

# Projeto de Circuitos Fotônicos Integrados

Circuitos fotônicos básicos

Atividade 1 – Interferômetro de Mach-Zehnder

Lucivaldo Barbosa de Aguiar Junior

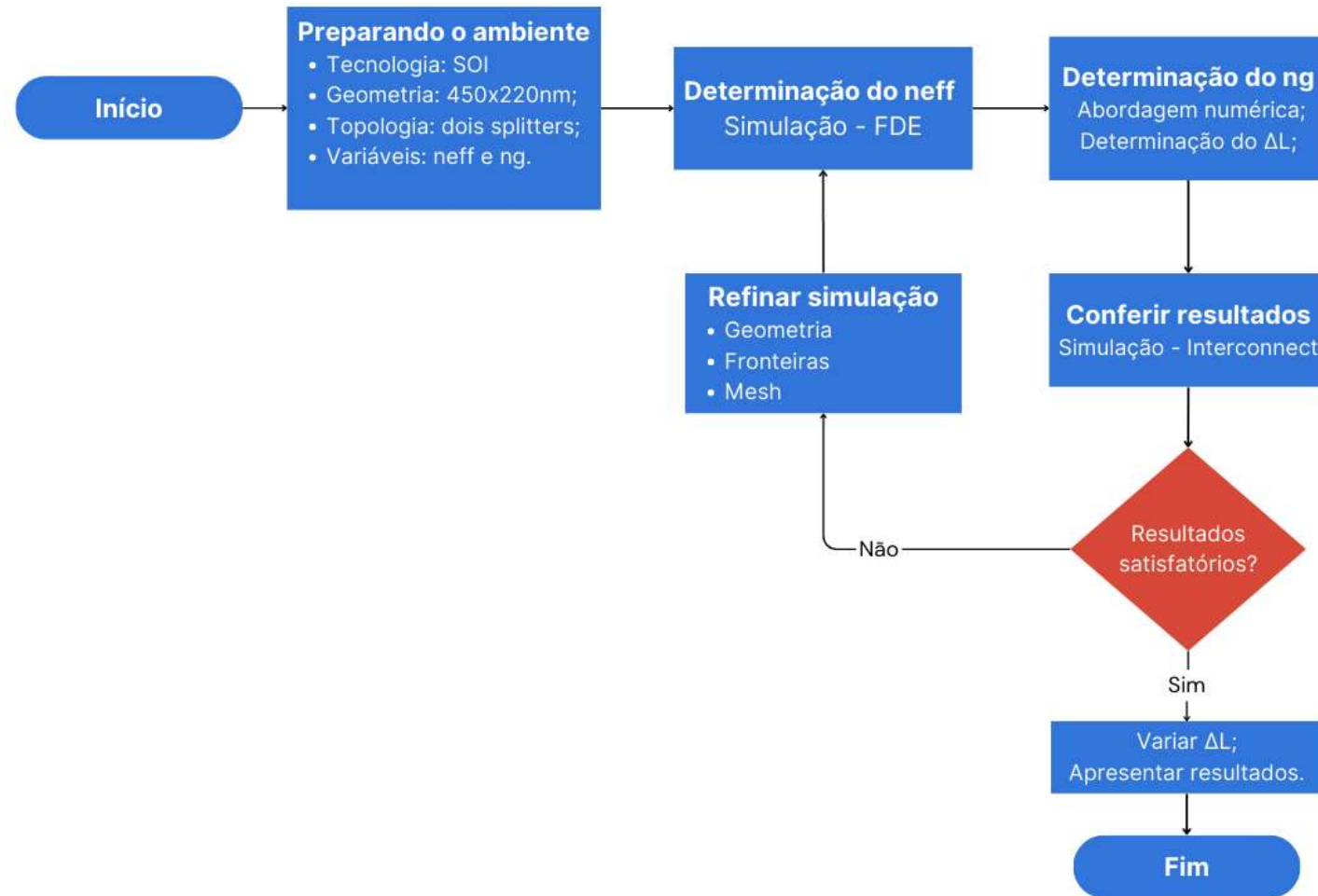


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Hardware Inteligente para a Indústria

