Passive Photonic Circuit Design, Measurement and Analysis

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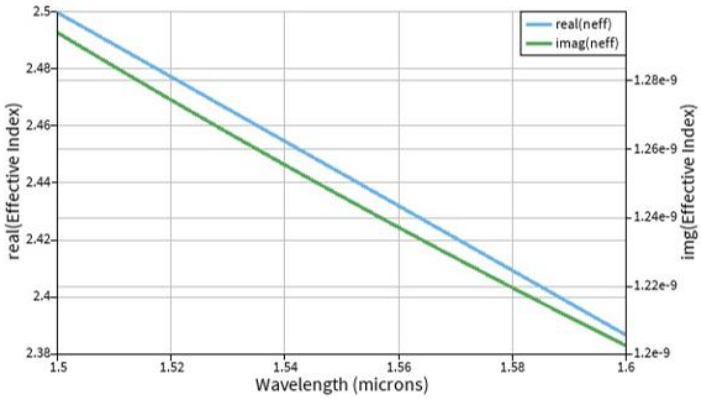
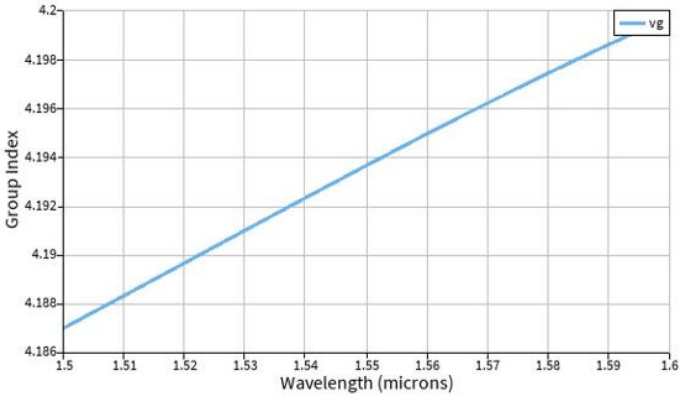
Photonic Circuit Structure: TE polarized unbalanced MZI

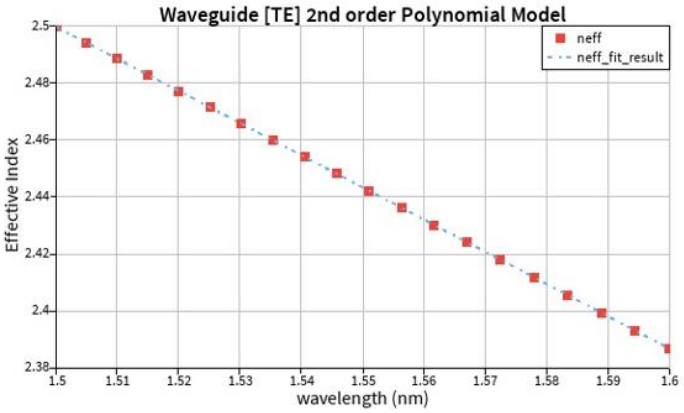
Design Flow:

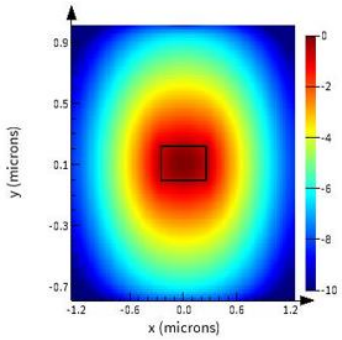
Step 1: Define waveguide parameters
Wavelength of interest: 1550nm
Geometry (width, thickness): 500nm, 220nm

Step 2: Simulate waveguide using ANSYS Lumerical Mode to extract and model group index



