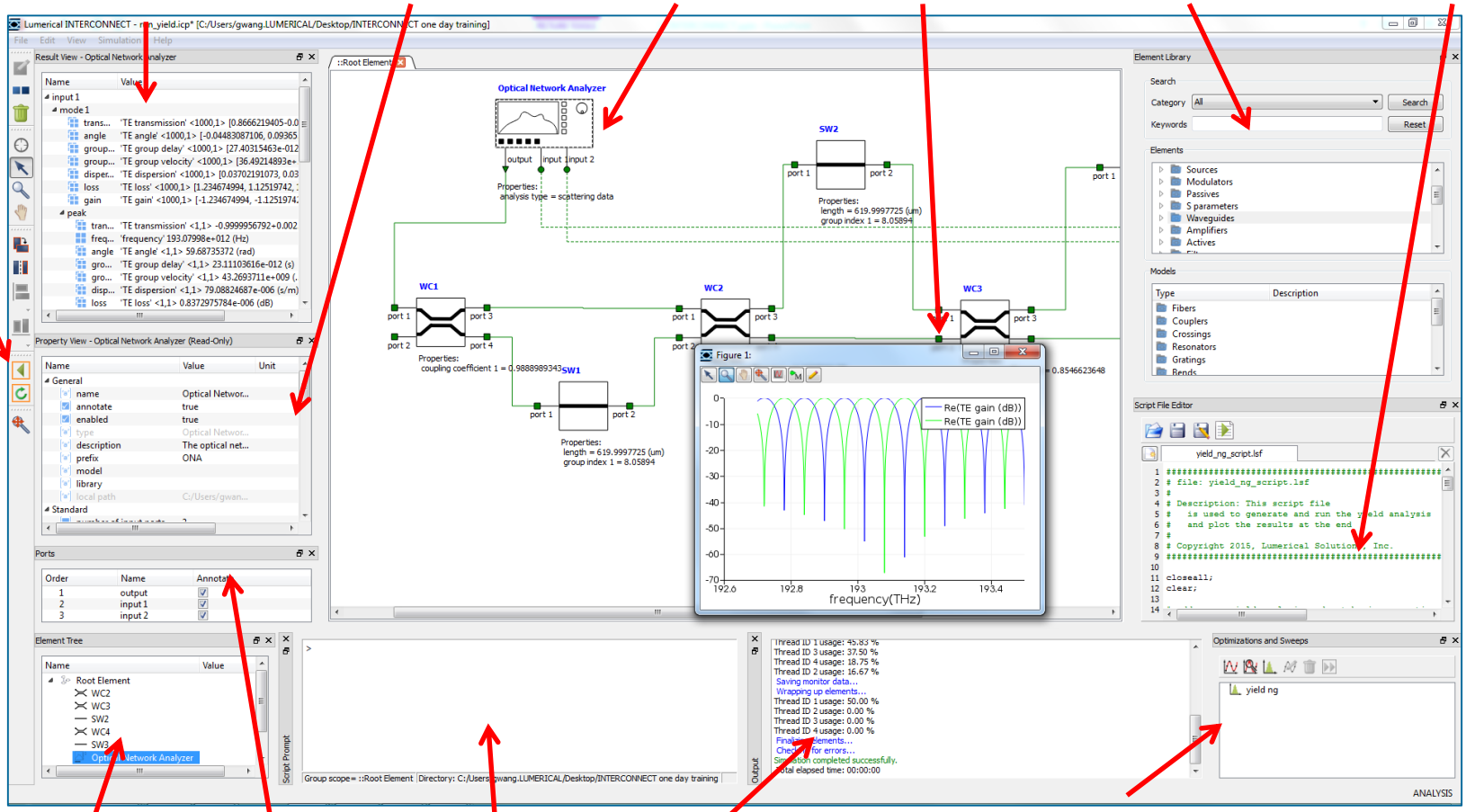
SC454 Silicon Photonics Circuits and Systems Design

OFC SHORT COURSE MARCH – 20TH, 2017

INTERCONNECT

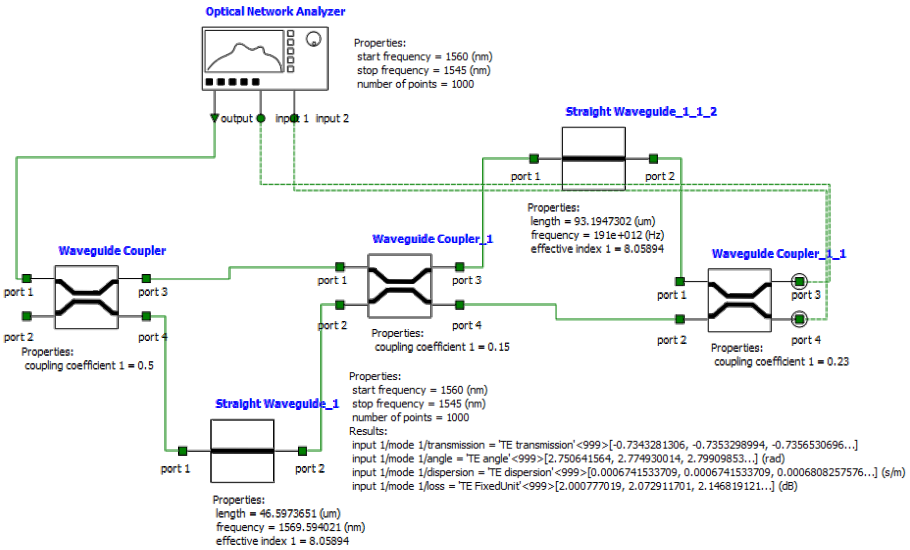
Photonic Integrated Circuit Simulator

INTERCONNECT GUI



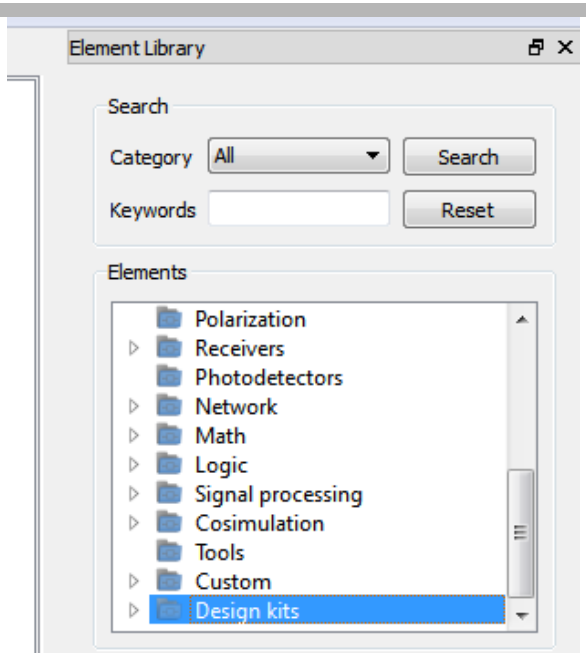
INTERCONNECT workflow

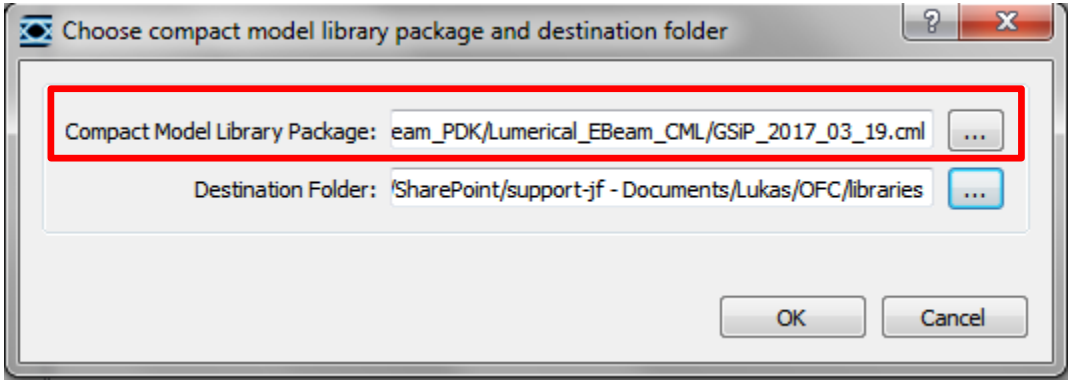
- Add circuit elements
- Add connections
- Add analyzer elements
- Set properties
- Run simulation
- Visualize results