CURSOS, CAPACITAÇÃO E TREINAMENTOS



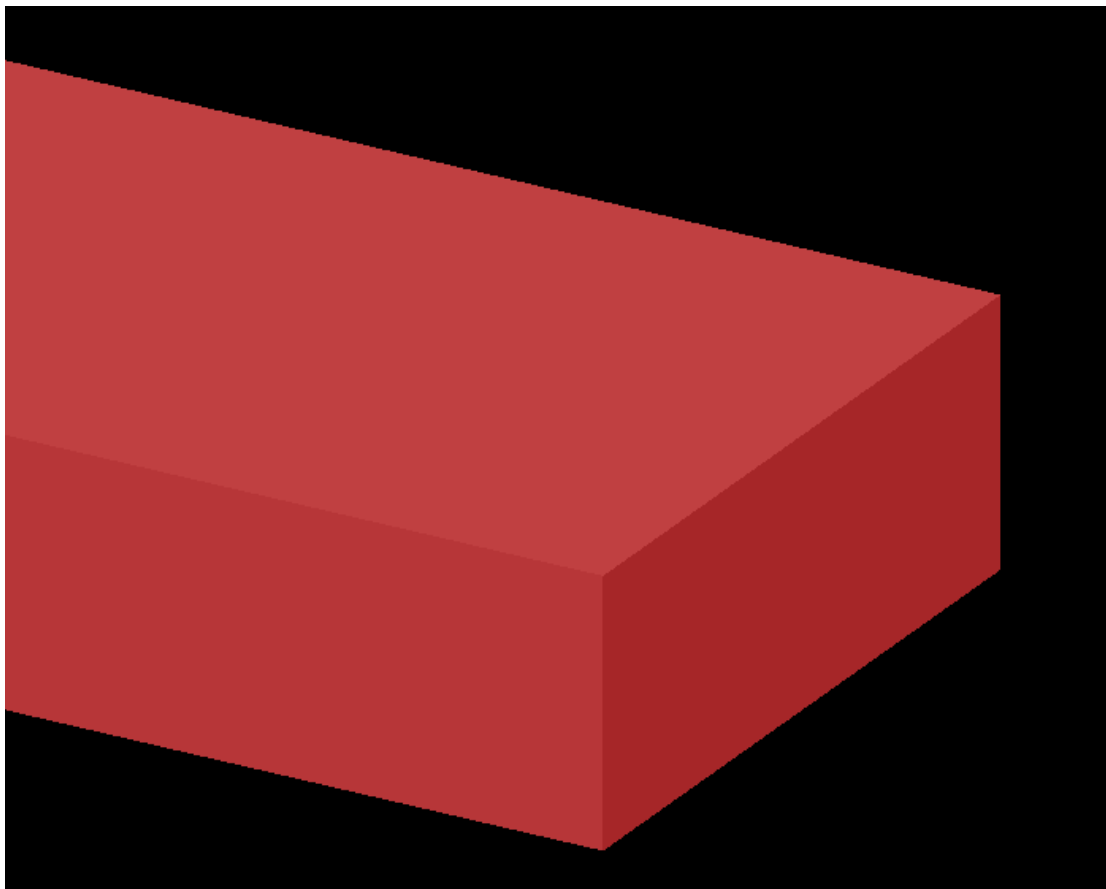
# Fluxograma de determinação dos parâmetros iniciais



