

Lab 6: Taper Design with Eigenmode Expansion (EME)

Objective:

Design a tapered edge coupler using EME.

Background:

Lumerical Eigenmode Expansion (EME):

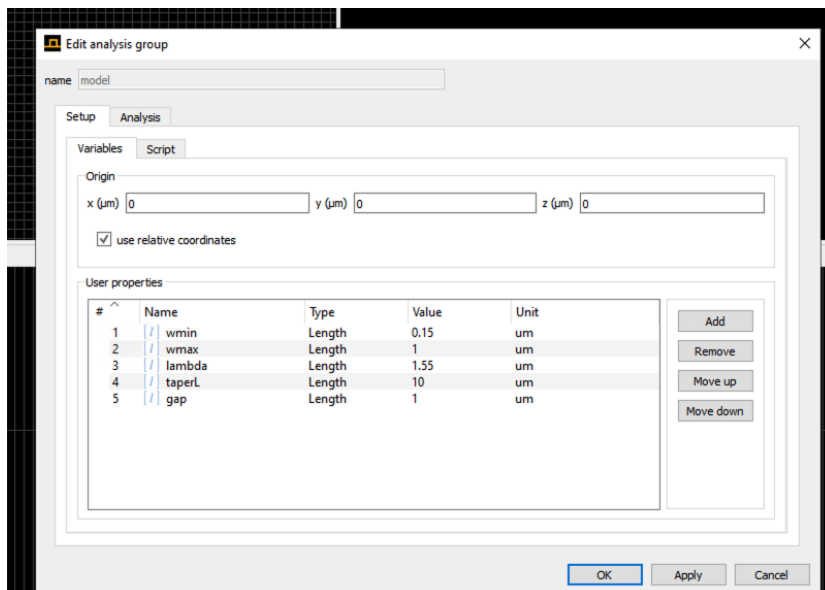
Lumerical EME is a software tool for computing the modes of waveguides and other structures. It expands the electric field distribution of a mode in terms of the eigenmodes of the waveguide or structure and computes the expansion coefficients using mode overlap integrals. EME can simulate the coupling between different eigenmodes and allows for the optimization of device designs.

Procedure:

Open MODE from the desktop shortcuts folder

1. Initialize simulation variables

Create four simulation variables: *wmin*, *wmax*, *taperL*, *lambda*, and *gap*. These will control the taper geometry, simulation wavelength, and the EME spacing.



2. Parameterize taper geometry

Create a Lumerical polygon based on the taper starting width, ending width, and length.
Assume 220 nm SOI with symmetric top oxide.

```
selectall;
delete;

V = [-taperL/2, -wmin/2; -taperL/2 - 5e-6, -wmin/2; -taperL/2 - 5e-6, wmin/2; -taperL/2,
wmin/2; taperL/2, wmax/2; taperL/2 + 5e-6, wmax/2; taperL/2 + 5e-6, -wmax/2; taperL/2, -
wmax/2];
addpoly;
set('name', 'taper');
set('vertices', V);
set('x', 0);
set('y', 0);
set('z', 0);
set('z span', 220e-9);
set('material', 'Si (Silicon) - Palik');
```

3. Define EME solver region

Create an EME solver with three groups. Make the groups span across the input waveguide, taper, and output waveguide respectively. Space the FDE cells by approx. one wavelength. Include two ports on the input and output of the component. Add a mesh.

```
emespan = 10e-6;
addeme;
set('background material', 'SiO2 (Glass) - Palik');
set('x min', -taperL/2 - 4e-6);
set('y min', -emespan/2);
set('y max', emespan/2);
set('z min', -2e-6);
set('z max', 2e-6);
set('z min bc', 'symmetric');
set('z max bc', 'metal');
set('wavelength', lambda);
set('number of modes for all cell groups', 4);
set('number of cell groups', 3);
set('cells', [floor((4e-6)/gap); floor((taperL)/gap); floor((4e-6)/gap)]);
set('group spans', [4e-6; taperL; 4e-6]);
set("subcell method", [1; 1; 1]);
set('display cells', true);

select("EME::Ports::port_1");
set('port location', 'left');
set('y min', -emespan/2);
set('y max', emespan/2);
set('z min', -2e-6);
set('z max', 2e-6);
set('x', -taperL/2-4e-6);
set('mode selection', 'fundamental TE mode');

select("EME::Ports::port_2");
set('port location', 'right');
set('y min', -emespan/2);
set('y max', emespan/2);
set('z min', -2e-6);
set('z max', 2e-6);
set('x', taperL/2+4e-6);
```

```
set('mode selection', 'fundamental TE mode');

dr = 50e-9;
addmesh;
set('x max', taperL/2 + 4e-6);
set('x min', -taperL/2 - 4e-6);
set('y', 0);
set('y span', emespan);
set('z', 0);
set('dx', dr);
set('dy', dr);
set('dz', dr);
```

4. Add field monitor

Add a field monitor to span the length of the taper.

```
addemeprofile;
set('name', 'profile');
set('x max', taperL/2 + 4e-6);
set('x min', -taperL/2 - 4e-6);
set('y', 0);
set('y span', emespan);
set('z', 0);
```

5. Run solver and perform propagation sweep

Switch to the EME Analysis Window. Click *eme propagate*

EME Analysis Window

Define propagation distance

Cell group definition

	group spans (μm)	cells	subcell method	modes	custom	cell range	start (μm)	stop (μm)
1	4	2	CVCS	4	default	[1,2]	-9	-5
2	10	6	CVCS	4	default	[3 ... 8]	-5	5
3	4	2	CVCS	4	default	[9,10]	5	9

energy conservation ☒ make passive ☐

Select source

amplitude

source port source mode

☐ override max modes

max modes

☐ override wavelength

wavelength (μm)

☐ Override periodicity

	start cell group	end cell group	periods
1	1	1	1

Cell group sequence

$[(1)^{1,2,3}]$

☒ include fast diagnostics ☒ update monitors

☐ include slow diagnostics ☐ calculate group delays

[Help me use diagnostics...](#)

☒ Propagation sweep

parameter

start (μm)

stop (μm)

interval number of points

☐ Wavelength sweep

start wavelength (μm)

stop wavelength (μm)

number of wavelength points

☐ calculate group delays

☐ Mode convergence sweep

start mode mode interval

S-matrix index mapping

S-matrix index	Source mode
1	port 1 mode 1
2	port 2 mode 1

6. Run convergence tests to verify simulation accuracy

Many variables contribute to the accuracy of the simulation. Vary the number of FDE cells, length of the initial taper, mesh size, etc.