To verify whether the required Virtuoso Photonics Solution licenses are checked out and that the EPDA framework is being enabled, check that the Command Interpreter Window (CIW) issues the confirmation messages as highlighted in the screenshot below. The CIW is the first window that opens when a Virtuoso session is launched.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

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**Note:** Alternatively you can look for these confirmatory messages in the Virtuoso log file, which is saved by default as `CDS.log` in the home directory.



```
Virtuoso® ICADVM18.1-64b - Log: /tmp/rishu.log
File Tools Options Help

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set forth at FAR 1252.227-19 or its equivalent.
Program: @(#)CDS: virtuoso version ICADVM18.1-64b 10/08/2019 19:07 (cpgbld02.cadence.co
Sub version: sub-version ICADVM18.1-64b.500.7 (64-bit addresses)
Initializing Virtuoso Multi Technology Framework.
Initializing Virtuoso Photonics (VPO).
Loading geView.cxt
Loading menuBuilder.cxt
Loading schView.cxt
Loading selectSv.cxt
Loading wireEdit.cxt
Loading pte2.cxt
Loading xLUI.cxt
Loading auCore.cxt
Loading vhd1.cxt
Loading seismic.cxt
Loading ci.cxt
Loading layers.cxt
Loading ams.cxt
Loading cli.cxt
Loading cle.cxt
Virtuoso Framework License (111) was checked out successfully. Total checkout time was 0.39s.
Loading oasis.cxt
Loading analog.cxt
```

### ***Related Information***

[Licensing in Design Framework II](#)

[Using the Command Interpreter Window](#)

## Generating Layout

In Virtuoso, you can use the Virtuoso Suite EXL layout editor (Layout EXL) to generate a single layout that allows you to define an initial placement of the electrical and optical components in the design.

This sections covers the following topics.

- Opening the Library Manager
- Creating a New Library
- Creating a New Library Cellview
- Creating a Schematic Cellview
- Creating a Schematic Cellview
- Creating a Layout Cellview
- Specifying the Components to be Generated
- Specifying the I/O Pins to be Generated
- Defining the Optical Pin Attributes

## Opening the Library Manager

All elements of a Virtuoso design—symbols, schematics, and layouts—belong to a library. Virtuoso can support several libraries simultaneously and a Virtuoso designer often works in a design library, which references a given fabrication process and uses the elements recommended for that process. Such a library is called a *process* library and it contains technology definitions in addition to containing information about basic devices. Optionally, a designer can use additional design elements from another library, called the *reference* library.

Virtuoso also supports some generic, process-independent libraries, such as `basic` and `analogLib`, which include common design elements.

**Note:** The generic libraries do not contain layout implementations for any elements.

To access the various libraries, you can open the Library Manager form in stand-alone mode from an `xterm` or a command line window or within the Virtuoso design environment using the CIW.

### To open the Library Manager in standalone mode:

- ➔ In a terminal window, type the following command:

```
libManager &
```

The Library Manager appears as a stand-alone application, which is not integrated in the Virtuoso design environment.

## Virtuoso Photonics Solution Guide

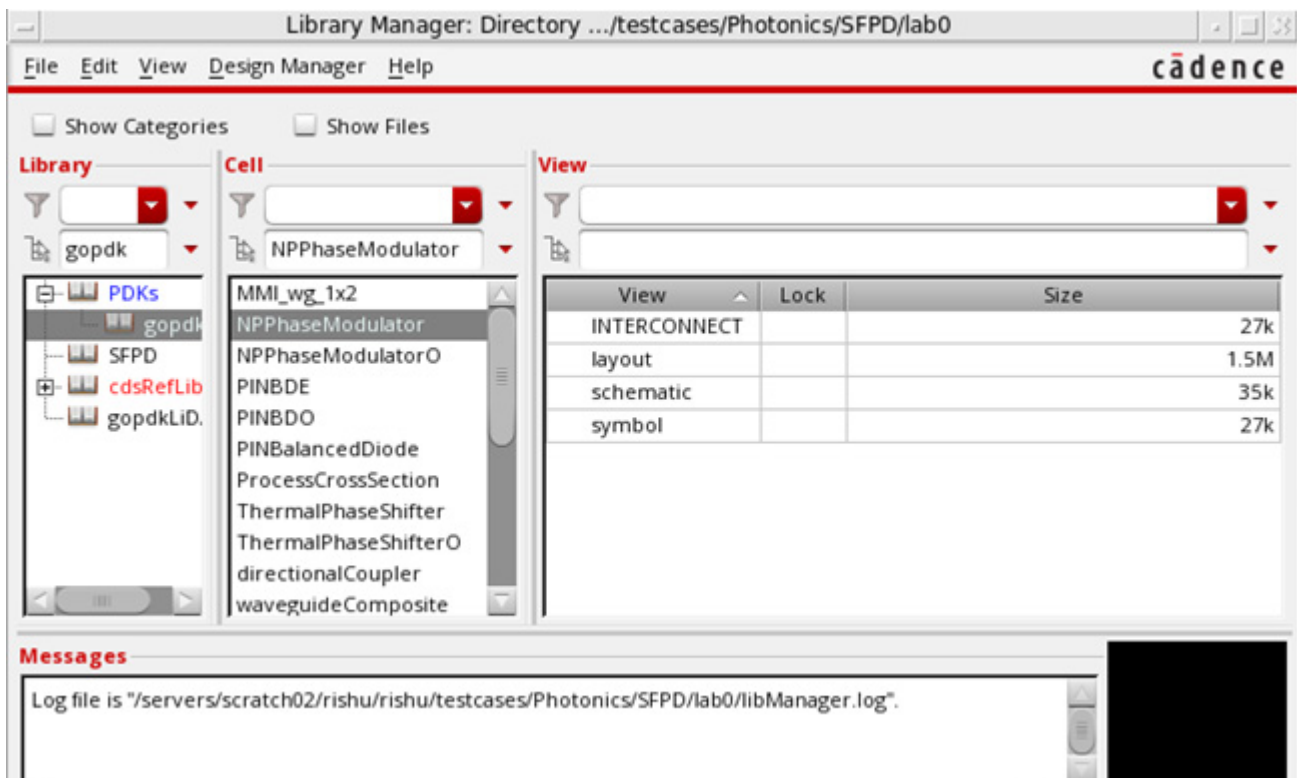
### Using EPDA in the Virtuoso Environment

**Note:** In stand-alone mode, you cannot open cellviews.

#### To open the Library Manager in Virtuoso Design Environment:

➔ In CIW, choose *Tools – Library Manager*.

The Library Manager form is displayed in the Virtuoso design environment as displayed in the figure.



#### Related Information

[Library Manager Form](#)

### Creating a New Library

In Virtuoso, you can create a new library using one of the following methods:

- [Creating a New Library using the Library Manager](#)
- [Creating a New Library Using the CIW](#)

## Creating a New Library using the Library Manager

To create a new library using the Library Manager:

1. In the Library Manager, choose *File – New – Library*.

Alternatively, you can click inside the *Library* list box and press `Ctrl+N` on the keyboard.

You can also type the name of the library in the *Library* field and press `Ctrl+N` to open the New Library form. In this case, the *Name* field in the New Library form is automatically populated with the name that you have entered in the *Library* field.

The New Library Form is displayed.

**Note:** Creating a new or temporary library within an existing library is not allowed because any directories within a library are handled as cells.

2. In the *Name* field, type the name of the library you want to create.

The new library name cannot be the same as another library.

3. The *Directory* navigation tools (list boxes and toolbar buttons) to specify the destination directory in which you want to create the new library. You can also type a directory path in the *Directory* field.

You must have permission to edit the directory in which you want to create a library.

**Note:** If you want the library to be under design management control, you must create it in a managed project area. For additional information about creating managed libraries, see the [Virtuoso Software Licensing and Configuration Guide](#).

4. (Optional) In the *Design Manager* group box, specify whether you want to use a design management system.

- ☐ If you want to use a design management system, select *Use <design management system>* (the default).
- ☐ If you do not want to use a design management system, select *Use No DM*.

**Note:** If there is no design management system available, *No design manager setup found* will be displayed.

For more information about design management systems, see [Design Manager](#).

5. You can select the *Compression Enabled* check box to write OpenAccess data to this library in a compressed format. For more information, see [Supporting OA Compressed Data Using Library Manager](#).

6. Click *OK*.



The Technology File for New Library form is displayed.

7. Choose the *Reference existing technology libraries* technology file options.

For more information about the various technology files options, see [Creating a Library](#) in the *Cadence Library Manager User Guide*.

For more information about technology files, see the [Virtuoso Technology Data User Guide](#).

## Creating a New Library Using the CIW

To create a new library using the CIW:

1. From the CIW, select *File – New – Library*.

The New Library form is displayed.

**Note:** Creating a new or temporary library within an existing library is not allowed because any directories within a library are handled as cells.

2. Enter a *Name* for your new library.
3. (Optional) Choose the name of the *Directory (non-library directories)* that you want to store your library in. Otherwise, you can specify the library path in the text box under the *Directory (non-library directories)* section.

**Note:** By default, the library will be created and stored in the current directory.

4. Choose the *Reference existing technology libraries* technology file options.

For more information about the various technology files options, see [Creating a Library](#) in the *Cadence Library Manager User Guide*.

For more information about technology files, see the [Virtuoso Technology Data User Guide](#).

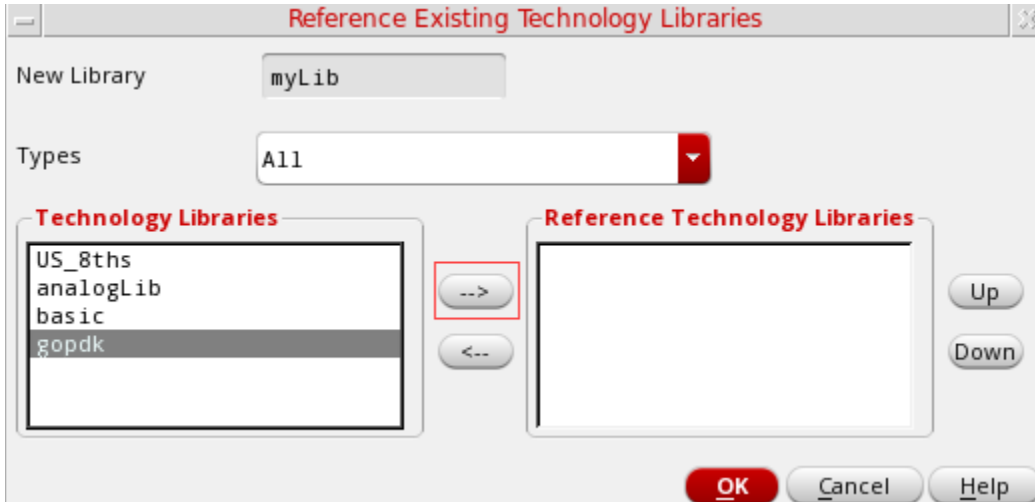
5. In the *Reference Existing Technology Libraries* form, double-click the *gopdk* library in the left column to move it to the right column.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

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Alternatively, you can move items from one column to the other by selecting the item and then clicking the appropriate arrow key to specify the direction of move.



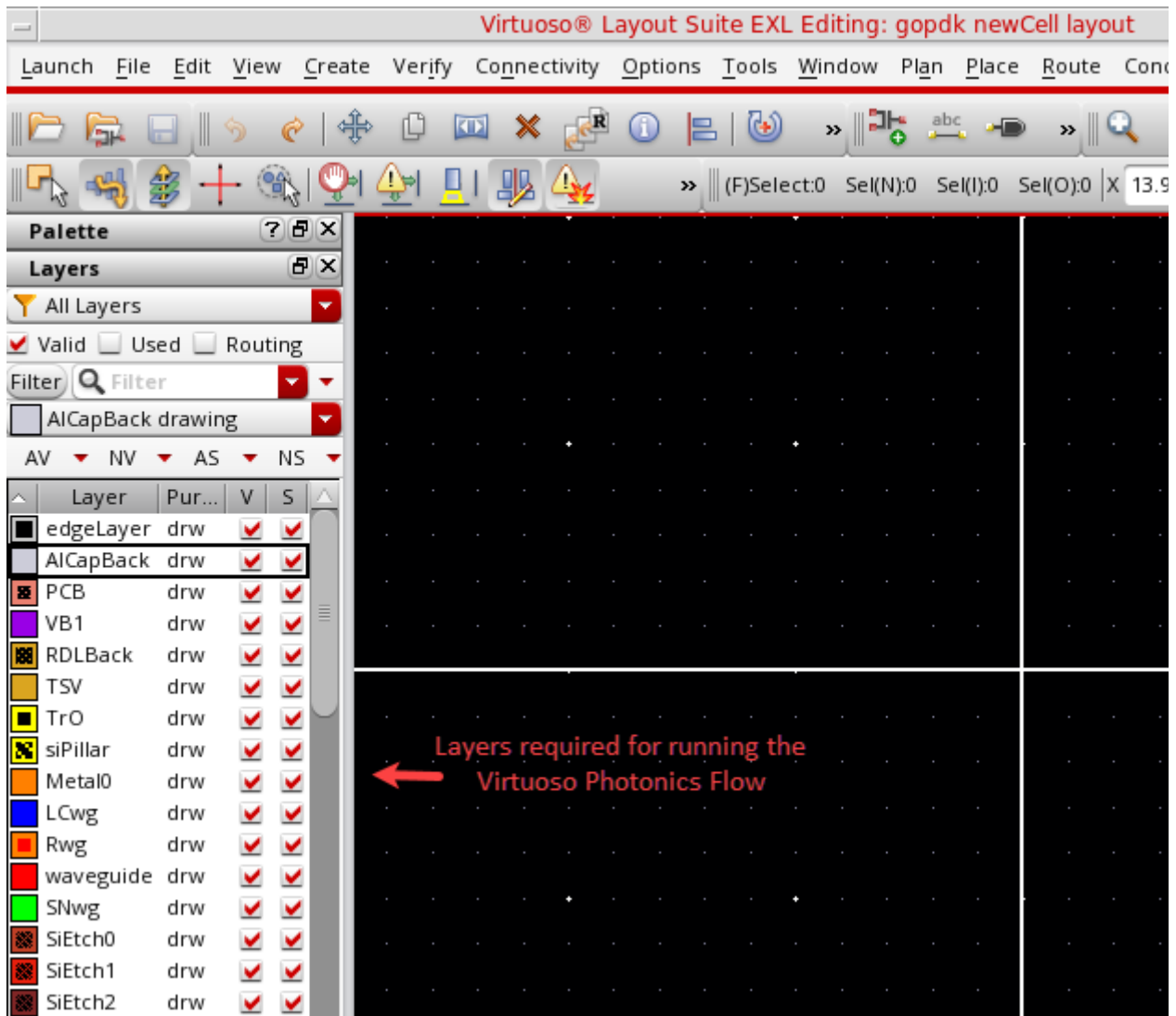
The new library is created.

6. Create a new layout cellview to verify if you have referenced the appropriate technology. See [Creating a Layout Cellview](#).
7. In the layout cellview opened in Layout EXL, right-click the menu bar and choose *Assistants – Palette*.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

8. The layout cellview displays the Palette assistant, as shown in the figure below. You can use the Palette assistant to verify that the layers required for running the Virtuoso Photonics Flow are supported.



### Related Information

#### Palette Assistant

## Creating a New Library Cellview

To create a new cellview:

1. Open the Library Manager.

**Note:** Alternatively, you can also create a new cellview from the CIW by following the same instructions.

2. Choose *File – New – Cell View*.

Alternatively, you can click inside the *Cell* or *View* list box and press `Ctrl+N` on the keyboard.

The New File form is displayed.

You can also type the name of the cell in the *Cell* field and press `Ctrl+N` to open the New File form. In this case, the *Cell* field in the New File form is automatically populated with the name that you have entered in the *Cell* field of the Library Manager form.

3. In the *Library* drop-down list, choose the name of the library in which you want to create a new cellview.
4. In the *Cell* field, type a cell name for the new cellview.
5. In the *View* field, type a view name for the new cellview.
6. In the *Type* drop-down list, choose the type of view to be opened.
7. In the *Application* section, select *Layout EXL*.
8. (Optional) Select *Always use this application for this type of file* to always open the selected application when the selected view type is opened.
9. Click *OK*.

The new cellview opens in the selected application.

### ***Related Information***

[Creating a Layout Cellview](#)

## **Creating a Schematic Cellview**

In Virtuoso, the schematic representation of the design forms the starting point for a design. As in the electrical flow, the schematic is also used to launch the circuit simulation and to generate a layout in the Virtuoso Photonics Flow. You can also update the schematic based on any design decisions made during the simulation or layout generation. After the layout updates have been backannotated to the schematic, you can use the updated schematic to run any verification checks. Therefore, it is important to create a good schematic design that

can serve all these purposes and help generate a connectivity-driven, correct-by-construction layout. For more information on creating schematics in Virtuoso, see the [Virtuoso Schematic Editor User Guide](#).

**Note:** Virtuoso supports the implementation of photonic Pcells in the same manner as that of electrical ones. Therefore, when you are in the EPDA framework, most of the Virtuoso features will continue to work the same way as in the pure electrical flow.

To launch the Virtuoso Schematic Editor to create a new schematic cellview:

1. Open the Library Manager.

**Note:** Alternatively, you can create a new cellview from the CIW by following the same instructions.

2. Choose *File – New – Cell View*.

Alternatively, you can click inside the *Cell* or *View* list box and press `Ctrl+N` on the keyboard.

The New File form is displayed.

3. In the *Library* drop-down list, choose the name of the library in which you want to create a new cellview.

If you have created any new libraries, they should be available in the list.

4. In the *Cell* field, type a cell name for the new cellview.

5. In the *View* field, type *schematic* to open the cell in the schematic view.

6. In the *Type* drop-down list, choose *schematic*.

7. In the *Application* section, choose *Schematics XL*.

8. Select *Always use this application for this type of file* to always open the selected application when the selected view type is opened.