Install a compact model library

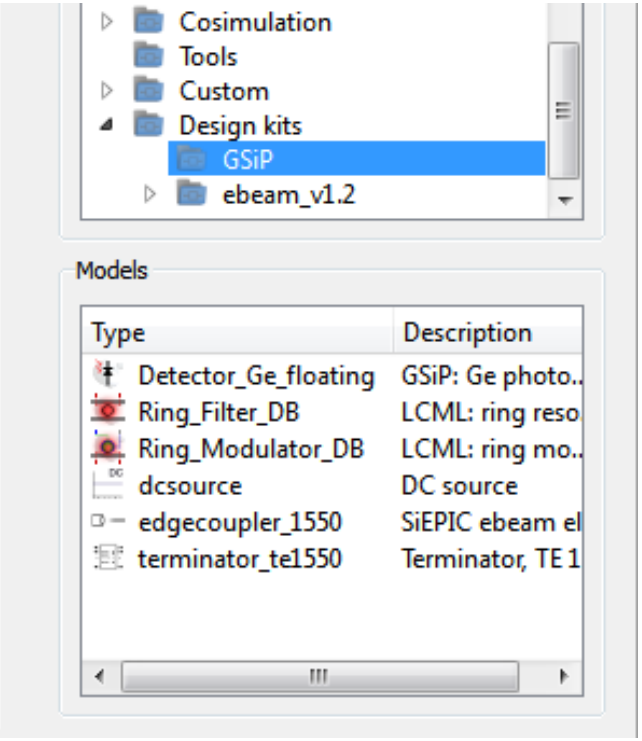
- Left mouse click on ‘Design Kit’ at the bottom of the element library
- Browse for the latest GSiP *.cml file (in the folder SiEPIC_Ebeam_PDK/Lumerical_Ebeam_CML)
- Choose a destination folder
- Repeat with the latest EBeam compact model library



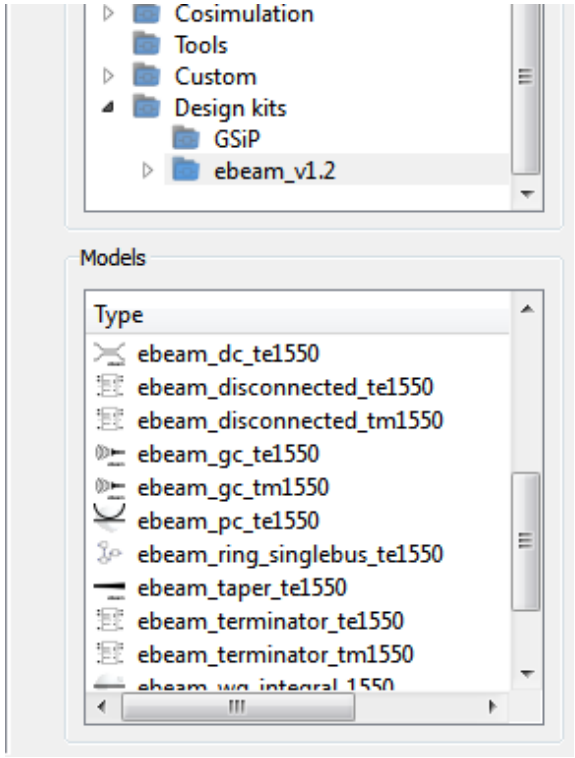


Compact model libraries

GSiP CML (active)

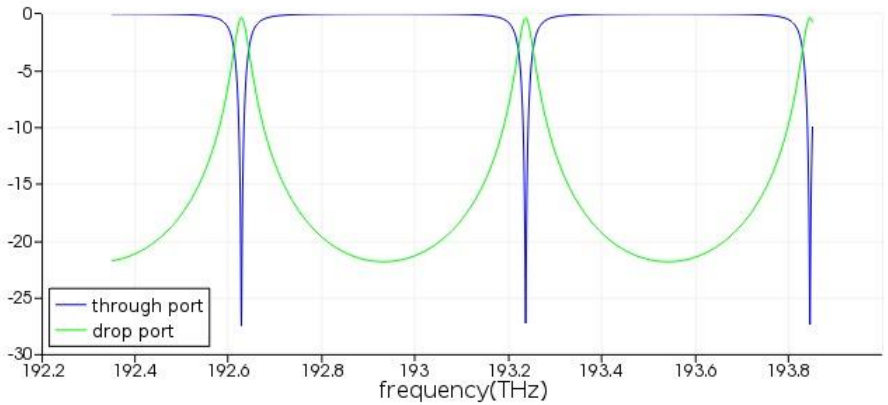


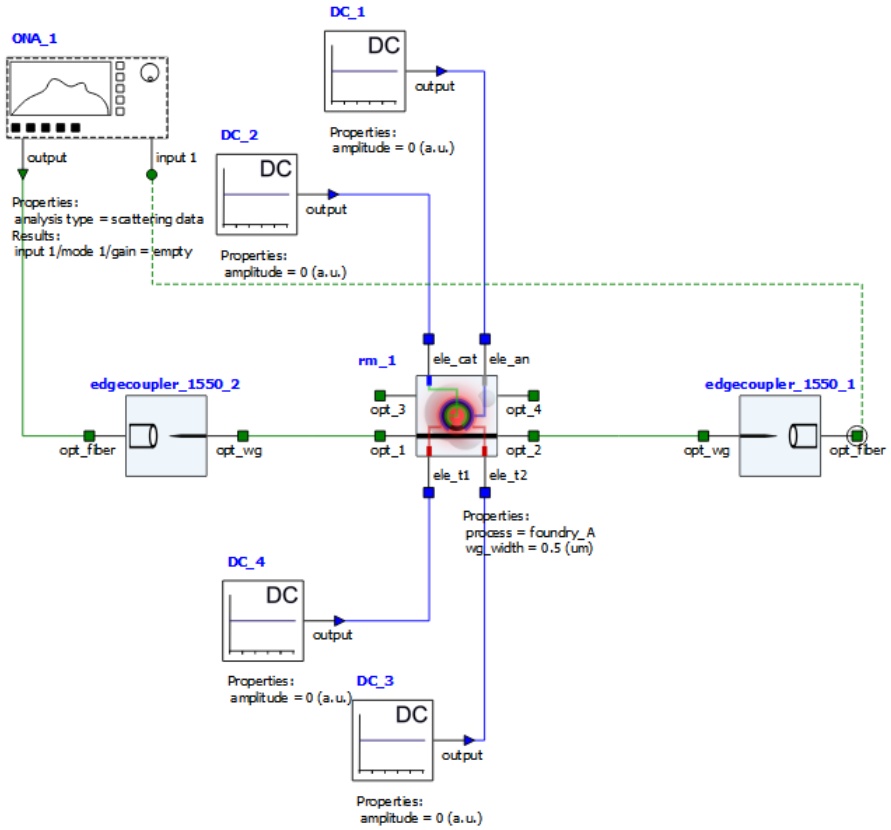
EBeam CML (passive)



