# EO Experiment 10

# EO Component Simulation


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## Contents

# 1 Gaussian Beam - MATLAB

Execute the MATLAB "gb_basic.m" m-file to see some basic properties of a Gaussian beam.

## Exercise

A student in the EE department constructed a green ($\lambda = 532$ nm) laser, which generates a laser beam with beam waist $w_0$ of 1 mm. He mounted his laser is on the front gate, pointing it to the library. (From the front gate of NTU to the library, the Royal Palm Boulevard is roughly 650 m long.)

- (a). Plot a graph of the laser beam size vs. distance (covering from z = 0 to z = 1 km).
- (b). How big is the beam size $w$ at the library? Indicate it on the graph.

His friend (also an EE student) made a light detector for him. He tested it with his laser and found that the detector has a pick-up threshold, failing to sense the laser at 1% of the initial laser intensity.

- (c). What is the longest distance away from the laser, that the detector can be mounted (and still able to detect the laser)?
- (d). How much must his laser power be amplified, for the detector to sense the laser at the library?

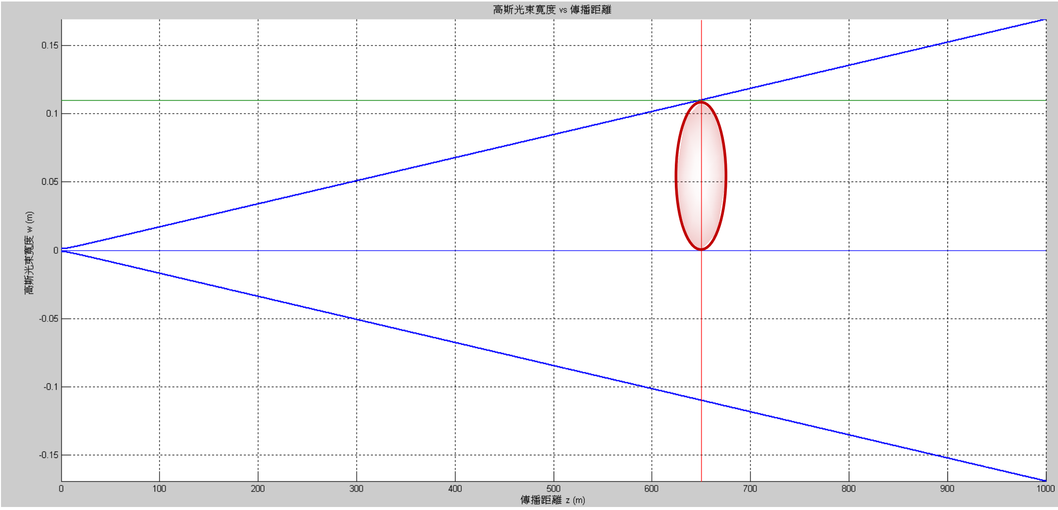
In an experiment, his professor needs him to mount a mirror at the library, to reflect the laser beam back into the laser mounted on the front gate. The curvature of the mirror must be the same as the laser's wavefront curvature at the library, given by

$$R = z\left(1 + \left(\frac{z_R}{z}\right)^2\right) \tag{1}$$

- (e). What is the radius of curvature of the mirror? And how big does the mirror needs to be?

# 1. Gaussian Beam - MATLAB

(a).