9. Choose the appropriate *Open for* option.

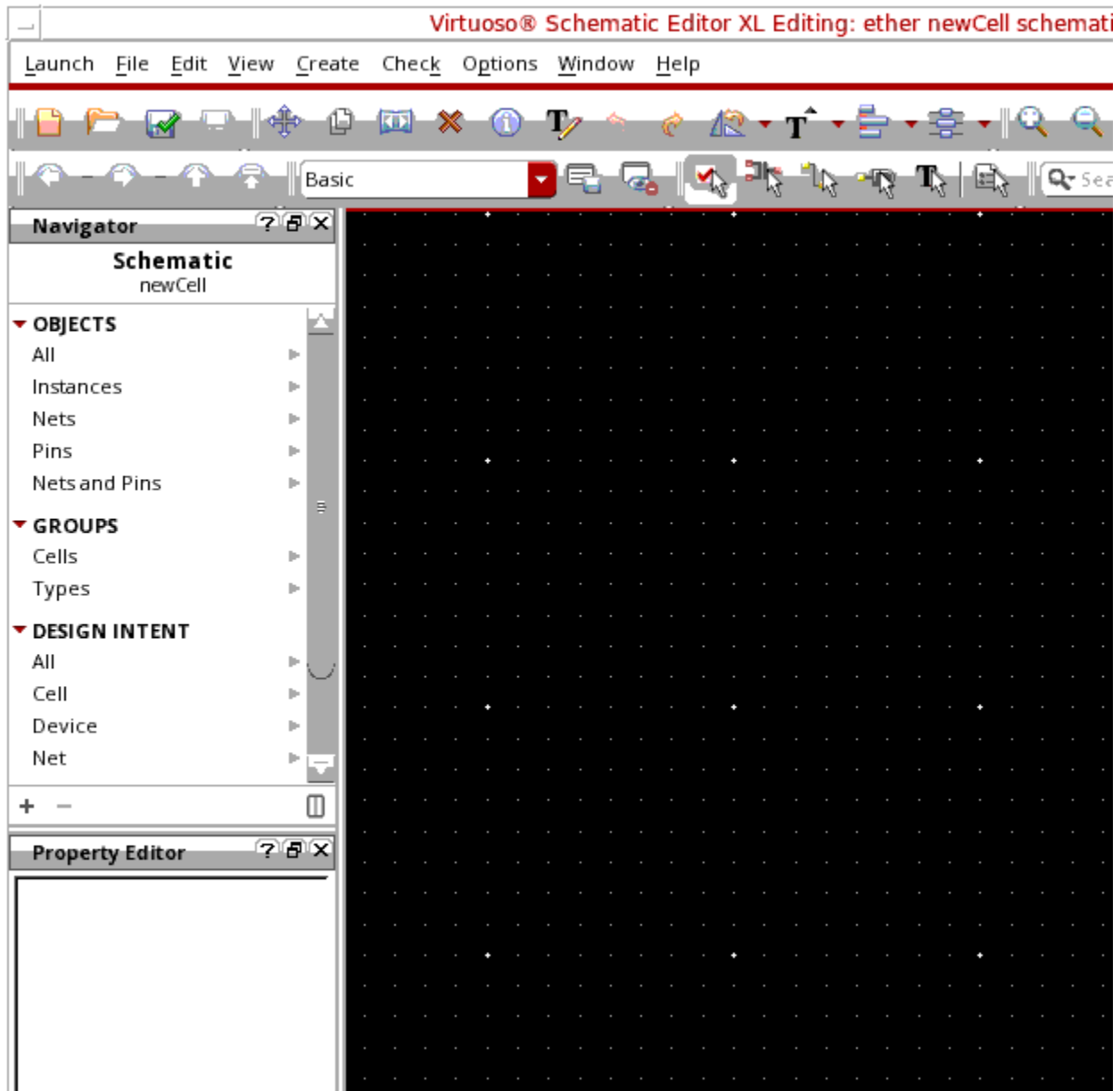
10. Click *OK*.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

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The new cellview opens in the selected application, as shown in the figure below.



### ***Related Information***

#### Creating Schematics

## Opening a Schematic Cellview

To open an existing schematic cellview:

1. Open the Library Manager.

**Note:** You can also open a new cellview from the CIW by following the same instructions.

2. Choose *File – Open – Cell View*. Alternatively, you can click inside the *Cell* or *View* list box and press `Ctrl+N` on the keyboard.

The Open File form is displayed.

3. In the *Library* drop-down list, choose the name of the library from which you want to open the schematic cellview.

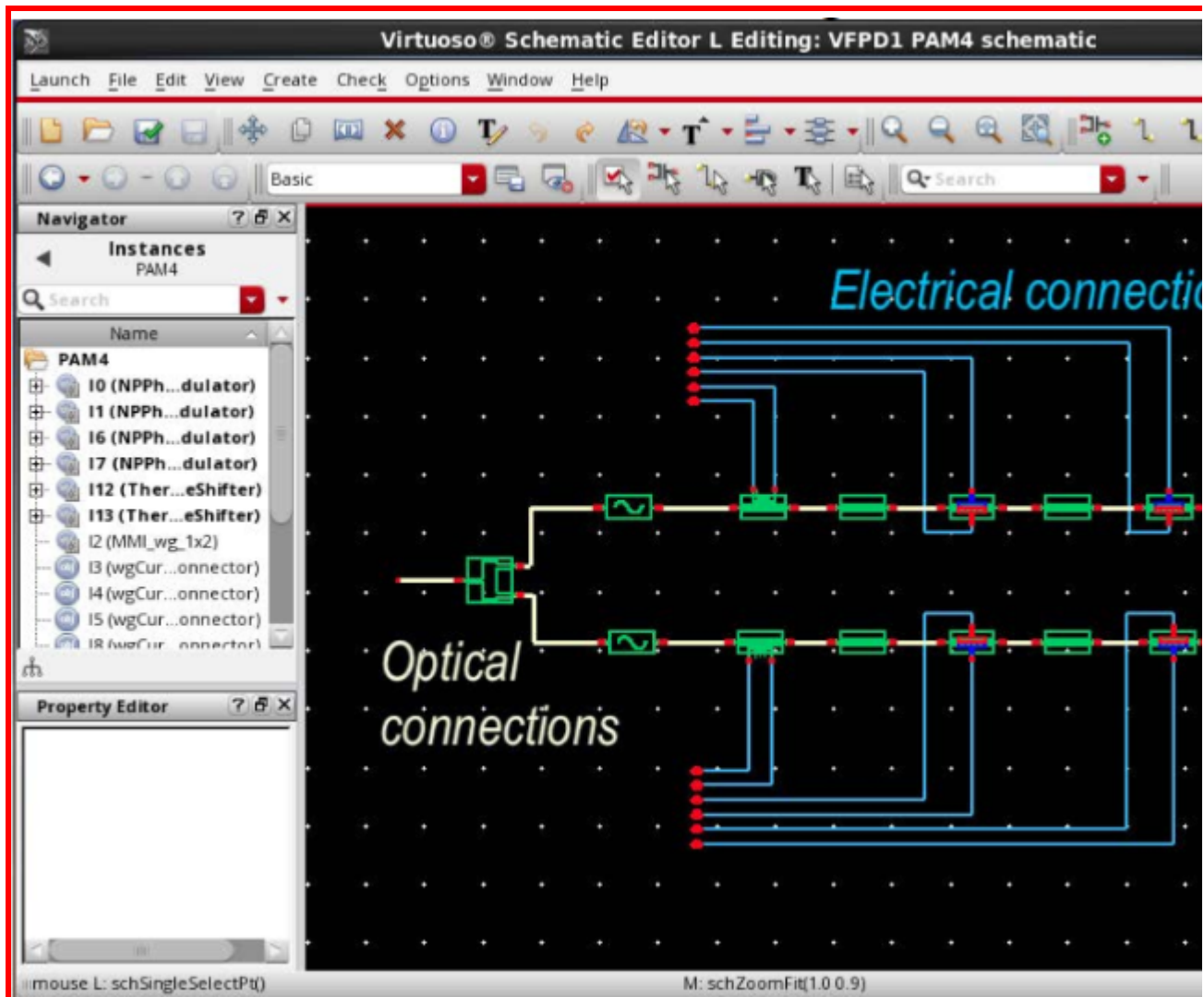
If you have created any new libraries, they should be available in the list.

4. In the *Cell* field, type the name of the cell to open.
5. In the *View* drop-down list, choose *schematic*.
6. In the *Application* section, choose *Schematics L*.
7. Click *OK*.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

The schematic cellview opens in the Virtuoso Schematic Editor window. If the schematic you opened includes both electrical and optical connections, the schematic editor displays the connections differently.



### Related Information

#### Creating Schematics

### Creating a Layout Cellview

To create a layout cellview:



1. Open the Library Manager.

**Note:** Alternatively, you can create a new cellview from the CIW by following the same instructions.

2. Choose *File – New – Cell View*.

Alternatively, you can click inside the *Cell* or *View* list box and press `Ctrl+N` on the keyboard.

The New File form is displayed.

3. In the *Library* drop-down list, choose the name of the library in which you want to create a new cellview.

If you have created any new libraries, they should be available in the list.

4. In the *Cell* field, type a cell name for the new cellview.

5. In the *View* field, type *layout* to open the cell in the layout view.

6. In the *Type* drop-down list, choose *layout*.

7. In the *Application* section, choose *Layout EXL*.

**Note:** The Virtuoso Photonics Flow is supported only in the Layout EXL application.

8. Select *Always use this application for this type of file* to always open the selected application when the selected view type is opened.

9. Choose the appropriate *Open for* option.

10. Click *OK*.

The new cellview opens in the selected application.

## Specifying the Components to be Generated

Use the Generate All From Source toolbar button to generate layout representations of the schematic design components. Alternatively, you can choose the *Connectivity — Generate* menu command to open the Generate Layout form.

For the schematic instances that have layout representations available, the *Generate All From Source* command creates corresponding layout views in the canvas.

To specify the components to be generated:

1. In the Generate Layout form, select the *Generate* tab.

2. In the *Generate* group box, select the *Instances*, *I/O Pins*, and *PR Boundary* options, as required.
  - a. To chain transistors, select the *Chain* check box.  
For information on chaining optical pins, see [Generating Optical Chains](#).
  - b. To stop Layout EXL from generating layout pins for global nets in the schematic, select *Except Global Pins*.
3. To preserve any user-defined binding of devices between the schematic and the layout, select *Preserve User-Defined Bindings*.
4. Click *OK*.

### ***Related Information***

#### Generating All Components From Source

## **Specifying the I/O Pins to be Generated**

You specify the pins to be generated on the *I/O Pins* tab of the Generate Layout form.

For each pin listed, the form shows the parameters that will be used to generate its equivalent in the layout. You can remove or change the specification of any of the listed pins, or add new pins to be generated.

When generating pins, Layout EXL uses the same naming convention as the Virtuoso Schematic Editor, allowing you to assign different names to terminals and nets. Where terminal and net names are different in the schematic, Layout EXL creates pins with the same terminal name as in the layout, even though the net name associated with the pin might be different.

Power and ground pins defined at a lower level of the design hierarchy are not listed on the *I/O Pins* tab but the pins are still generated in the layout view. Virtuoso issues a message in the CIW to notify you about the operation.

## **Specifying the Default Values for All Electrical Pins**

To specify the default values for all electrical pins:

1. In the Generate Layout form, select the *I/O Pins* tab.
2. Choose the default routing layer from the *Layer* cyclic field.

The list of pin layers is obtained from the technology information applied to the design.

3. Specify the default *Height* and *Width* of the electrical pins and the *Number* of pins you want to create.
4. Check the *Create* box to specify that the pins are to be created in the layout view.
5. Click *Apply*.

The specified values are applied to all the electrical pins displayed in the list box.

### ***Related Information***

#### Specifying the I/O Pins to be Generated

### **Defining the Optical Pin Attributes**

When generating optical pins, Layout EXL uses the same naming convention as specified in the Virtuoso Schematic Editor, allowing you to assign different names to ports and nets. Where port and net names are different in the schematic, Layout EXL creates pins with the same terminal name as in the layout, even though the net name associated with the pin might be different.

If a pin is associated with an optical net, Layout EXL automatically generates optical pins on an optical layer, such as the `waveguide` layer. By default, the layer to be used for the optical pin generation is determined from the value set for the `phoPinLayer` environment variable. If the environment variable does not have a valid layer set, the first photonic layer in the `validLayer` list is used.

Each optical pin can have the following attributes defined:

- **Width:** Width of the waveguide associated with the photonic port.
- **Radius:** Curvature of the waveguide associated with the photonic port.  
By default, the radius is not defined.
- **Angle:** Access direction of the photonic port.

### **Generating Optical Pins**

To generate an optical pin in the layout:

1. In the Generate Layout form, select the I/O Pins tab.

2. Choose the default routing layer from the *Layer* cyclic field.

The default pin layer is determined from the value set for the `phoPinLayer` environment variable.

3. Specify the default *Width*, *Radius*, and *Input Angle* of the pins you want to create.

**Note:** The default value set for *Input Angle* applies only to the input pins. The output pins are set to a complementary angle value.

4. Select the *Create* check box to specify that the pins are to be created in the layout view.
5. Click *Apply* to generate the pins in the layout.

### Updating Optical Pins

1. In the Generate Layout form, select the I/O Pins tab.
2. In the *Optical* tab, select the pins to be updated.

**Note:** The *I/O Pins* tab is split into *Electrical* and *Optical* tabs, if the schematic has both the pin types defined. To update a specific pin type, the appropriate pin tab must be selected.

3. Specify the new *Layer*, *Width*, *Radius*, and *Angle*, as appropriate.
4. (Optional) Select the *Create* check box, if you want the pins to be created after the update.
5. Click the *Update* button.

The selected pins are updated.

## Generating Selected From Layout

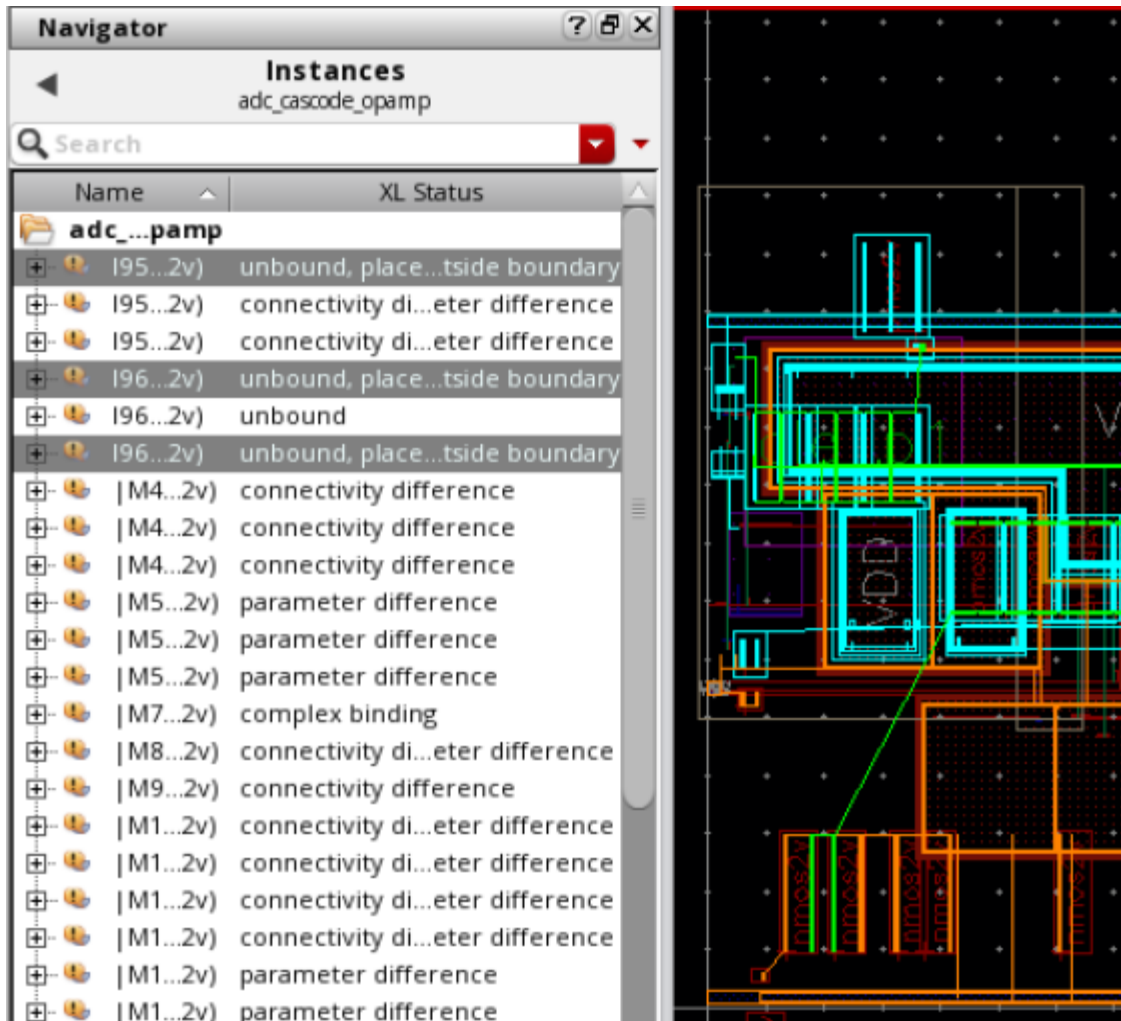
In Virtuoso Layout Suite EXL, if you have the `Virtuoso_Photonics_Option` license checked out, you can select unbound layout components and generate them in the schematic.

To generate the selected layout components in the corresponding schematic window:

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

1. In the Layout EXL Navigator assistant, select the instances or terminals that display their *XL Status* as *unbound*.



2. Choose *Connectivity – Generate – Selected From Layout*.

Alternatively, click the *Generate Selected From Layout* button on the Layout XL toolbar.

If the corresponding schematic cellview is read-only, a message is issued to prompt that the cellview be made editable.

If the corresponding schematic cellview is editable and the schematic has not already been extracted, a dialog box pops up to ask if the schematic cellview can be extracted.