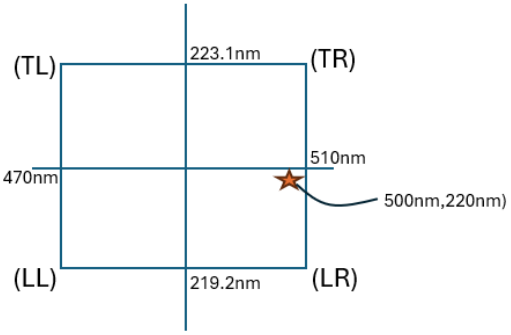






Step 3: Derive compact model for waveguide using 2nd order polynomial fit
TE mode, neff(lambda)=2.443-1.12919(lambda-1.55)-0.0416916(lambda-1.55)^2

Step 4: Perform 5-point corner analysis



Coordinate	Group Index (ng)
Nominal	4.17694
LL	4.2302
LR	4.15984
TR	4.17104
TL	4.24234

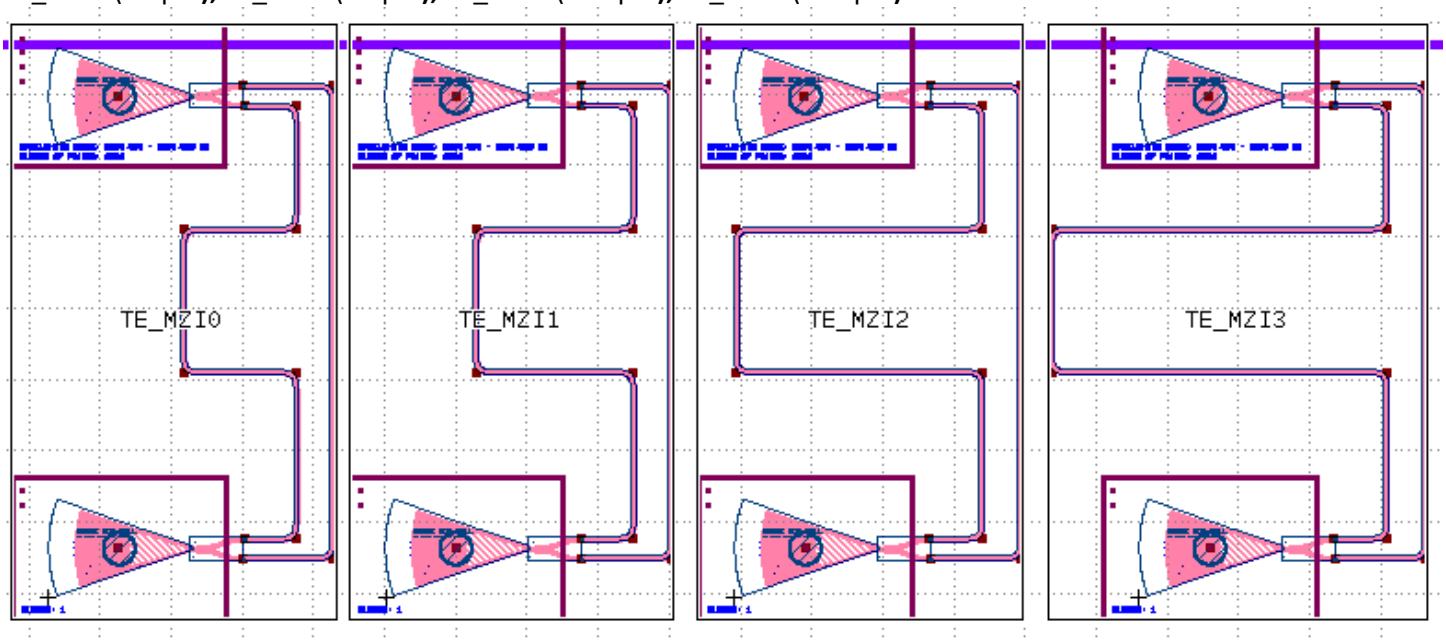
Step 5: Define length imbalance values for TE MZI
Lengths (micron): 25, 50, 100, 150

Step 6: Compute theoretical TE MZI free spectral range (FSR)

