

DBR LASER INTERCONNECT Simulation

**High-Speed Circuits & Systems Lab.
Dept. of Electrical and Electronic Engineering
Yonsei University**

Lumerical Solutions

Our Products

 **FDTD Solutions:** Single and multi-processor finite-difference time-domain optical design software.
[Product Details](#) | [Trial Download](#)

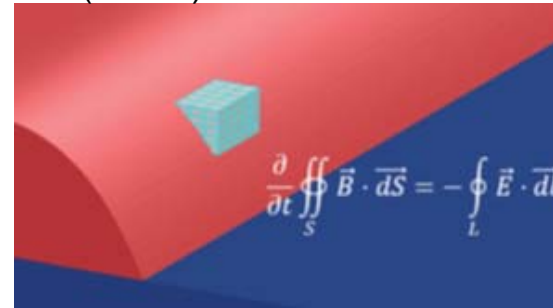
 **MODE Solutions:** Waveguide eigenmode solver and omnidirectional broadband propagator design software.
[Product Details](#) | [Trial Download](#)

 **INTERCONNECT:** Optoelectronic and photonic integrated circuit (PIC) design software package.
[Product Details](#) | [Trial Download](#)

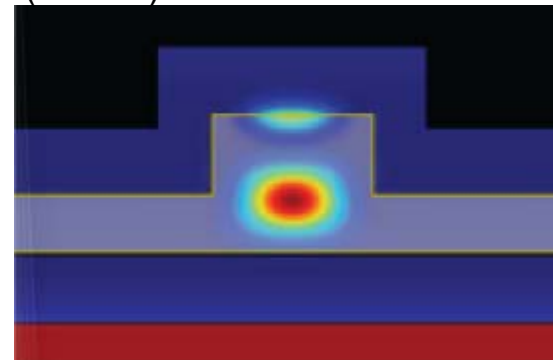
 **DEVICE:** Powerful semiconductor TCAD device simulation software for silicon-based optoelectronic structures.
[Product Details](#) | [Trial Download](#)

Please download 2016b version!

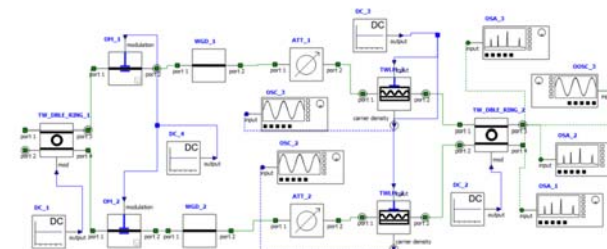
3D Maxwell solver(FDTD)



Modal analysis(MODE)



Hierarchical Simulation(INTERCONNECT)



License setup

INTERCONNECT - Configure License

Floating Node Locked

Manage which floating license servers get checked from this tab.

Options

Server: 165.132.112.189 Port: ☒ Default ☐ Specify

☐ Configure redundant servers

*Server can be either the hostname or IP address of a Flex license server

Actions

☒ Apply these settings to my user account only

☐ Make these settings the system defaults (requires elevation)

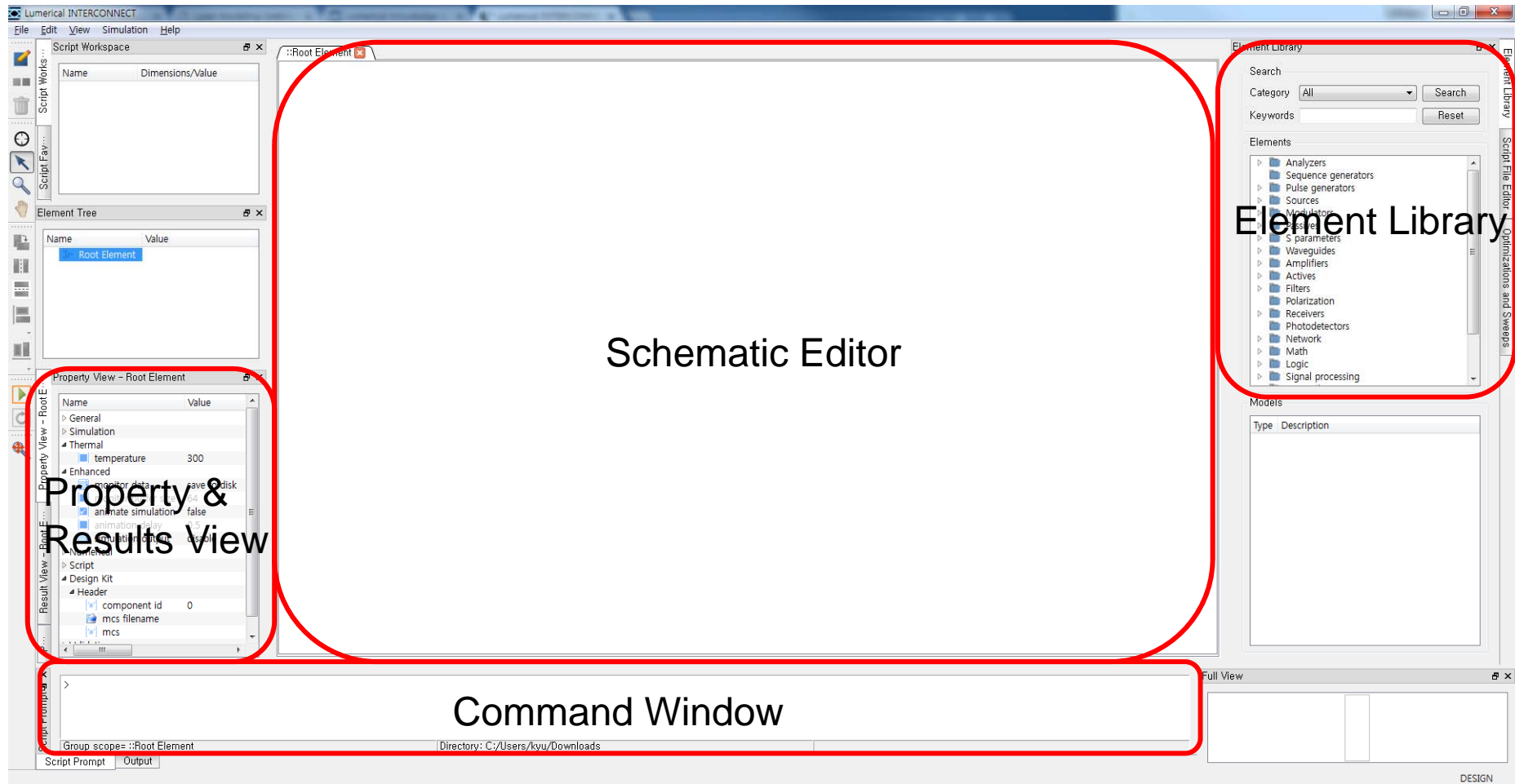
☐ Configure my account to use system defaults

[Instructions on how to activate your floating license](#)

[View your active licenses in the FlexNet Publisher dashboard](#)

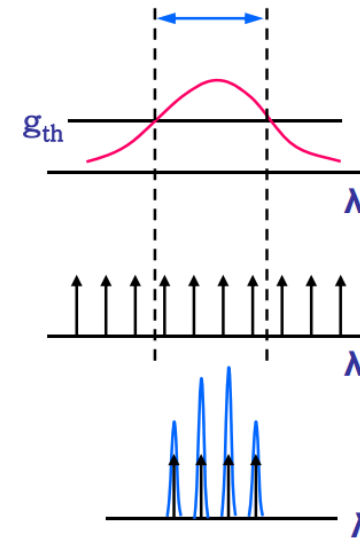
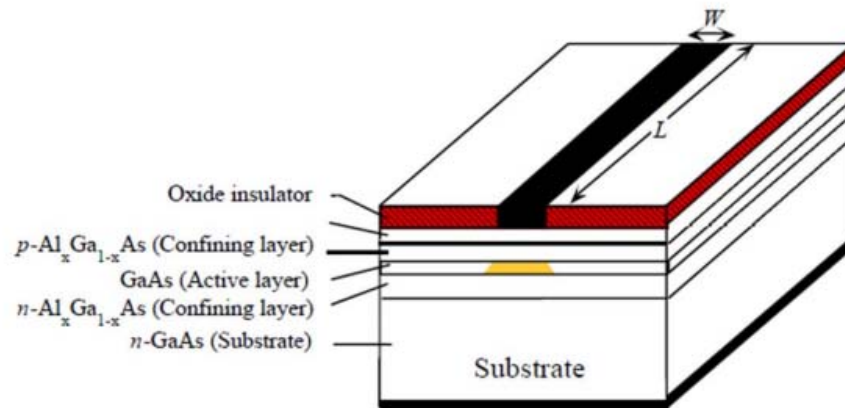
OK Cancel