(b). $0.1101(\mathrm{m})$

(c). $58.756(\mathrm{m})$

(d). $\frac{1\%}{8.254\times10^{-5}} = 121.15$

(e). Because

$$w_0 = \sqrt{\frac{\lambda z_0}{\pi}}$$

We can get

$$z_0 = \frac{w_0^2 \pi}{\lambda} = 5.905(\mathrm{m})$$

The radius of curvature of the mirror is

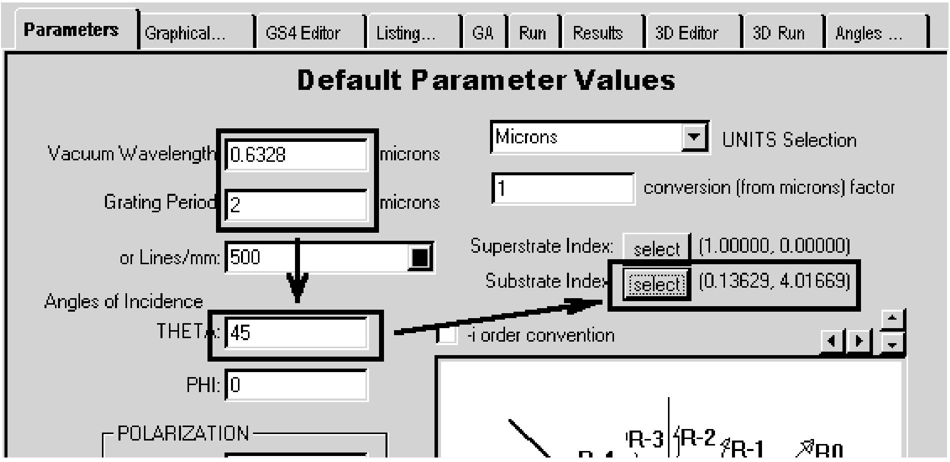
$$R\big(650(\mathrm{m})\big) = 650\left[1 + \left(\frac{z_0}{650}\right)^2\right] = 650.05(\mathrm{m})$$

And the radius of the mirror is 1(b), which is $0.1101(\mathrm{m})$

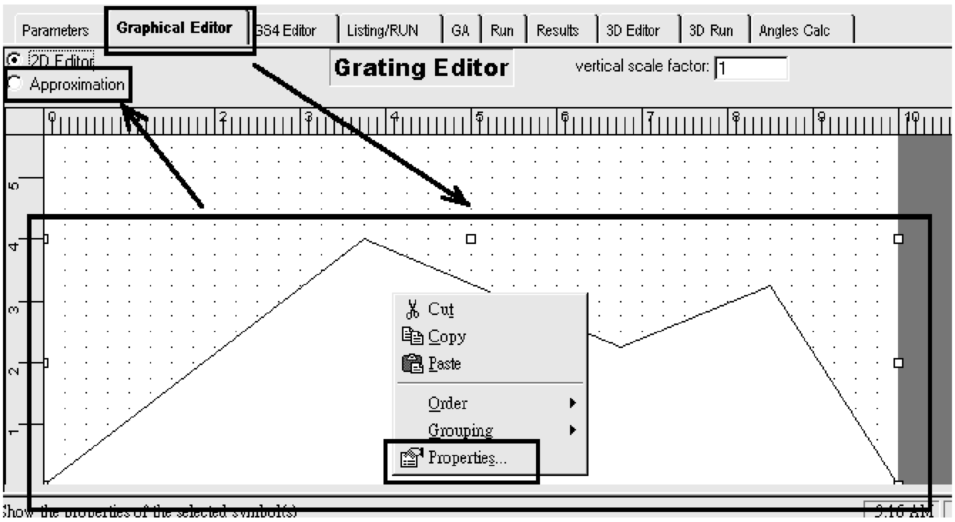
# 2 Reflection Grating - GSolver

A grating (both reflective or transmissive) can be simulated using GSolver (Grating Solver). The version used is a free demo version obtained directly from the official website, and retains all functionalities except for the ability to "save", as well as a forced shutdown after 20 min of usage.