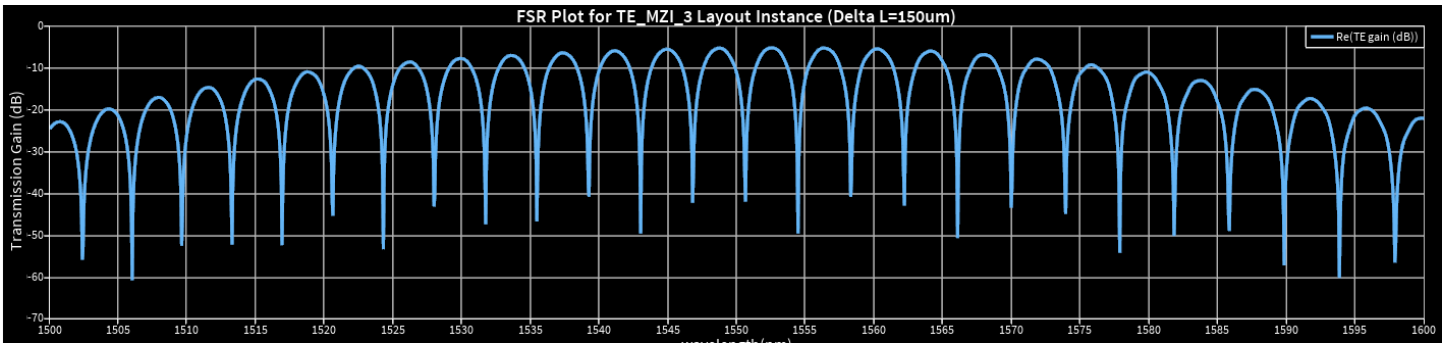
TE MZI ΔL (μm)	FSR** (nm)
25	22.915
50	11.457
100	5.728
150	3.819