Tutorial 1 – Getting Started

- Start application
- Create basic circuit
- Set properties
- Run simulation
- Visualize results
- Script

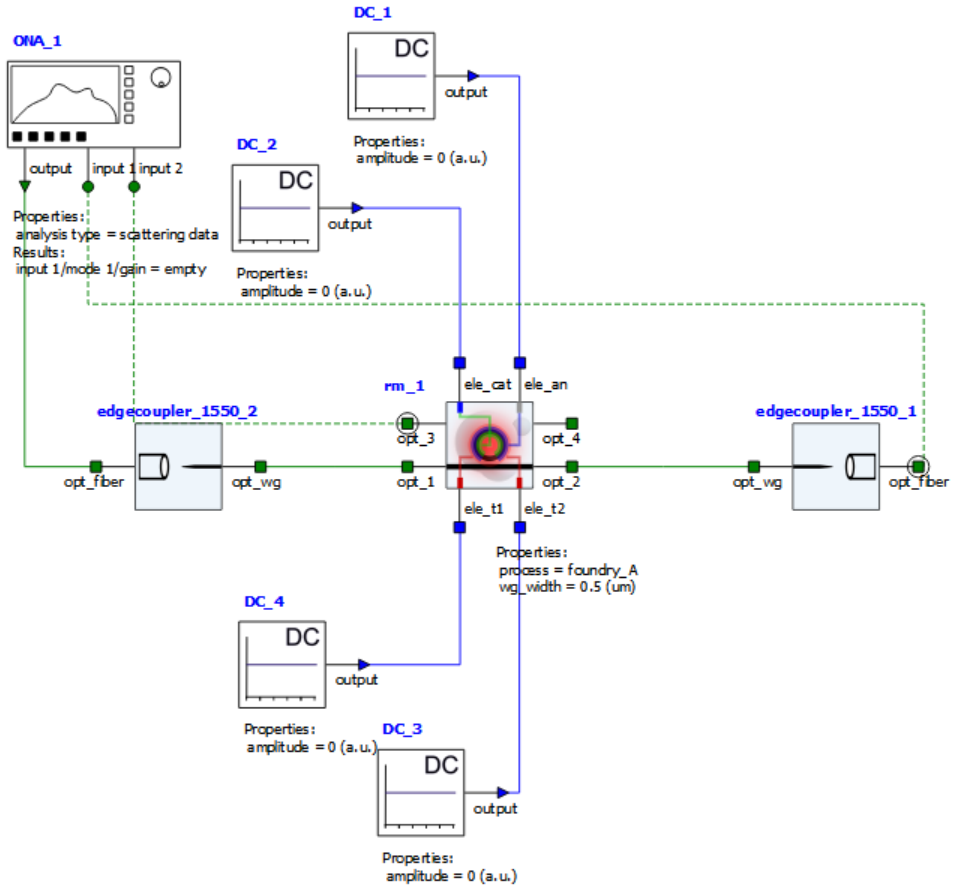




Frequency analysis

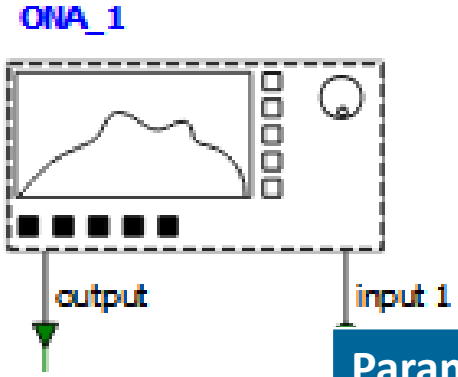
Create a simple circuit by drag and dropping components from the GSiP and the primitive element library.

- From the primitive element library
  - ONA – optical network analyzer
- From the GSiP
  - Ring_Modulator_DB
  - Edge_coupler_1550
  - dcsource



Optical Network Analyzer

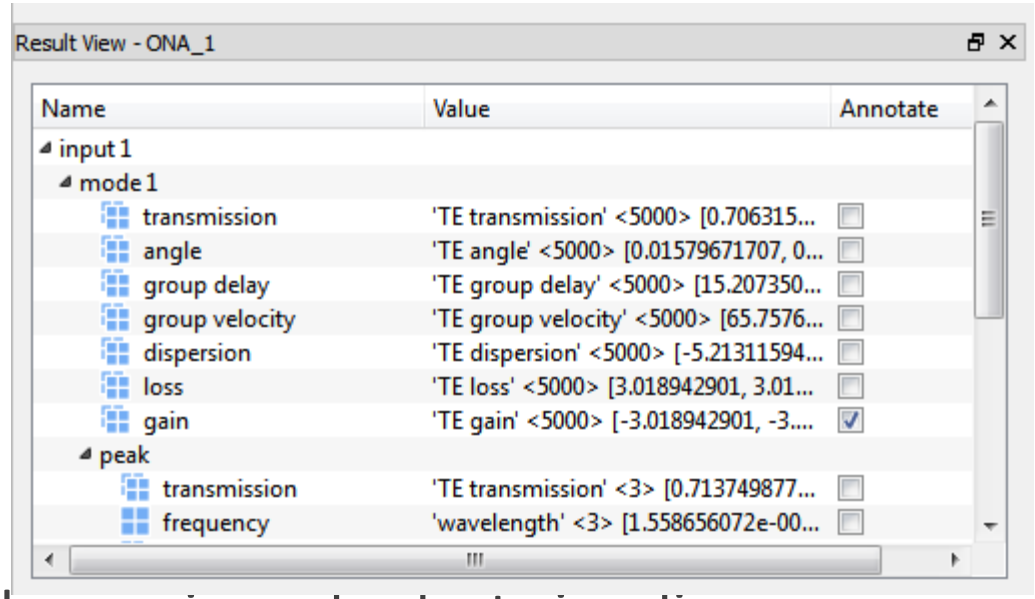
Use the following settings for the ONA (make sure the ONA is selected – dashed outline)



Parameter	value
Input parameter	Center and range
Center frequency	1550 [nm]
Frequency range	40 [nm]
Number of points	5000
Plot kind	wavelength
Number of input ports	2

Optical Network Analyzer

- Run a frequency analysis by clicking the green triangle
  - After a successful run the triangle should point the other direction
- Select the ONA (dashed outline) and find the result view window

