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Foundry Logo

[Foundry Name] INTERCONNECT CML User Guide

[Month, Year]

Confidential

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# Introduction

## Purpose

The [Foundry Name] compact model library (CML) enables circuit designers to simulate and optimize photonic integrated circuit (PIC) behavior and performance within Ansys’s PIC simulator, Lumerical INTERCONNECT.

## Scope

This document is the User Guide for the [Foundry Name] CML. While it contains information about the [Foundry Name] devices and specifications, its main purpose is to describe the information needed for circuit simulations based on the CML. For more information about the device library and device performance specifications, users should use the [Foundry Design Manual] as primary source of information.

## Responsibility

Ansys and [Foundry Name] cannot provide any guarantee with respect to the model accuracy.

# Licensing

Users will need to obtain the following licenses directly from Ansys:

* Ansys Lumerical INTERCONNECT license

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| CML File Name: | [CML filename] |  |
| INTERCONNECT Version: | INTERCONNECT 2021 R1 or later | |

Install instructions:

<https://support.lumerical.com/hc/en-us/articles/360036620313-Install-Compact-Model-Library>

# Support

* For specific [Foundry Name] elements and models, please contact [Foundry Name] directly.
* For general INTERCONNECT usage, please go to the [Ansys Lumerical Support Center](https://support.lumerical.com/hc/en-us).

# General guidelines

## Notes

When using the model, please first read all the notes (if applicable) in the Property View, such as:

* Wavelength range
* Polarizations
* Biasing scheme
* Bias range
* Model limitations
* Simulation tips

## HTML page

Each element also comes with an HTML page, where you may find more model information such as symbols, ports, and properties. To access the HTML page from INTERCONNECT, simply select the element in the Schematic View (not in the Element Library), right-click on the element, and select “Help…”.

## Waveguide modes

All elements are designed for the fundamental TE-like and/or the fundamental TM-like mode [update accordingly].

* Fundamental TE-like mode corresponds to orthogonal identifier = 1
* Fundamental TM-like mode corresponds to orthogonal identifier = 2
* All elements support TE-like and TM-like fundamental modes except for the following elements, which support the fundamental TE-like (or TM-like) mode only:
  + [Include list here]
* No higher-order modes are supported [update accordingly].
* The mode mismatch losses at the interface between a waveguide element and the ports of a waveguide arc (*include list of waveguide arc elements*) are currently not included in the compact model as they depend on the geometry of the element connected to the arc. Only propagation losses in the arc region have been considered. [Remove if no arc element is present in the cml]

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| NOTE: The ‘polarization’ note on each element lists the fundamental modes supported by that element. [Remove if not applicable] |

## Waveguide connection

Users should remember to connect waveguides of different types ([include type list here]) or with different widths through the appropriate waveguide transition. Otherwise, the models will not consider the loss and/or reflection due to the waveguide mode mismatch. Several transition elements are available in the PDK [Remove if not applicable]. Similarly, if the waveguides are left disconnected, the reflection at the waveguide facet will not be considered. These considerations also apply to the optical ports of components terminated in waveguides.

## Electrical connection

All electrical ports require electrical signal inputs (i.e. connected to DC or time-variant electrical signal). All electrical signals are applied at their base unit (e.g., a voltage source with an amplitude of 1 a.u. is equivalent to 1 V; a current source with an amplitude of 0.01 a.u. is equivalent to 10 mA.) Please check the bias and/or current ranges in the model (“CML/Notes”) before applying electrical signals. [Remove if not applicable]

If anode/cathode or signal/ground are used for the electrical port names, please follow the conventions below: [update if necessary]

* V = V\_anode - V\_cathode; or V = V\_signal – V\_ground
* V < 0: reverse bias; V > 0: forward bias

The following elements have ports with electrical current as input or output. Please check the “electrical\_port” in the model (“CML/Notes”) for these elements: [Remove if not applicable]

* [All photodetector elements]

## Electrical filters

All the elements with electrical ports have internal electrical filters that can be disabled by setting the property "internal electrical equivalent" (under “Design Kit”) to false. This is sometimes necessary for interoperability with third-party tools, such as SPICE simulators.

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| NOTE: The “internal electrical equivalent” property inherits its value from the Root Element by default. Changing the value of this property in the Root Element therefore updates this property in all elements automatically. |

## Minimum sample rate (time-domain simulation)

### Short waveguides

When simulating short waveguides in time-domain simulations, if the sample rate is too low, a warning message will appear in the Output window, advising to increase the sample rate above a minimum value. Increasing the sample rate above this value will resolve the warning.

Example:

“Warning: increase the sample rate to '1.8e+013' Hz.”

### General

The frequency range over which time-domain simulations are accurate may depend on the sample rate. In this case, a larger sample rate can be used to achieve accuracy over a larger bandwidth.

## Statistical variations

The following elements have been statistically enabled. The CML comes with a library file that contains information about all the statistical parameters. The library file can be loaded into the [Monte-Carlo](https://support.lumerical.com/hc/en-us/articles/360034403194-Monte-Carlo-analysis) or [corner analysis](https://support.lumerical.com/hc/en-us/articles/360043102714-Corner-analysis-utility) objects in INTERCONNECT to perform yield or corner analysis.

* [list all statistical elements]

## Temperature sensitivity and range

Temperature sensitivity has been included in some models. For those, the temperature range is specified in the element notes ("temperature\_range"); otherwise, the model's best accuracy is for room temperature only (300 K). [Update or remove if necessary]

## Delay compensation settings (advanced, time-domain simulation)

This section assumes the user is familiar with the use of the delay compensation parameter in the primitive Optical Straight Waveguide in INTERCONNECT, which is explained in [Delay Compensation in Transient Sample Mode Time-Domain Simulations](https://support.lumerical.com/hc/en-us/articles/360034919833-FSR-with-cavity-delay-compensation-in-Transient-Sample-Mode-simulator). **These settings are only important in time-domain simulations**.

The default delay compensation settings in models that support this feature are:

* delay compensation = 0
* internal delay compensation = false

The “delay compensation” parameter can be used to reduce the number of delays or digital filter taps used by the element in time-domain simulations. This is useful when the element is part of a closed-loop circuit or cavity (e.g. a ring resonator or a Fabry-Perot cavity), where it is necessary to compensate for the time step delay introduced by elements inside the loop or cavity so that the round-trip time of the signal is correct. Otherwise, “delay compensation” should be set to zero, as it is by default.

The “delay compensation” parameter in the models behaves identically to the “delay compensation” parameter in the primitive Optical Straight Waveguide element (provided the “internal delay compensation” is enabled in those elements that have this property, as explained below). An example of how to use this setting can be found in [Delay Compensation in Transient Sample Mode Time-Domain Simulations](https://support.lumerical.com/hc/en-us/articles/360034919833-FSR-with-cavity-delay-compensation-in-Transient-Sample-Mode-simulator).

Depending on the internal structure of the model, some of them require an additional property to set the delay compensation, “internal delay compensation”, which is false by default. Enabling this property ensures that the element will introduce only one delay, and so it will behave like the primitive straight waveguide in terms of the number of delays. As the “delay compensation”, this property should only be used in applications where strict control of the number of delays is necessary.