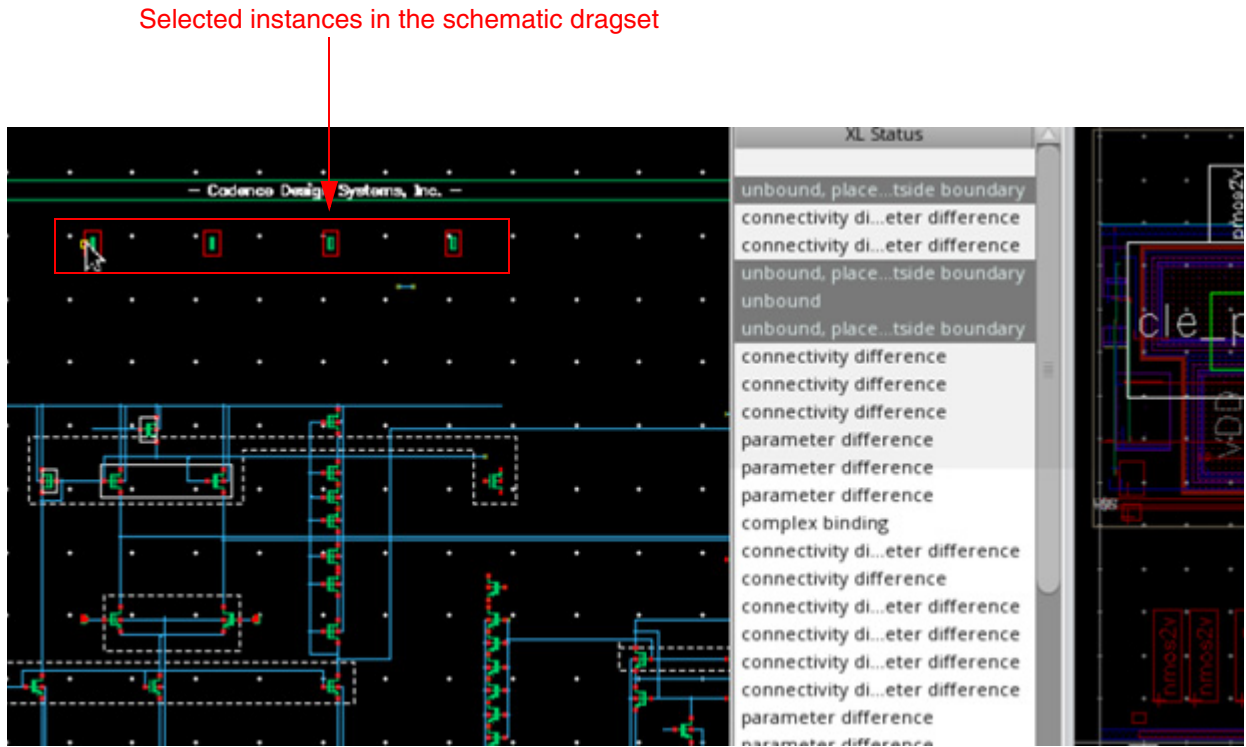
3. Click OK to proceed with the extraction of the schematic cellview.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

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The selected instances are added to the dragset and are available for placement in the schematic view.

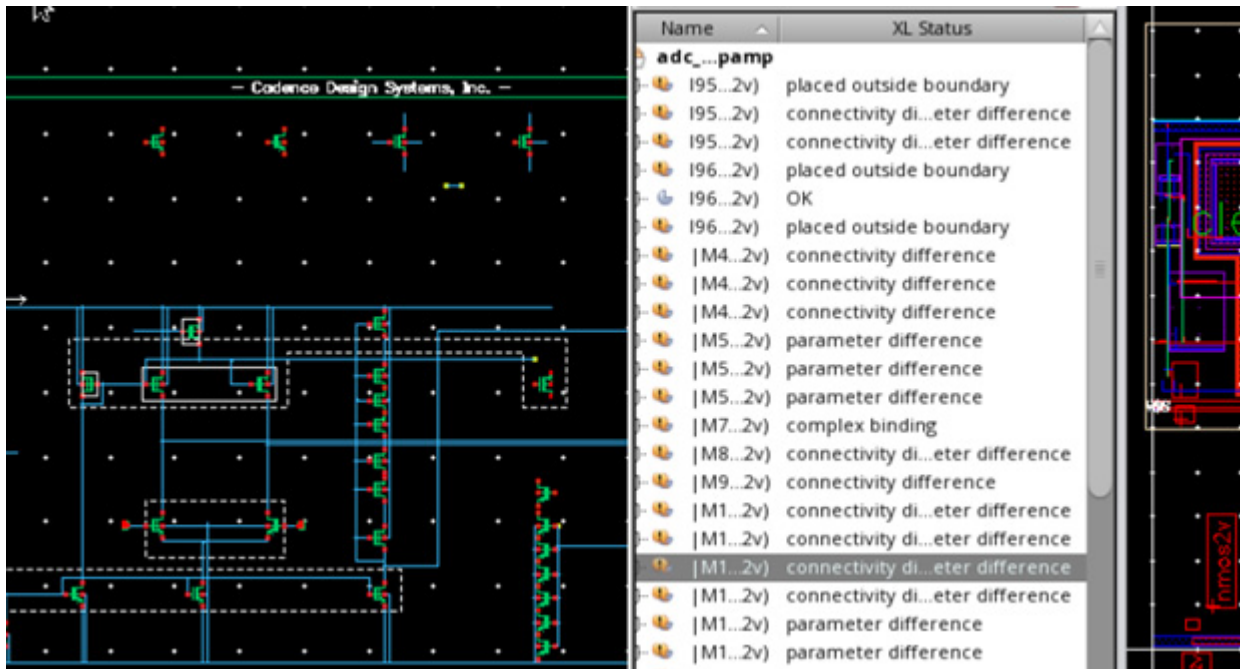


4. Click anywhere in the schematic canvas to place the selected instances.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

The selected instances are placed in a row in the schematic cellview, reflecting their layout connectivity. The XL Status of the instances in the layout view is updated to reflect the current status.



### Related Information

[IxHiGenerateSelectedFromLayout](#)

[generateSchematicMfactor](#)

[Generating Layout](#)

## Abutting Photonic Elements

The Virtuoso Photonics Flow supports all the abutment features for photonic elements as are currently supported for electronic elements. In addition, the flow allows an additional type of abutment, which aligns the center point of an optical port with the matching facet (*width*, *angle*, or *layer*) information. This enables any-angle abutment support for photonic elements.

For photonic elements, abutment is triggered by overlapping photonics ports, provided the corresponding layers have been set up to trace optical connectivity in the technology database.

In addition, for photonic layouts, abutment is enabled for optical pins of non-Pcell devices. Abutment is also supported with optical ports, enabling creation of optical chains through the hierarchies.

If you set the `phoAbutNonPcells` environment variable to `t`, Layout EXL also supports the abutment of non-Pcell instances with Pcell instances and other non-Pcell instances. During non-Pcell abutment, top-level pins can abut with instance pins. By default, instance pins on the same pin layer are abutted and aligned at the center.

For photonic designs, waveguide abutment is also supported. However, for the waveguide abutment to be possible, the two abutting waveguides must be perfectly aligned and the abutting ports must be on the same net. If the abutting waveguides result in any shorts, the corresponding markers are generated in the [Annotation Browser](#) assistant.

## Related Information

[Device Abutment](#)

## Generating Optical Chains

In the EPDA framework, you can use the following Layout XL commands to chain optical waveguide instances:

- *Generate All From Source*
- *Update Components And Nets*
- *Generate Selected From Source*
- *Generate Chained Devices*

When using *Generate All From Source* and *Update Components And Nets*, the layout instances selected for chaining are checked using the `phoIsWaveguide` SKILL function to verify them as waveguide instances. If the selected instances are found to be waveguides, they are chained during layout generation.

However, when layout generation is being performed using the *Generate Selected From Source* command, all the connected optical devices are chained. The `phoIsWaveguide` SKILL function is not used in this case.

You can also chain waveguide instances and top-level photonic pins using the Virtuoso® Layout Suite XL *Connectivity – Generate – Chained Devices* command or use the context-sensitive *Chain* menu option. When the selected set includes only waveguide



instances and photonic pins, the *Chain* context-sensitive menu has only the *Default* option enabled. The other menu options, *Top*, *Center*, and *Bottom*, are disabled in this case.

**Note:** The following interactive chaining options are not supported for photonic devices:

- *Preserve Existing Chains*
- *Use Device Order*
- *Interdigitate Chains*
- *Mirror*
- *Permute Pins*
- *Align PMOS*
- *Align NMOS*

### ***Related Information***

[1xChain](#)

[Manual Device Abutment](#)

[Create Pin Options: Virtuoso Photonics Solution \(ICADVM18.1 Only\)](#)

[Composite Waveguide Editor](#)

[Abutment in Virtuoso Photonics Solution](#)

## **Generating an Incremental Chain**

When using the Virtuoso Photonics Solution, you can incrementally create a chain by adding an object to an anchor. An anchor can be an instance or a top-level pin object, or a group of such abutted objects, which retains its position after chaining.

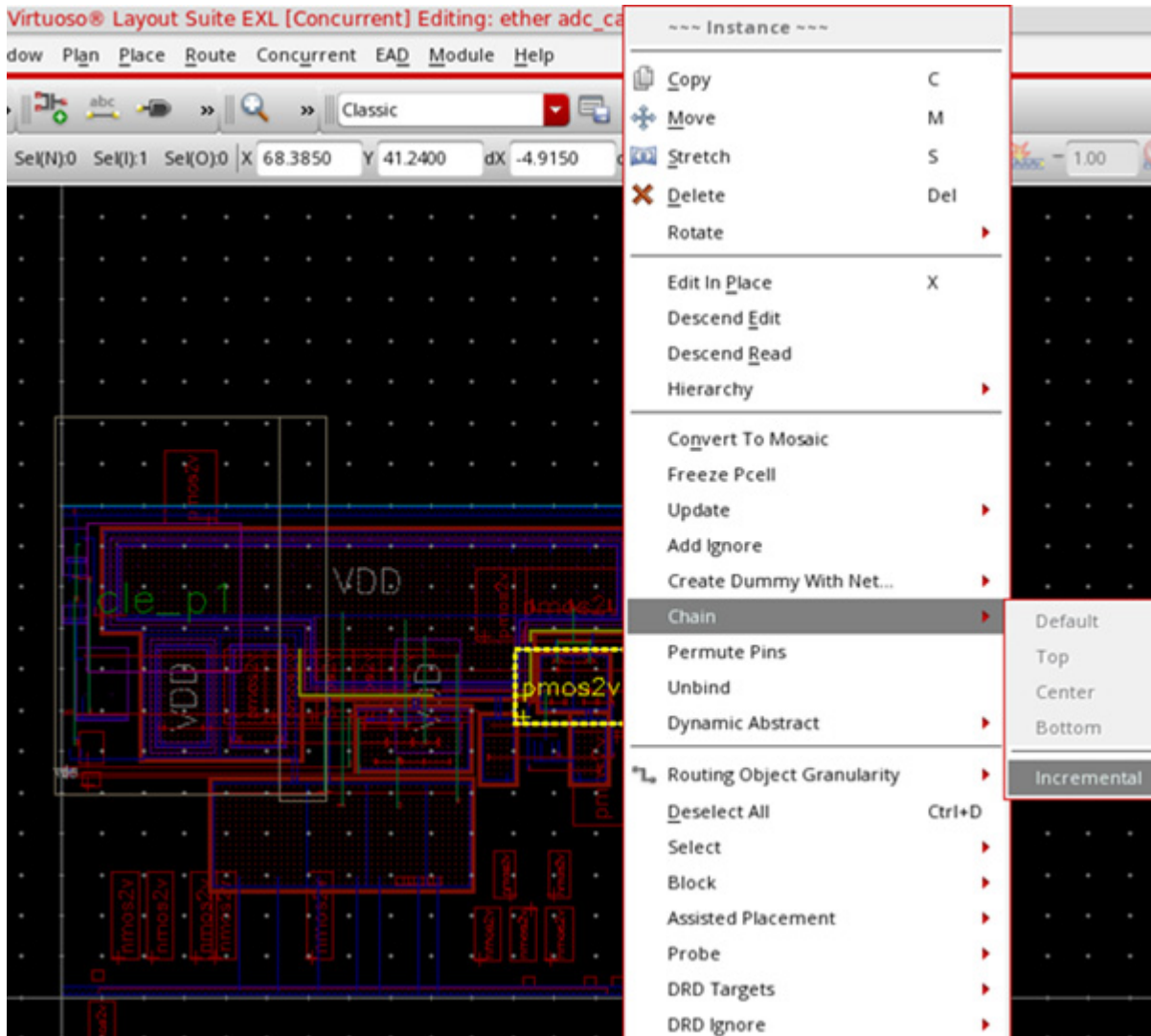
When *Incremental* chaining is invoked on an anchor, Virtuoso prompts to select an appropriate object for chaining by highlighting the suitable chaining connections on the nets associated with the selected anchor. Select any of the objects connected to the highlighted connections. You can iteratively add instances to the chain until the *Incremental* chaining command is interrupted by pressing the `ESC` key.

To incrementally chain instances:

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

1. In the layout canvas or the Navigator assistant, right-click an instance or a group of abutted objects to be used as an anchor.
2. From the shortcut command, choose *Chain – Incremental*.



All the candidate instances for chaining are highlighted in the layout canvas using probes.

3. Select an object to be added to the chain.  
The selected object is added to the chain, with the anchor retaining its position.
4. To add another object to the chain, select the object. Do this iteratively, if more objects must be added to the chain.
5. To stop adding more objects to the chain, press the *Esc* key.

## ***Related Information***

[1xHiIChain](#)

## **Editing Layout**

Virtuoso Layout Suite EXL provides a lot of editing capabilities to work with electro-photonics layout designs. You can use the layout editor to create custom layouts or edit any existing layout. From supporting basic parameter updates to layout components to enabling editing of composite waveguides, the Virtuoso Layout Suite EXL editor is well-equipped to support the editing of a Virtuoso-enabled Photonic design.

### **Editing the Layout Parameters**

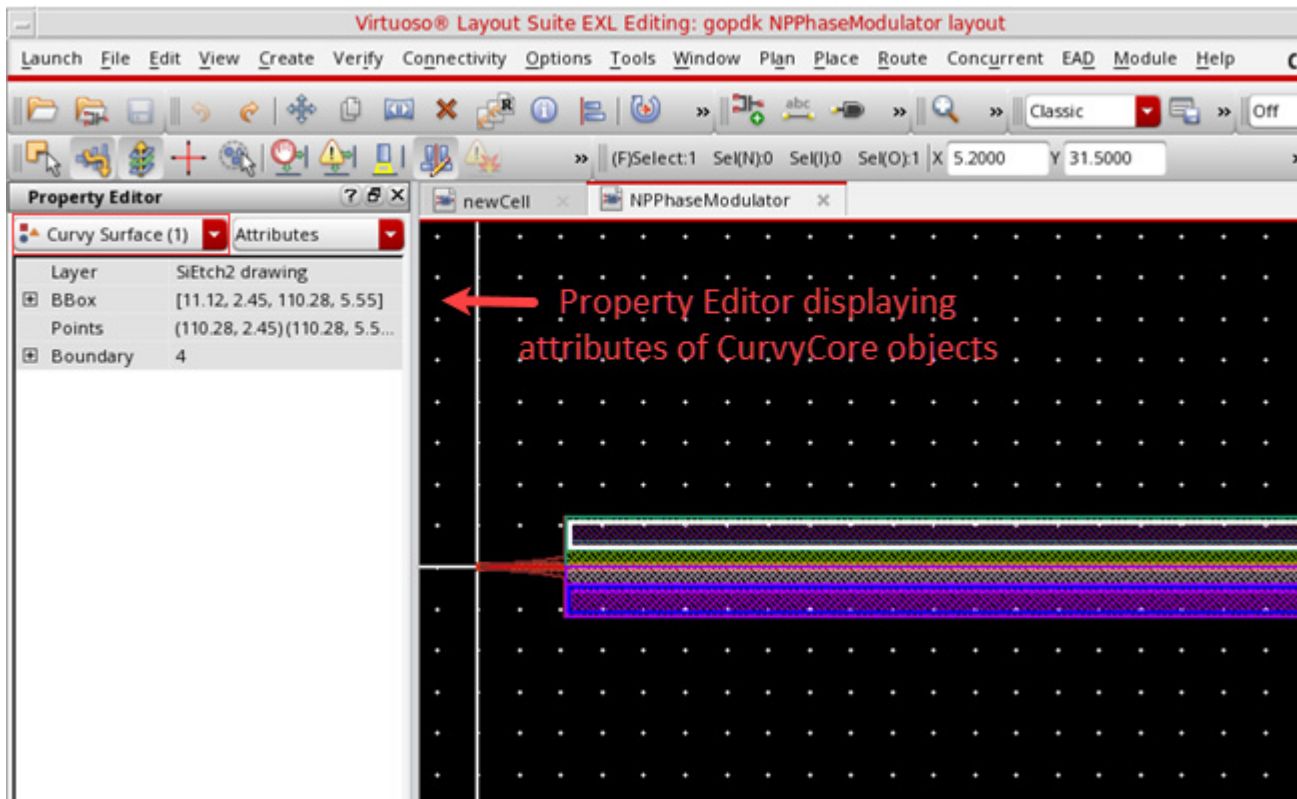
Photonics elements are formed as a result of complex mathematical calculations used to generate shapes. Therefore, these elements are “wrapped” into a generator and can be controlled through parameters. In fact, all the elements, including interconnect elements such as waveguides in a Photonic Integrated Circuit are defined as fixed or Pcell instances that can be controlled using parameters. Electronic circuit designs in Virtuoso, on the other hand, use a different methodology where the interconnects (wires) are often defined as top-level shapes. Because most photonic elements in a Photonic Integrated Circuit can be controlled through parameters, these instances can be interactively controlled using the Property Editor assistant or the Instance Property form.

The *Property Editor* assistant enables you to view and edit object property values for all electrical and optical components in your design. By default, each property is displayed in a separate table row in the *Property Editor*.

## Virtuoso Photonics Solution Guide

### Using EPDA in the Virtuoso Environment

The Property Editor table in the figure displays the properties for the selected CurvyCore® objects in the design.



For detailed information about the *Property Editor* user interface, how to work with it and how to edit property values, see [The Property Editor Assistant](#) in the *Virtuoso Schematic Editor User Guide*.

## Editing the Composite Waveguides

In the Virtuoso Photonics Solution, Layout EXL enables you to use optical connections called waveguides in your design. When several such optical connections or waveguides are used in a design, the resultant waveguide is called a composite waveguide.