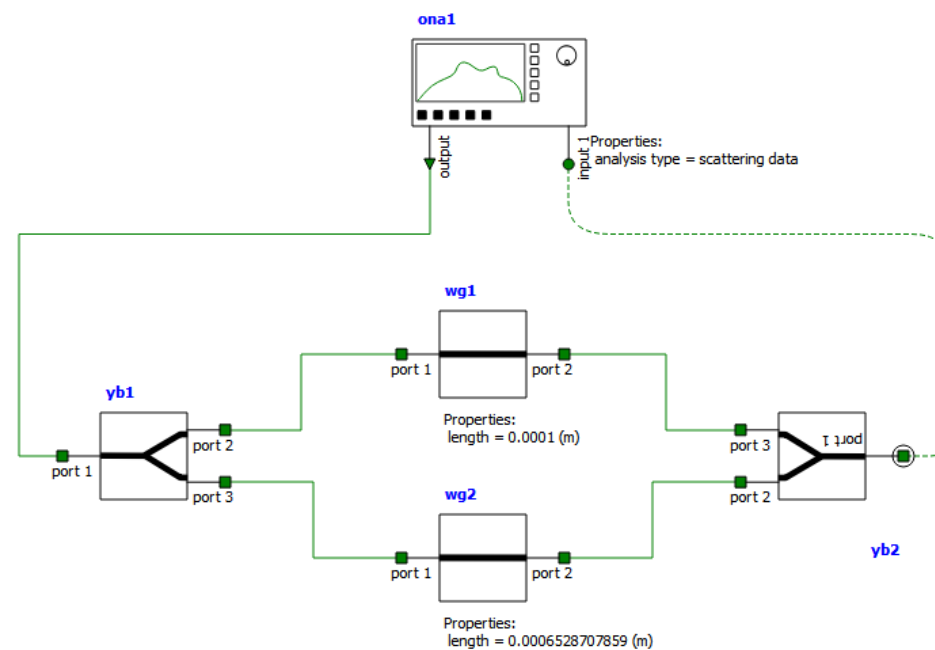
# Tecnologia, geometria e topologia



SOI - 450 x 220 nm



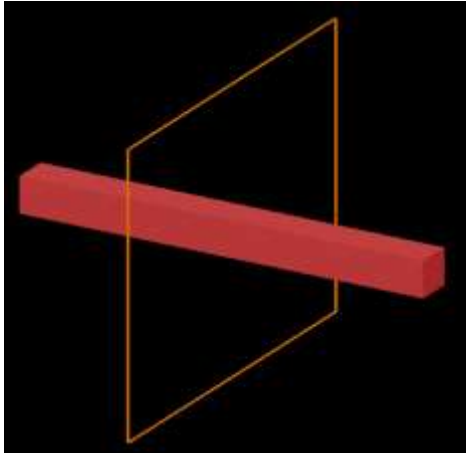
Topologia: dois splitters



# Extração do índice efetivo - FDE

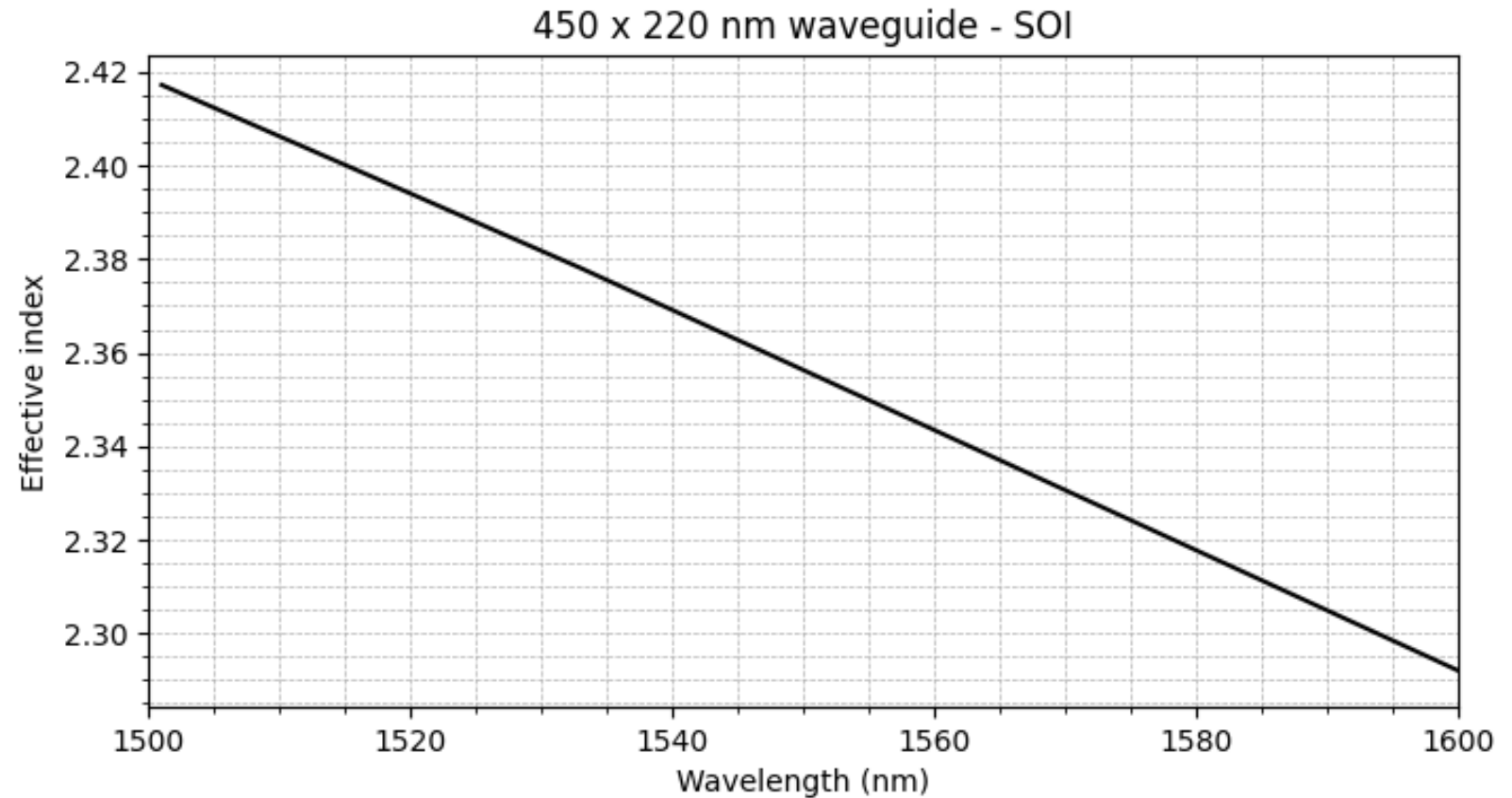


Solver: 2D x normal



Condições de fronteira

x min bc	Metal
x max bc	Metal
y min bc	Metal
y max bc	Metal
z min bc	Metal
z max bc	Metal