INTERCONNECT Window

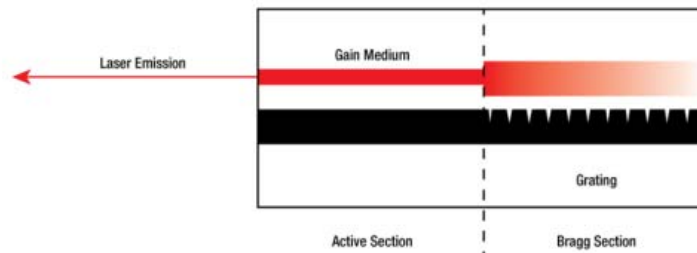


Several Types of LASERs

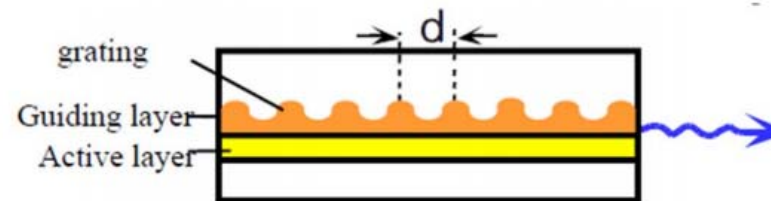
Fabry-Perot(FP) Laser



Distributed Bragg Reflector (DBR) Laser



Distributed Feedback (DFB) Laser

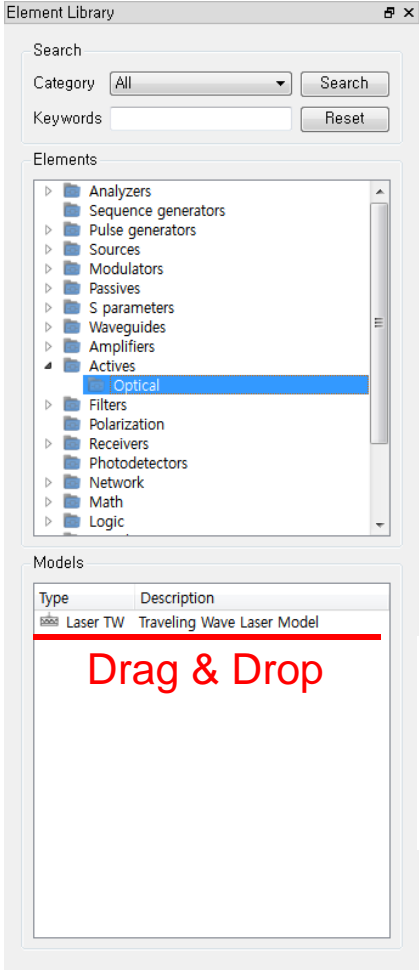


Simulation Setup

The screenshot displays the Lumerical INTERCONNECT interface. A red box highlights the 'Property View - Root Element' window, which is also shown as a larger inset on the right. The inset window shows the following settings:

Name	Value	Unit
General		
Simulation		
bitrate	2.5e+10	bits/s
simulation input	sample rate	
samples per bit	1000	
sequence length	128	
time window	5.12e-09	s
sample rate	25	THz
number of samples	128000	
Signal Mode		
output signal m...	sample	
number of outp...	1	
Sample		
sample mode f...	automatic	
sample mode ...	193.1	THz
Thermal		
temperature	300	K
Enhanced		
monitor data	save to disk	
monitor buffer size	64	
animate simulation	false	
animation delay	0.5	s
simulation output	disable	
Numerical		
multithreading	automatic	
number of threads	4	
Script		
Design Kit		
Header		
component id	0	
mcs filename		
mcs		
Validation		

Gain Medium(TWLM)



Element Library

Search

Category: All Search

Keywords: Reset

Elements

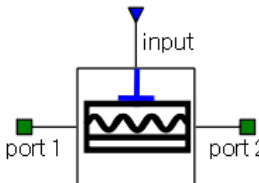
- Analizers
- Sequence generators
- Pulse generators
- Sources
- Modulators
- Passives
- S parameters
- Waveguides
- Amplifiers
- Actives
 - Optical**
- Filters
- Polarization
- Receivers
- Photodetectors
- Network
- Math
- Logic

Models

Type	Description
Laser TW	Traveling Wave Laser Model

Drag & Drop

➔

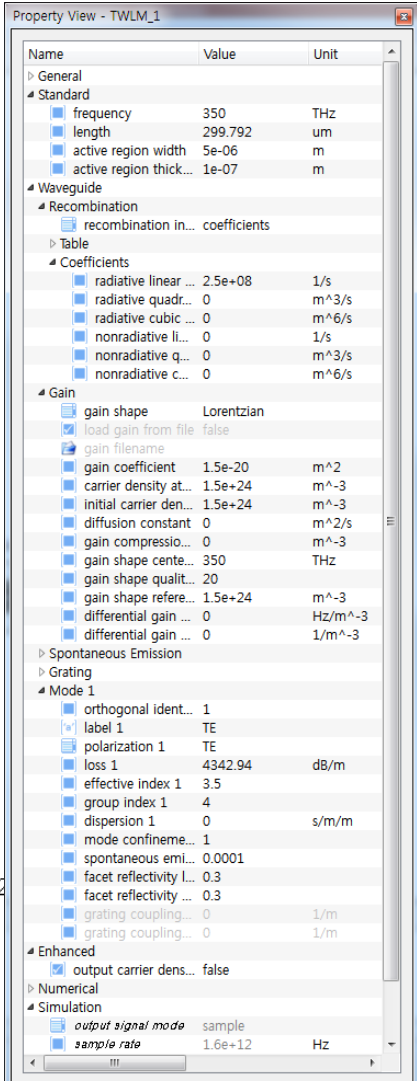


input

port 1

port 2

Properties



Property View - TWLM_1

Name	Value	Unit
General		
Standard		
frequency	350	THz
length	299.792	um
active region width	5e-06	m
active region thick...	1e-07	m
Waveguide		
Recombination		
recombination in... coefficients		
Table		
Coefficients		
radiative linear ...	2.5e+08	1/s
radiative quadr...	0	m^3/s
radiative cubic ...	0	m^6/s
nonradiative li...	0	1/s
nonradiative q...	0	m^3/s
nonradiative c...	0	m^6/s
Gain		
gain shape	Lorentzian	
load gain from file	false	
gain filename		
gain coefficient	1.5e-20	m^2
carrier density at...	1.5e+24	m^-3
initial carrier den...	1.5e+24	m^-3
diffusion constant	0	m^2/s
gain compressio...	0	m^-3
gain shape cente...	350	THz
gain shape qual...	20	
gain shape refere...	1.5e+24	m^-3
differential gain ...	0	Hz/m^-3
differential gain ...	0	1/m^-3
Spontaneous Emission		
Grating		
Mode 1		
orthogonal ident...	1	
label 1	TE	
polarization 1	TE	
loss 1	4342.94	dB/m
effective index 1	3.5	
group index 1	4	
dispersion 1	0	s/m/m
mode confine...	1	
spontaneous emi...	0.0001	
facet reflectivity l...	0.3	
facet reflectivity ...	0.3	
grating coupling...	0	1/m
grating coupling...	0	1/m
Enhanced		
output carrier dens...	false	
Numerical		
Simulation		
output signal mode	sample	
sample rate	1.6e+12	Hz

Standards

:Frequency, structure of laser

Recombination

Gain

:Gain curve shape

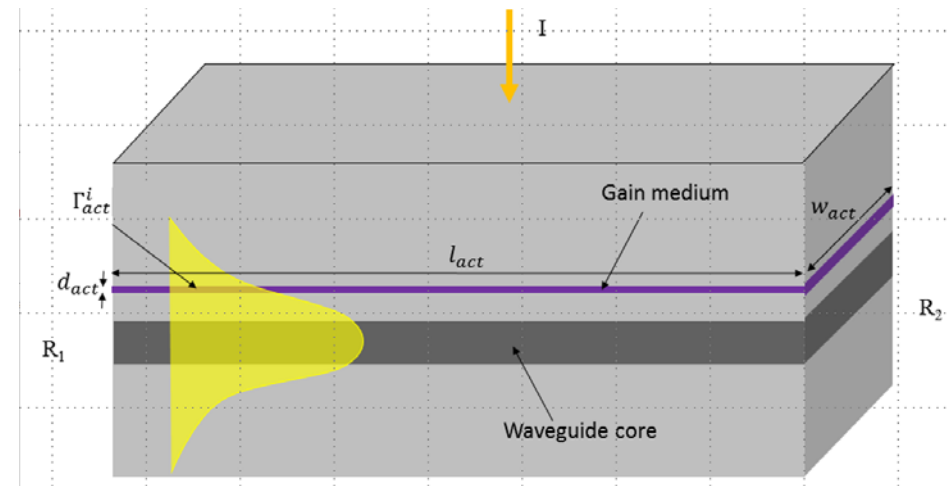
Mode1

:Loss, n_g , facet reflectivity

Properties of TWLM

✓ Structure of laser(Standard)

Standard		
frequency	350	THz
length	299.792	um
active region width	5e-06	m
active region thick...	1e-07	m



✓ Recombination

Recombination		
recombination in...	coefficients	
Table		
Coefficients		
radiative linear ...	2.5e+08	A 1/s
radiative quadr...	0	B m^3/s
radiative cubic ...	0	C m^6/s
nonradiative li...	0	1/s
nonradiative q...	0	m^3/s
nonradiative c...	0	m^6/s

$$\frac{dN}{dt} = \frac{N}{\tau} \quad \tau = [A + BN + CN^2]^{-1} \quad \frac{\Delta N}{\Delta T} = AN + BN^2 + CN^3$$