** ng=4.17694 (nominal)

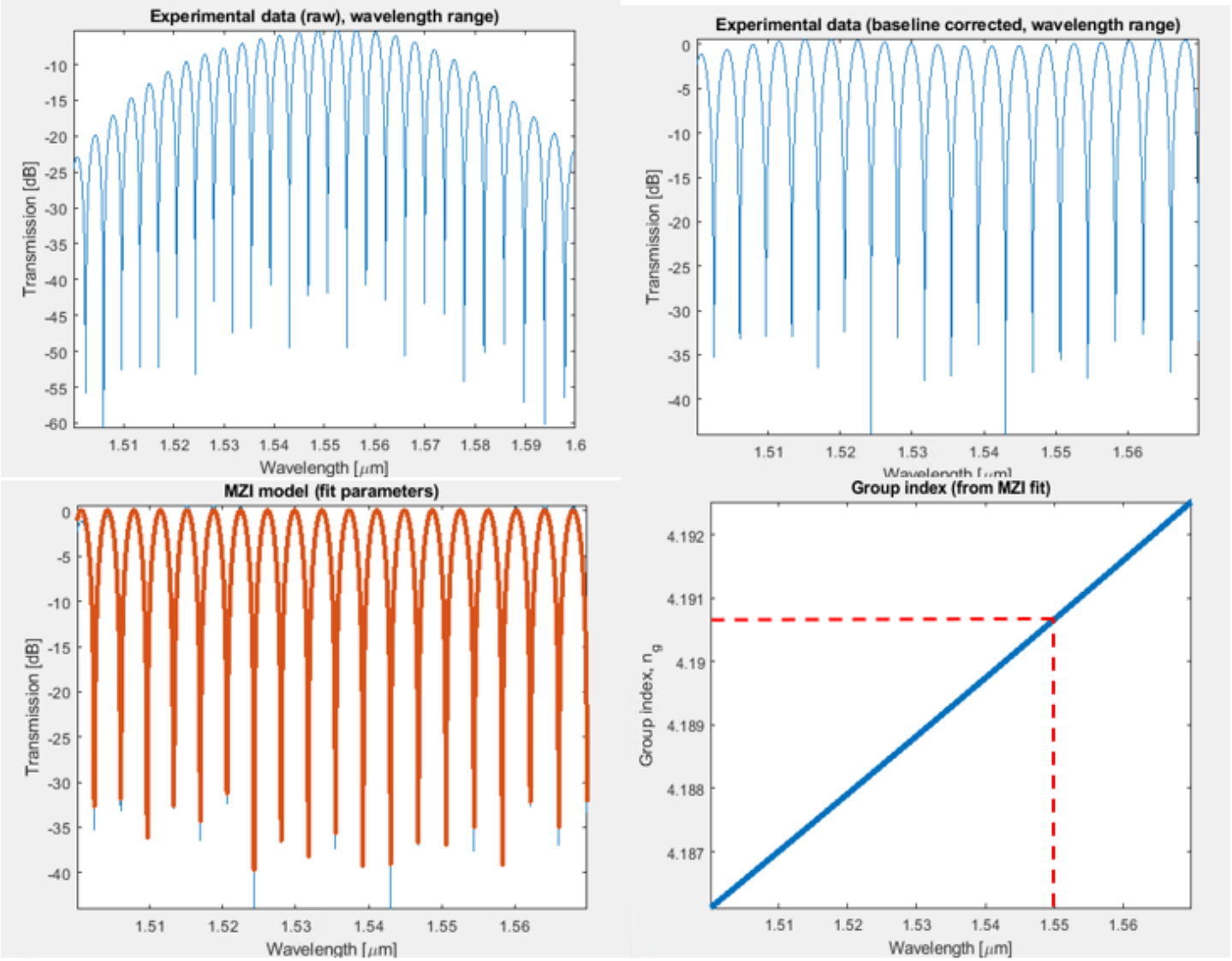
Step 7: Create TE MZI layout using KLayout
TE_MZI0 (25 μm**),** TE_MZI0 (50 μm**),** TE_MZI0 (100 μm**),** TE_MZI0 (150 μm**)**