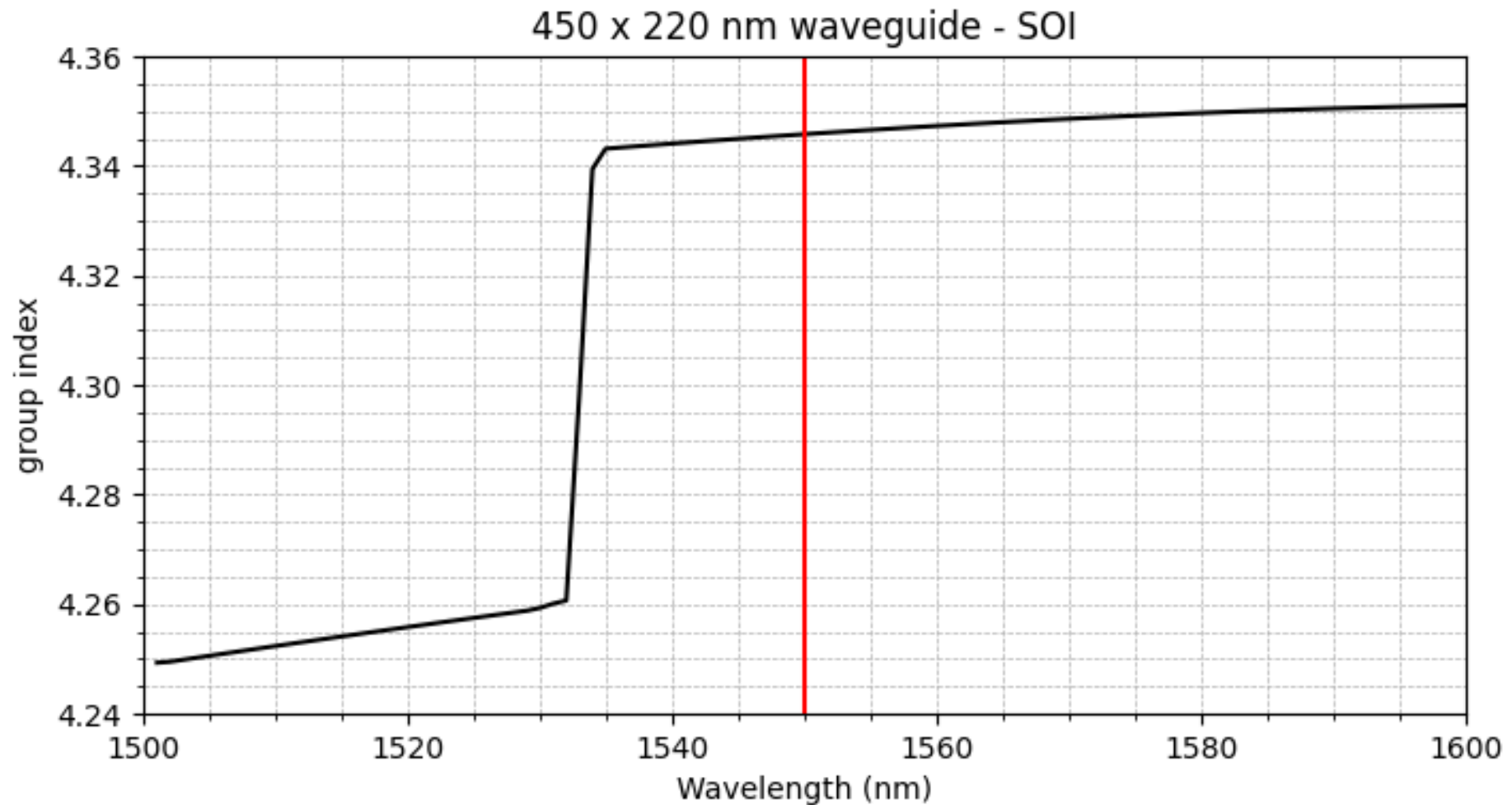
## Determinação numérica do índice de grupo