A: monomolecular

B: bimolecular

C: Auger

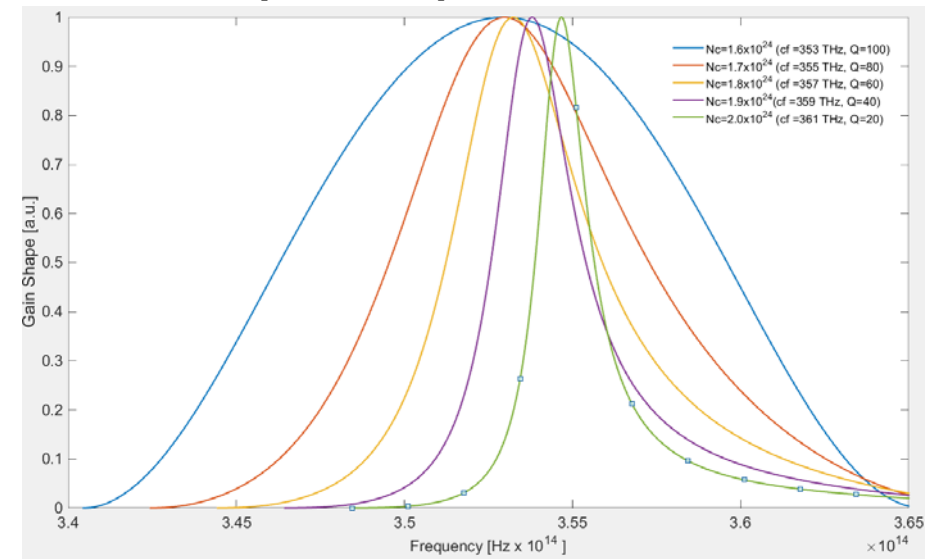
Properties of TWLM

✓ Gain shape

Gain			
gain shape	Lorentzian		
load gain from file	false		
gain filename			
gain coefficient	1.5e-20	a_p	m^{-2}
carrier density at...	1.5e+24	N_{tr}	m^{-3}
initial carrier den...	1.5e+24		m^{-3}
diffusion constant	0		m^2/s
gain compressio...	0		m^{-3}
gain shape cente...	350		THz
gain shape qualit...	20		
gain shape refere...	1.5e+24		m^{-3}
differential gain ...	0		Hz/ m^{-3}
differential gain ...	0		1/ m^{-3}

$$g(f, N) = g_{peak} L(f_c, Q)$$

$$g_{peak} = a_p (N - N_{tr})$$



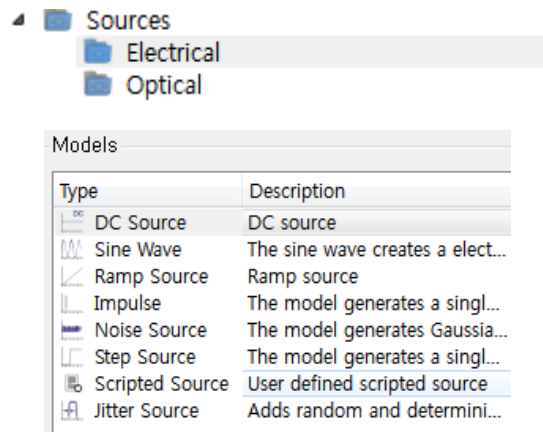
✓ Mode setting

Mode 1			
orthogonal ident...	1		
label 1	TE		
polarization 1	TE		
loss 1	4342.94		dB/m
effective index 1	3.5		
group index 1	4		
dispersion 1	0		s/m/m
mode confineme...	1	Γ	
spontaneous emi...	0.0001		
facet reflectivity l	0.3	Reflectivity	
facet reflectivity	0.3		
grating coupling...	0		1/m
grating couplina...	0		1/m
Enhanced			
output carrier dens...	true		
Diagnostic			
run diagnostic	true	Gain spectrum	
diagnostic size	1024		

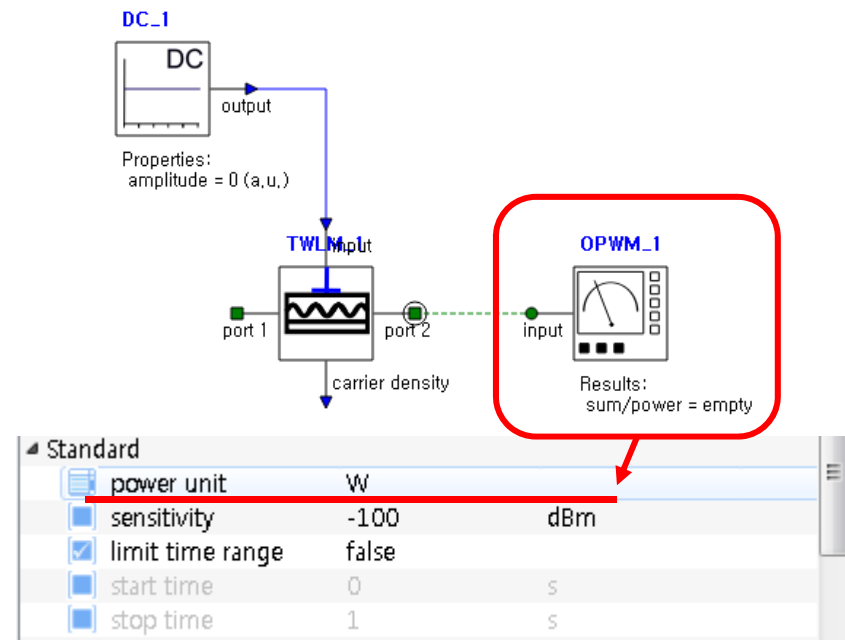
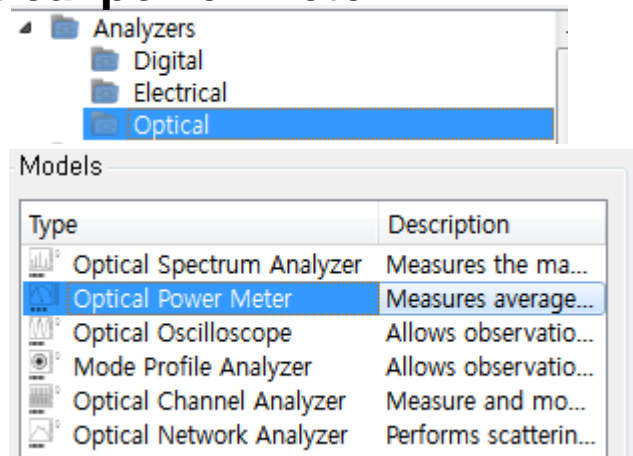
Facet reflectivity can be used for Fabry-Perot laser simulation

Gain spectrum and LI curve

✓ DC source



✓ Optical power meter



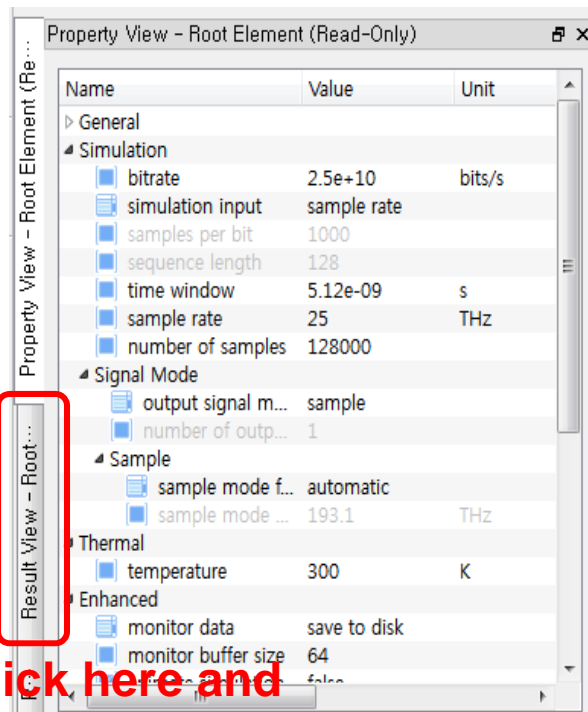
Simulate, and sweep setup!