Step 8: Simulate FSR using KLayout interface to ANSYS Lumerical Interconnect

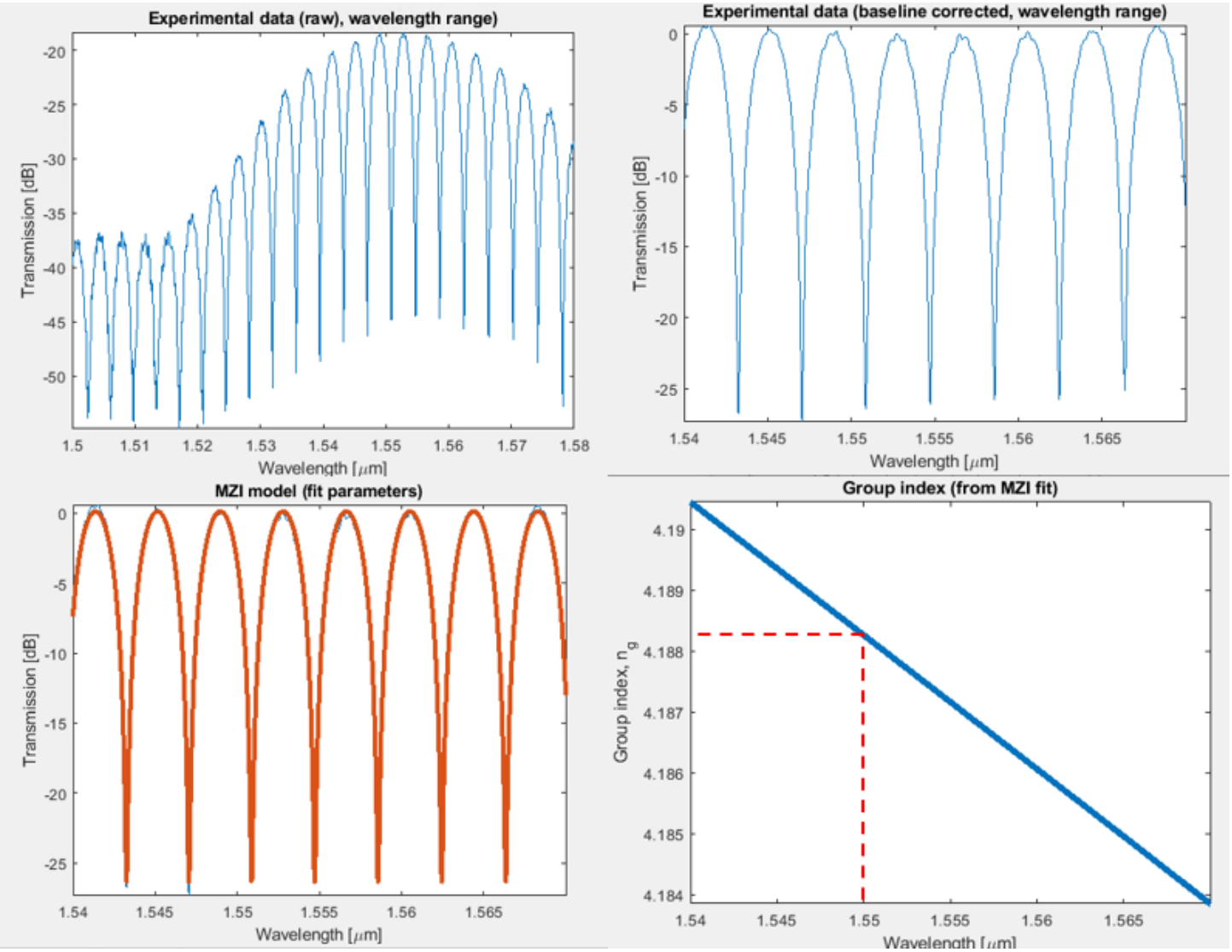


Step 9: Apply ACF based grating coupler bias correction [MATLAB processing]
Auto Correlation based baseline (bias) correction parameters:
Reference wavelength: 1553.50nm
Group Index: 4.1890
FSR: 3.84nm



Step 9: Extract group index (ng) and FSR from measurement data

Auto Correlation based baseline (bias) correction parameters:
MZI length imbalance: 150µm ***(selected for comparison with simulation)***
Reference wavelength: 1555.0nm
Group Index: 4.1872
FSR: 3.84nm



Conclusion:
Measured values for group index (ng) and MZI free spectral range for the structure with length imbalance of 150µm falls within estimates from waveguide model and corner analysis simulation.

Wavelength: 1550nm
Waveguide geometry: 500nm (width), 220nm (Thickness)
Waveguide polarization: TE
Waveguide material (simulation): Silicon – Dispersive & lossless
Passive photonic circuit structure: Mach-Zehnder Interferometer (MZI)
Layout instance used for analysis: **TE_MZI_3** (ΔL=150nm)

Parameter		**Simulated**		**Measured**
		Min	**Max**	
Group Index (ng)		4.1598	4.24234	4.1872
Compact model	n1	2.443		2.4317
	n2	-1.12919		-1.1450
	n3	-0.04169		-0.0299
Free Spectral Range (nm)		3.876	3.8	3.84

Future Work:

Extend analysis to include:

(a) Accurate representation of waveguide loss from simulation vs measured from calibration structure
(b) TM MZI structure

References:

1. EdX: Silicon Photonics Design, Fabrication and Data Analysis course materials
2. SiEPIC EBeam libraries and documentation
3. ANSYS suite of tools for photonics modeling and simulation (Mode, Interconnect)
4. KLayout tool for photonics layout and design rule checking
5. Silicon Photonics Design: From Devices to Systems, L. Chrostowski & M. Hochberg, Cambridge University Press