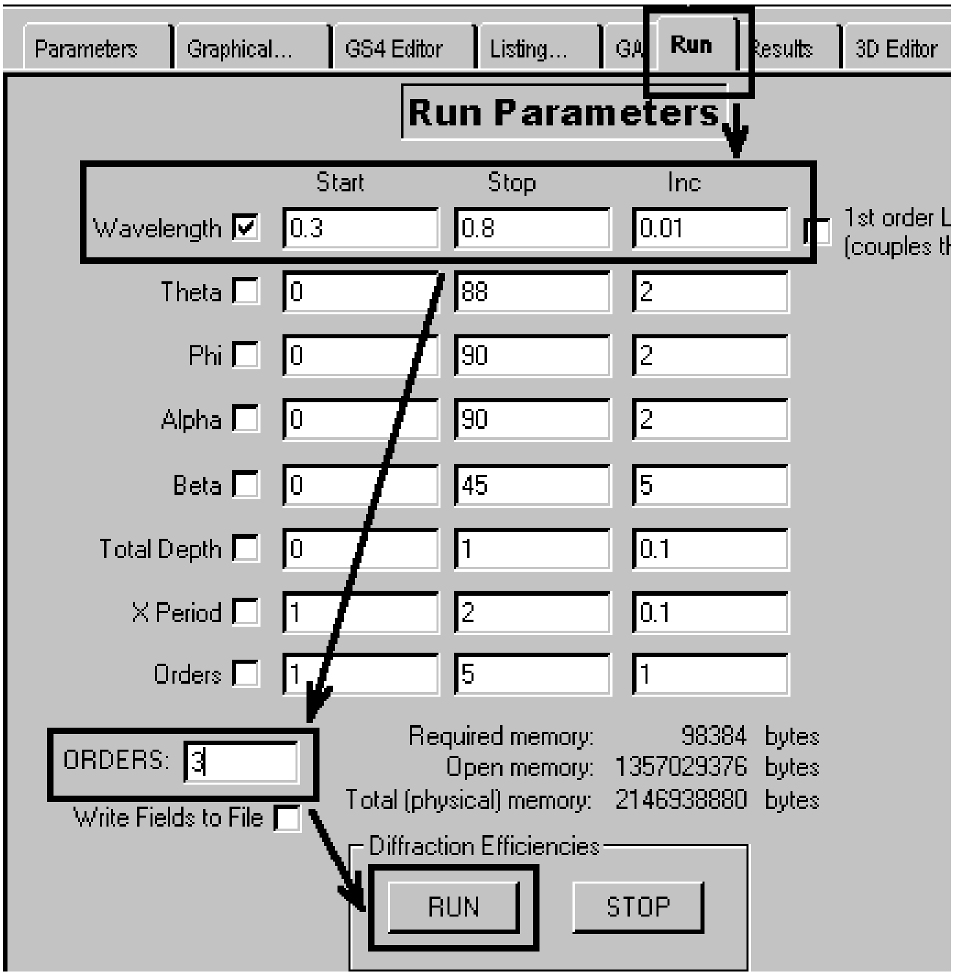
- To simulate a grating, first enter the initial parameters such as, wavelength $\lambda$, grating pitch $\Lambda$, angle of incidence *theta*, and define the substrate material.



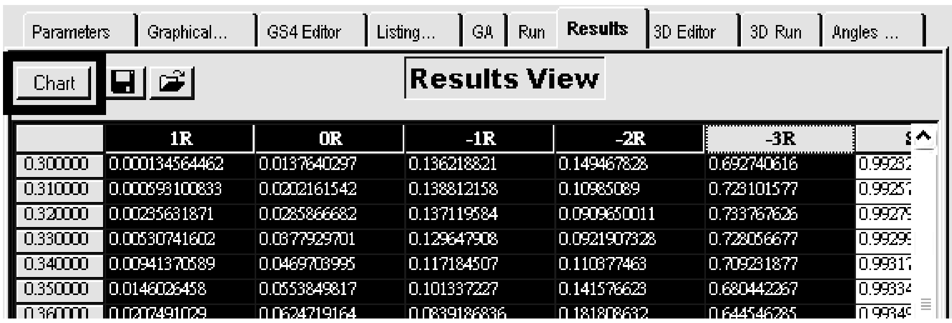

- Move to the "Graphical Editor" tab, draw one period of the grating structure in the editor, define the grating material, and hit "Approximation".



- Go to the “Run” tab, define the wavelengths to sweep over (from 0.3 to 0.8 $\mu$m, in 0.01 $\mu$m increments), set the number of orders to simulate, and hit “RUN”.




- In the “Results” tab, select the orders to plot, and hit “Chart”.