→ Sweep DC amplitude,
save result of power

Gain spectrum

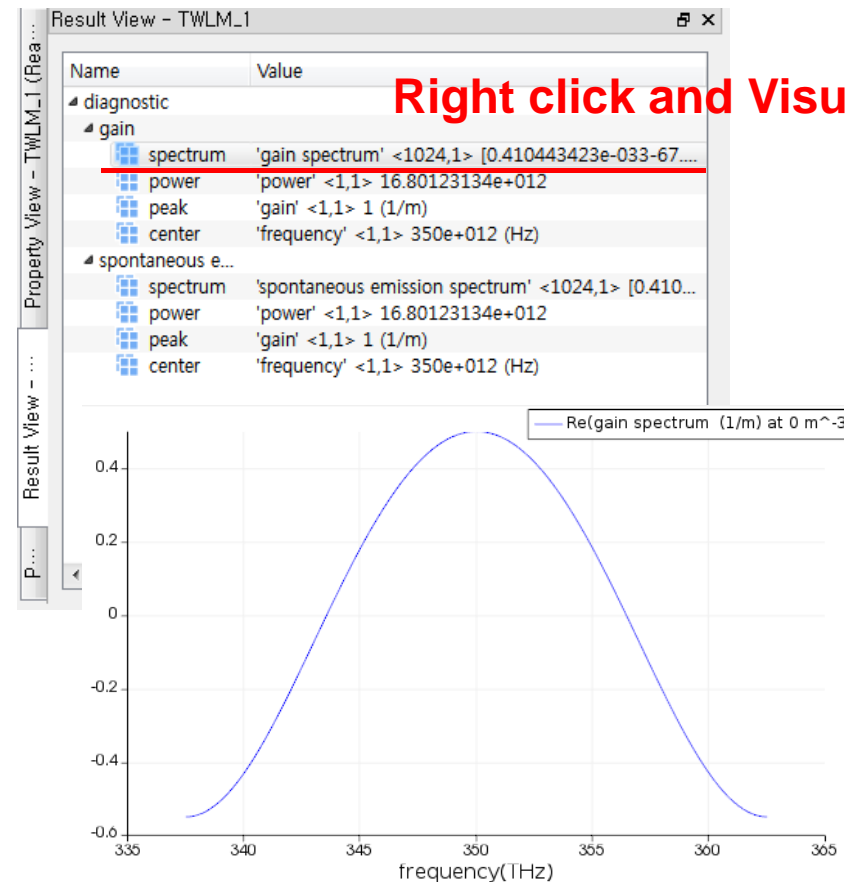


Click run



Click here and click object to view result

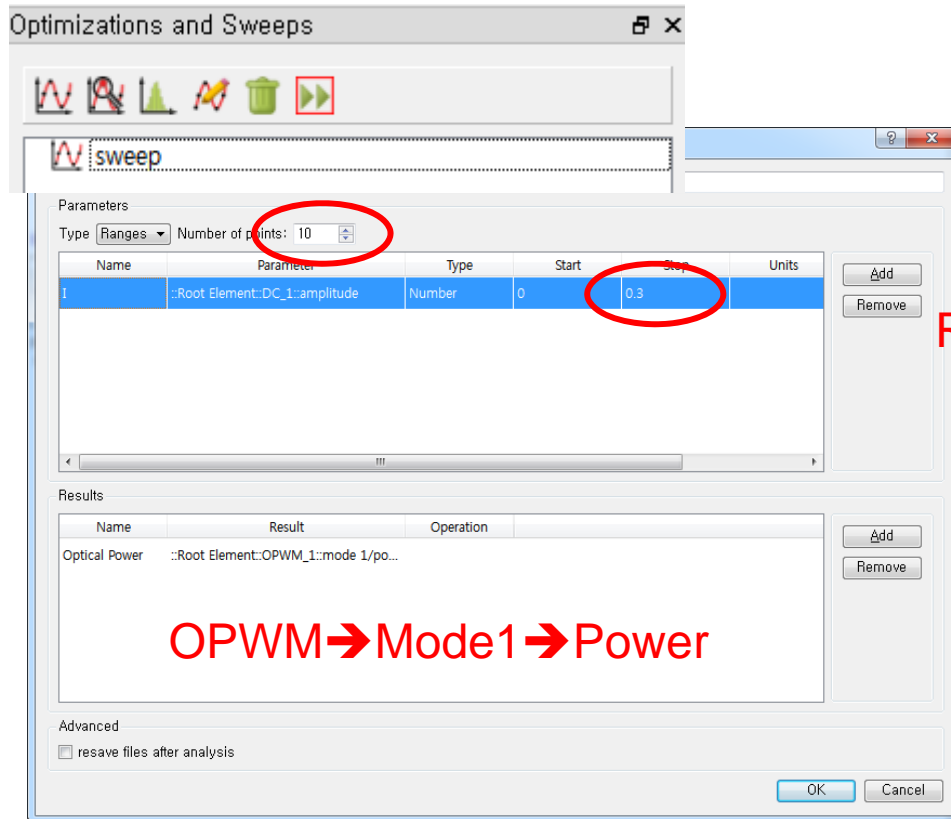
✓ TWLM gain curve



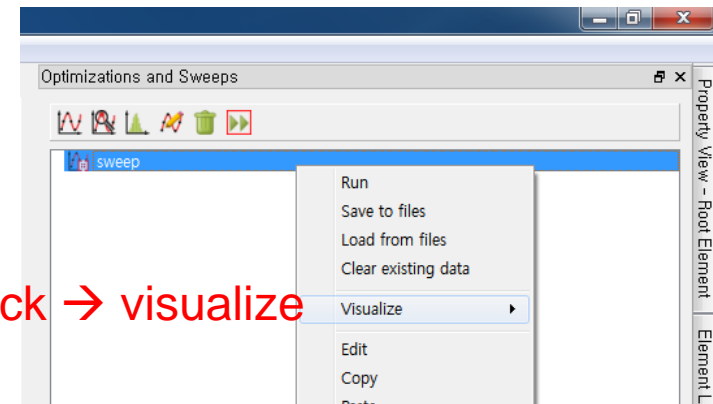
Right click and Visualize

→ FP Laser's gain spectrum

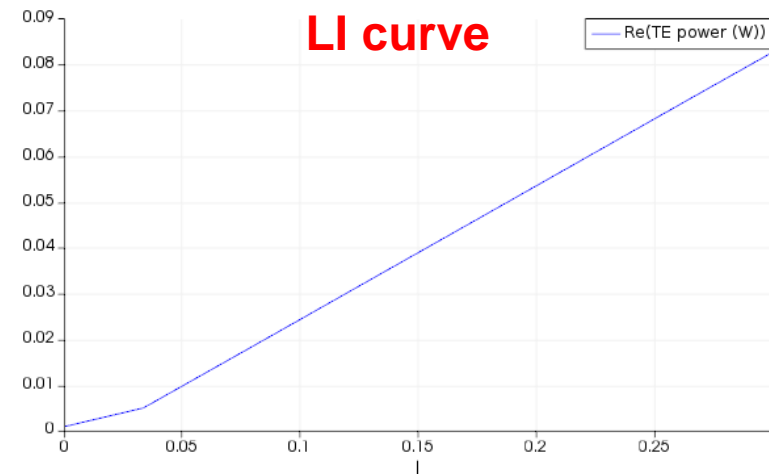
Sweep setup for LI curve



OPWM → Mode1 → Power

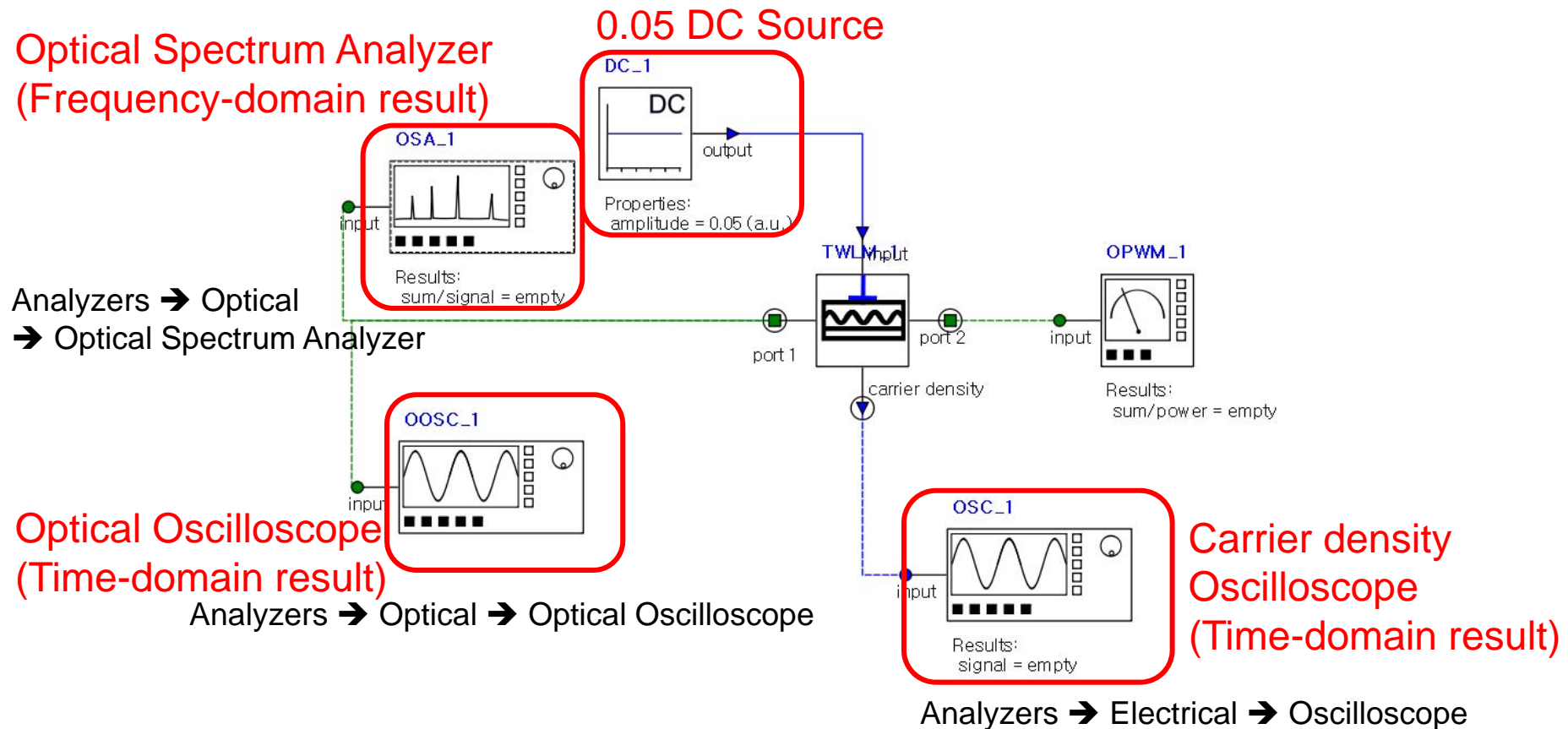


Right click → visualize



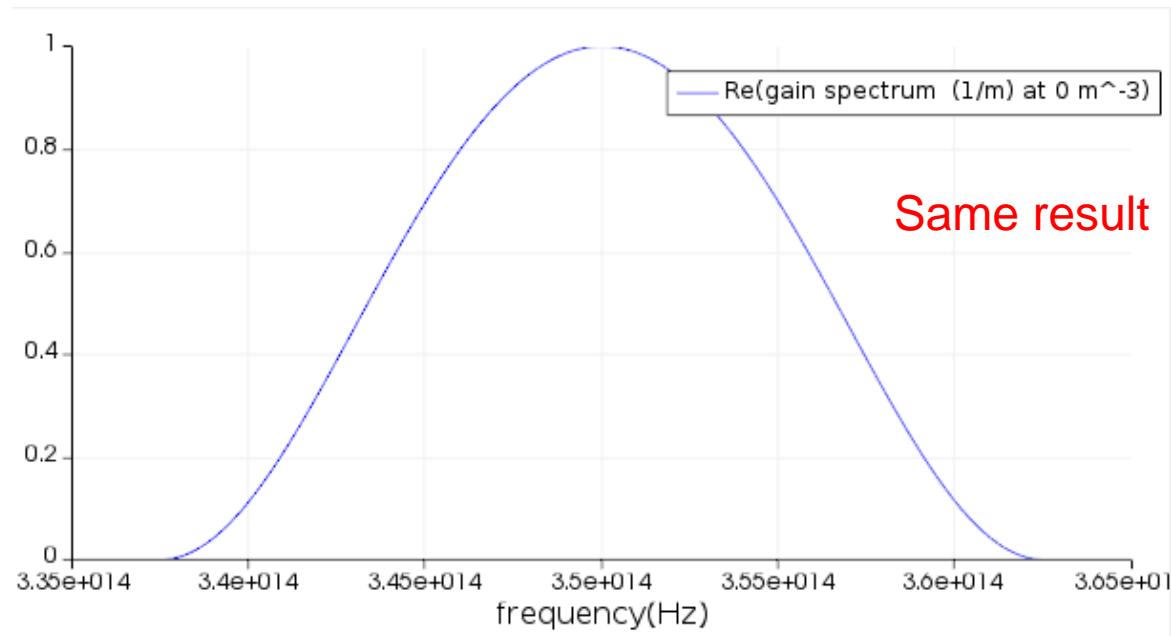
!!! To set output power as sweep output parameter, you have to run simulation first.