$$n_g(\lambda) = n_{\text{eff}}(\lambda) - \lambda \frac{dn_{\text{eff}}}{d\lambda}$$

```
def derivative(data):
    derive = np.zeros(len(data[:, 1]))
    derive[1:-1] = (data[2:, 1] - data[:-2, 1]) / (data[2:, 0] - data[:-2, 0]) # central
    derive[0] = (data[1, 1] - data[0, 1]) / (data[1, 0] - data[0, 0]) # forward
    derive[-1] = (data[-1, 1] - data[-2, 1]) / (data[-1, 0] - data[-2, 0]) # backward
    return np.transpose([data[:, 0], derive])

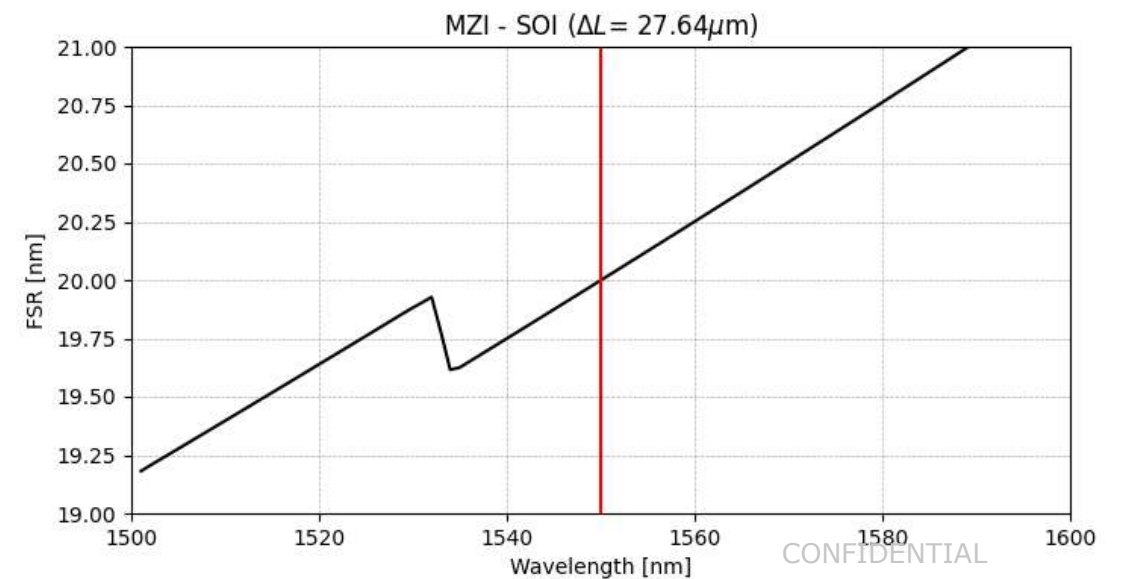
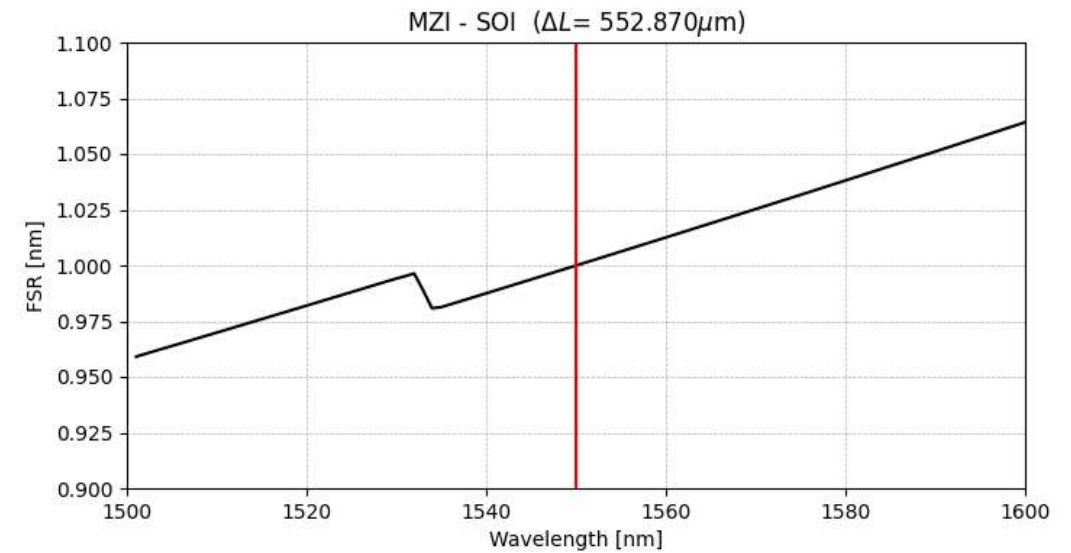
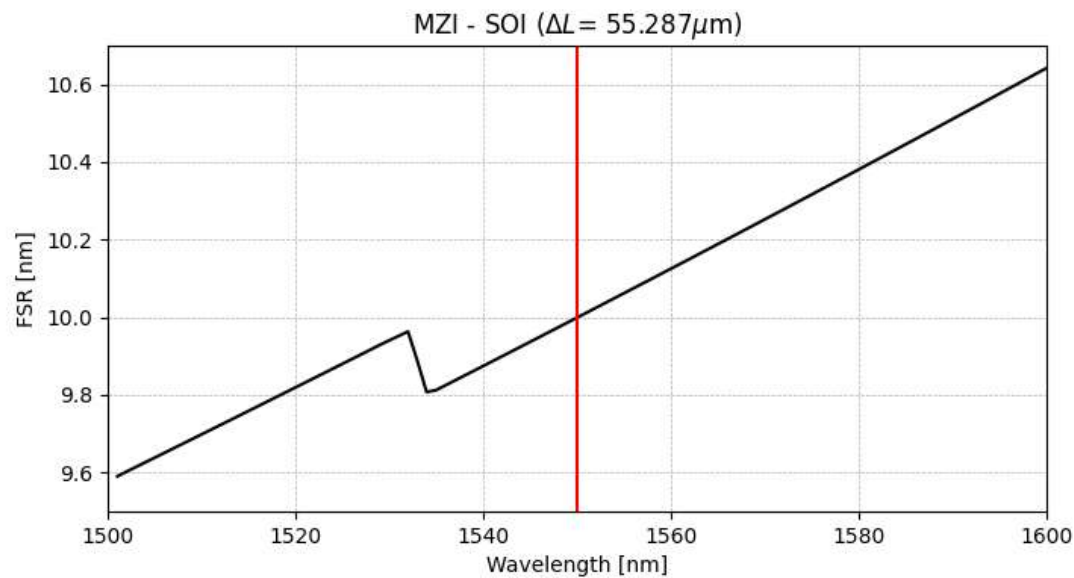
#####
neff_lambda = np.column_stack((wavelength_sweep, neff_sweep))
derivative_neff = derivative.derivative(neff_lambda)
ng = neff_sweep.flatten() - (derivative_neff[:, 1] * wavelength_sweep.flatten())
```