The Virtuoso Photonics Solution supports the generation of such composite waveguides using the [Generate All From Source](#) command and supports editing of the composite waveguides using the Composite Waveguide Editor. Each component of the composite waveguide is called an *Element*.

**Note:** The Composite Waveguide Editor can be launched from both the editors, schematic and layout. If launched in the Schematic view, the Composite Waveguide Editor allows early estimation of the waveguide geometry.

The various ways you can launch the Composite Waveguide Editor in the schematic and layout view are:

■ *From the Create Instance form*

When creating a composite waveguide instance, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the *Waveguide* parameter list.

■ *From the Property Editor assistant*

In the Property Editor assistant, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the *Waveguide* parameter list.

■ *From the Property Editor form*

In the *Parameters* tab of the Property Editor form, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the *Waveguide* parameter list.

Editing a waveguide can involve the following:

- Adding a Waveguide Element
- Deleting a Waveguide Element
- Changing the Position of a Waveguide Element
- Adding an Optical Waveguide Connector
- Rotating a Waveguide Element

## **Adding a Waveguide Element**

To add a waveguide element:

1. In the layout canvas, select the composite waveguide instance to update.

The Property Editor assistant populates to display the properties of the selected optical instance.

2. In the Property Editor assistant, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the *Waveguide* parameter list.

The Composite Waveguide Editor displays.

3. In the Composite Waveguide Editor, right-click an existing waveguide element to use as the reference and choose *Add Before* or *Add After* to specify the position of the element to add.

The Add Element form displays.

4. Specify the *Library*, *Cell*, and *View* to use for the new waveguide element.
5. Click *OK* to apply the settings and close the editor.

A new waveguide element gets added at the position you specify.

## Deleting a Waveguide Element

To delete a waveguide element:

1. In the layout canvas, select the composite waveguide instance to update.  
  
The Property Editor assistant populates to display the properties of the selected optical instance.
2. In the Property Editor assistant, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the Waveguide parameter list.  
  
The Composite Waveguide Editor displays, listing the various waveguide elements that comprise the composite waveguide.
3. In the Composite Waveguide Editor, right-click the waveguide element that you want to remove and choose *Delete* from the context-sensitive menu.  
  
The selected element is removed from the waveguide element list and from the layout canvas.
4. Click *OK* to apply the settings and close the editor.

## Changing the Position of a Waveguide Element

To change the position of an element in the composite waveguide:

1. In the layout canvas, select the composite waveguide instance to update.  
  
The Property Editor assistant populates to display the properties of the selected optical instance.
2. In the Property Editor assistant, click the *Ellipses (...)* button corresponding to the *Edit* label displayed just above the *Waveguide* parameter list.  
  
The Composite Waveguide Editor displays, listing the various waveguide elements that comprise the composite waveguide.
3. In the Composite Waveguide Editor, right-click the waveguide element for which the position needs to be changed and choose *Move Up* or *Move Down* to specify the new position for the element.

The selected element is moved to the new position in the element list. The composite waveguide displayed in the layout canvas also reflects the element at its new position.

## Adding an Optical Waveguide Connector

Optical waveguide connectors are complex waveguides that can automatically generate a waveguide layout by using basic input information such as curve type.

To add an optical connector:

1. In the layout canvas, select the composite waveguide instances to connect.
2. Right-click and choose *Optical Connector* from the context-sensitive instance menu.

The Waveguide Connector for Optical Connections dialog box opens.

3. From the *Connector* drop-down list, choose a connector type to use for connecting the selected waveguides.

**Note:** The second value in the listed *Connector* options indicates the style of the connector that will be created—*curve*, *sine*, and so on.

4. Click *OK*.

An optical connector is created in the layout canvas based on the connector style you selected.

## Rotating a Waveguide Element

If a composite waveguide has the rotation parameter set, you can rotate all the elements inside the composite waveguide by the specified rotation value. The rotation of the waveguide elements is determined based on the rotation value set on the individual waveguide elements and the value set on the composite waveguide.

Let us consider that a composite waveguide includes two `waveguideStraight` elements with rotation on each element set to 0. Let us also assume that the rotation of the composite waveguide is set to 45.

On canvas, both the waveguide elements are rotated by 45 degrees, which puts them at an effective rotation of 45 degrees. If the `waveguideStraight` elements were set to rotation of 45 and the composite waveguide was set to rotate by 45 degrees, the effective, on-canvas rotation of the `waveguideStraight` elements will be 90 degrees.

However, when you edit a composite waveguide using the Composite Waveguide Editor, the composite waveguide is considered to be at rotation 0. This allows editing the rotation of the

individual waveguide elements without taking into account the rotation of the composite waveguide.

For more information on rotating objects using the Virtuoso Photonics Solution, see [Rotating Objects: Virtuoso Photonics Solution](#) in the *Virtuoso Layout Suite XL: Basic Editing User Guide*.

### ***Related Information***

[Composite Waveguide Editor](#)

[Generating Optical Pins](#)

## **Managing the Layout Constraints**

Use the **Constraint Manager** assistant to add, modify, check or delete constraints in your design.

The Constraint Manager displays a full set of constraints for a design wherever you are in the design hierarchy and wherever the constraints were created in that hierarchy. It displays the constraints in a logical manner, and shows which constraints are currently met and which have been overridden during the course of the physical implementation.

The Constraint Manager user interface comprises two main component parts: the Constraint Manager table at the top, which lets you browse the constraints in your design and the Constraint Editor underneath it, which lets you change the values of one or more selected constraints.

For more information on the Constraint Manager toolbar, see [Constraint Manager Toolbar](#).

## **Routing Layout**

To complete the electrical routing, Virtuoso supports the use of assisted routing for Virtuoso Photonics Solution.



To run the assisted router, you can use the options available in the *Virtuoso Space-based Router* toolbar.



Notice the *Lidar* icon in the *Virtuoso Space-based Router* toolbar, which has been introduced to set the required Wire Editing capabilities for Photonic Integrated Circuits. Virtuoso supports automatic routing for photonic designs, following the same rules as defined for the electrical layers.

For more information on how to use the various advanced routing capabilities of the *Virtuoso Space-based Router* to plan an efficient routing run for the Photonic Integrated Circuit, see the [Virtuoso Space-based Router User Guide](#).

## Verifying Design

### Checking a Layout Against a Schematic

To check the components in your layout view against the schematic view:

1. From the layout window menu bar, choose *Connectivity – Check – Against Source*.

**Note:** The *Check Against Source* command is also available through the *Check Against Source* icon ( ) in the Layout XL toolbar.

The Check Against Source form is displayed.

2. In the *Check* group box, choose the differences you want to report.
3. In the *Output* group box, choose whether you want to open the CAS workspace or the Info window, or both, and specify whether you want to overwrite the log file from a previous CAS run, or append the results to the log file.
4. Specify the name of the log file in which the report of the CAS run can be logged.
5. Click *OK* to run the check.

The schematic is extracted and the CAS report is generated and displayed based on the *Output* options that you selected.

- ☐ If *Open workspace* is selected, Layout XL opens the CAS workspace to display the generated markers in the Annotation Browser CAS tab.

- ❑ If *Display info window* is selected, the schematic versus layout differences for the selected checks are reported in an information window.

6. In the Info window, choose *File – Save As to* save the report to an ASCII file.

### ***Related Information***

#### Check Against Source

## **Checking XL Compliance**

To check if your design fulfills the compatibility criteria that allow it to fully leverage the connectivity-driven features of Virtuoso Layout Suite EXL, run the *Connectivity – Check – XL Compliance* command.

**Note:** Alternatively, you can call the [IxCheck](#) SKILL function to verify XL-compliance of a layout. To check each unique layout master in the layout hierarchy, use the [IxHierCheck](#) SKILL function.

The XL Compliance check evaluates the design for device correspondence with the schematic and reports information about ungenerated and unbound devices, if any. The report is intended to help you resolve any XL-compliance issues beforehand so that you can take full advantage of the numerous connectivity-driven capabilities provided by Layout EXL for optimal layout generation.

**Note:** The XL Compliance report is issued in CIW and you can choose to also display the report in HTML, if the [xlComplianceHtmlOpen](#) environment variable is set in accordance.

### ***Related Information***

#### Checking XL Compliance

## CurvyCore Building Blocks

The CurvyCore data model is made up of three layers, the base layer, which has a mathematical core, the layer-purpose pair (LPP) aware layer, and the physical layer.



The base layer comprises three mathematical objects, `ccCurve`, `ccFacet`, and `ccPolyCurve`.

Objects in LPP layer are aware of the relevant grid, but are not limited in the number of vertexes. As a set of objects, they are `ccFigs`. When a `ccFig` is discretized (or when geometry for `ccFig` is generated), facets are subjected to a special treatment to reflect the fact that they

## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

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represent interface vertexes between elements. Origin of each facet is automatically snapped to the closest point on the grid while angle of the facet is kept unchanged.

The physical layer or the OpenAccess level represents the manufactured polygons. These physical shapes have limitations in the number of vertexes. When a physical representation is generated for a `ccFig`, the algorithm takes into account the vertex number limitation and slices the figures appropriately, resulting in one (`ccFig`) to many (`oaFigs`) relationship.

There is a collection of `pho` and `cc` SKILL functions, above the base `cc` SKILL functions that provide higher-level functionality, such as a full-feature straight generator, including the interface for tapering, controlling modal property computation.

**Note:** As a PDK developer, you can either your elements build from the ground-up, getting full control and full visibility or quickly putting together a PDK using predefined elements. You can also use or refer the available generic photonics PDK `gopdk`.

Photonics also has `db`-level SKILL functions that can be used to deal with the signal type for optical connection and the optical port definition. For more information regarding the `db`, `cc` and `pho` SKILL functions related to Photonics, see [Photonics Functions](#) in *Virtuoso Design Environment SKILL Reference*.

This chapter discusses the following:

#### ■ CurvyCore Mathematical Objects

- Curves
- Paths and Facets
- Surfaces and Facets

#### ■ CurvyCore Pcells

#### ■ Waveguide Connectors

- Straight Connectors
- Bend Connectors
- Curve Connectors
- Waypoint Connectors

## CurvyCore Mathematical Objects

This section discusses the mathematical base layer of the CurvyCore engine. The curvilinear shapes are represented in the curvilinear mathematical domain as parameterized curves. In mathematics, these curves are described by their Cartesian equation as:

$$f(x, y) = c$$

Here  $x$  and  $y$  are Cartesian coordinates and  $c$  is a constant.

A parameterized representation of a curve is the representation used in the mathematical domain of the CurvyCore engine. This means that the first step to create a curvy shape is to find its parametric representation.

According to implicit function theorem, if:

$$\frac{\partial f}{\partial y} \big|_{(x_0, y_0)} \neq 0$$

Then, a curve can be described around that point as  $y = f(x)$ .

For example, if:

$$y = 2x - 1 \rightarrow 2x - y = 1 \rightarrow f(x, y) = 2x - y, c = 1$$

$$y = x^2 \rightarrow y - x^2 = 0 \rightarrow f(x, y) = y - x^2, c = 0$$

A curve can also be represented as a path traced by a point. This means that if  $x$  and  $y$  are Cartesian coordinates describing the position of a point of a curve, the curve is represented as:

$$\gamma(t) = (x(t), y(t))$$

where,  $\gamma$  specifies the location of the point at time  $t$ . The parameterized curve is described as:

A parameterized curve in  $\mathbb{R}^n$  is a map  $\gamma: (\alpha, \beta) \rightarrow \mathbb{R}^n$ , for some  $\alpha, \beta$  with  $-\infty \leq \alpha < \beta \leq \infty$

the symbol  $(\alpha, \beta)$  denotes an open interval

$$(\alpha, \beta) = \{t \in \mathbb{R} \mid \alpha < t < \beta\}$$

### ***Related Information***

[ccCreateCurve](#)

[ccCreatePath](#)

[ccCreatePolyCurve](#)

[ccCreateSurface](#)

[ccGenFigs](#)

[ccLayerOr](#)

[ccLayerAnd](#)

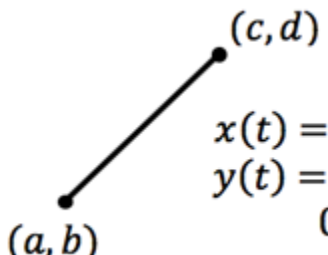
[ccSmoothenFig](#)

## **Curves**

Curves are one of the primary data structures of a CurvyCore engine. Two main types of curves are `ccCurve` and `ccPolyCurve`.

### **ccCurve**

`ccCurve` is one of the primary data structure of a CurvyCore engine. A `ccCurve` is a parametrized representation of a curve in a given interval. The following parametric equation is an example of the parametric equation that can be used to create a `ccCurve` representing a straight segment.


$$\begin{aligned}x(t) &= a + (c - a) * t \\y(t) &= b + (d - b) * t \\0 \leq t &\leq 1\end{aligned}$$

You can use the [ccCreateCurve](#) SKILL function to create a `ccCurve` object using its parametric representation. It retrieves the string representation of the Cartesian coordinates of the parameterized curve and the begin and end values of the parameter and returns a `ccCurve` object.

## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

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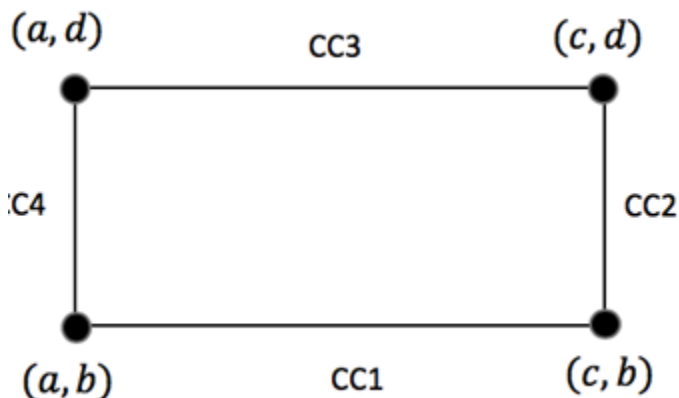
```
;ccCreateCurve(t_x t_y list(n_begin n_end))
;The following code creates a line segment between (0,0) and (2,4) and then
;displays the created ccCurve's attributes
LineSeg = ccCreateCurve("2*t" "4*t" 0:1)
cc00xb25fc433
LineSeg~>??
(cc00xb25fc433 objType "ccCurve" xExpr "(2*t)"
  yExpr "(4*t)" range
  (0.0 1.0)
)
```

The only parameter that can be used in the parametric representation of a curve is  $t$ , other parameters are numerical constants. This means that if you want to create a line segment whose endpoints need to be passed as a parameter, first you need to create the string representation using the numerical parameters and then create the `ccCurve` object.

### ccPolyCurve

`ccPolyCurve` is a data structure that is used to stitch a sequence of `ccCurves` to create a more complicated curve. You can create a `ccPolyCurve` object using the [`ccCreatePolyCurve`](#) SKILL function.

To create a `ccPolyCurve` object from a rectangle shape, you need to consider that a rectangle is represented by line segments connecting its vertices.



Here the bounding box of a rectangle, `list(a:b c:d)`, generates `ccCurve` objects `CC1`, `CC2`, `CC3`, and `CC4` representing the edges of the rectangle. You can use the `ccCreatePolyCurve` SKILL function to join these edges.

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### CurvyCore Building Blocks

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The `ccCreatePolyCurve` SKILL function checks if the `polyCurve` object is a simple closed `polyCurve` and what is the level of smoothness between the segments while the `polyCurve` object is being created. For example, when a rectangle is generated from line segments, you might want to check whether it is continuous. `G0` enforces the continuity check and generates an error if the `polyCurve` object is not continuous.

In the following example, first the `CCSCreateLineSegment` function is defined to create and return a `ccCurve` object representing a line segment between two points.

```
procedure(CCSCreateLineSegment(point1 point2)
  let((ParameterizedLine XcoordPoint1 YcoordPoint1 XcoordPoint2 YcoordPoint2)
    XcoordPoint1 = xCoord(point1)
    YcoordPoint1 = yCoord(point1)
    XcoordPoint2 = xCoord(point2)
    YcoordPoint2 = yCoord(point2)
    ParameterizedLine.ParamX = lsprintf("%n + (%n-%n)*t", XcoordPoint1,
    XcoordPoint2,XcoordPoint1);X(t)=XcoordPoint1 + (XcoordPoint2-XcoordPoint1)*t
    ParameterizedLine.ParamY = lsprintf("%n + (%n-%n)*t", YcoordPoint1,
    YcoordPoint2,YcoordPoint1);X(t)=YcoordPoint1 + (YcoordPoint2-YcoordPoint1)*t
    ccCreateCurve(ParameterizedLine.ParamX ParameterizedLine.ParamY 0:1.)
  );let
);procedure
```

Next, the `CCSCreateRectangle` function is defined to use `CCSCreateLineSegment` to create and return a `polyCurve` object representing a rectangle with positive area as shown below.

```
procedure(CCSCreateRectangle(bBox)
  let((llx lly urx ury CC1 CC2 CC3 CC4)
    ury = yCoord(upperRight(bBox))
    urx = xCoord(upperRight(bBox))
    lly = yCoord(lowerLeft(bBox))
    llx = xCoord(lowerLeft(bBox))
    CC1 = CCSCreateLineSegment(llx:lly urx:lly)
    CC2 = CCSCreateLineSegment(urx:lly urx:ury)
    CC3 = CCSCreateLineSegment(urx:ury llx:ury)
    CC4 = CCSCreateLineSegment(llx:ury llx:lly)
    ccCreatePolyCurve(list(CC1 CC2 CC3 CC4)
      ?close t
      ?smoothness 'G0)
  );let
);procedure
```

The following example shows how to check the `ccPolyCurve` attributes associated with the created rectangle.