Febry-Perot Laser Schematic



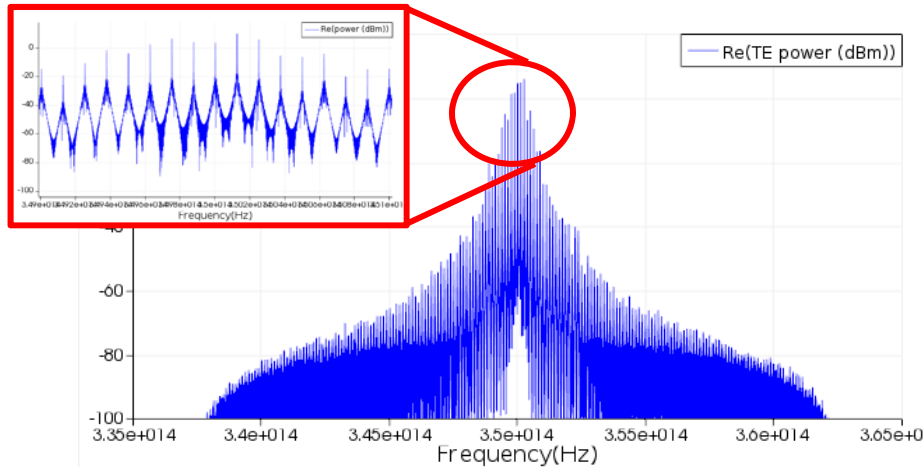
FP Laser Simulation Results

✓ Gain spectrum

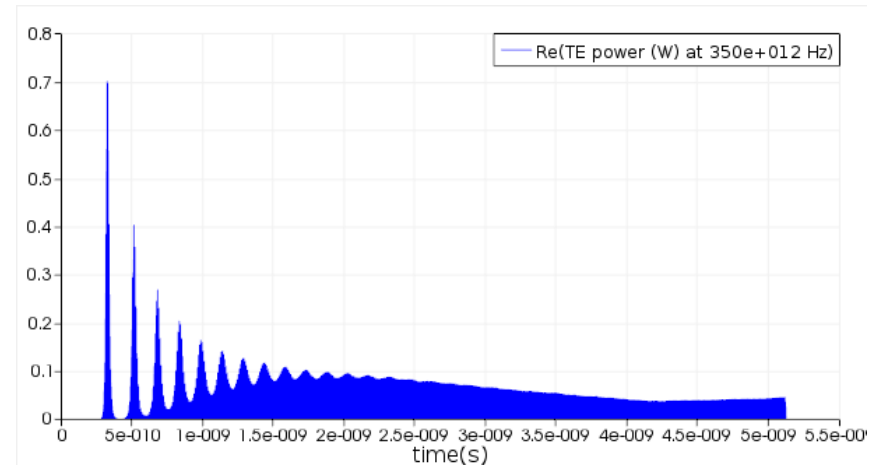


FP Laser Simulation Results

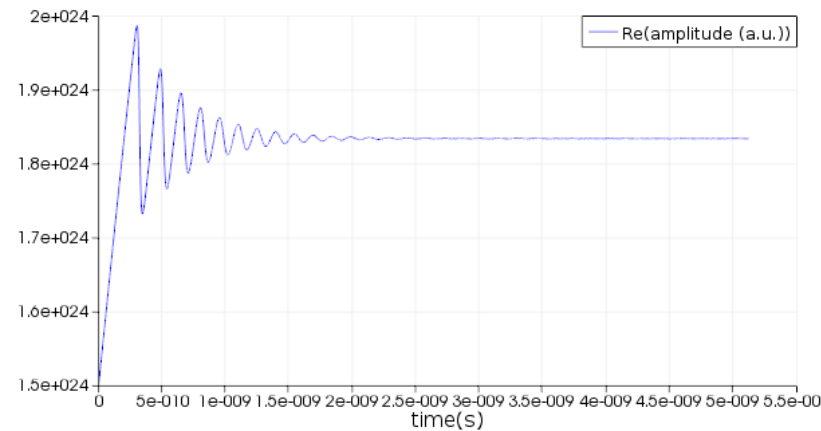
✓ OSA



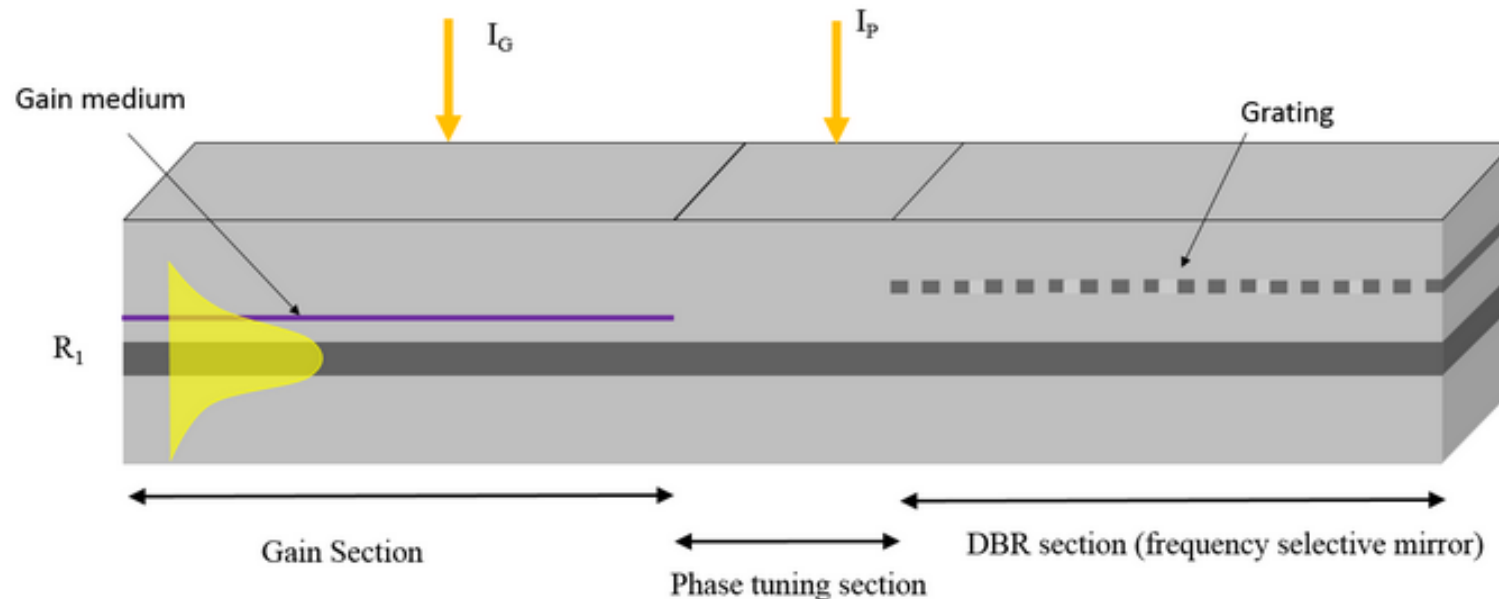
✓ Optical Oscilloscope(Mode1)



✓ Electrical Oscilloscope

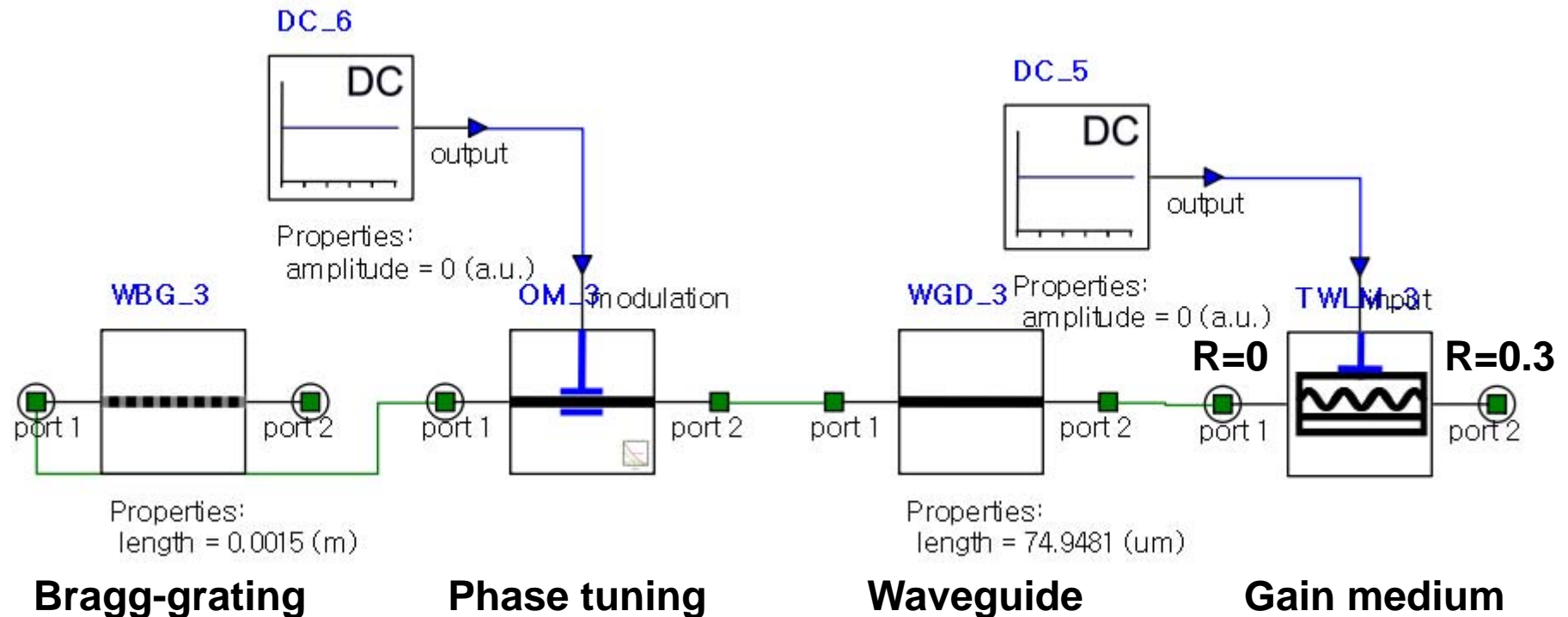


Distributed Bragg Reflector LASER



- ✓ Single-mode by Bragg grating structure
- ✓ Phase tuning region can be controlled with another DC bias