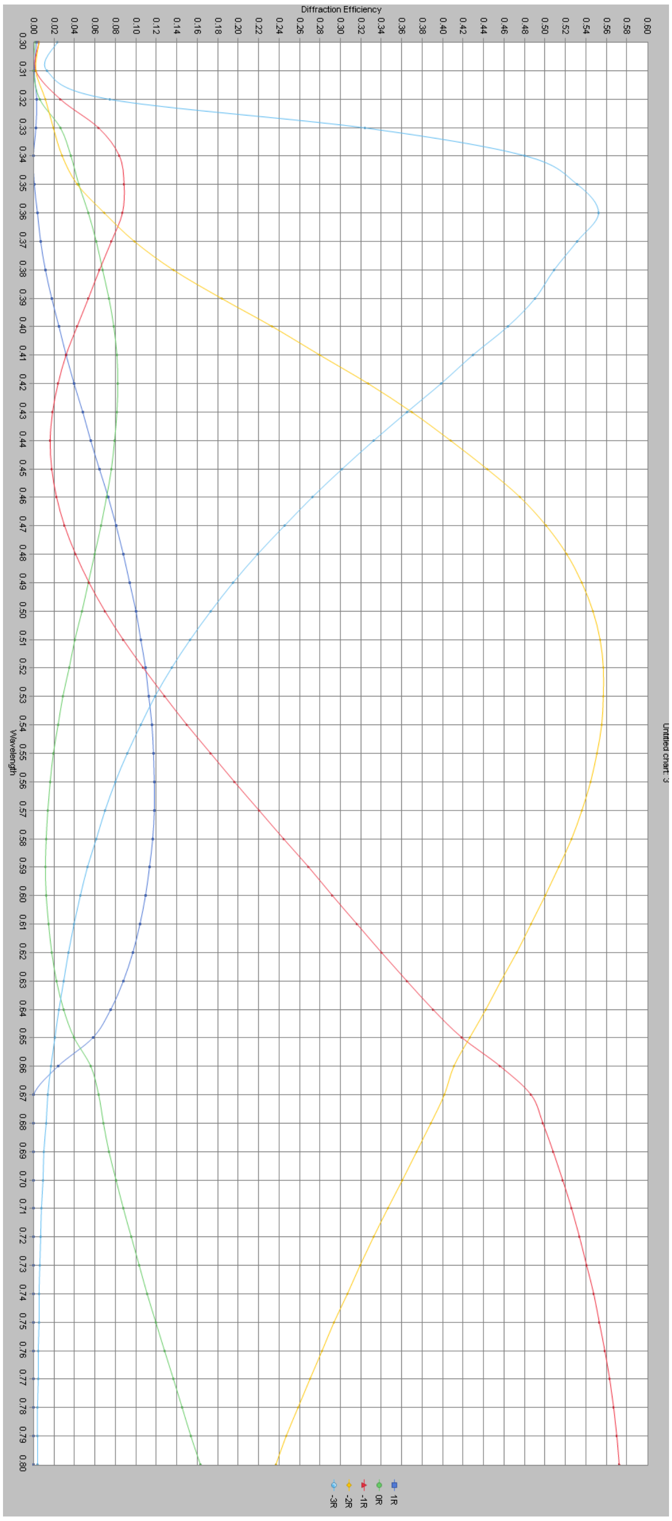



## Exercise

Design and simulate a blazed grating, for maximum diffraction efficiency at wavelength $\lambda$ of 532 nm.

# 2. Reflection Grating – Gsolver

At `532nm`, `42°` of incidence will cause the max diffraction efficiency.