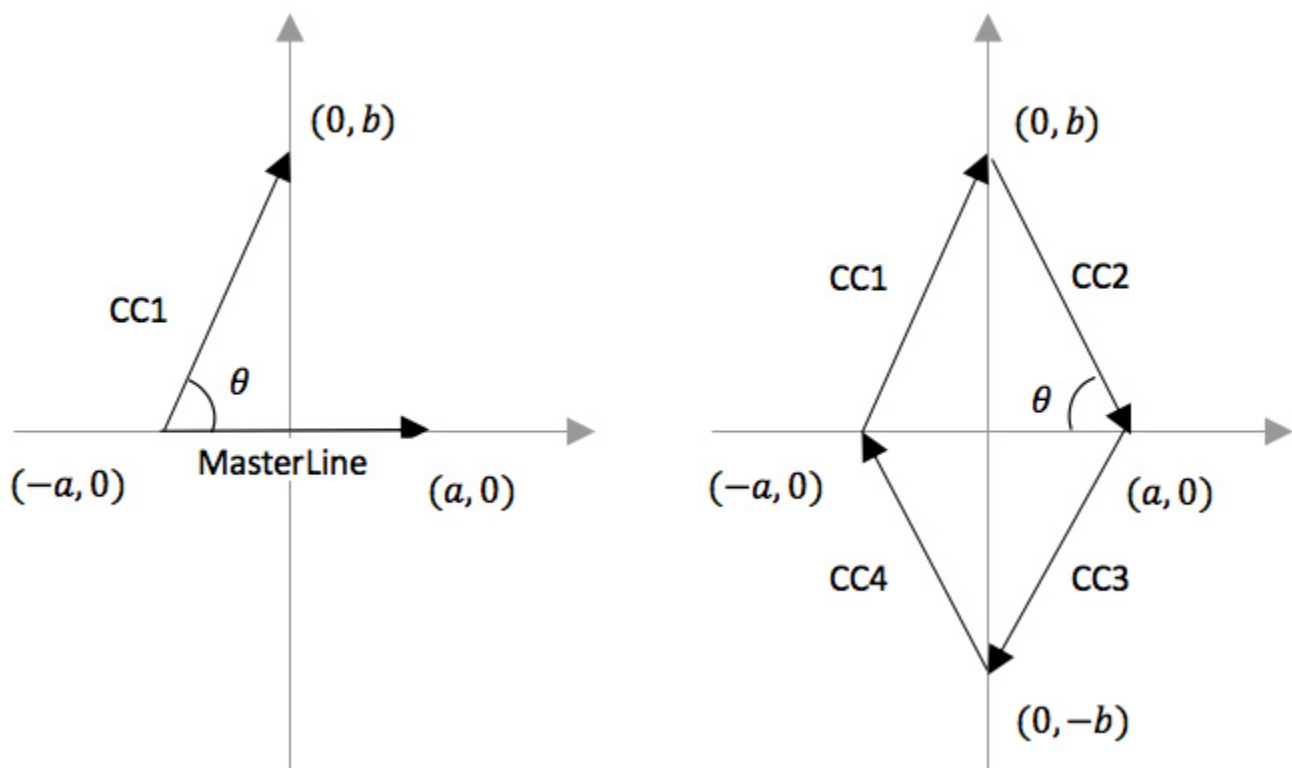
## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

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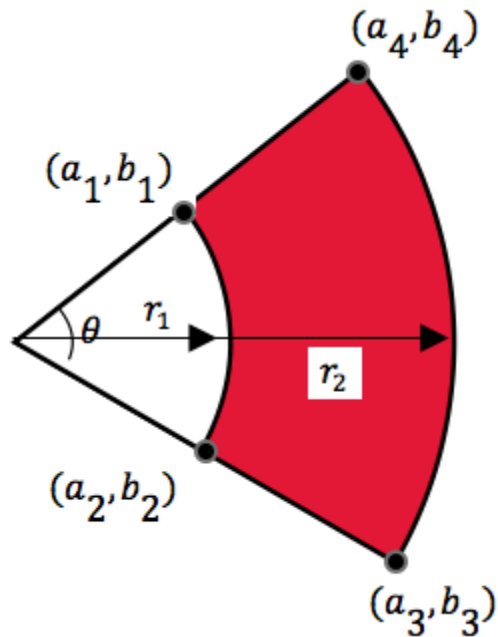
```
Rectangle = CCSCreateRectangle(list(0:0 10:10))  
Rectangle~>??  
;The segment property returns ccCurve segments of the rectangle  
Rectangle~>segments
```

When a polyCurve object is created using segmented curves, it is possible to apply a transformation to them. You can use this technique to create rhombus shapes by applying a transformation to a line segment. Rhombus curve segments can be created by generating a masterLine curve and then applying a proper transformation to create CC1, CC2, CC3, and CC4 as shown below.



**Note:** Counterclockwise rotation is described by positive sign and clockwise rotation is described by a negative sign.

To create pie polyCurve shapes, you first need to create a ccCurve object representing a circular arc. A pie polyCurve is composed of two circular arcs and two line-segments connecting these circular arcs.



It is simpler to represent the above arcs in cylindrical coordinates.

$$\begin{aligned} (r(t), \theta(t)) &= (r, t); \quad -\frac{\theta}{2} \leq t \leq \frac{\theta}{2} \\ (x(t), y(t)) &= (r(t) \sin(\theta(t)), r(t) \cos(\theta(t))) \end{aligned}$$

Considering that the parameterized curve should have Cartesian coordinates, you can define a utility function that converts the parametric form from cylindrical to Cartesian. The following function gets a parametric polar coordinates of a curve and returns its Cartesian coordinates.

```
procedure(CCSPolartoCartesian(ParameterizedPolar)
  let((Radius Theta ParamX ParamY)
  Radius = car(ParameterizedPolar)
  Theta = cadr(ParameterizedPolar)
  ParamX = lsprintf("%s*cos(%s)" Radius Theta)
  ParamY = lsprintf("%s*cos(%s)" Radius Theta)
  list(ParamX ParamY)
  );let
);procedure
```

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The following example defines the `CCSCreateArcSegment` function to create an arc. The function uses `CCSPolartoCartesian` described above to convert polar coordinates to Cartesian coordinates. The example defines two functions `CCSCreateArcSegment` and `CCSCreatePie`.

`CCSCreateArcSegment` creates a `ccCurve` object representing an arc. The operands are radius of the circle where `ArcLength` is 0. If the symmetric parameter is not `t`, the function will create an `ArcSegment` starting from 0.

```
procedure(CCSCreateArcSegment(Radius ArcLength @key(Symmetric t))
  let((ParameterizedArc ParameterizedPolar)
    ParameterizedPolar = list(lsprint("%n" Radius) lsprintf("%s" t))
    ; (R(t) Theta(t)) = (Radius t)
    ParameterizedArc.ParamX = car(CCSPolartoCartesian(ParameterizedPolar))
    ; (Radius t) --> (X(t), Y(t))
    ParameterizedArc.ParamY = cadr(CCSPolartoCartesian(ParameterizedPolar))
    if(Symmetric
      then
        ccCreateCurve(ParameterizedArc.ParamX ParameterizedArc.ParamY -ArcLength/
          2:ArcLength/2)e
      else
        ccCreateCurve(ParameterizedArc.ParamX ParameterizedArc.ParamY
          0:ArcLength)
    );if
  );let
);procedure
```

`CCSCreatePie` creates a `polyCurve` object representing a pie shape with positive area.

```
procedure(CCSCreatePie(Radius1 ArcLength1 Radius2 ArcLength2)
  let((ParameterizedPie ParameterizedArc1 LineSeg1 ParameterizedArc2 LineSeg2)
    ParameterizedArc1 = CCSCreateArcSegment(Radius1 -ArcLength1)
    ParameterizedArc2 = CCSCreateArcSegment(Radius2 ArcLength2)
    LineSeg1 = CCSCreateLineSegment(
      Radius1*cos(-ArcLength1/2):Radius1*sin(-ArcLength1/2)
      Radius2*cos(-ArcLength2/2):Radius2*sin(-ArcLength2/2))
    LineSeg2 = CCSCreateLineSegment(
      Radius2*cos(ArcLength1/2):Radius2*sin(ArcLength1/2)
      Radius1*cos(ArcLength2/2):Radius1*sin(ArcLength2/2))
    ccCreatePolyCurve(
      list(ParameterizedArc1 LineSeg1 ParameterizedArc2 LineSeg2)
      ?close t ?smoothness 'G0)
  )let;
);procedure
```

## ***Related Information***

[ccCreateCurve](#)

[ccCreatePolyCurve](#)

## **Paths and Facets**

A path is a center curve that has parallel inner and outer curves. The center curve is defined as a ccCurve object. You can create a ccPath object using the [ccCreatePath](#) SKILL function. One of the uses of a ccPath object is to represent a photonics waveguide.

Consider that you want to create a  $90^\circ$  bend waveguide path with  $0.5\mu\text{m}$  width and  $15\mu\text{m}$  radius on a layer-purpose pair. The first step is to create the center ccCurve object of the path, as shown below.

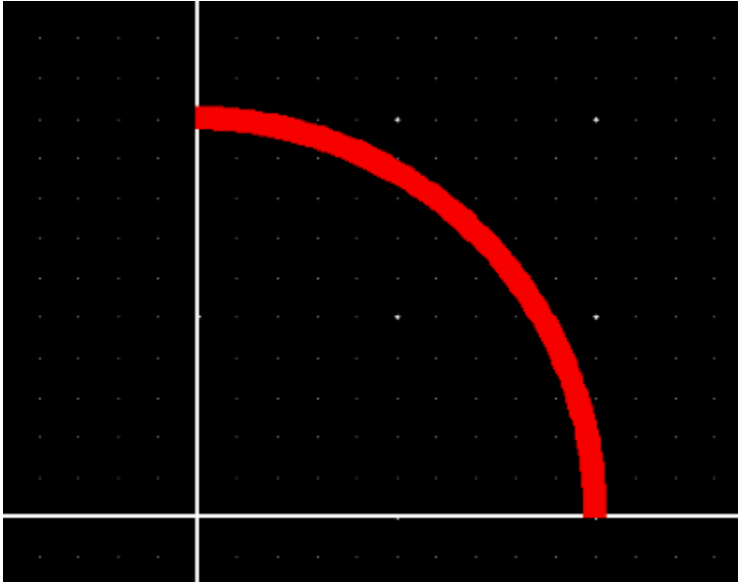
```
BendCenterCurve = CCSCreateArcSegment(15 asin(1))
```

The path needs to be associated with a layer in a technology file, therefore, you need to create a layout cell where the path can be created.

To generate a path object in the currently opened Layout Editor window, you can run the following command.

```
BendPath = ccCreatePath(geGetEditCellView() list("waveguide" "drawing")
    list(list(BendCenterCurve list(0:0 45) 0.5)))
;Generate the physical shape of BendPath
ccGenFigs(BendPath)
```

You should be able to see your 90° waveguide bend as shown below.



To generate physical shapes associated with a CurvyCore mathematical objects such as paths and surfaces, you need to use the [ccGenFigs](#) SKILL function.

Lets now create another ccPath object representing a straight waveguide with width 0.5μm.

```
StraightCenterCurve = CCSCreateLineSegment(0:0 10:0)
StraightPath = ccCreatePath(geGetEditCellView() list("waveguide" "drawing")
list(list(StraightCenterCurve list(0:0 0) 0.5)))
;Generate the physical shape of the path
ccGenFigs(StraightPath)
```

This example generates a straight path representing a straight photonic waveguide.



## Attributes of ccPath Objects

A ccPath object consists of segments that are the center ccCurve objects with their associated inner and outer parallel curves. They also consists of two facets, `beginFacet` and `endFacet`.

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### CurvyCore Building Blocks

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```
StraightPath~>??
(cc:0x33874050 objType "ccPath" cellView db:0x20c7d39a
  lpp
  ("waveguide" "drawing") figs
  (db:0x20c78a9a) beginPt
  (0.0 0.0) endPt
  (10.0 0.0) beginFacet cc@0x68c1d0a6
  endFacet cc@0x47be58d4 segments
  ((cc@0xb16d5f44
    ((0.0 0.0) 0.0) "0.5"
  )
  ) smoothness
  G1
)
```

Facets are essential when ccPath objects need to be joined together at different levels of the hierarchy.

A facet is a mathematical object in the CurvyCore engine with following attributes:

- During physical shape generation, the center-point of a facet is always snapped to the manufacturing grid. This means that if a facet is rotated and the center point is not on the grid then the whole facet will be parallelly shifted to the nearest grid point.
- After the facet is shifted, the end points of the facet are shifted to the nearest points on the manufacturing grid. If there is an ambiguity to which point it should be shifted to (that is, if there are two or more nearest points on the manufacturing grid), then the end point is shifted to the farthest point from the origin of the facet (among those nearest points on the manufacturing grid).

## Surfaces and Facets

Mathematically, any simple-closed curve or polyCurve can be used to represent a surface.

When you go counter-clockwise on a closed surface, the enclosed area on the left-side of the boundary represents the surface having a positive surface area associated with that boundary. If you go clockwise, the associated surface is the same but the associated area is negative. A negative surface represents a hole that can be subtracted from another surface.

You can create CurvyCore surfaces using the [ccCreateSurface](#) SKILL function.

The following example creates a rectangular surface:

```
Rectangle = CCSCreateRectangle(list(0:0 10:10))
```

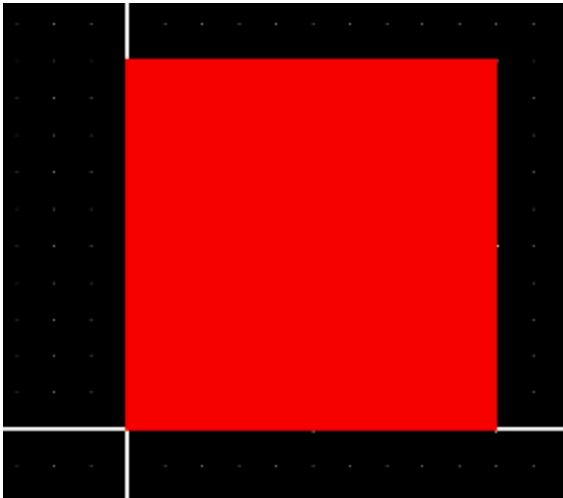
## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

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```
RectangleSurface = ccCreateSurface(  
  geGetEditCellView()  
  list("waveguide"  
    "drawing")  
  Rectangle)  
ccGenFigs(RectangleSurface)  
RectangleSurface~>??  
(cc:0x2a0d3bf0 objType "ccSurface" cellView db:0x20c3d91a  
  lpp  
  ("waveguide" "drawing") figs  
  (db:0x20c3c99a) area  
  100.0 boundary cc@0x4e636b3f holes nil  
)
```

This following figures shows the rectangular surface created using the above example.



The following example shows how to create a polygon with  $N$  number of sides or an *N-gon closed polyCurve* that can be used to create a hexagon surface.

```
procedure(CCSCCreateNgon(Radius NumberofSides)  
  let((Vertices(pi2*asin(1)))  
  Vertices = tconc(nil Radius:0)  
  for(i 1 NumberofSides-1  
    tconc(  
      Vertices  
      Radius*cos(2*pi*i/NumberofSides):Radius*sin(2*pi*i/NumberofSides)  
    );tconc  
  );for  
  Vertices = car(Vertices)
```

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### CurvyCore Building Blocks

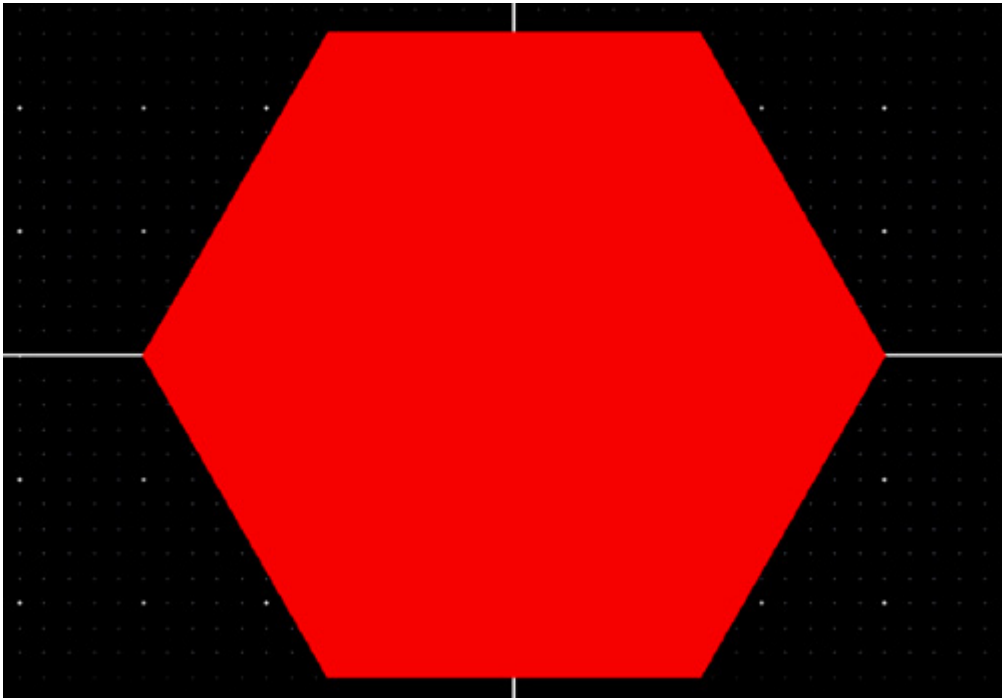
---

```
CCSCreatePolygon(Vertices)
);let
);procedure
```

Next, you can use the N-gon polyCurve to create a hexagon surface as shown below.

```
Hexagon = CCSCreateNgon(15 6)
HexagonSurface = ccCreateSurface(geGetEditCellView() list("waveguide" "drawing")
Hexagon)
ccGenFigs(HexagonSurface)
```

The figure shows the hexagon created using the above example.