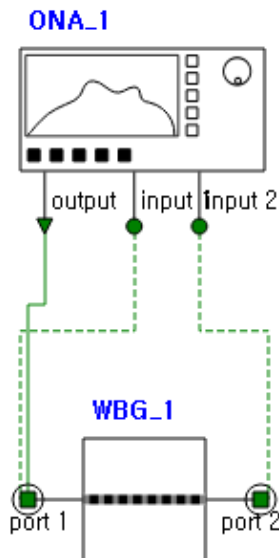
DBR Laser Schematic



- ✓ Each response analysis is necessary
 - Grating response, FP response(gain medium + waveguide + phase tuning)

Bragg Grating

Optical Network Analyzer (Gain simulation)



Waveguide → Gratings → Bragg Grating

✓ Optical Network Analyzer setup

Standard		
number of input ports	2	
power	0	dBm
input parameter	center and range	
center frequency	350	THz
frequency range	25	THz
start frequency	337.5	THz
stop frequency	362.5	THz
number of points	10000	
plot kind	frequency	
relative to center	false	
delay	0	s
limit time range	false	
start time	1	s
stop time	1	s

Numerical	
analysis type	impulse response
maximum number of iterations	1000
stop on convergence	false
multithreading	user defined
number of threads	4

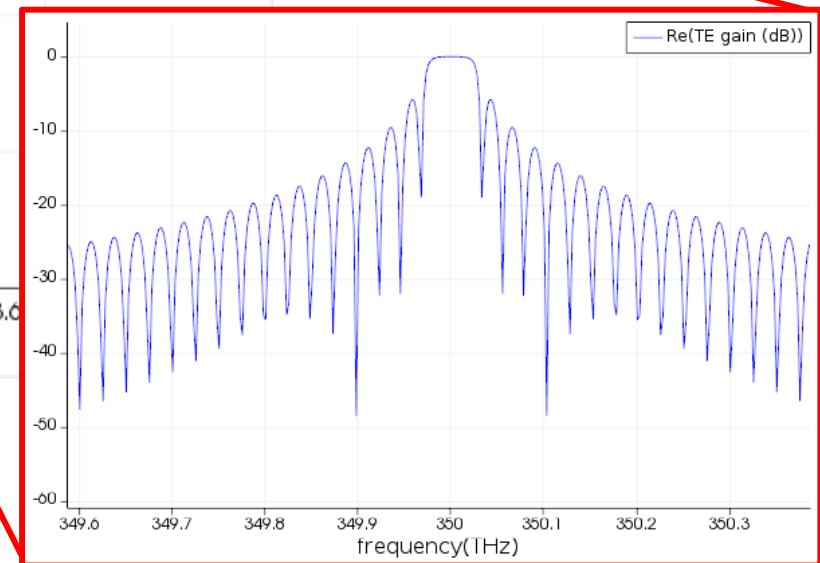
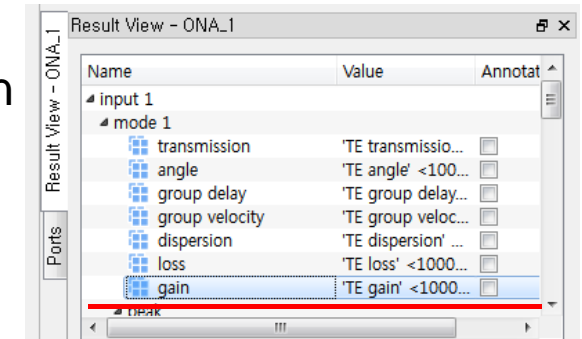
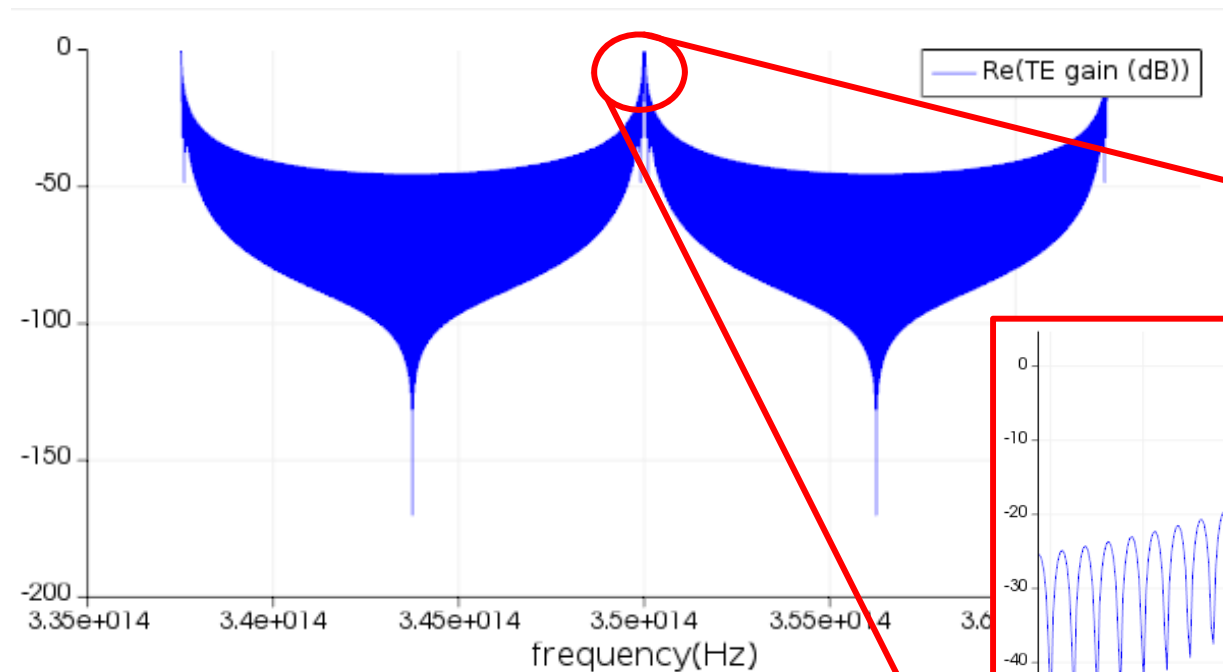
✓ Bragg Grating setup

Standard		
configuration	bidirectional	
length	0.0015	m
input parameter	Bragg frequency	
period	5.3e-07	m
frequency	856.55	nm
coupling parameter	effective index ...	
effective index change ac	0.0005	
effective index change dc	0	
grating coupling coefficient	800	
phase shift	0	rad

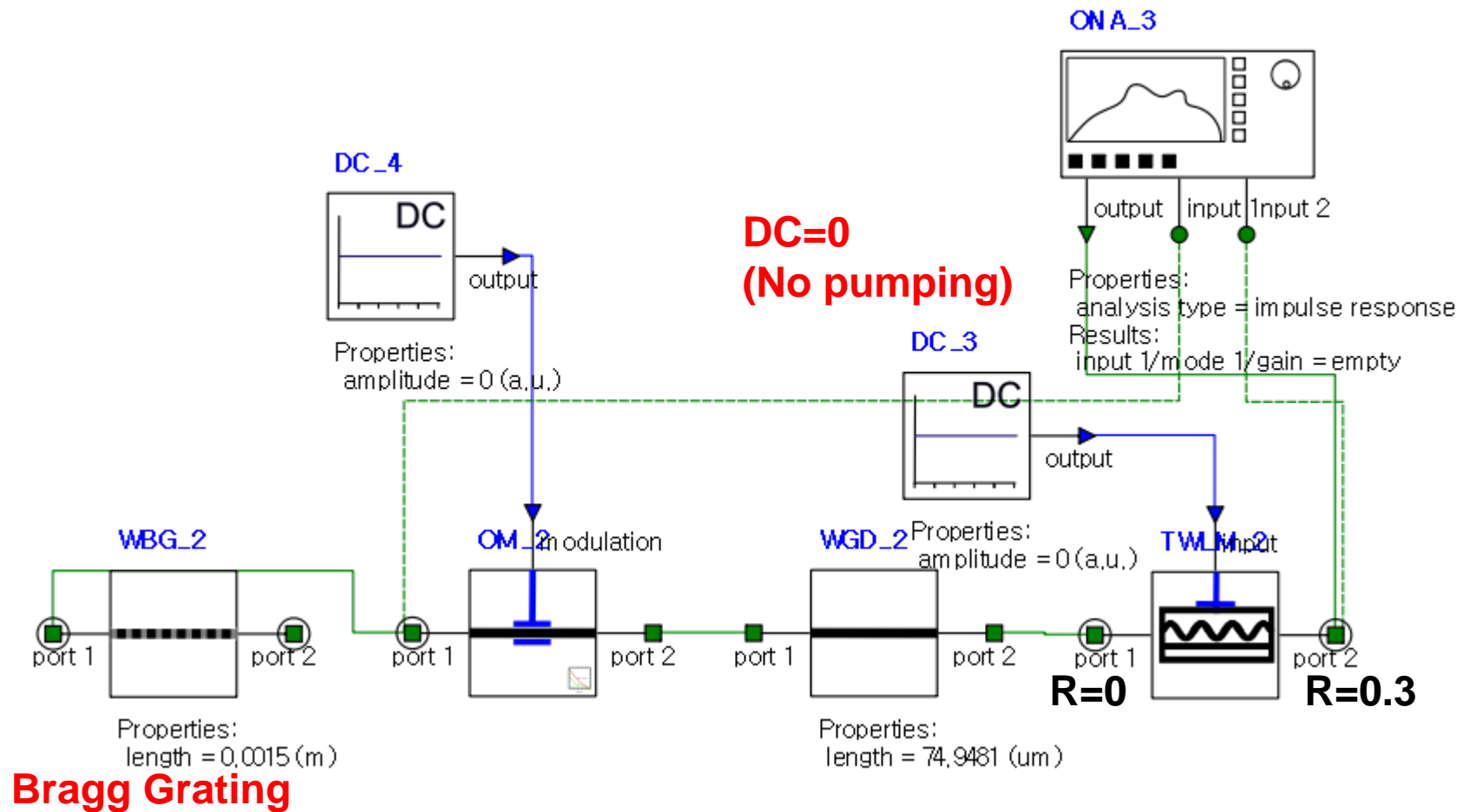
Mode 1		
orthogonal identifier 1	1	
label 1	TE	
loss 1	0	dB/m
effective index 1	4	
group index 1	4	
facet reflectivity left 1	0	
facet phase left 1	0	rad
facet reflectivity right 1	0	
facet phase right 1	0	rad
Thermal		
effective index temperatur...	0	/K
excess loss temperature ...	0	/K

