EC591 Lab 8 Report Notes

All the plots generated in these simulations are included at the bottom of this document

1B For a planar dielectric waveguide, the number of modes for each polarization is: $M \doteq \frac{2d}{\lambda}\sqrt{n_{core}^2 - n_{clad}^2}$ ← ceiling

Here: $\lambda = 1\,\mu m$

$n_{clad} = 1.46$

$n_{core} = 1.47$

$\Rightarrow$

$d(\mu m)$	8	6	4	2
M	3	3	2	1

1C From the calculated plot of n_{eff} versus λ, we find that

as $\lambda \to \begin{cases} 0 \\ \infty \end{cases}$, $n_{eff} \to \begin{cases} n_{core} \\ n_{clad} \end{cases}$. This makes sense because

as $\lambda \to \begin{cases} 0 \\ \infty \end{cases}$, the guided mode is $\begin{cases} \text{mostly confined in the core} \\ \text{widely spread out in the cladding} \end{cases}$

Given n_{eff} versus λ, you can plot ω versus β using:

$$\beta = \frac{n_{eff}\,\omega}{c_0}$$

$$\omega = 2\pi \frac{c_0}{\lambda}$$

2C] The fraction of input power coupled into mode # m is proportional to $|a_m|^2$, where $a_m = \iint dx\, dy\; E_m'^*(x,y)\, E_{in}'(x,y)$

complex amplitude of mode # m

complex amplitude of input light

Here there are 3 modes $(m = 1, 2, 3)$ and E_m' is an $\begin{Bmatrix} \text{even} \\ \text{odd} \end{Bmatrix}$ function of x about the center of the waveguide for m $\begin{Bmatrix} \text{odd} \\ \text{even} \end{Bmatrix}$

E_{in}' is an even function (Gaussian)

$\Rightarrow$ If the input light is aligned to the center ($x = 0$) of the waveguide, E_{in}' is an even function of x about $x = 0$. Therefore $a_2 = 0$ by symmetry (the product of an even and an odd function is odd, and the integral of an odd function over a symmetric integration interval is zero)

If the input light is misaligned along the x direction by δx, the shape of $|a_m|^2$ versus δx resembles the shape of $|E_m'|^2$ versus x

3A] To ensure that the total output power is $\geq 80\%$ of the input power, the transmission through each S-bend should be $\geq \sqrt{80\%} = 89\%$ (because there are 2 S-bends from input to output)

From the calculated plot of output power versus L_{sbend}, we find that the smallest length of the S-bends for which this condition is satisfied is about 1200 μm

3B) From the calculated plots of output powers in the two waveguides versus L_{couple}, we find that the smallest length of the coupling section for which the two output powers are equal is about 250 μm

3C) In the simulation software, the refractive index of each segment is set to the Background Index (3.26 in this case) plus the segment' Index Difference

⇒ an Index Difference of 0.011 produces an index of 3.271

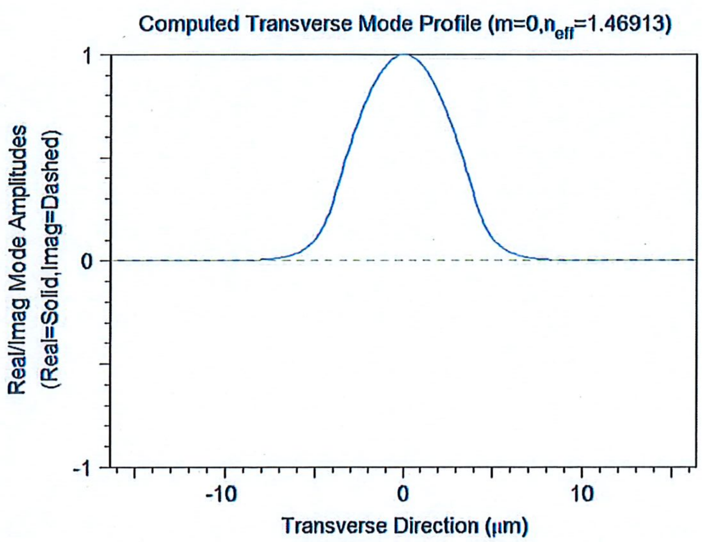
If the two waveguides of the coupler are identical, their modes are phase-matched (travel with the same phase velocity) and therefore by varying L_{couple} you can transfer 100% of the input power from one waveguide to the other (see simulation results of 3B). If the two waveguides are different, their modes are mismatched and complete power transfer is no longer possible (see results of this part).