The following procedure uses a closed pie polyCurve to create a pie surface.

```
PiePolyCurve = CCSCreatePie(10 asin(1)*3/4 12 asin(1)*3/4)
PieSurface = ccCreateSurface(geGetEditCellView() list("waveguide" "drawing")
PiePolyCurve)
ccGenFigs(PieSurface)
```

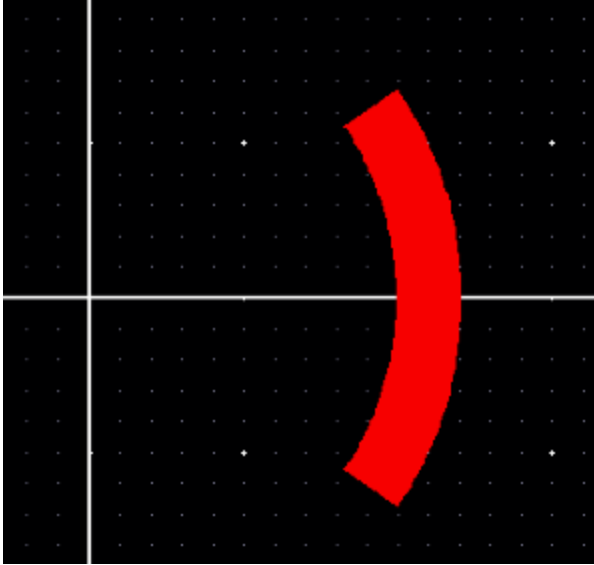


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This figure shows pie surface created using a closed pie polyCurve.



Lets now see how to create a grating coupler shape as an array of grating pie shapes.

```
procedure(GratingCoupler(cv @key(designIntentLayer "waveguide")
    (GratingNum 10)
    (GratingSpace 3.0)
    (GratingArcLength 2.0)
    (Gratingwidth 1.0)
    (GratingStartRadius 5.0)
    (rotation 0.0)
    (boundingBox t)
)
let((ccPolyCurves ccSurfaces BoundingBox BoundingBoxSurface
    urx ury llx lly(pi asin(1)))

GratingArcLength = pi/GratingArcLength
declare(ccPolyCurves[GratingNum])
declare(ccSurfaces[GratingNum])

for(i 0 GratingNum-1
    ccPolyCurves[i] = CCSCreatePie(
        GratingStartRadius+GratingSpace*i
        GratingArcLength
        GratingStartRadius+GratingSpace*i+Gratingwidth
        GratingArcLength)
    ccPolyCurves[i] = ccTransformPolyCurve(ccPolyCurves[i]
        list(0:0 rotation))
```

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---

```
ccSurfaces[i] = ccCreateSurface(cv
                                list(designIntentLayer "drawing")
                                ccPolyCurves[i])
);for
when(boundingBox
    urx = GratingStartRadius+GratingSpace*(GratingNum-1) + Gratingwidth
    ury = (GratingStartRadius+GratingSpace*(GratingNum-1)) +
          Gratingwidth*sin(GratingArcLength/2)
    lly = -ury
    llx = GratingStartRadius*cos(GratingArcLength/2)
    BoundingBox = CSCCreateRectangle(list(llx:lly urx:ury))
    BoundingBoxSurface = ccCreateSurface(cv
                                          list("SiEtch0" "drawing")
                                          BoundingBox)
    ccMoveFig(BoundingBoxSurface ?transform list(0:0 rotation))
);when

list(ccSurfaces BoundingBoxSurface)
);let
);procedure
```

After the GratingCoupler function is loaded, you can check the creation of a grating coupler.

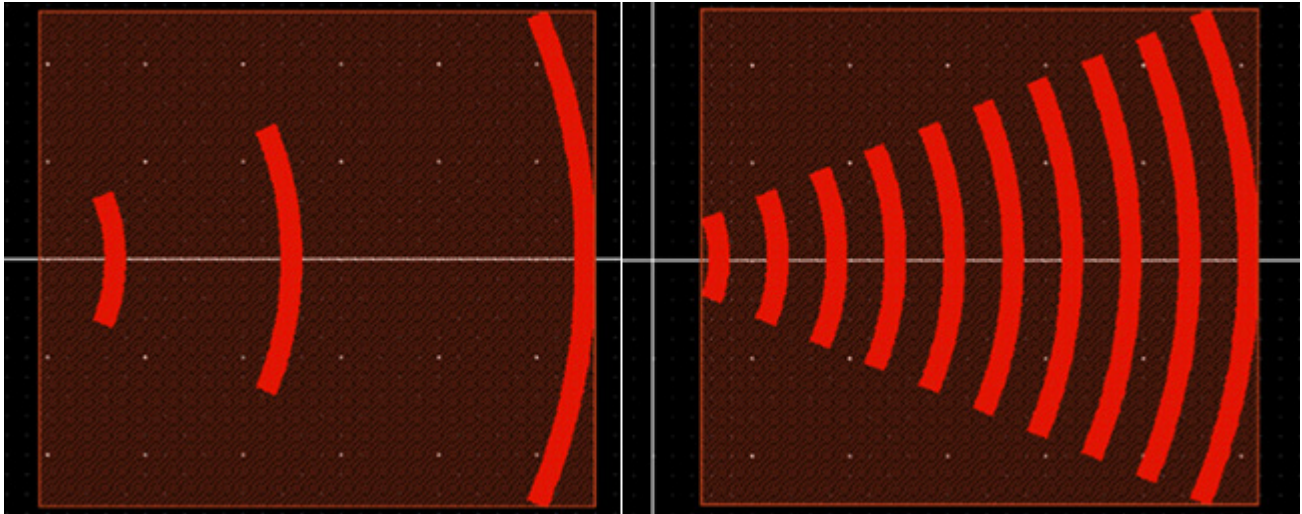
```
ccGrating = GratingCoupler(geGetEditCellView())
Gratings = car(ccGrating)
BoundingBox = cadr(ccGrating)
ccGenFigs(BoundingBox)
ccGenFigs(Gratings[1])
ccGenFigs(Gratings[4])
ccGenFigs(Gratings[9])
```

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### CurvyCore Building Blocks

---

The following figures show the grating coupler shape with grating number 1, 4, 9, and the complete grating coupler.



A surface with a negative area represents a hole. This means that it is possible to subtract some holes from a surface when using `ccCreateSurface` SKILL function.

The holes that are going to be subtracted from the original surface are passed as a list parameter to the `ccCreateSurface` function as shown below.

```
procedure(GratingCouplerInverted(cv @key(designIntentLayer "waveguide")
    (GratingNum 10)
    (GratingSpace 3.0)
    (GratingArcLength 2.0)
    (Gratingwidth 1.0)
    (GratingStartRadius 5.0)
    (rotation 0.0)
)
```

```
let(
(ccPolyCurves ccSurfaces BoundingBox BoundingBoxSurface
  urx ury llx lly(pi asin(1)))
```

```
GratingArcLength = pi/GratingArcLength
```

```
;Create bounding box rectangle
```

```
urx = GratingStartRadius+GratingSpace*(GratingNum-1)+Gratingwidth+1
```

```
ury = (GratingStartRadius+GratingSpace*(GratingNum-1)+Gratingwidth)*sin(GratingArcLength/2)+1
```

```
lly= -ury
```

```
llx = GratingStartRadius*cos(GratingArcLength/2)-1
```

```
BoundingBox = CCCreateRectangle(list(llx:lly urx:ury))
```

```
for(i0 GratingNum-1
```

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```
;ccPolyCurves are simple closed curves with negative area that represent
;the holes in the bounding box rectangle
ccPolyCurves=tconc(
    ccPolyCurves
    ccReverseCurve
    (CCSCreatePie(
        GratingStartRadius+GratingSpace*i
        GratingArcLength
        GratingStartRadius+GratingSpace*i+Gratingwidth
        GratingArcLength)
    )
);tconc
);for

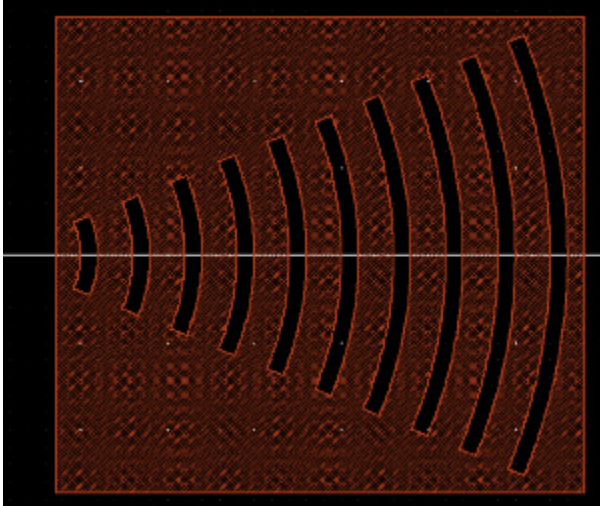
ccPolyCurves = car(ccPolyCurves)
ccSurfaces = ccCreateSurface(cv
    list("SiEtch0" "drawing")
    BoundingBox
    ccPolyCurves)

ccMoveFig(ccSurfaces ?transform list(0:0 rotation))

);let
);procedure
```

After defining and loading the `GratingCouplerInverted` function, you can create an instance where the gratings are subtracted from the bounding box.

```
ccGratingInverted = GratingCouplerInverted(geGetEditCellView())  
ccGenFigs(ccGratingInverted)
```



### **Related Information**

[ccCreatePath](#)

[ccGenFigs](#)

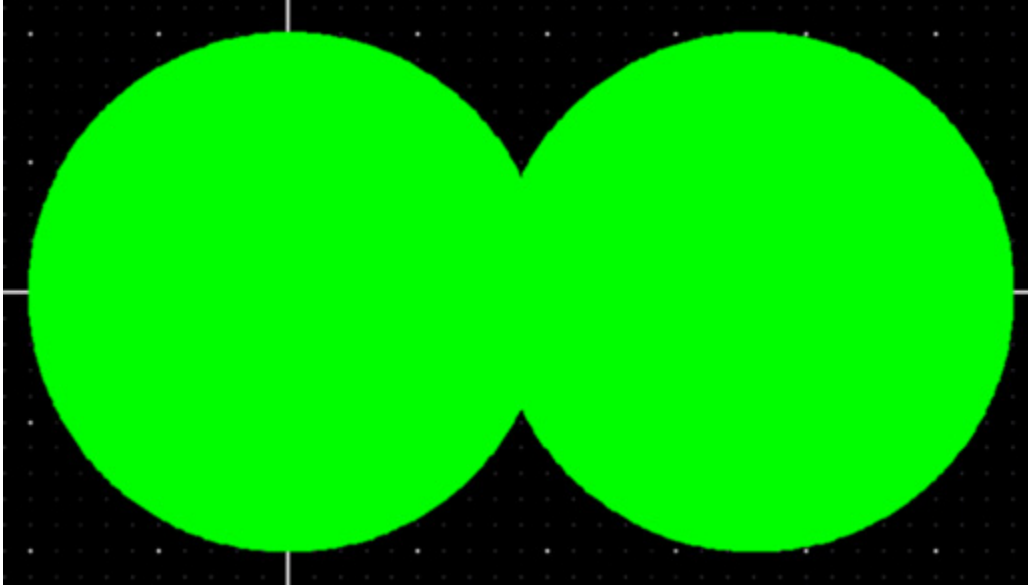
[ccCreateSurface](#)

### **Boolean Operations of Surfaces**

Boolean operator `or` can be applied using the [ccLayerOr](#) SKILL function to create two circular surfaces and combine them to create a larger surface. The surfaces that this function acts on can be on different layers and the generated surface can also be in a different layer.

```
Circle = ccCreateCurve("10*cos(t)" "10*sin(t)" 0:4*asin(1))  
Surf1 = ccCreateSurface(geGetEditCellView() list("waveguide" "drawing")  
CirclePoly)  
Surf2 = ccCreateSurface(geGetEditCellView() list("SiEtch0" "drawing")  
ccTransformPolyCurve(CirclePoly list(18:0 0)))  
SurfOr = ccLayerOr(Surf1 Surf2)  
ccGenFigs(car(SurfOr))
```

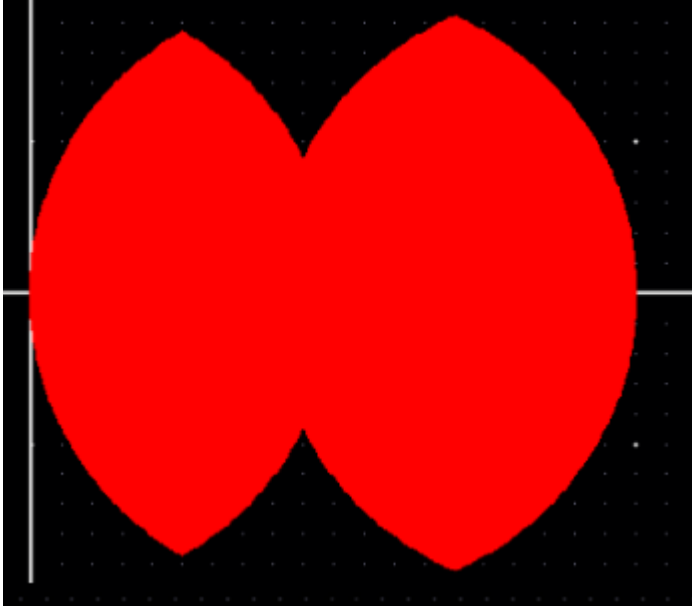
The following figure shows how two circular surfaces are combined to create a larger surface using the `ccLayerOr` function.



Boolean operator `and` can be applied using the `ccLayerAnd` SKILL function to extract the overlap area of the above shape with a transformed circle surface.

```
Surf3 = ccCreateSurface(geGetEditCellView() list("waveguide" "drawing")
ccTransformPolyCurve(CirclePoly list(10:0 0)))
SurfAnd = ccLayerAnd(SurfOr Surf3 ?lpp list("wavgeuide" "drawing"))
ccGenFigs(car(SurfAnd))
```

In this figure, you can see that the overlap area of the shape has been extracted from the shape.



### ***Related Information***

[ccLayerOr](#)

[ccLayerAnd](#)

### **Smoothing of Surfaces**

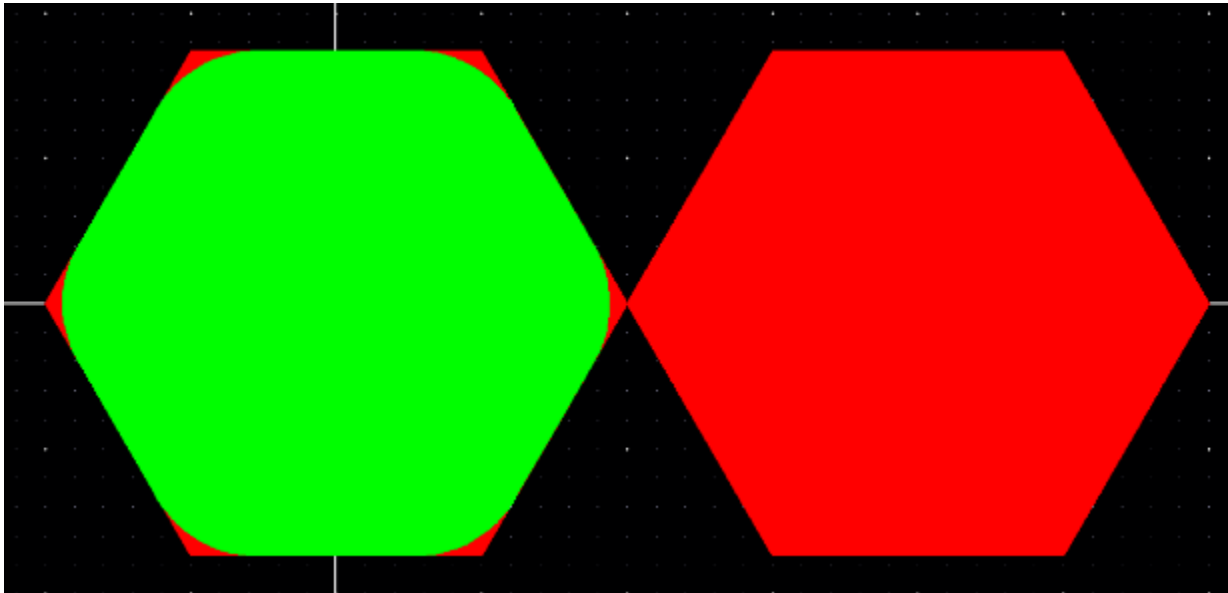
You can use the [ccSmoothenFig](#) SKILL function to smoothen a surface. Assume that you have a hexagonal surface, and that at the sharp corners of the hexagon, the bend radius is zero. Now assume that you want to smoothen the shape and specify the minimum radius of curvature for the shape to be 4.

In the example below you get similar results.

```
Hex = CCSCreateNgon(10 6)
HexSurf = ccCreateSurface(getEditCellView() list("waveguide" "drawing") Hex)
Hex2Surf = ccCreateSurface(getEditCellView() list("waveguide" "drawing")
ccTransformPolyCurve(Hex list(20:0 0)))
Hex3 = ccCreateSurface(getEditCellView() list("SiNWaveguide" "drawing") Hex)
HexSmooth = ccSmoothenFig(Hex3 -4)
ccGenFigs(HexSurf)
ccGenFigs(Hex2Surf)
```

`ccGenFigs (HexSmooth)`

In this figure, there are three hexagonal surfaces, the red surface on the right is the original hexagonal surface and the two overlapped surfaces are the same original hexagonal surface and its smoothed version.



### ***Related Information***

[ccSmoothenFig](#)

## **CurvyCore Pcells**

There is no significant difference between a typical Pcell and a CurvyCore Pcell other than the fact that in a CurvyCore Pcell, you can use the CurvyCore and photonic functions to generate and manipulate your shapes. This means that all the concepts and best practices of creating a Pcell also work in this situation.

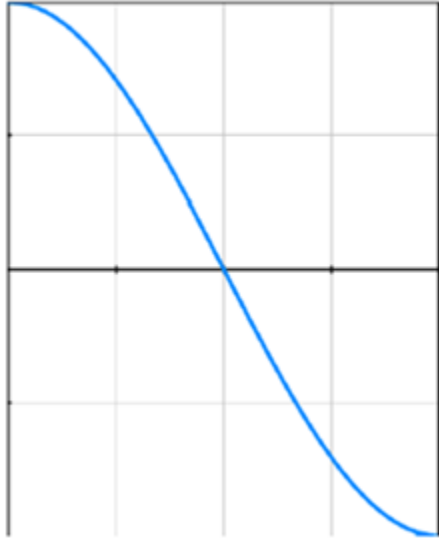


## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

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To understand how to work with CurvyCore Pcells, let's consider an S-bend connector Pcell. The parameterized equation and the shape of this connector is shown below.



$$x(t) = t$$
$$y(t) = \frac{Height}{2} * \cos\left(\frac{t * \pi}{Length}\right)$$
$$0 \leq t \leq 4 ; Height = 4 ; Length = 4$$

Let's see how to create a generator for the S-bend shape and then use that inside the Pcell code to create the ccPath object.

The following procedure creates a generator for cosine S-bend curve:

```
procedure(CCSCreateSBend(height length)
  let((parameterizedArc)
    parameterizedArc.ParamX = "t"
    parameterizedArc.ParamY = lsprint("%n/2*cos(t*pi/%n)" height length)
    ccCreateCurve(parameterizedArc.ParamX parameterizedArc.ParamY 0:length)
  );let
);procedure
```

In the following Pcell code, width parameter specifies the width of the waveguide path and rotation parameter specifies the rotation applied to the final waveguide path. Next, S-bend generator is used to create the S-bend curve and build the waveguide path.