Bragg Grating Simulation Result

Click ONA → Result View → Input1 → Mode1 → plot gain



DBR Laser

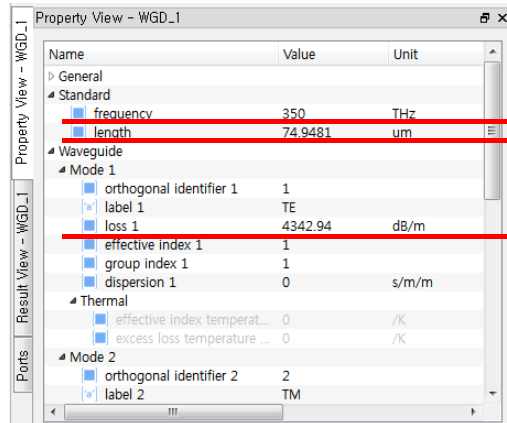


✓ Same models in previous simulations (Bragg grating instead of mirror)

Model Setup

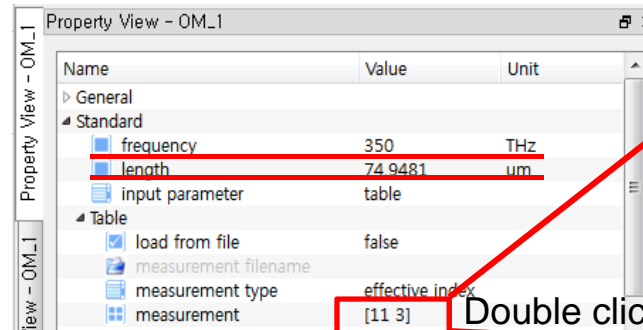
✓ Waveguide setup

Waveguide → Straight waveguide

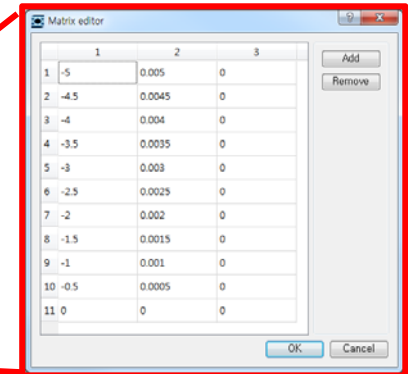


✓ Optical modulator setup

Modulators → Optical → Optical Modulator Measured



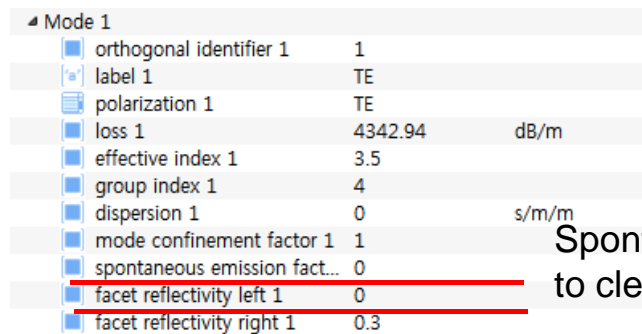
Double click, edit



First row: Input source
Second row: n_{eff} changes

✓ TWLM setup

Same as FP simulation, but two changes



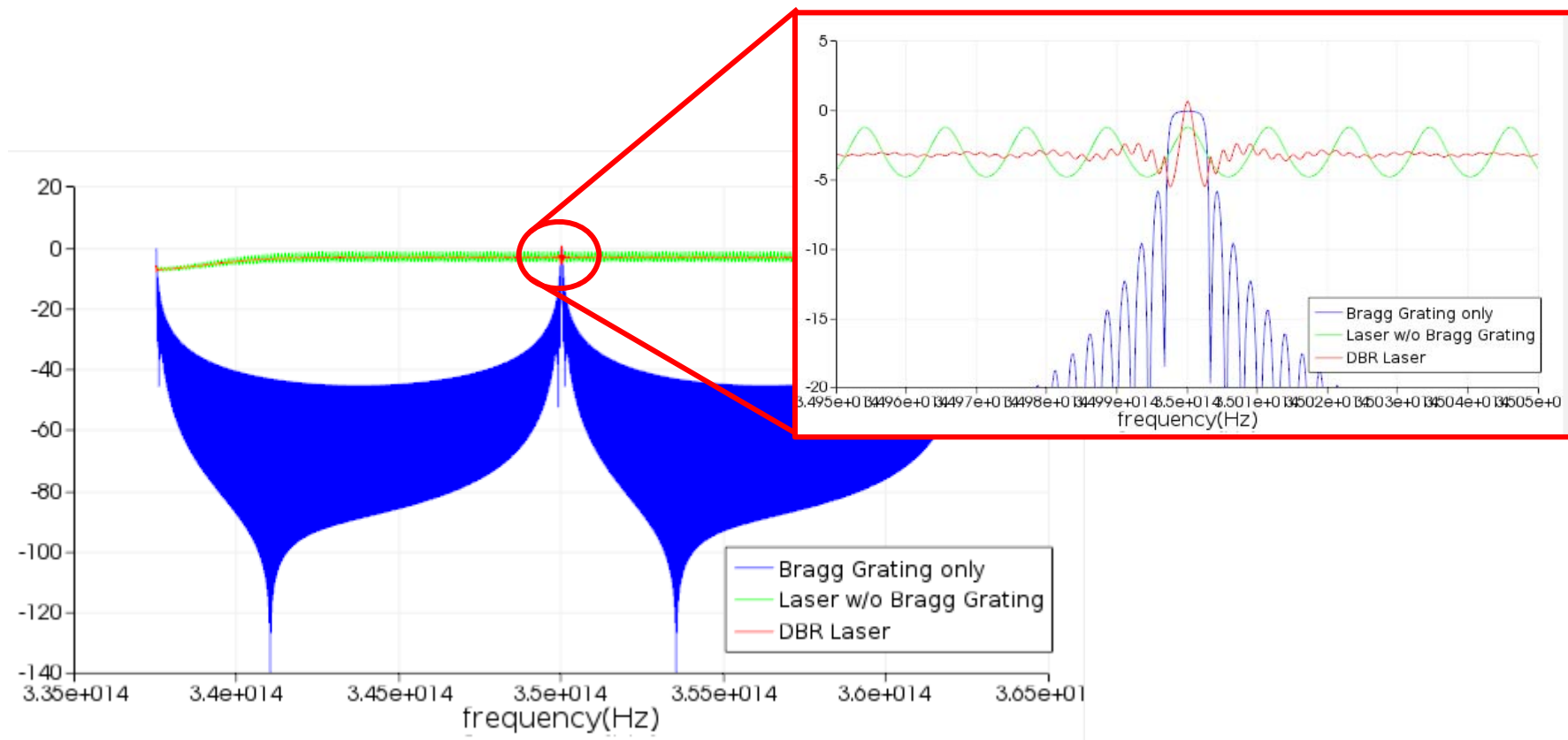
Spontaneous factor should be zero
to clearly verify response