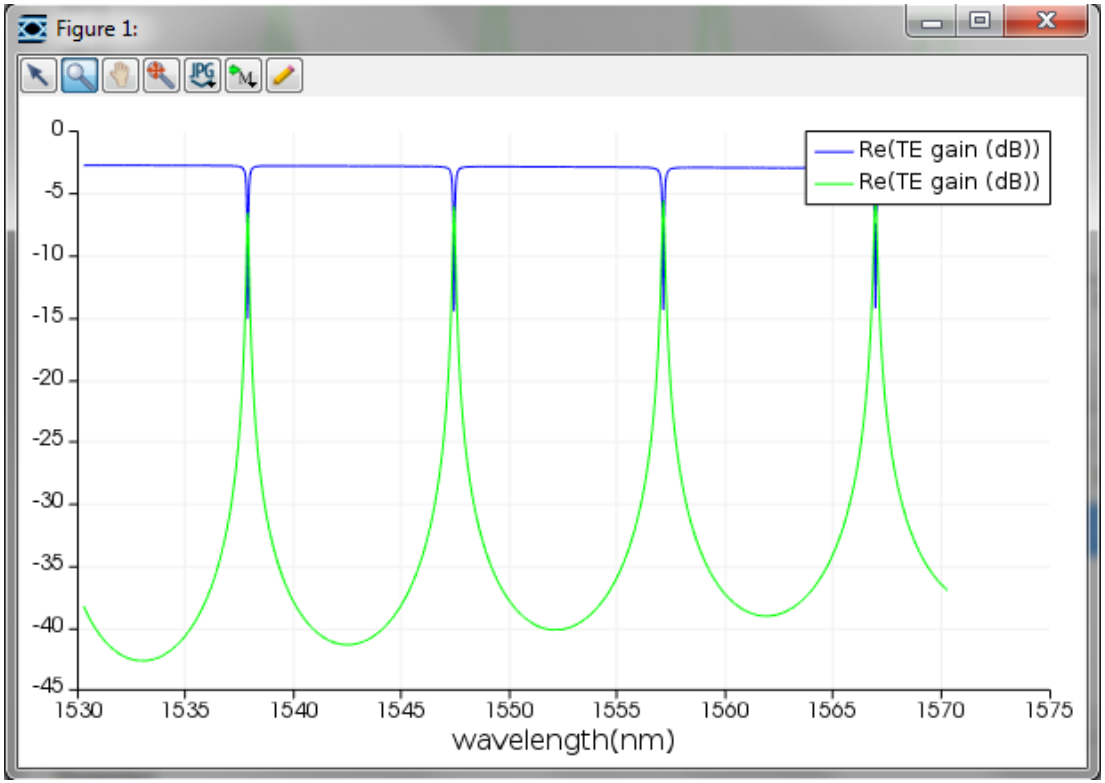


- Right click on gain and select visualize

Optical network analyzer

Multiple results can be send to the same visualizer

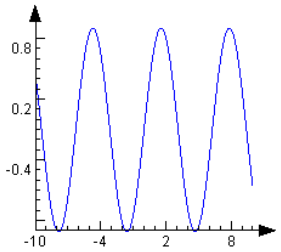
- Add the gain spectrum of the drop port to the same visualizer



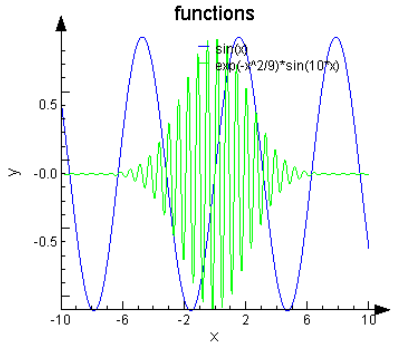
Scripting: Mathematics

Simple Mathematics: plot some simple functions

```
> x=linspace(-10,10,500);
> y=sin(x);
> plot(x,y);
```



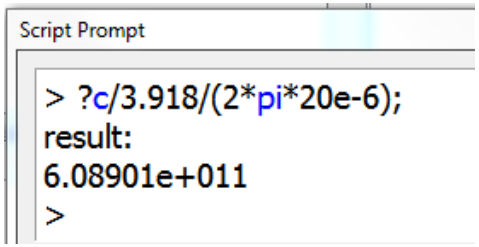

```
> y2=exp(-x^2/9)*sin(10*x);
> plot(x,y,y2,"x","y","functions");
> legend("sin(x)","exp(-x^2/9)*sin(10*x)");
```




```
>?size(x);
result:
500  1
```

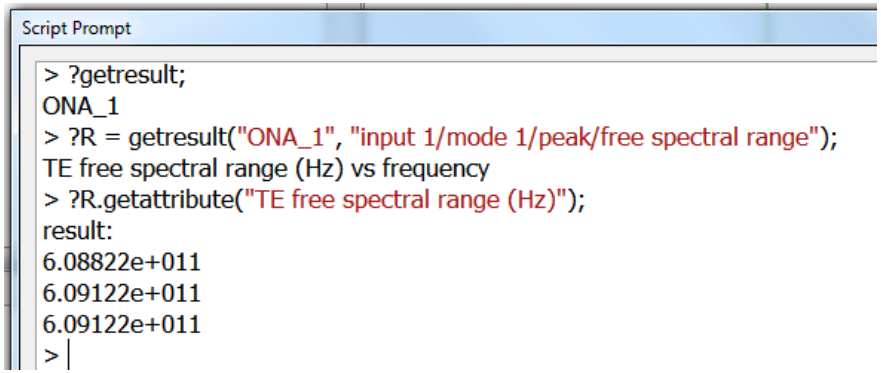
Frequency analysis

Free spectral range



$$\Delta v = \frac{c}{n_g l}$$

Peak analysis

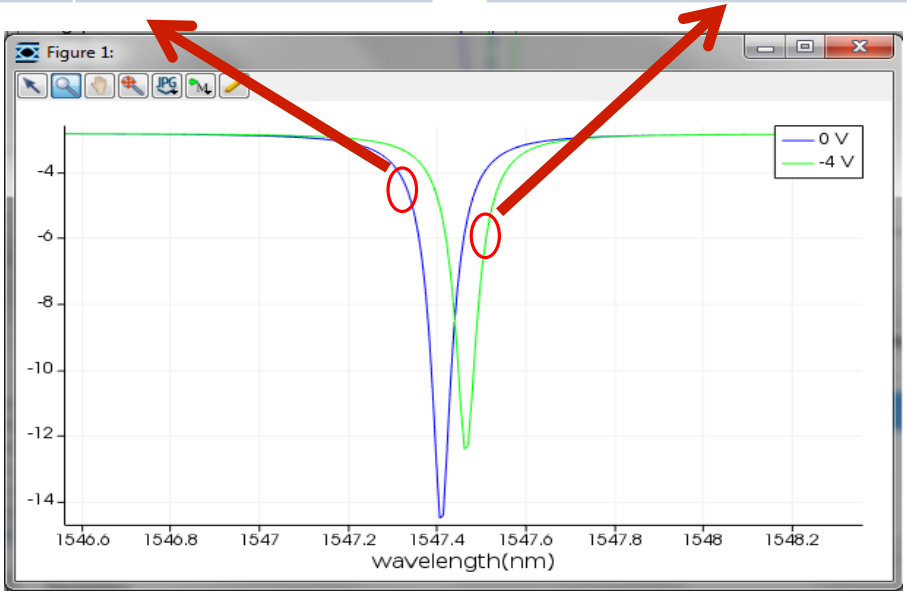


Frequency analysis

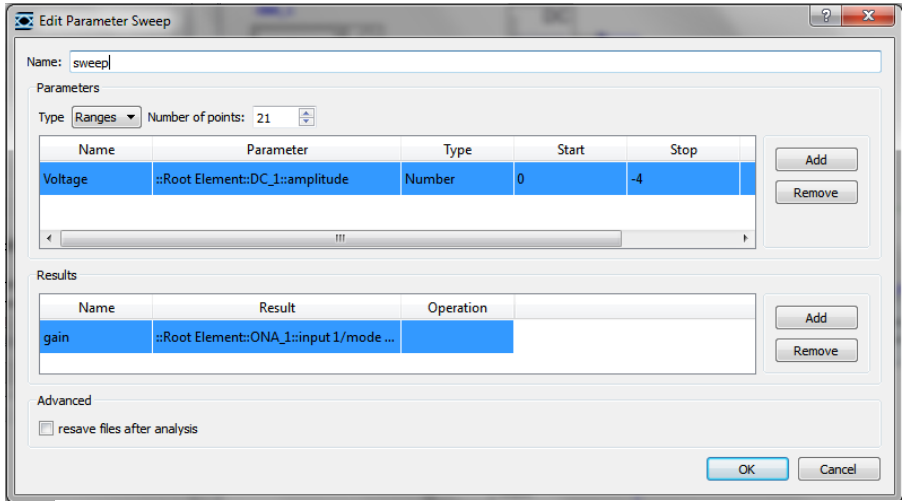
- Run the simulation twice with the DC source amplitude equals 0 and 4, respectively (applied to the anode of the modulator). Plot the gain curves in one figure.