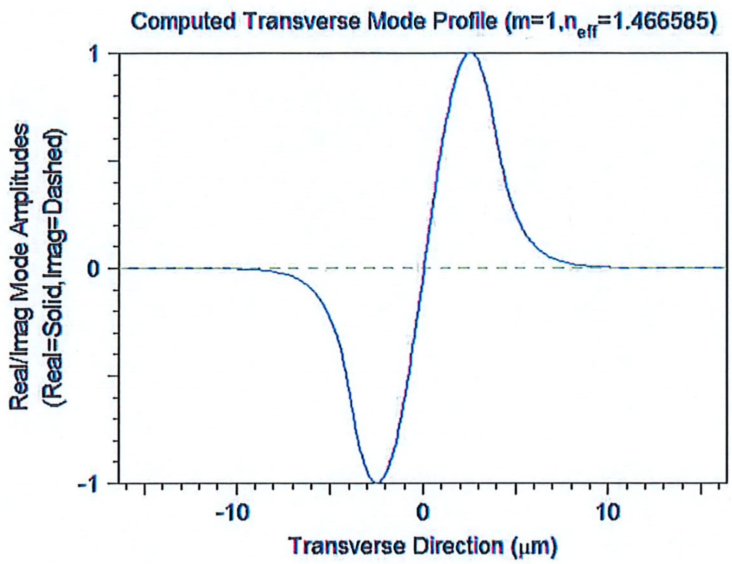
Simulation Assignment 1: The Beam Propagation Method

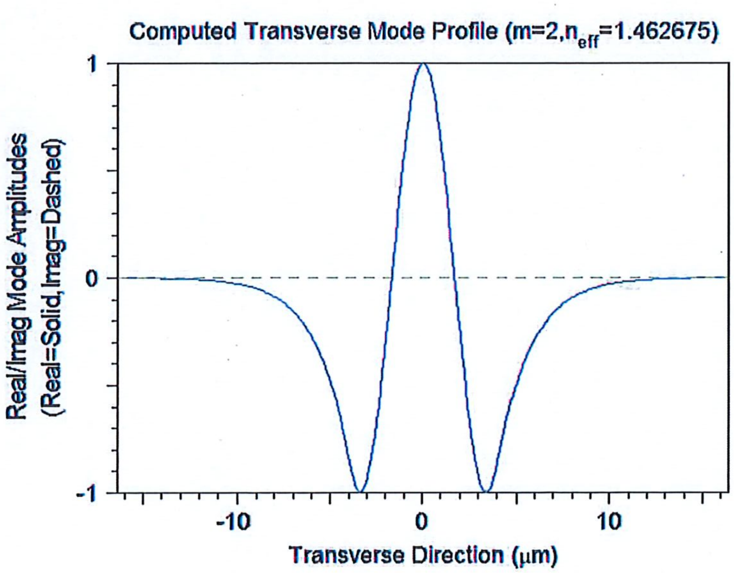
Part 1. Planar dielectric waveguides

B. Modal Field Distributions

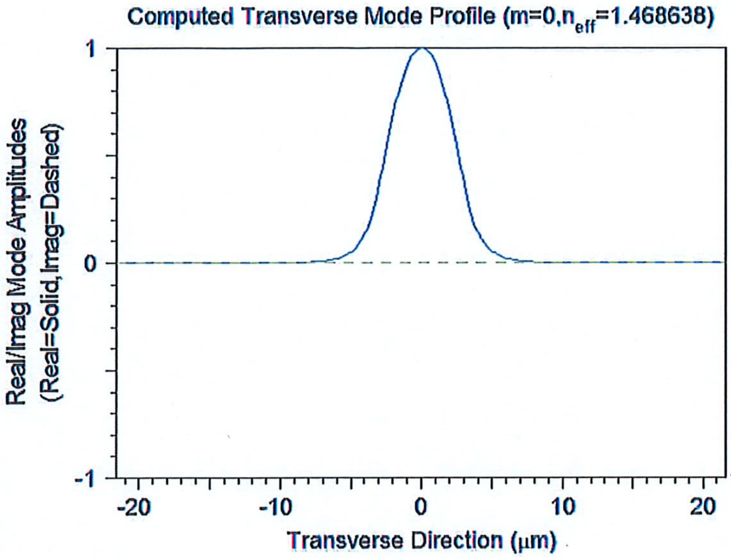
Core thickness = 8um:

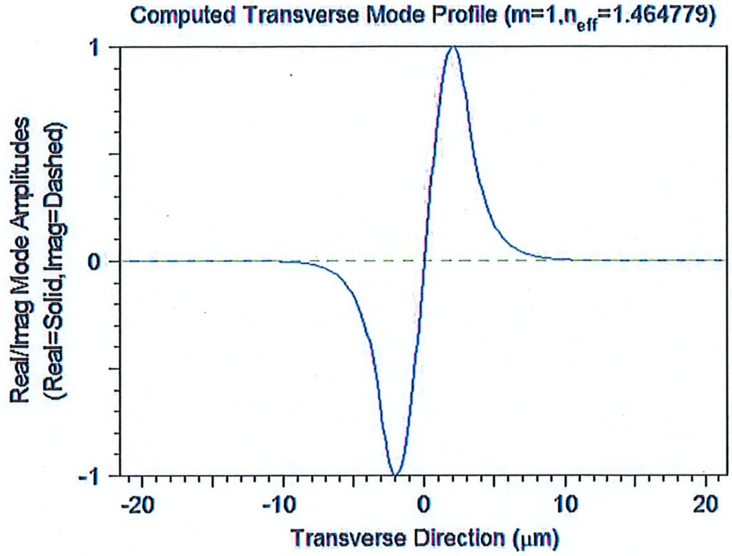


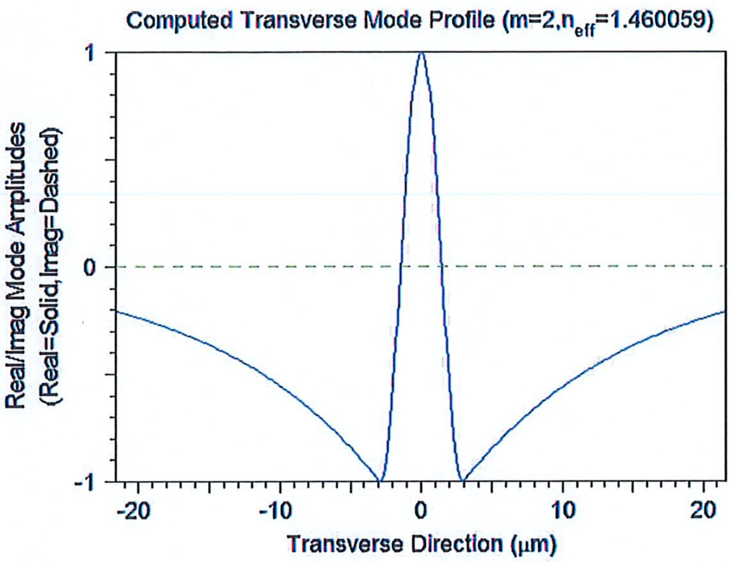




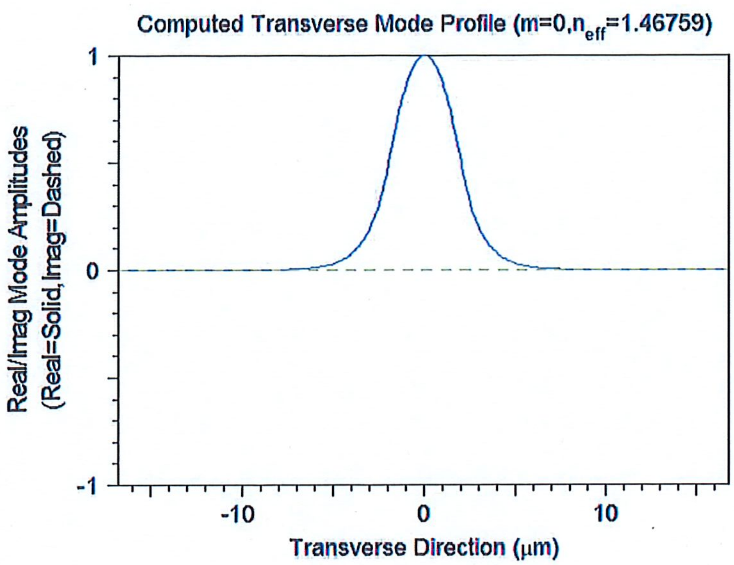
Core thickness = 6um:

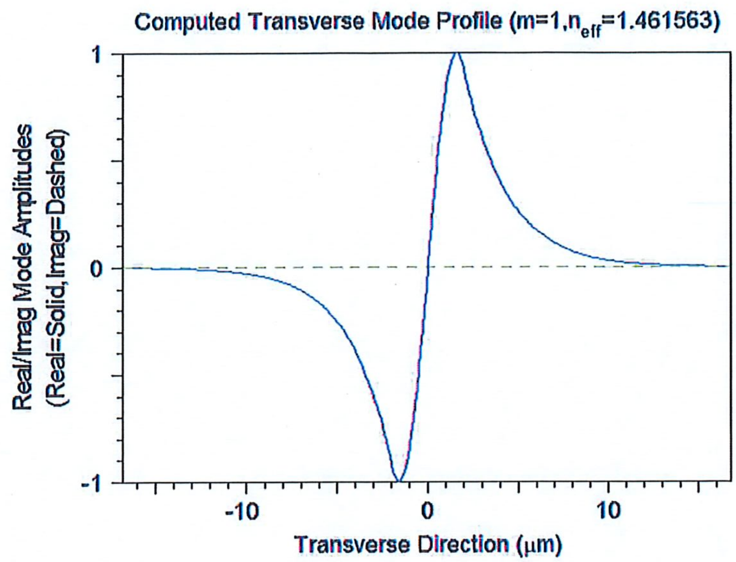




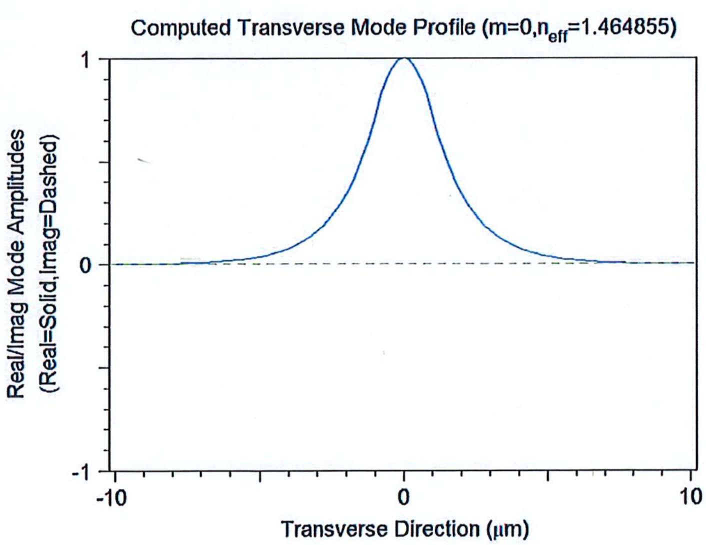


Core thickness = 4um:

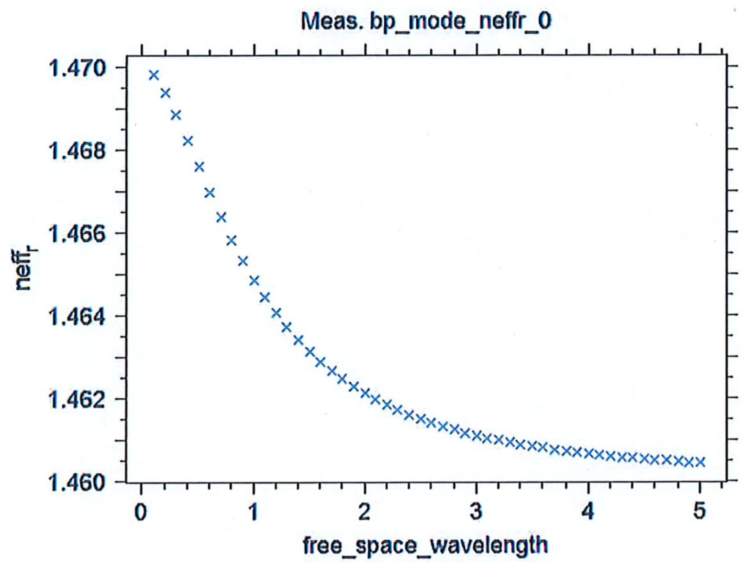




Core thickness = 2um:

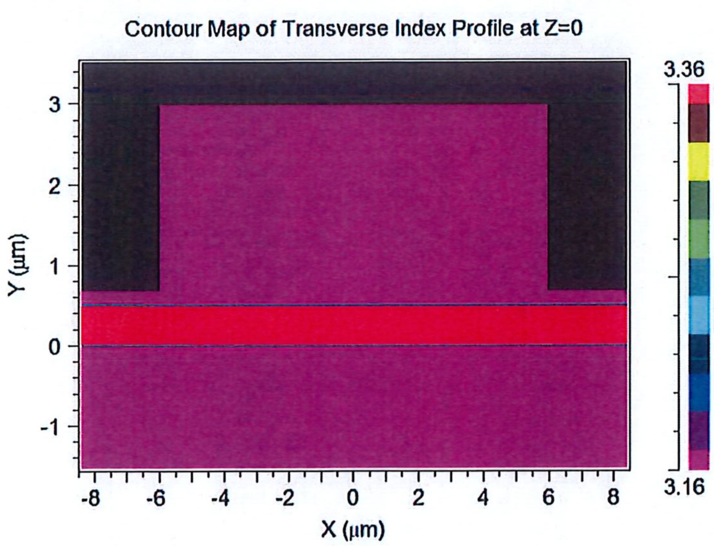


C. Dispersion relation

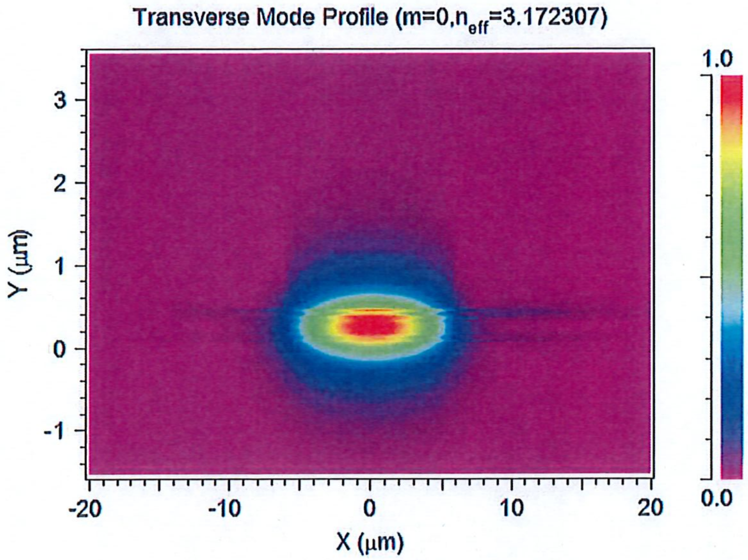


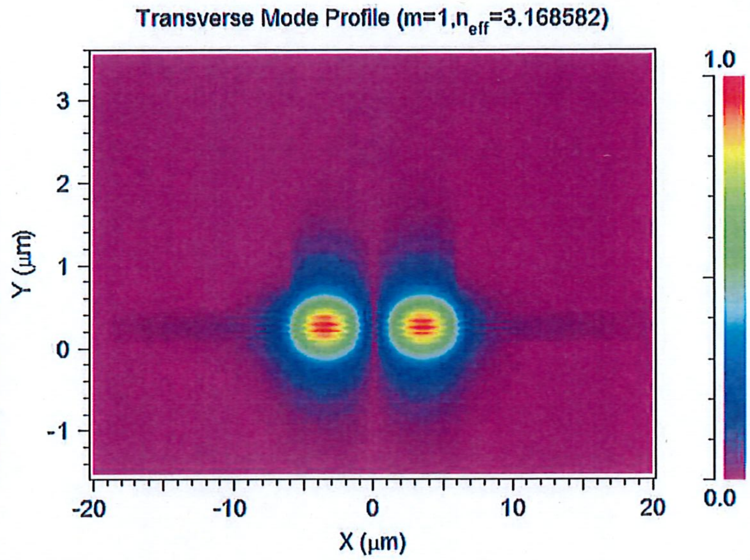
Part 2. 3D ridge waveguides

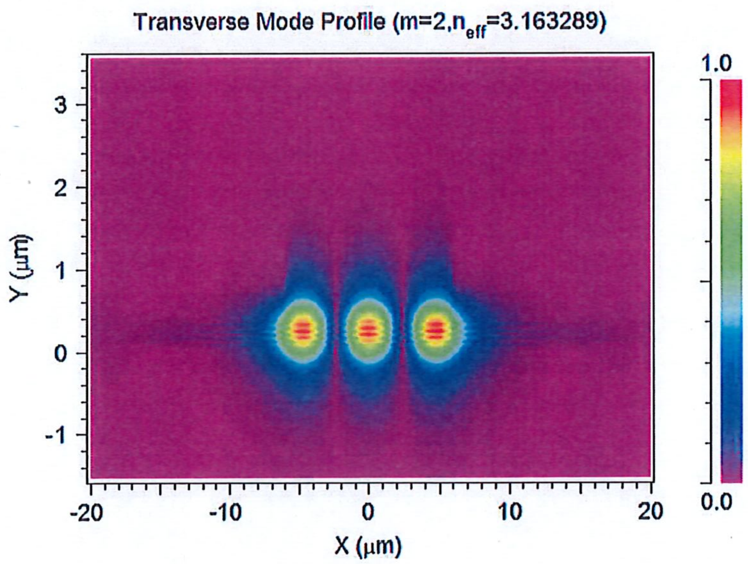
Index profile:



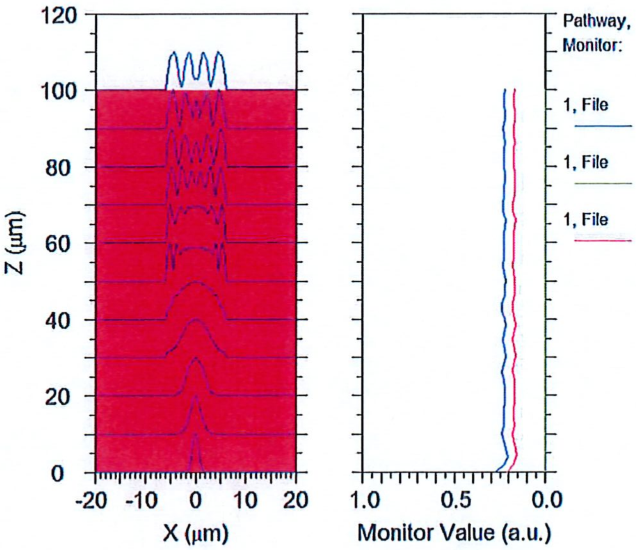
B. Modal field distribution

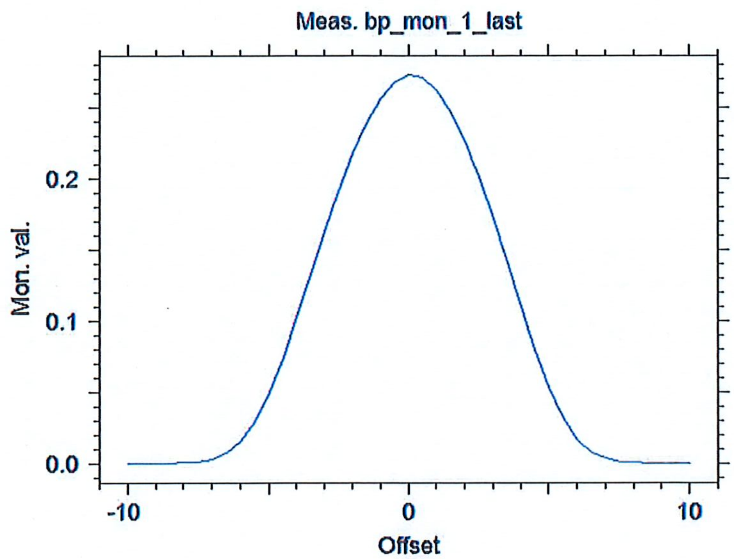


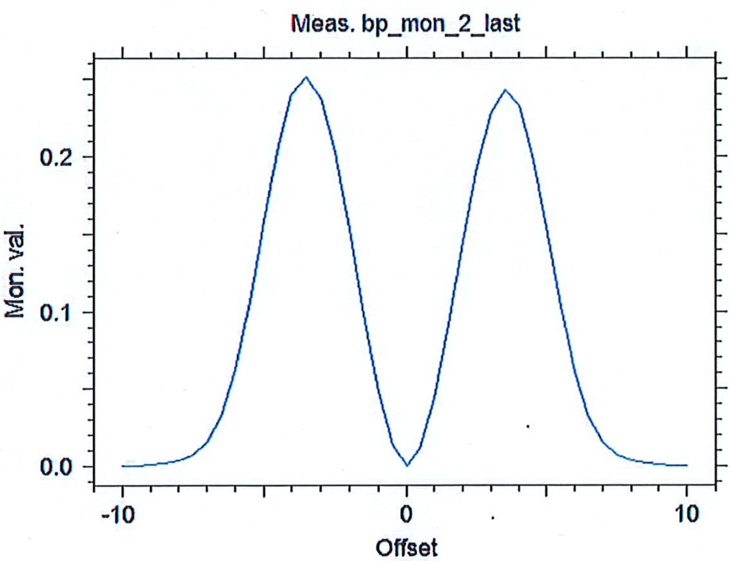


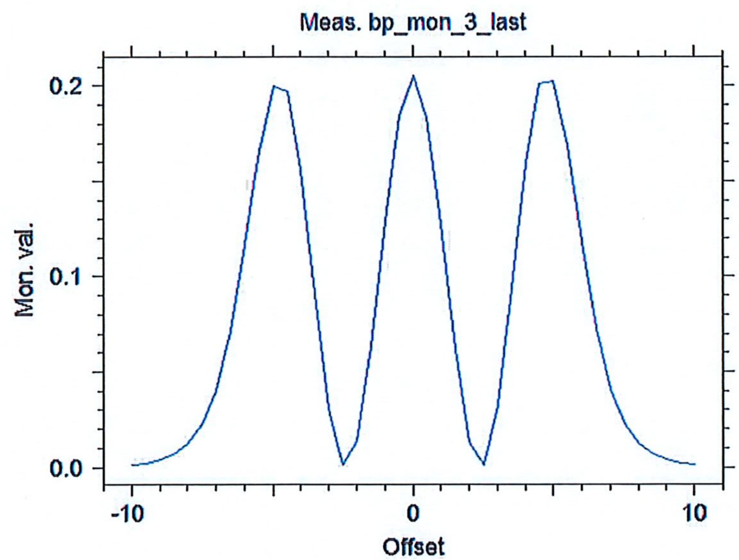