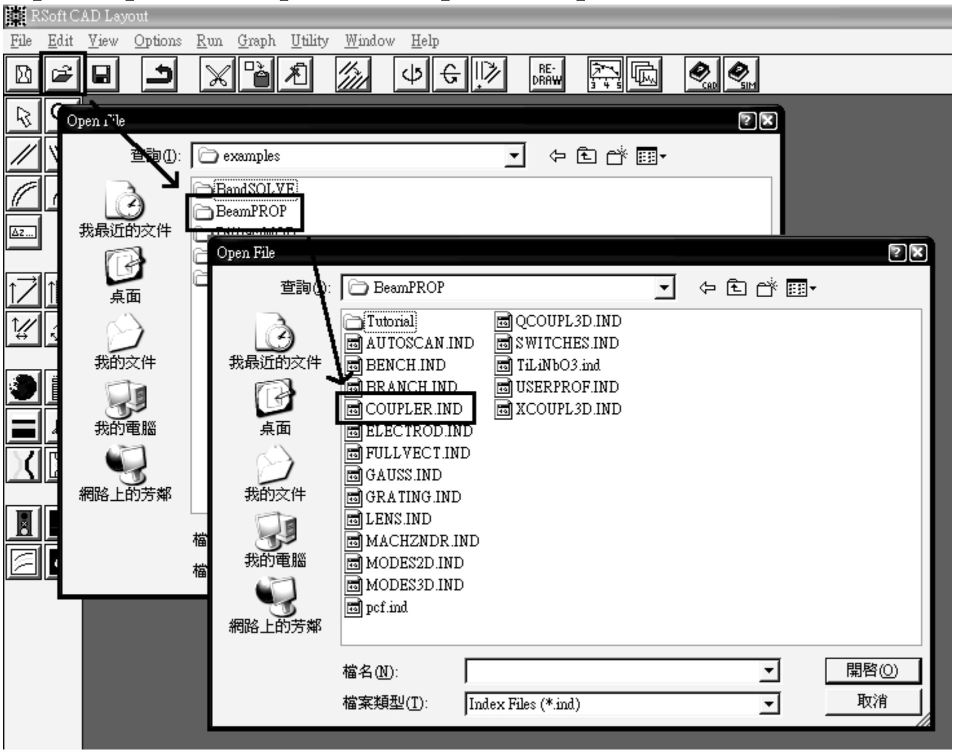


# 3 Waveguide Coupler - RSoft

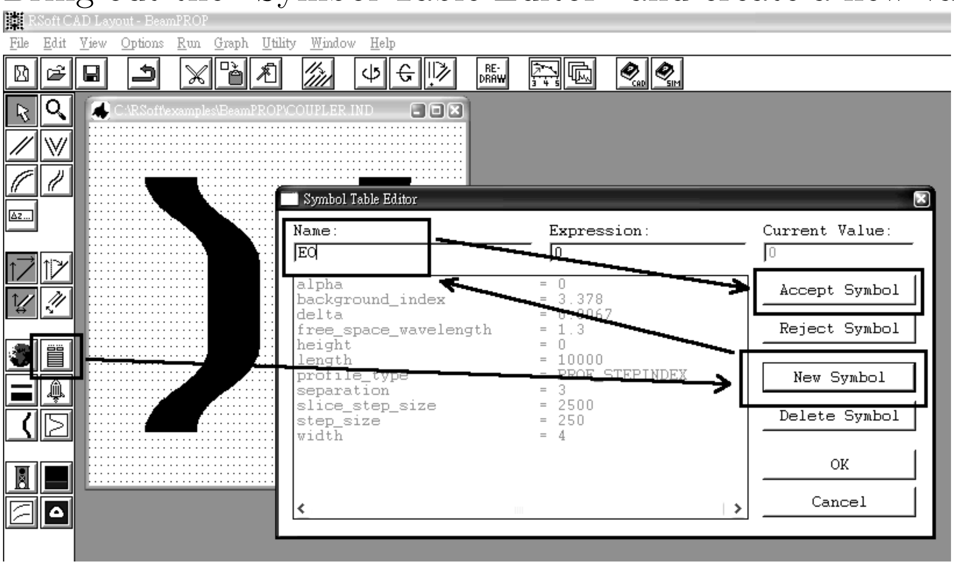
A waveguide coupler can be switched electrically for (1) complete coupling, (2) 50-50 coupling, and (3) no coupling. By constructing a section of the coupler using materials with electro-optic effect, the refractive index of the material can be changed according to the applied voltage.

**Find the required change in the waveguide material refractive index for the above three conditions.**

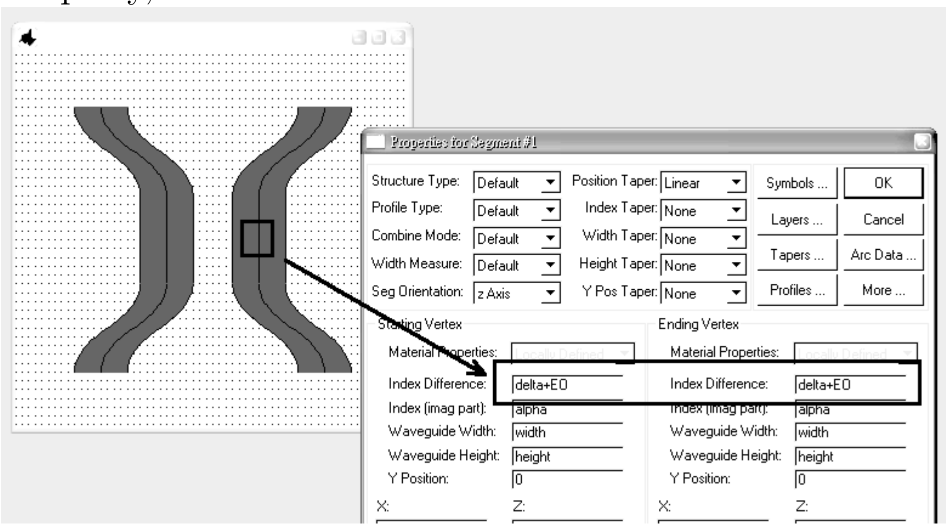
- Open up the coupler example "coupler.ind".




- Bring out the "Symbol Table Editor" and create a new variable "EO".