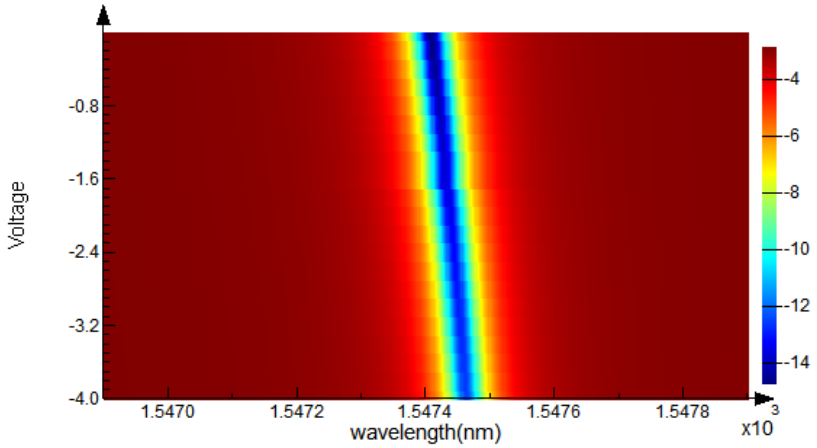
DC_1 Property	Value
Amplitude	0

DC_1 Property	Value
Amplitude	-4

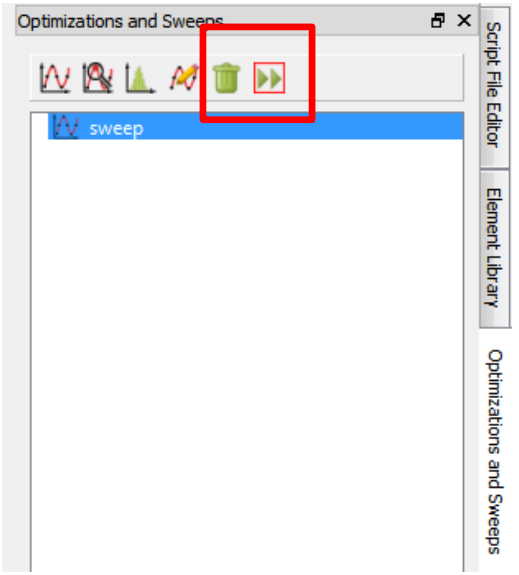


Sweep framework



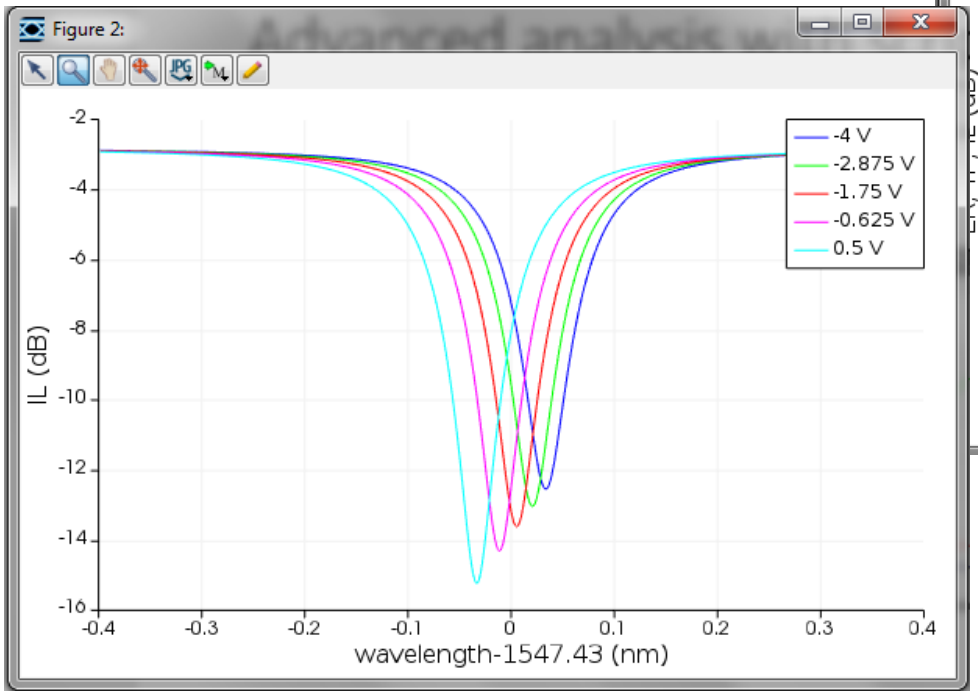


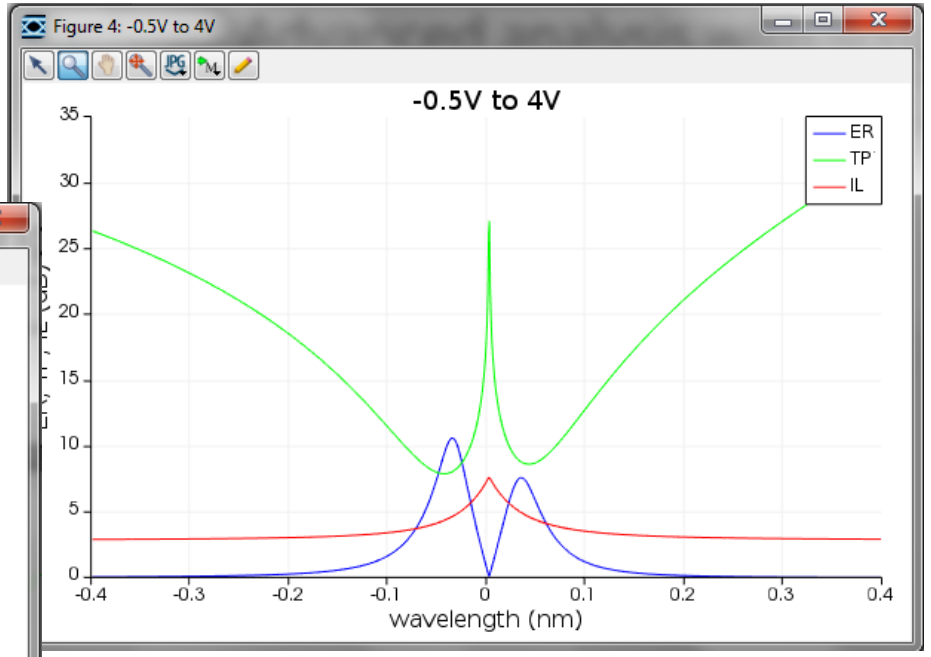
- DC_1 amplitude: from 0 to 4V
- Transmission at center (1547.4 nm)
- Change the center wavelength of the ONA to 1547.4 nm and the range to 1nm
- Run the sweep
- Right click on sweep to visualize