C. Input coupling efficiency



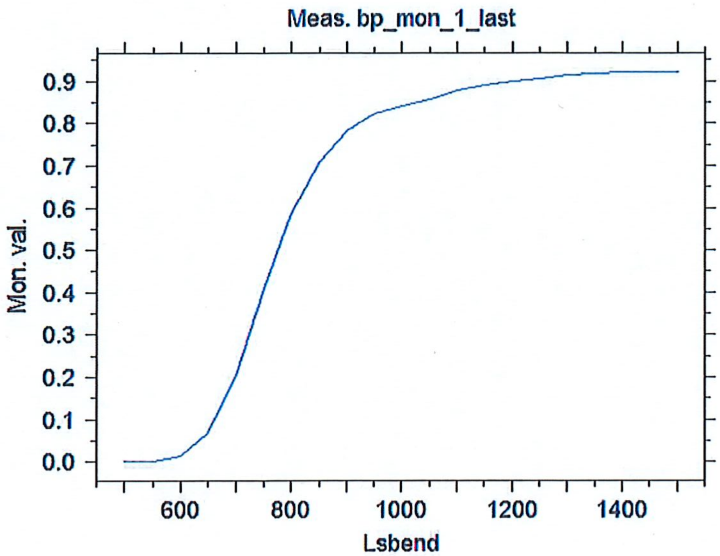




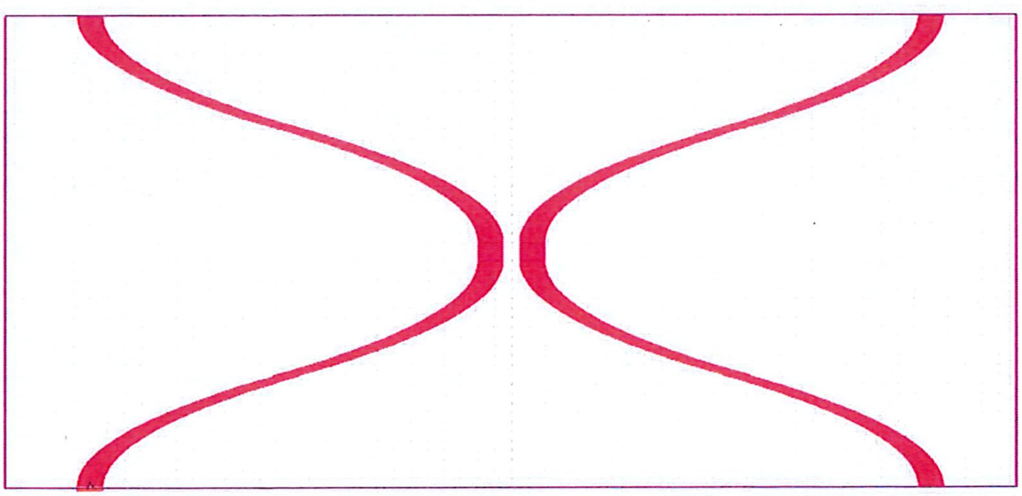


Part 3. Integrated 3-dB coupler

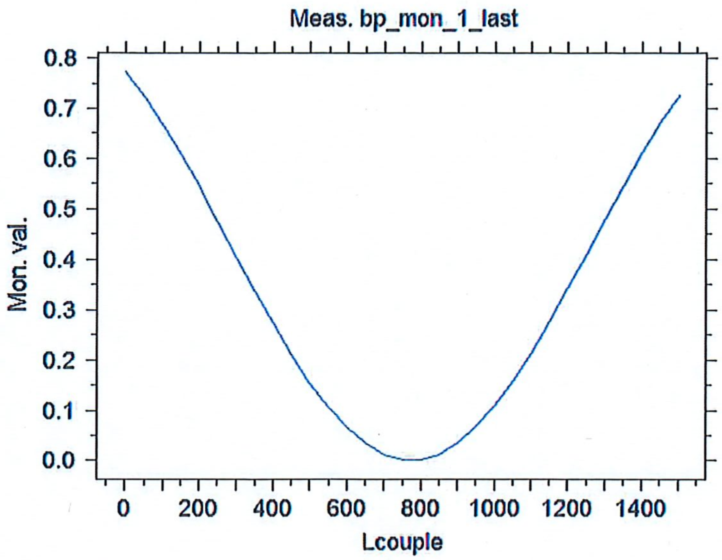
A. Waveguide bends