```
pcDefinePCell(
  list(ddGetObj("gopdk") "CustomSBend" "layout")
    ;Pcell parameters
    (
      (designIntentLayer "string" "waveguide")
      (rotation "string" "0.0")
      (height "string" "10.0u")
      (length "string" "40.0u")
      (width "string" "0.5u")
    );end of parameters
```

## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

---

```
;Pcell body code
let((ccCurve ccPath ccWaveguide)
  height = readstring(pcCellView~>parameters~>height)*1e6;
  length = readstring(pcCellView~>parameters~>length)*1e6;
  width = readstring(pcCellView~>parameters~>width)*1e6;
  rotation = readstring(pcCellView~>parameters~>rotation);
);let
);pcDefinePCell
```

The following code adds three CDF parameters and sets how interpreted labels should be evaluated. Populate the CDF data after loading the file.

**Note:** Pcell parameter names and their associated CDF property names should be the same.

```
let((cellId cdfId)
  cellId = ddGetObj("gopdk" "CustomSBend")
  when(cdfId = cdfGetBaseCellCDF(cellId)
    cdfDeleteCDF(cdfId)
  );when

  cdfId = cdfCreateBaseCellCDF(cellId)
  cdfCreateParam(cdfId
    ?name      "width"
    ?prompt    "Waveguide Width(M) "
    ?defValue  "0.5u"
    ?type      "string"
    ?storeDefault"t")

  cdfCreateParam(cdfId
    ?name      "length"
    ?prompt    "Bend Length(M) "
    ?defValue  "40.0u"
    ?type      "string"
    ?storeDefault"t")

  cdfCreateParam(cdfId
    ?name      "height"
    ?prompt    "Bend Height(M) "
    ?defValue  "10.0u"
    ?type      "string"
    ?storeDefault"t")

;These are related to Cell/Instance Name(cdsName)
cdfId->instDisplayMode = "instName"
cdfId->instNameType = "schematic"
;These are related to terminals(cdsTerm)
cdfId->termDisplayMode="natName"
cdfId->netNameType="schamatic"
```

## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

---

```
;These are related to Parameters(cdsParam)
cdfId->paramDisplayMode="parameter"
cdfId->paramLabelSet="width length height"

cdfSaveCDF(cdfId)
);let
```

When waveguideTemplates are defined in the technology database, it is possible to use them to generate a waveguide from a ccPath object.

```
("Deep SOI Waveguide" ("waveguide" "drawing")
  'minWidth      0.5
  'minBendRadius 10.0
  'modeProperties(
    'function "gopdkModePropWG"
    'namespace(("TE 0")("TM" 1))
  )
  'derivedShapeSpecs(
    ( "SiEtch0" 'type "enclosure" 'enclosure 0.05)
    ( "SiEtch2" 'type "enclosure" 'enclosure 2.0)
  )
)
```

Next, call phoGenWaveguide to generate the required derived shapes.

```
cdfCreateParam(cdfId
  ?name      "generateWaveguide"
  ?prompt    "Generate Waveguide Derived Shapes"
  ?defValue  "t"
  ?parseAsCel "no"
  ?type      "boolean"
  ?storeDefault "t"
  :storeDefault "yes"
  ?display   "t")

pcDefinePCell(
  list(ddGetObj("gopdk") "CustomSBend" "layout")
    ;Pcell parameters
    (
      (designIntentLayer "string" "waveguide")
      (rotation "string" "0.0")
      (height "string" "10.0u")
      (length "string" "40.0u")
      (width "string" "0.5u")
      (generateWaveguide "boolean" t)
    );end of parameters
  ;Pcell body code
  let((ccCurve ccPath ccWaveguide)
```

## Virtuoso Photonics Solution Guide

### CurvyCore Building Blocks

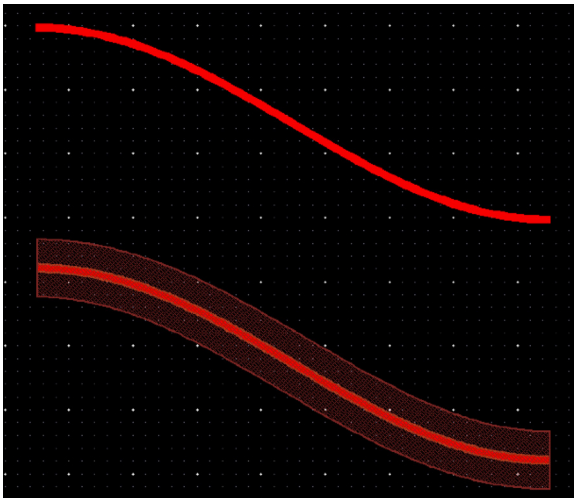
---

```
height = readstring(pcCellView~>parameters~>height)*1e6;
length = readstring(pcCellView~>parameters~>length)*1e6;
width = readstring(pcCellView~>parameters~>width)*1e6;
rotation = readstring(pcCellView~>parameters~>rotation);

ccCurve = CCSCreateSBend(height length)
ccpath = ccCreatePath(
    pcCellView
    list(designIntentLayer "drawing")
    list(list(ccCurve list(0:0 rotation)width)))
ccGenFigs(ccpath)

when(generateWaveguide
    ccWaveguide=phoGenWaveguide(ccPath)
    foreach(CCObj ccWaveguide
        ccGenFigs(CCObj)
    );foreach
);when
);let
);pcDefinePCell
```

The following figure shows the S-bend generated on the design intent layer (top shape) and the same S-bend when its associated derived waveguide layers are generated (bottom shape).



## ***Related Information***

[Photonics Functions](#)

[Waveguide Connectors](#)

[Virtuoso Parameterized Cell Reference](#)

## **Waveguide Connectors**

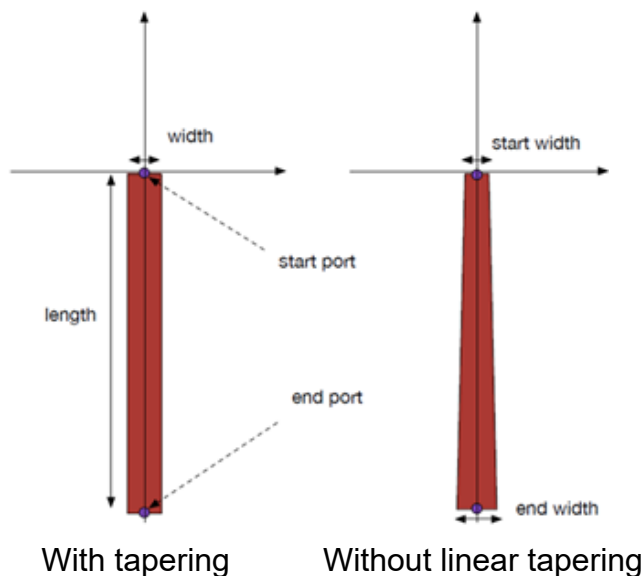
CurvyCore building blocks include a set of waveguide connectors such as straight, bend, curve, sine, and waypoint connectors. These connectors are two-port optical waveguides that are used as connector between other optical devices.

CurvyCore building blocks have a set of common features and parameters. Two of these parameters are offset and rotation.

### **Straight Connectors**

The general shape of a straight waveguide connector is shown in the following figure.

General shape of a straight waveguide connector



A straight waveguide connector supports two type of straight connections, with tapering and without tapering. It further supports four types of tapering, linear, exponential, logarithmic, and parabolic. If tapering is enabled, you need to set the start and end width and also type of taper

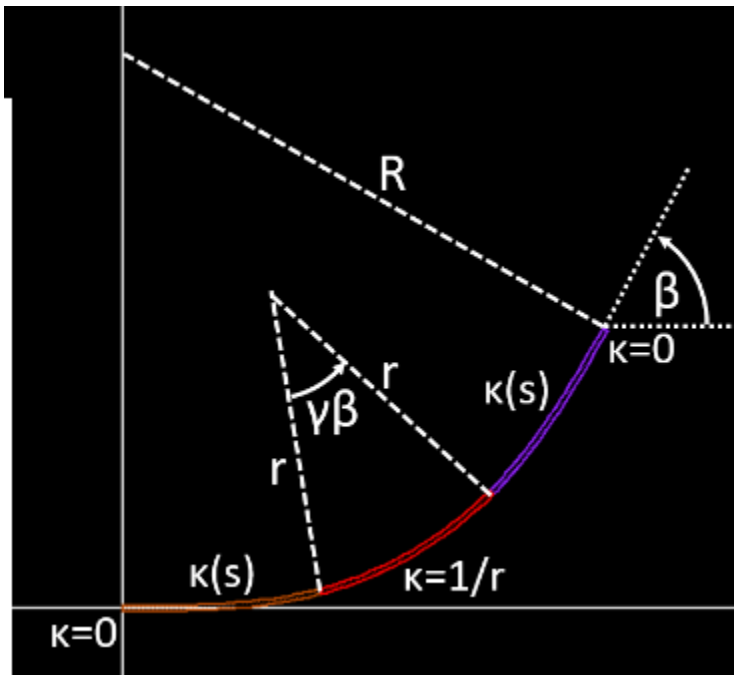
when you call the generator, otherwise, width specifies the default width of the straight waveguide. It also supports parameters such as start port and end port names.

### ***Related Information***

Photonics Functions

## **Bend Connectors**

A bend connector connects two points on the same circle with angles equal to the angles of the tangents to that circle. The bend connector is described by the bend radius  $R$  of the circle and the bend angle of the arc of that circle. In its simplest form, a bend connector consists of a single circular arc segment. If the bend connector connects two straight waveguide segments with zero curvature  $\kappa = 0$ , the curvature at the ports changes discontinuously, causing additional connection loss. This curvature discontinuity can be avoided if additional curve segments are inserted between the straight line segments and the circular arc segments so that the curvature becomes a continuous function  $\kappa(s)$  of the arc length as shown in the following figure.



Structure of a bend connector

### ***Related Information***

[ccBendConnector](#)

## **Curve Connectors**

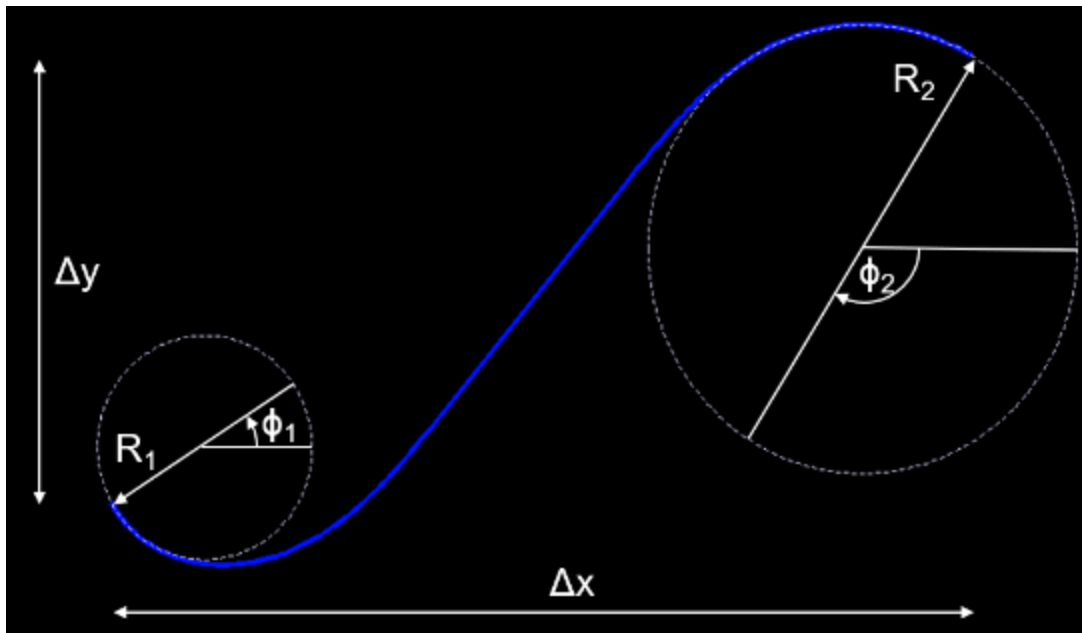
A curve connector connects one port with the following specifications:

- coordinates:  $x_1, y_1$
- facet angle:  $\phi_1$
- curvature radius:  $R_1$

To another port with the following specifications:

- coordinates:  $x_2, y_2$
- facet angle:  $\phi_2$
- curvature radius:  $R_2$

Curve connectors connect two points with a set of constraints on the facet angles and curvature radius as shown in the following figure:



If the coordinate system is rotated and translated such that one port is at the origin and another port is on the x-axis, the curve connector is described in terms of the distance

between the ports, the two facet angles with respect to the x-axis, and the two curvature radii. These five boundary conditions together with the minimum curvature radius  $R_{min}$  represent six constraints for the calculation of the curve connector. With only six constraints, the calculation of curve connectors is an under-constrained issue. One additional constraint can be imposed by requiring that:

$$d^2\kappa(s)/d^2s = 0$$

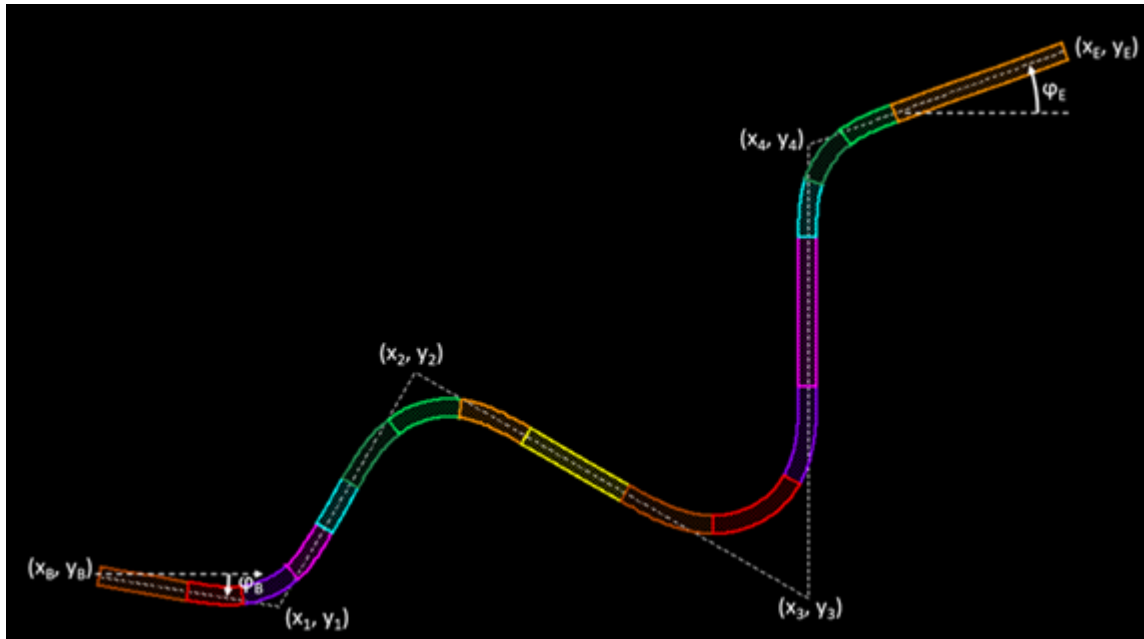
This limits the solution space to only three classes of curves, namely straight lines, circular arcs and clothoids. Curve connectors are thus a special case of clothoid splines.

### ***Related Information***

[ccCurveConnector](#)

## **Waypoint Connectors**

Waypoint connector connects the begin port with coordinates  $(x_b, y_b)$  to the end port with coordinates  $(x_E, y_E)$  by a sequence of straight line segments and bend connectors. The straight line segments are defined by a polygonal line through the series of waypoints with coordinates  $(x_i, y_i)$  as shown in the following figure:



Structure of a waypoint connector



The facet angles at the ports are determined by the angles  $\phi_b$  and  $\phi_E$  of the lines connecting the begin point with the first waypoint and the end point with the last waypoint, respectively.

Similarly as a single bend connector, each bend connector in a waypoint connector can also consist of a circular arc connected to the straight lines at its ends by a pair of apex clothoids. This is also shown in the above figure, with the straight line segments, the circular arc segments, and the clothoid segments displayed in different colors. The waypoint connector can be calculated using the [ccWaypointConnector](#) SKILL function.

### ***Related Information***

[ccWaypointConnector](#)

# **Virtuoso Photonics Solution Guide**

## **CurvyCore Building Blocks**

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## Environment Variables

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This appendix provides information on the environment variable names, descriptions, and graphical user interface equivalents for the Virtuoso<sup>®</sup> Photonics Solution.

**Note:** Only the environment variables documented in this chapter are supported for public use. All other Photonics Solution environment variables, regardless of their name or prefix, and undocumented aspects of the environment variables that are described below are private and are subject to change at any time.

### *Related Topics*

- [Setting Environment Variables](#)
- [List of Photonics Solution Environment Variables](#)

## Setting Environment Variables

Environment variables control the values of the Virtuoso Photonics Solution options.

For information on setting the environment variables, see [Setting Environment Variables](#).

For a list of all the supported environment variables and their values, see [List of Photonics Solution Environment Variables](#).

## List of Photonics Solution Environment Variables

generateSchematicMfactor

opticalSigTypePropagation

opticalNetColor

opticalNetColoring

opticalNetLineStyle

phoAbutClass

phoAbutFunction

phoComposeMaster

phoComposeMasterPromptOff

phoAbutNonPcells

phoPinInputAngle

phoPinLayer

phoPinRadius

phoPinWidth

photonicDisplay

photonicPinWidth

photonicPinAngle

photonicPinFacetInPacket

photonicPinFacetOutPacket

photonicPinLabelPacket

photonicPinRadius

photonicPinRadiusLinePacket

## Virtuoso Photonics Solution Guide

### Environment Variables

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photonicPinWidthLinePacket

srcOpticalElectricalConnection

srcOpticalMultiToSingle

srcOpticalSingleToMulti

srcOpticalTooManyConnections

## generateSchematicMfactor

```
layoutXL generateSchematicMfactor boolean { t | nil }
```

### Description

Creates mfactors for layout instances and dummies during a *Generate Schematic From Layout* run.

The default is `nil`.

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "generateSchematicMfactor")
envSetVal("layoutXL" "generateSchematicMfactor" 'boolean t)
envSetVal("layoutXL" "generateSchematicMfactor" 'boolean nil)
```

### ***Related Topics***

[Generating Selected From Layout](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## opticalSigTypePropagation

```
schematic opticalSigTypePropagation boolean { t | nil }
```

### Description

Propagates the optical signal type.