Advanced analysis with scripting

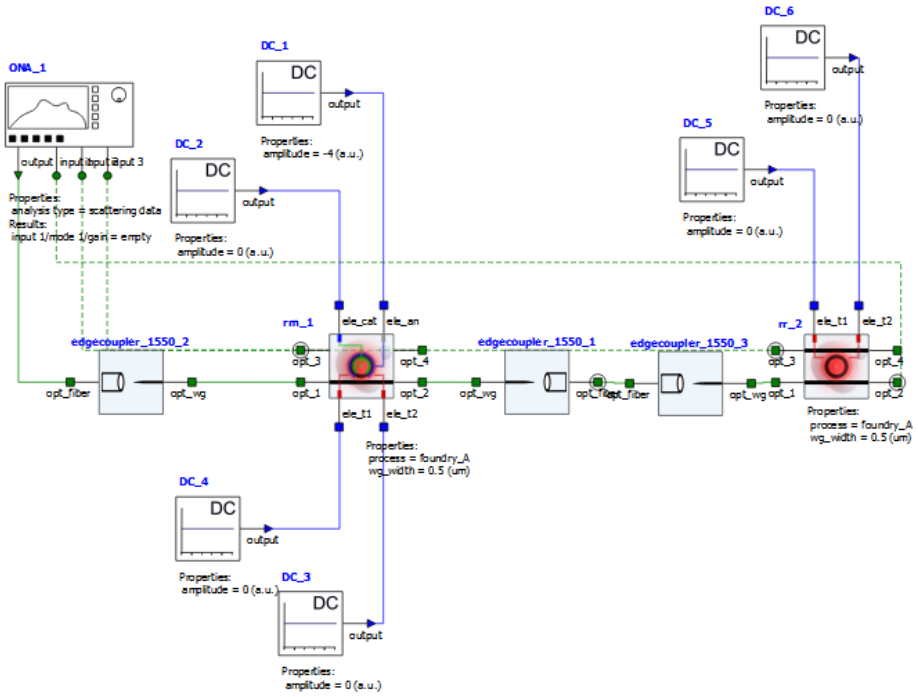
- Run the script ‘ring_mod_characterization.lsf’ to further analyze the ring modulator performance





Frequency analysis

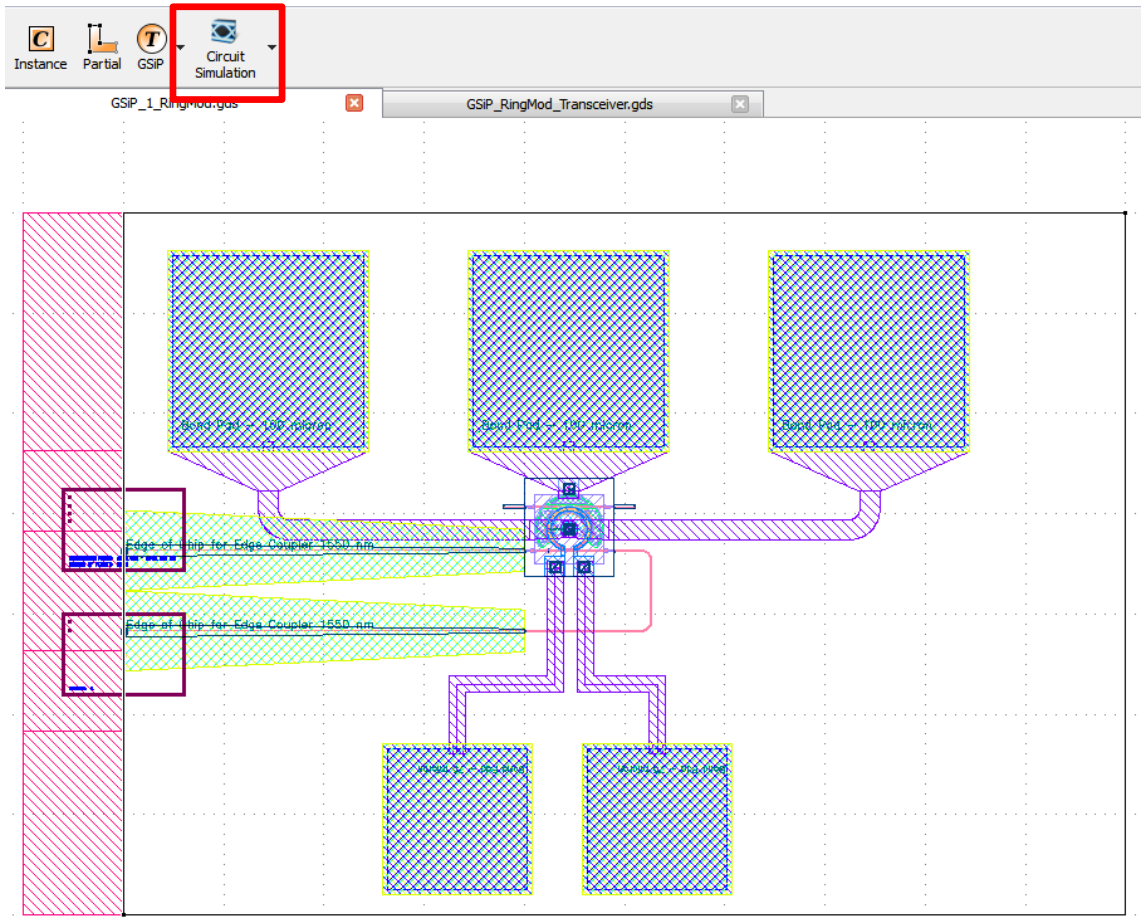
Ring modulator + drop filter (gap = 300nm and monitor gap = 310nm)