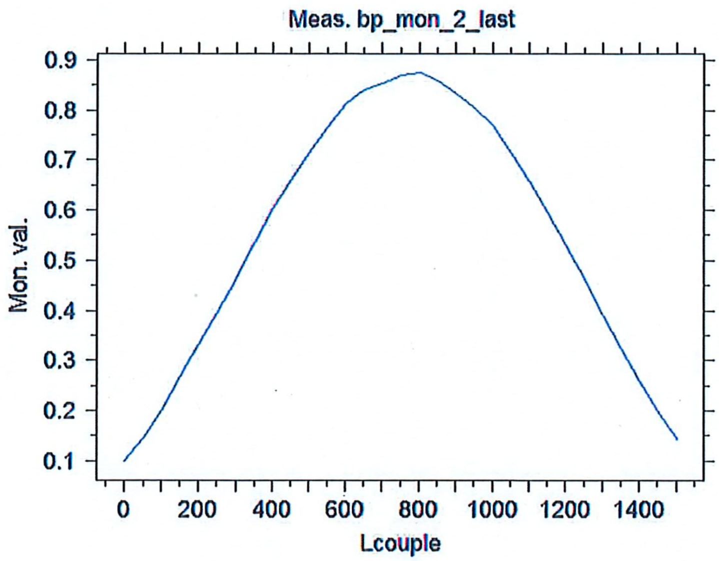


Set Lsbend ≈ 1200um

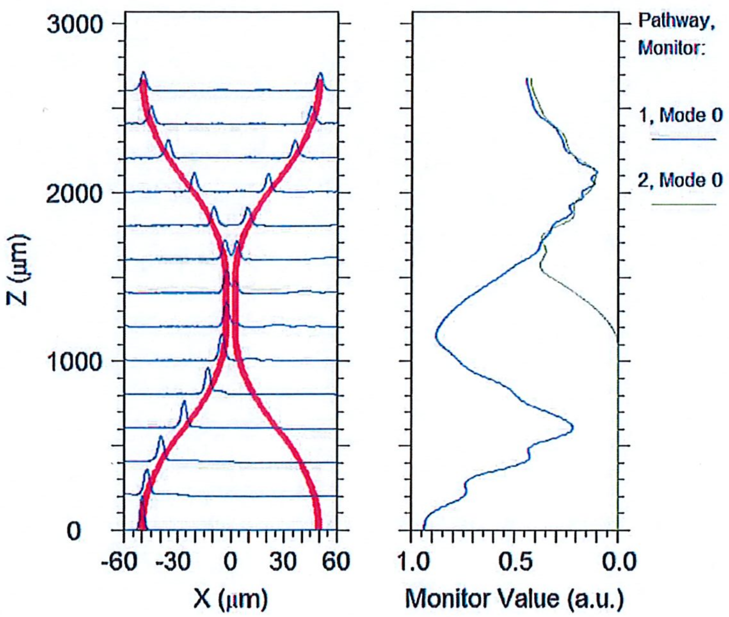


B. 3-dB coupler





Set Lcouple ≈ 250um



Monitor value ≈ 0.42

C. Unbalanced coupler