✓ ONA setup

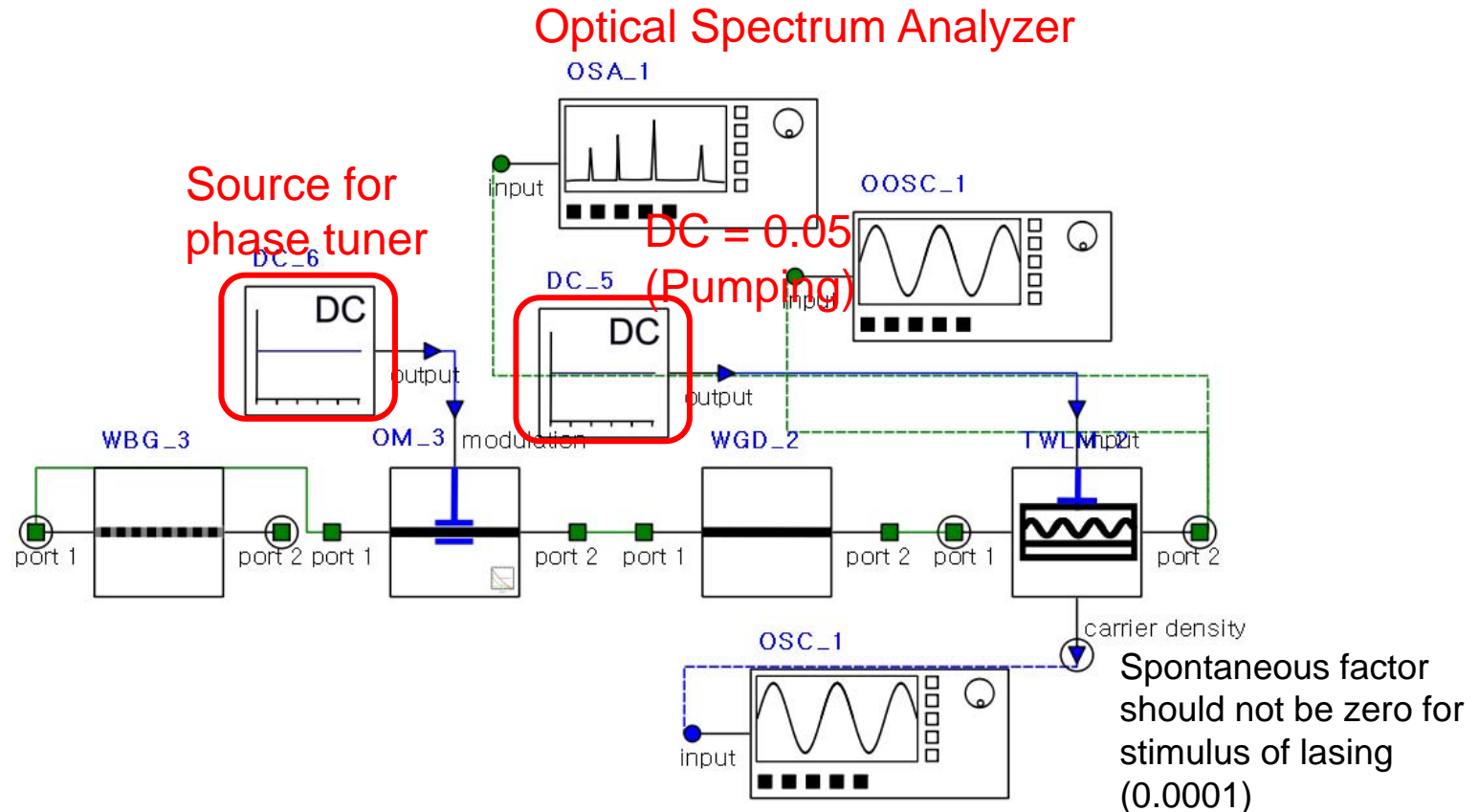
Same as
Bragg grating simulation
(page 16.)

Simulation Result

Click ONA → Result View → Input1 → Mode1 → plot gain

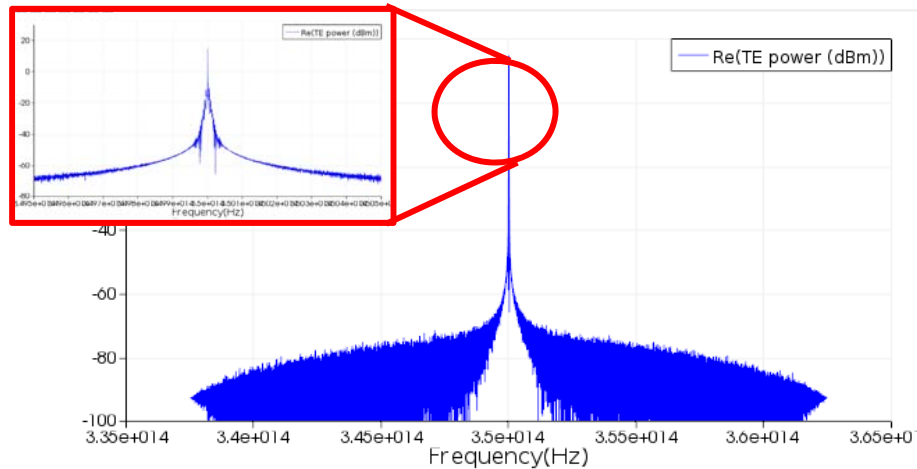


DBR Laser with Pumping Schematic

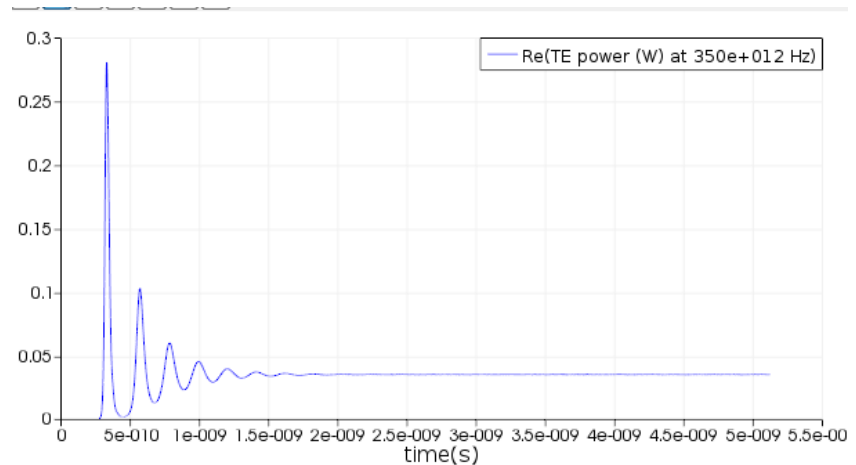


Simulation Result

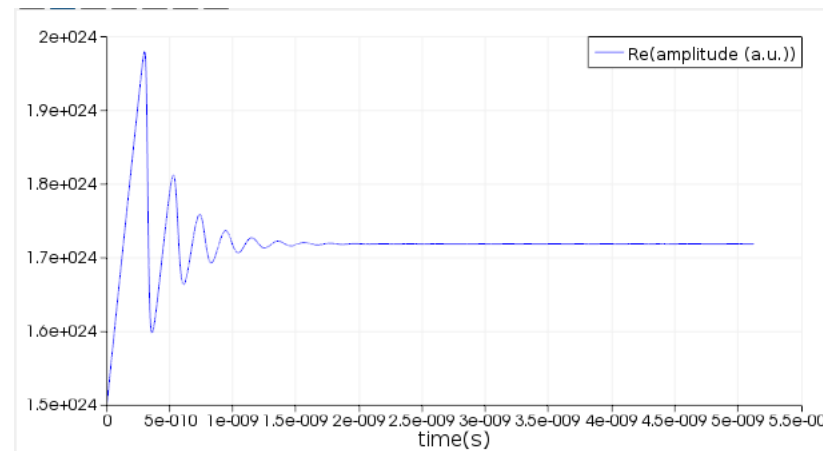
✓ OSA



✓ Optical Oscilloscope(Mode1)

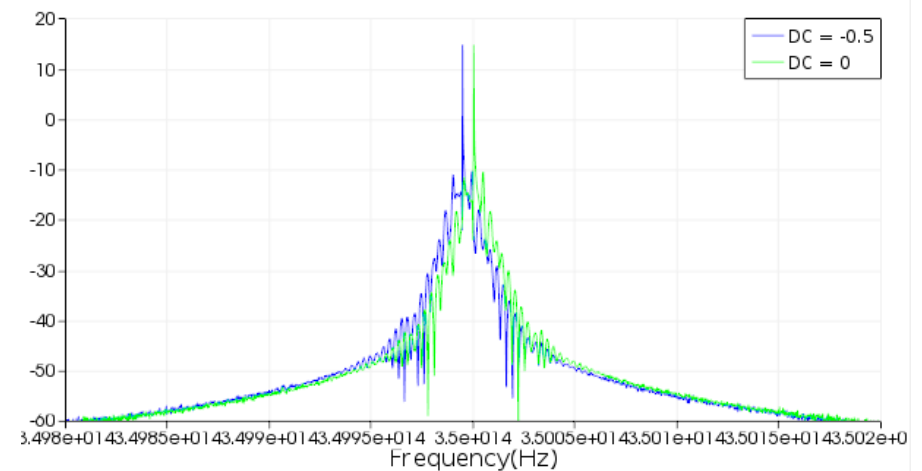
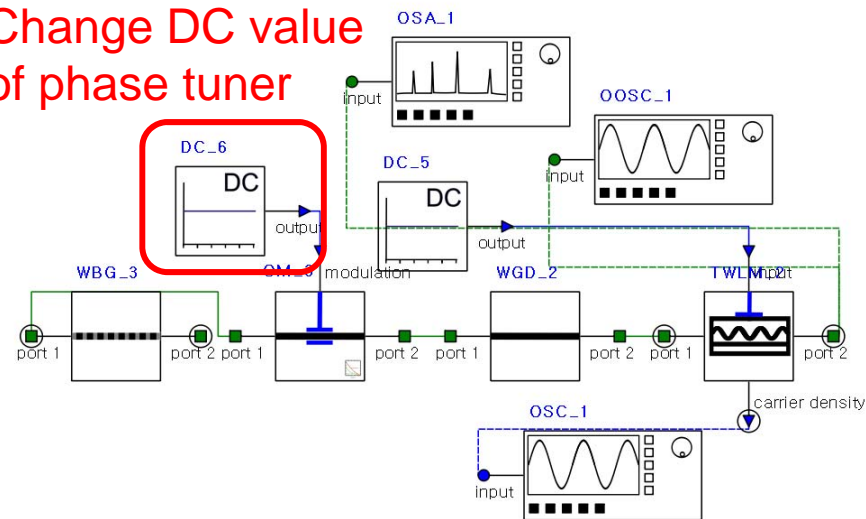


✓ Electrical Oscilloscope



Phase Tuned Simulation

Change DC value
of phase tuner



✓ Peak frequency can be tuned with phase tuning

Design Exercise 3

a) With Bragg-gating frequency as 349.95 THz (856.672 nm), simulate three different gain response simulation without phase tuning. Also, plot the optical spectrum with optical pumping. Compare & analyze the result with the simulation results obtained in the class.

-Bragg-grating, FP, DBR simulation

b) With phase tuning, find out DC source value for highest output power at 349.95 THz (856.672 nm). Explain how to get the value. Also, analyze the simulation results with theoretical background.

Due date: 22 Dec. PM 6:00 @ B629