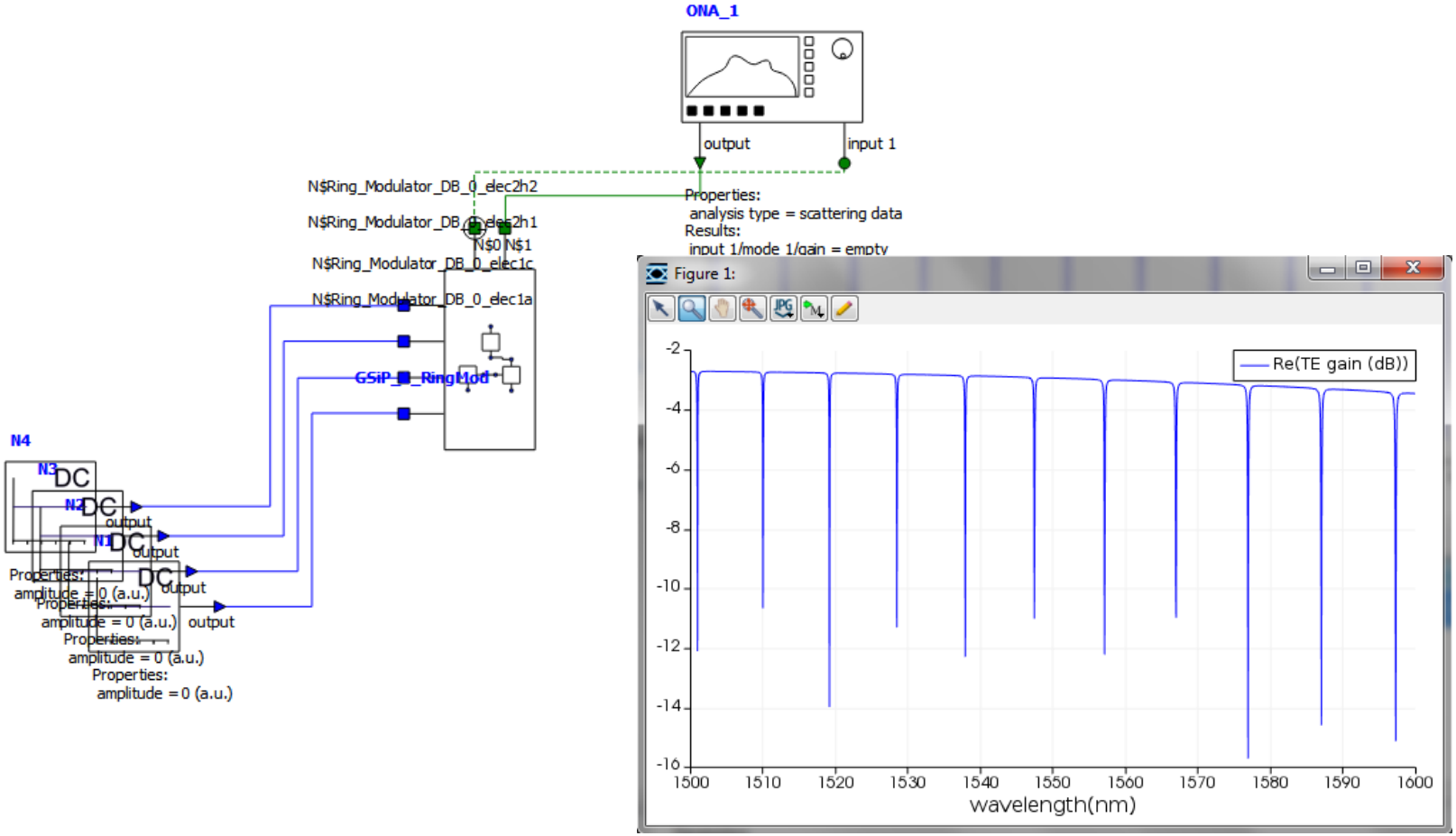
Tutorial 2 – Transient Analysis

Layout driven simulation

Export netlist and launch INTERCONNECT

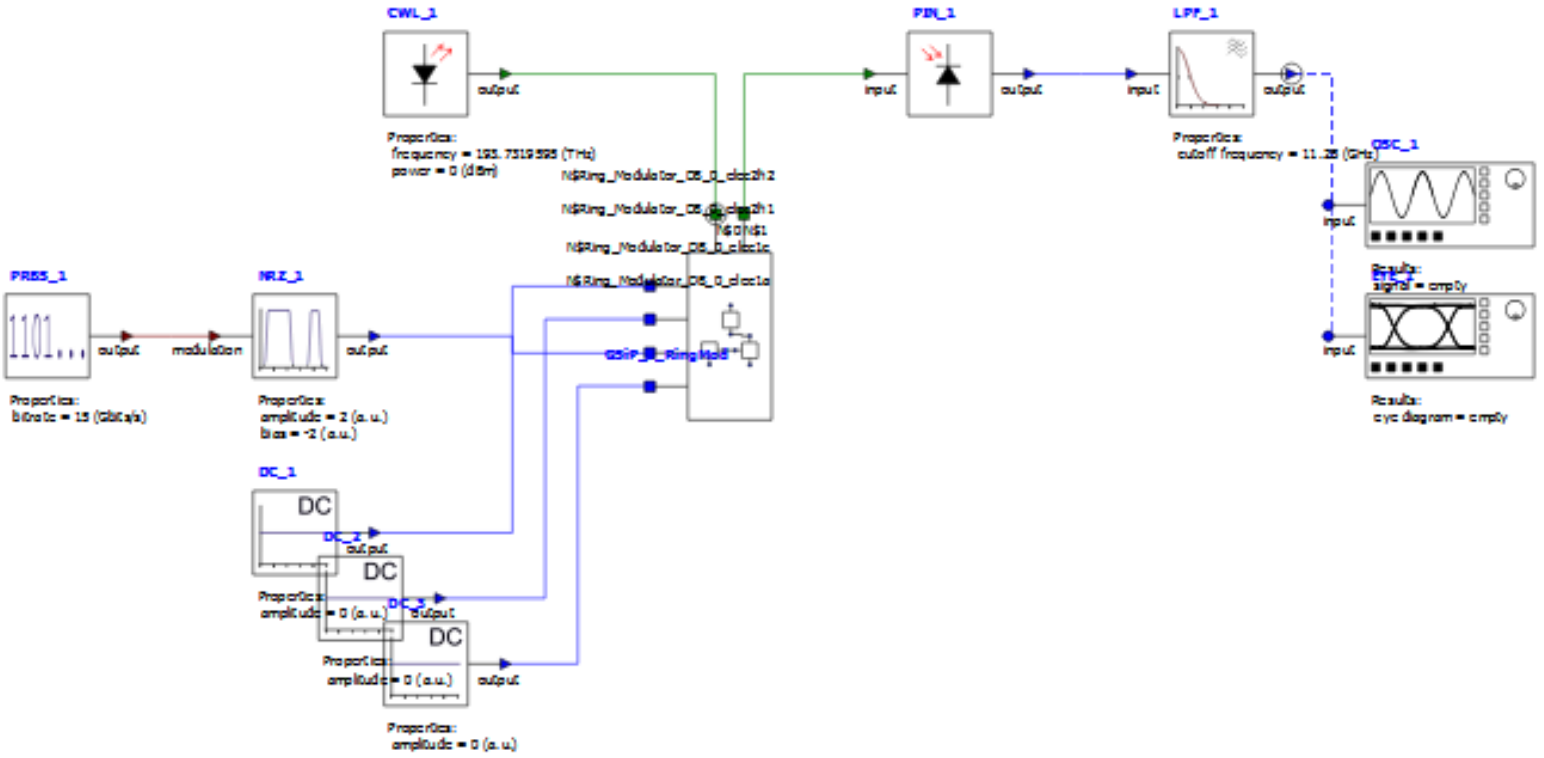


Frequency analysis

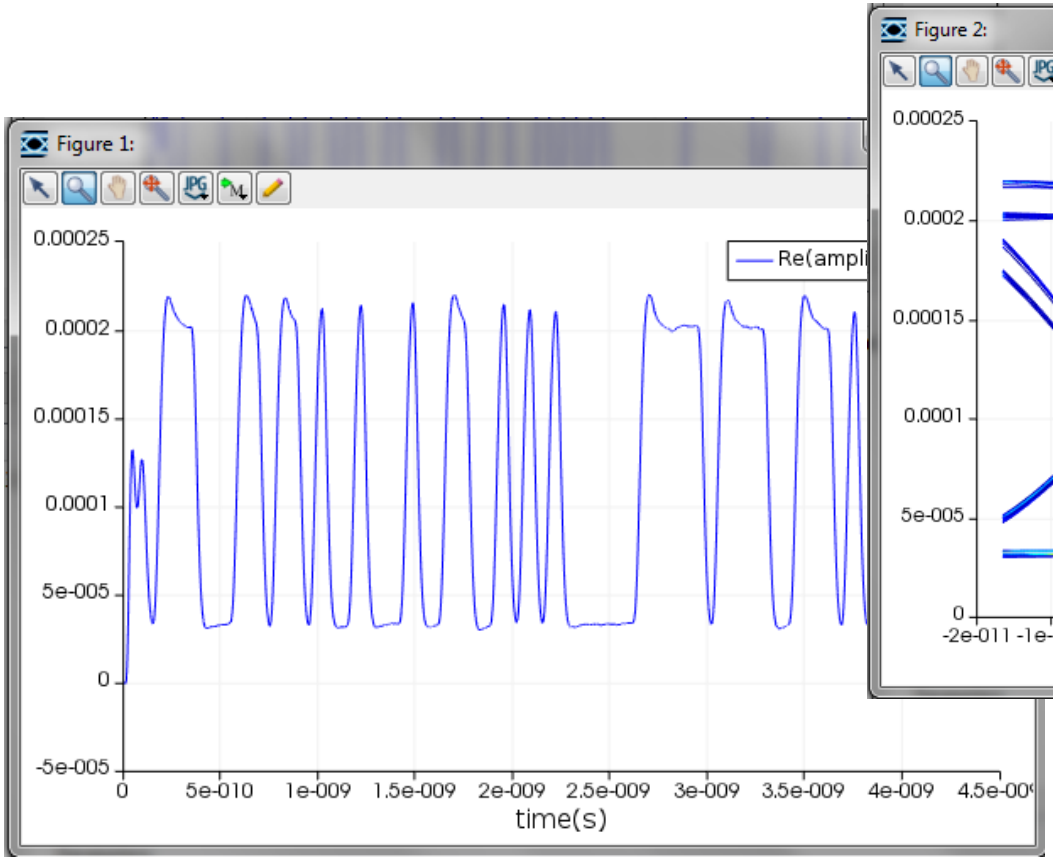


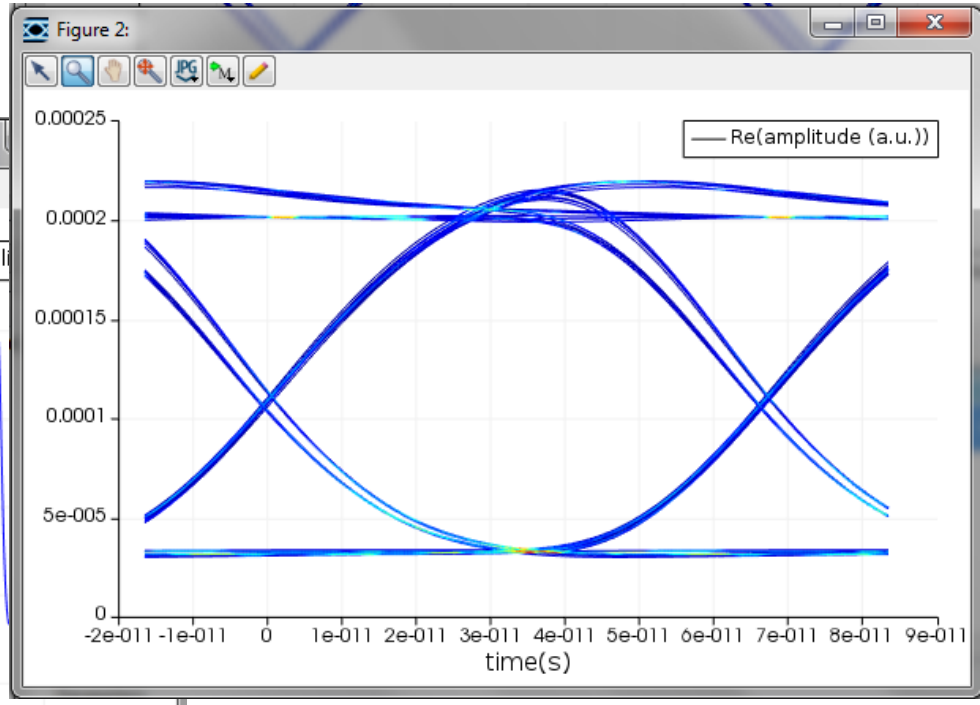
Time domain test bench

- Run the script ‘Time_domain_testbench_single_modulator.lsf’ to convert the frequency domain testbench into a time domain testbench

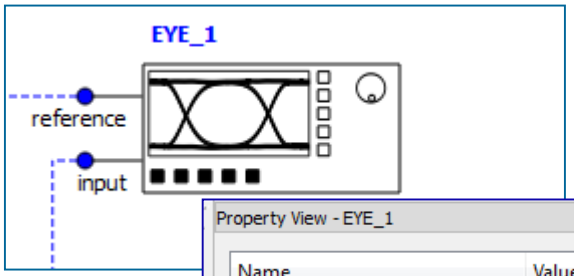


Time domain results





Time domain – result analysis



Property View - EYE_1

Name	Value	Unit	Expression
signal reference input	true		
eye period	1.5	bit p...	
ignore start periods	8		
ignore end periods	8		
delay compensation	automatic		
delay	0	s	
Enhanced			
color grading	false		
binning size	500		
smoothness	10		
random sampling	false		
time unit	s		
decision point	automatic		
decision instant	2e-10	s	
threshold	0	a.u.	
BER estimation	Gaussian		
calculate measurements	true		
calculate graphs	true		
eye opening tolerance	0	ratio	
plot waveforms	true		
Display			
refresh	true		
refresh length	8192		
limit display memory	true		
display memory length	2048		

Result View - EYE_1

Name	Value	Annotate
eye diagram	'amplitude' <4512,1> [0.0009687698296, 0.0009580644452, 0.0009...	☑
measurement		
decision instant	'time' 0.25e-009 (s)	☐
threshold	'amplitude' 0.0004995075353 (a.u.)	☐
level zero mean	'amplitude' -4.450158418e-006 (a.u.)	☐
level zero sigma	'amplitude' 4.067774101e-006 (a.u.)	☐
level one mean	'amplitude' 0.001004248213 (a.u.)	☐
level one sigma	'amplitude' 4.210775934e-006 (a.u.)	☐
BER	'BER' 0	☐
Q factor	'ratio' 121.8448118	☐