The default is `t`.

### GUI Equivalent

Command

*Options – Check*

Form Field

*Propagate the Optical Signal Type Values (Schematic Check Options form)*

### Examples

```
envGetVal("schematic" "opticalSigTypePropagation")
envSetVal("schematic" "opticalSigTypePropagation" 'boolean t)
envSetVal("schematic" "opticalSigTypePropagation" 'boolean nil)
```

### ***Related Topics***

List of Photonics Solution Environment Variables

Setting Environment Variables

## opticalNetColor

```
schematic opticalNetColor string "cream"
```

### Description

Specifies the color of the optical nets.

The line style for the optical nets can also be specified using [opticalNetLineStyle](#).

### GUI Equivalent

Command	<i>Options – Check</i>
Form Field	<i>Set Optical Wire Style (<a href="#">Schematic Check Options</a> form)</i>

### Examples

```
envGetVal("schematic" "opticalNetColor")  
envSetVal("schematic" "opticalNetColor" 'string "blue")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)



## opticalNetColoring

```
schematic opticalNetColoring boolean { t | nil }
```

### Description

Specifies whether the optical nets need to have a specified color.

The default is `t`.

### GUI Equivalent

None

### Examples

```
envGetVal("schematic" "opticalNetColoring")  
envSetVal("schematic" "opticalNetColoring" 'boolean t)  
envSetVal("schematic" "opticalNetColoring" 'boolean nil)
```

### *Related Topics*

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## opticalNetLineStyle

```
schematic opticalNetLineStyle string "thickLine"
```

### Description

Specifies the line style for the optical nets.

The color for the optical nets can also be specified using [opticalNetColor](#).

### GUI Equivalent

Command

*Options – Check*

Form Field

*Set Optical Wire Style ([Schematic Check Options](#) form)*

### Examples

```
envGetVal("schematic" "opticalNetLineStyle")  
envSetVal("schematic" "opticalNetLineStyle" 'string "thinline")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoAbutClass

```
layoutXL phoAbutClass string "valid_abutment_class"
```

### Description

Specifies that two optical pins can abut only when they belong to the same abutment class. Examples of abutment classes that can be used for abutting pins include the pin layer, pin edge, and so on.

The default is " ", which means that the pin layer is used to get the `abutClass` property because the property is neither set on the Pcell, nor defined by this environment variable.

### Note:

- When the environment variable is set to t, the pin layer refers to the layer, irrespective of the layer purpose.
- If the Pcell or non-Pcell instances do not have the `abutClass` abutment property set on the abutting pinFigs, the value set for the `phoAbutClass` environment variable is used for abutment.

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "phoAbutClass")  
envSetVal("layoutXL" "phoAbutClass" 'string "pin_layer")
```

### ***Related Topics***

[Abutment in Virtuoso Photonics Solution](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoAbutFunction

```
layoutXL phoAbutFunction string "valid_function_name"
```

### Description

Specifies a user-defined callback to process abutment and unabutment.

The default is "phoWGAbut", which means that this function is used to abut Pcells, non-Pcells, or both in photonic designs.

**Note:** If the Pcell or non-Pcell instances do not have the abutment property set on the abutting pinFigs, the value set for the `phoAbutFunction` environment variable is used for abutment.

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "phoAbutFunction")  
envSetVal("layoutXL" "phoAbutFunction" 'string "phoWGAbut")
```

### *Related Topics*

[Abutment in Virtuoso Photonics Solution](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoComposeMaster

```
layoutXL phoComposeMaster string "master_cellview_name"
```

### Description

Specifies the library cellview of the cell master to be used for creating the composite waveguide.

The default is " "

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "phoComposeMaster")  
envSetVal("layoutXL" "phoComposeMaster" 'string "pholib waveMaster layout")
```

### ***Related Topics***

[phoComposeMasterPromptOff](#)

[Abutment in Virtuoso Photonics Solution](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoComposeMasterPromptOff

```
layoutXL phoComposeMasterPromptOff boolean { t | nil }
```

### Description

Uses the bound schematic instances, if available, to determine the master library cellview to use for creating the composite waveguide. If the bound schematic instances are not available, uses a previous selection to determine the master cellview to use.

The default is "nil", which means a form is raised that enables you to specify the master library cellview to be used.

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "phoComposeMasterPromptOff")
envSetVal("layoutXL" "phoComposeMasterPromptOff" 'boolean t)
envSetVal("layoutXL" "phoComposeMasterPromptOff" 'boolean nil)
```

### *Related Topics*

[phoComposeMaster](#)

[Abutment in Virtuoso Photonics Solution](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoAbutNonPcells

```
layoutXL phoAbutNonPcells boolean { t | nil }
```

### Description

Controls whether the abutment of photonic non-Pcell instances is supported.

The default is "t", which means:

- Top-level pins can abut with instance pins.
- Photonic non-Pcell instances can abut with both non-Pcell and Pcell instances.

### GUI Equivalent

None

### Examples

```
envGetVal("layoutXL" "phoAbutNonPcells")  
envSetVal("layoutXL" "phoAbutNonPcells" 'boolean t)  
envSetVal("layoutXL" "phoAbutNonPcells" 'boolean nil)
```

### *Related Topics*

[Abutment in Virtuoso Photonics Solution](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoPinInputAngle

layoutXL phoPinInputAngle float *floating\_point\_number*

### Description

Specifies the default angle to use for generating the optical input pins in the layout.

The default is 90.0.

### Arguments

*floating\_point\_number*,

A floating point number that specifies the default angle to use for creating the optical input pins in the layout.

### GUI Equivalent

Command:      *Connectivity – Generate – All From Source – I/O Pins* (tab)

Field:          *Default Values for Optical Pins – Input Angle* (field)

### Examples

```
envGetVal("layoutXL" "phoPinInputAngle")  
envSetVal("layoutXL" "phoPinInputAngle" 'float 45.0)
```

### ***Related Topics***

[Generating Optical Pins](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)



## phoPinLayer

```
layoutXL phoPinLayer string "valid_photonic_layer_name"
```

### Description

Specifies the default photonic layer to use for generating optical pins in the layout.

The default is "".

If no default layer is specified in the environment variable, the first photonic layer in the list of `validLayers` is used for optical pin generation.

### GUI Equivalent

Command: *Connectivity – Generate – All From Source – I/O Pins* (tab)

Field: *Default Values for Optical Pins – Layer* (field)

### Examples

```
envGetVal("layoutXL" "phoPinLayer")  
envSetVal("layoutXL" "phoPinLayer" 'string "waveguide drawing")
```

### ***Related Topics***

[Generating Optical Pins](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoPinRadius

layoutXL phoPinRadius float *floating\_point\_number*

### Description

Specifies the default radius to use for generating optical pins in the layout.

The default is 0.0.

### Arguments

*floating\_point\_number*,

A floating point number that specifies the default radius for creating the circular optical pins in the layout.

### GUI Equivalent

Command:      *Connectivity – Generate – All From Source – I/O Pins* (tab)

Field:          *Default Values for Optical Pins – Radius* (field)

### Examples

```
envGetVal("layoutXL" "phoPinRadius")  
envSetVal("layoutXL" "phoPinRadius" 'float 0.2)
```

### ***Related Topics***

[Generating Optical Pins](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## phoPinWidth

layoutXL phoPinWidth float *floating\_point\_number*

### Description

Specifies the default width to use for generating optical pins in the layout.

The default is 0.0.

### Arguments

*floating\_point\_number*,

A floating point number that specifies the default width for creating the optical pins in the layout.

### GUI Equivalent

Command:      *Connectivity – Generate – All From Source – I/O Pins* (tab)

Field:          *Default Values for Optical Pins – Width* (field)

### Examples

```
envGetVal("layoutXL" "phoPinWidth")  
envSetVal("layoutXL" "phoPinWidth" 'float 0.2)
```

### ***Related Topics***

[Generating Optical Pins](#)

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## photonicDisplay

```
graphic photonicDisplay boolean { t | nil }
```

### Description

Controls whether to display photonic pin attributes in layout (t) or not (nil).

The default is nil.

### GUI Equivalent

None

### Examples

```
envGetVal("graphic" "photonicDisplay")  
envSetVal("graphic" "photonicDisplay" 'boolean t)  
envSetVal("graphic" "photonicDisplay" 'boolean nil)
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## photonicPinWidth

```
layout photonicPinWidth float float_number
```

### Description

Specifies the width of the facet of the waveguide that connects to a pin. The default value is 0.1.

### GUI Equivalent

Command	<i>Create – Pin – Manual</i>
Field	<i>Photonic Width (<a href="#">Create Pin Form</a>)</i>

### Examples

```
envGetVal("layout" "photonicPinWidth")  
envSetVal("layout" "photonicPinWidth" 'float 0.5)
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## photonicPinAngle

```
layout photonicPinAngle float float_number
```

### Description

Specifies the angle of the facet of the waveguide at the intersection of the pin.

The default is 0.0.

### GUI Equivalent

Command	<i>Create – Pin – Manual</i>
Field	<i>Photonic Angle (<a href="#">Create Pin Form</a>)</i>

### Examples

```
envGetVal("layout" "photonicPinAngle")  
envSetVal("layout" "photonicPinAngle" 'float 15)
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## **photonicPinFacetInPacket**

`graphic photonicPinFacetInPacket string packetName`

### **Description**

Specifies the name of the packet for the pin on which a waveguide facet is drawn inside.

### **GUI Equivalent**

None

### **Examples**

```
envGetVal("graphic" "photonicPinFacetInPacket")  
envSetVal("graphic" "photonicPinFacetInPacket" 'string "phoPinFacetIn")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## **photonicPinFacetOutPacket**

`graphic photonicPinFacetOutPacket string packetName`

### **Description**

Specifies the name of the packet for the pin on which a waveguide facet is drawn outside.

### **GUI Equivalent**

None

### **Examples**

```
envGetVal("graphic" "photonicPinFacetOutPacket")  
envSetVal("graphic" "photonicPinFacetOutPacket" 'string "phoPinFacetOut")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)



## photonicPinLabelPacket

graphic photonicPinLabelPacket string *packetName*

### Description

Specifies the name of the packet in which the photonic pin label is drawn.

### GUI Equivalent

None

### Examples

```
envGetVal("graphic" "photonicPinLabelPacket")  
envSetVal("graphic" "photonicPinLabelPacket" 'string "phoPinLabel")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## photonicPinRadius

layout photonicPinRadius float *float\_number*

### Description

Specifies the radius of the curve of the waveguide center at the point it meets the facet.

The default value is 0.0.

### GUI Equivalent

Command	<i>Create – Pin – Manual</i>
Field	<i>Photonic Radius (<a href="#">Create Pin Form</a>)</i>

### Examples

```
envGetVal("layout" "photonicPinRadius")  
envSetVal("layout" "photonicPinRadius" 'float 2)
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## photonicPinRadiusLinePacket

graphic photonicPinRadiusLinePacket string *packetName*

### Description

Specifies the name of the packet in which the photonic pin radius line is drawn.

### GUI Equivalent

None

### Examples

```
envGetVal("graphic" "photonicPinRadiusLinePacket")
envSetVal("graphic" "photonicPinRadiusLinePacket" 'string "phoPinRadiusLine")
```

### ***Related Topics***

List of Photonics Solution Environment Variables

Setting Environment Variables

## photonicPinWidthLinePacket

`graphic photonicPinWidthLinePacket string packetName`

### Description

Specifies the name of the packet in which the photonic pin width line is drawn.

### GUI Equivalent

None

### Examples

```
envGetVal("graphic" "photonicPinWidthLinePacket")  
envSetVal("graphic" "photonicPinWidthLinePacket" 'string "phoPinWidthLine")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## srcOpticalElectricalConnection

```
schematic srcOpticalElectricalConnection cyclic { "ignored" "warning" "error" }
```

### Description

Specifies the severity of the schematic rules checker (SRC) check for any optical to electrical connections.

The default is `error`.

### GUI Equivalent

Command	<i>Check – Rules Setup</i>
Form Field	<i>Electrical Connections (Optical tab) (<u>Schematic Rules Checks Setup</u> form)</i>

### Examples

```
envGetVal("schematic" "srcOpticalElectricalConnection")  
envSetVal("schematic" "srcOpticalElectricalConnection" 'cyclic "ignored")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## **srcOpticalMultiToSingle**

```
schematic srcOpticalMultiToSingle cyclic { "ignored" "warning" "error" }
```

### **Description**

Specifies the severity of the schematic rules checker (SRC) check for any multi mode optical to single mode optical connections.

The default is `error`.

### **GUI Equivalent**

Command	<i>Check – Rules Setup</i>
Form Field	<i>Multi Mode to Single Mode (Optical tab) (<u>Schematic Rules Checks Setup</u> form)</i>

### **Examples**

```
envGetVal("schematic" "srcOpticalMultiToSingle")  
envSetVal("schematic" "srcOpticalMultiToSingle" 'cyclic "ignored")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## **srcOpticalSingleToMulti**

```
schematic srcOpticalSingleToMulti cyclic { "ignored" "warning" "error" }
```

### **Description**

Specifies the severity of the schematic rules checker (SRC) check for single mode nets or outputs that are connected to multi mode inputs or nets.

The default is `ignored`.

### **GUI Equivalent**

Command	<i>Check – Rules Setup</i>
Form Field	<i>Single Mode to Multi Mode (Optical tab) (<u>Schematic Rules Checks Setup</u> form)</i>

### **Examples**

```
envGetVal("schematic" "srcOpticalSingleToMulti")  
envSetVal("schematic" "srcOpticalSingleToMulti" 'cyclic "ignored")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)

## **srcOpticalTooManyConnections**

```
schematic srcOpticalTooManyConnections cyclic { "ignored" "warning" "error" }
```

### **Description**

Specifies the severity of the schematic rules checker (SRC) check for optical nets to ensure each has a maximum of 2 connections.

The default is `error`.

### **GUI Equivalent**

Command	<i>Check – Rules Setup</i>
Form Field	<i>Too Many Connections (Optical tab) (<u>Schematic Rules Checks Setup</u> form)</i>

### **Examples**

```
envGetVal("schematic" "srcOpticalTooManyConnections")  
envSetVal("schematic" "srcOpticalTooManyConnections" 'cyclic "ignored")
```

### ***Related Topics***

[List of Photonics Solution Environment Variables](#)

[Setting Environment Variables](#)



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# Forms

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This section lists and describes the Virtuoso<sup>®</sup> Photonics Solution forms.

## Virtuoso Photonics Solution Forms

Composite Waveguide Editor

## Composite Waveguide Editor

Use the Composite Waveguide Editor to edit a composite waveguide. A composite waveguide is a general placeholder for waveguide paths between optical components and can be generated in the layout when using the Virtuoso Photonics Solution. Using the Composite Waveguide Editor, you can edit the different building blocks of a waveguide path, such as straight waveguide and bend waveguide.

### Elements

Lists the various waveguide instances that together comprise the composite waveguide.

For each waveguide element, the corresponding *Library*, *Cell*, and *View* information is also listed.

For the selected waveguide element, the adjoining preview pane displays an image of the composite waveguide, highlighting the part represented by the selected element.

### Parameters

Lists the parameters corresponding to the selected waveguide element. Only those parameters that correspond to the selected waveguide element are displayed. The *Orientation* parameter is applicable to all the supported waveguide elements. Therefore, the *Orientation* parameter is always displayed.

**Orientation** lists the supported orientations for generating the selected waveguide element.

**waveguide layer** specifies the valid layer on which the optical connection is supported.

**Rotation** specifies the angle at which the selected waveguide element can rotate.

**Radius** specifies the curvature of the selected waveguide element.

**Length** specifies the length of a straight waveguide element.

**Width** specifies the width of the selected waveguide element.

**Total Angle (deg)** specifies the length of an arc (in degrees) for the circle whose radius is specified by the *Radius* parameter.

**Note:** The *Total Angle (deg)* and *Total Angle (rad)* parameters are used for bend waveguides.

**Total Angle (Rad)** specifies the length of an arc (in radians) for the circle whose radius is specified by the *Radius* parameter. This parameter is automatically calculated using the *Total Angle (deg)* value.

**Note:** The *Total Angle (rad)* and *Total Angle (deg)* parameters are used for bend

waveguide elements.

### Options

**Align elements** specifies that when a change such as the change in rotation, total angle, or radius, is made to the selected element, all the subsequent elements are automatically rotated to maintain their alignment.

For example, out of the three elements present, if you rotate the middle waveguide element, the last waveguide element is also automatically rotated to stay in alignment. However, due to this re-alignment, the original alignment between the middle element and the first element is broken. If you add an element at the end of the current elements, the new element is also automatically rotated to correctly align.

**Show updates on canvas** enables the dynamic zooming in and panning that is performed on clicking *Apply*.

**Apply** zooms into and pans to display on the canvas the waveguide element selected for editing. The zoom and pan functionality is controlled by the dynamic zoom and pan functionality supported by the Display Options form.

By default, the selected waveguide element is panned into and displayed on the canvas, keeping the zoom settings unchanged.

### ***Related Topics***

Generating Optical Pins

**Virtuoso Photonics Solution Forms**

## **Virtuoso Photonics Solution Guide**

### **Forms**

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