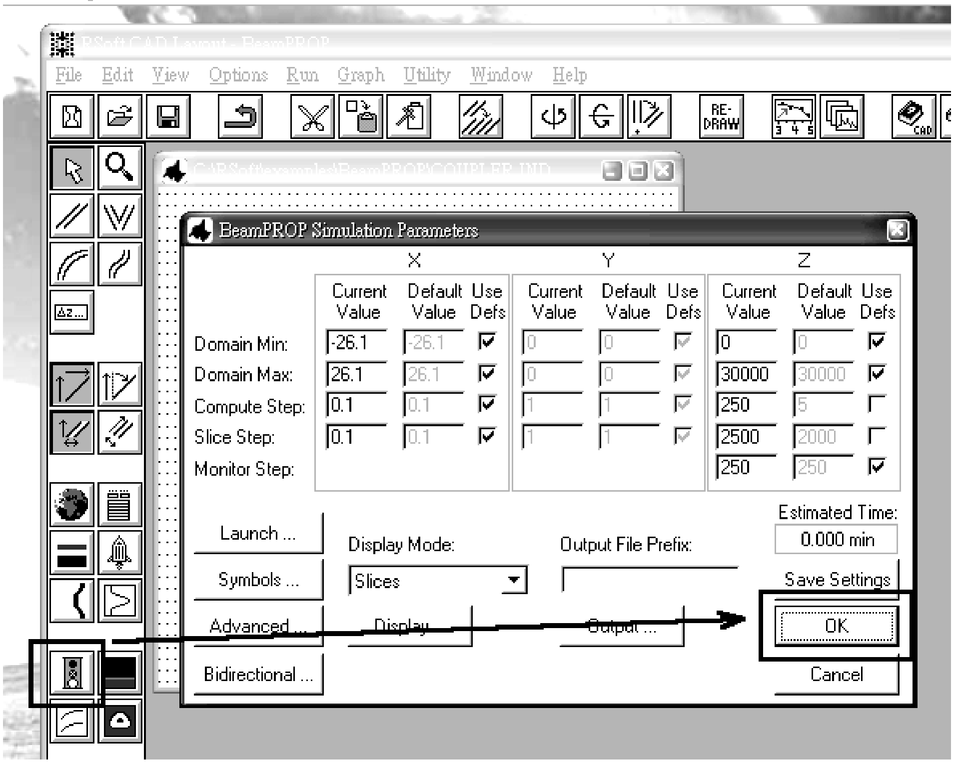


- Right click on the middle section of one channel to edit the Segment Property, add the new "EO" variable to the "Index Difference" box.

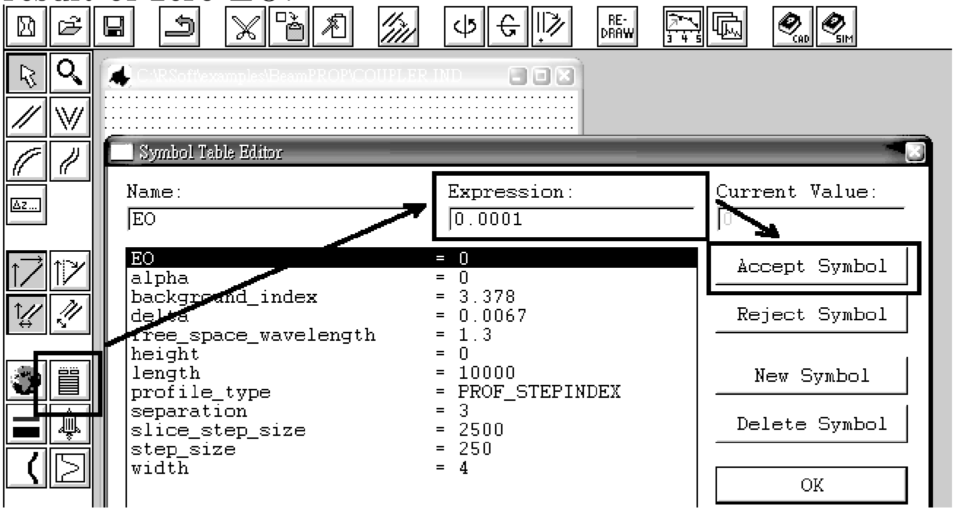



- Do the same with the other middle segment.

- Run the simulation with the initial condition.



- Bring out the "Symbol Table Editor" again, change the value of "EO" (try 0.0001 first) and re-run the simulation. Compare with the initial result of zero EO.




### Exercise

- Repeat the above step, and find the "EO" required for:
(1) **Complete Coupling** (Zero in Channel 1, max in Channel 2.)
(2) **50-50 Coupling** (Split evenly between Channel 1 and 2.)
(3) **No Coupling** (Max in Channel 1, zero in Channel 2.)

Remember to attach the results of the simulation.

## 3. Waveguide Coupler – Rsoft

(a). $EO = 0.0032$
(b). $EO = 0.00223$
(c). $EO = 0.001474$