height	'amplitude' 0.0009838627211 (a.u.)	☐
amplitude	'amplitude' 0.001008698371 (a.u.)	☐
extinction ratio	'ratio' 23.53465596 (dB)	☐
opening factor	'ratio' 0.9917928389	☐
width	'time' 0.3993955507e-009 (s)	☐
pulse width	'time' 0.4001714451e-009 (s)	☐
jitter RMS	'time' 0.1471843164e-012 (s)	☐
peak to peak jitter	'time' 0.6145806978e-012 (s)	☐
rise time	'time' 0.1899530508e-009 (s)	☐
fall time	'time' 89.61706091e-012 (s)	☐
graph		
threshold at min BER	'amplitude' <64,1> [0.0005098341574, 0.0005084810127, 0.000507...	☐
min BER	'BER' <64,1> [0.1564401769, 0.1236627777, 0.09283178859...]	☐
Q factor	'ratio' <64,1> [1.008941367, 1.156647113, 1.323322107...]	☐
level zero mean	'amplitude' <64,1> [0.0002619076763, 0.000244546129, 0.0002275...	☐
level zero sigma	'amplitude' <64,1> [0.0002403628896, 0.0002243774077, 0.000208...	☐
level one mean	'amplitude' <64,1> [0.0007476196707, 0.0007643344799, 0.000780...	☐
level one sigma	'amplitude' <64,1> [0.000241044663, 0.0002250149308, 0.0002093...	☐
height	'amplitude' <64,1> [-0.0009585106635, -0.0008283886645, -0.0007...	☐
amplitude	'amplitude' <64,1> [0.0004857119944, 0.0005197883509, 0.000553...	☐
extinction ratio	'ratio' <64,1> [2.854516069, 3.12552271, 3.431288405...] (dB)	☐
opening factor	'ratio' <64,1> [0.008862127813, 0.1354320702, 0.2443260829...]	☐
waveform		
reference	'amplitude' <4096,1> [0, 0, 0...] (a.u.)	☐
correlation	'amplitude' <4096,1> [0.0003806109164, 0.0003764310337, 0.0003...	☐
input	'amplitude' <4096,1> [-3.487493865e-018, -3.284639609e-018, -3....	☐
bit pattern	'amplitude' <4096,1> [0, 0, 0...] (a.u.)	☐

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