## Gráfico obtido – índice de grupo

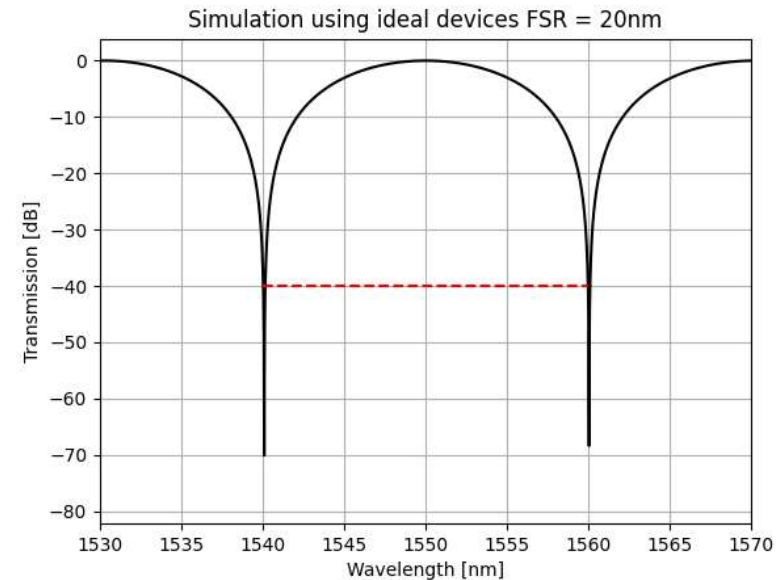
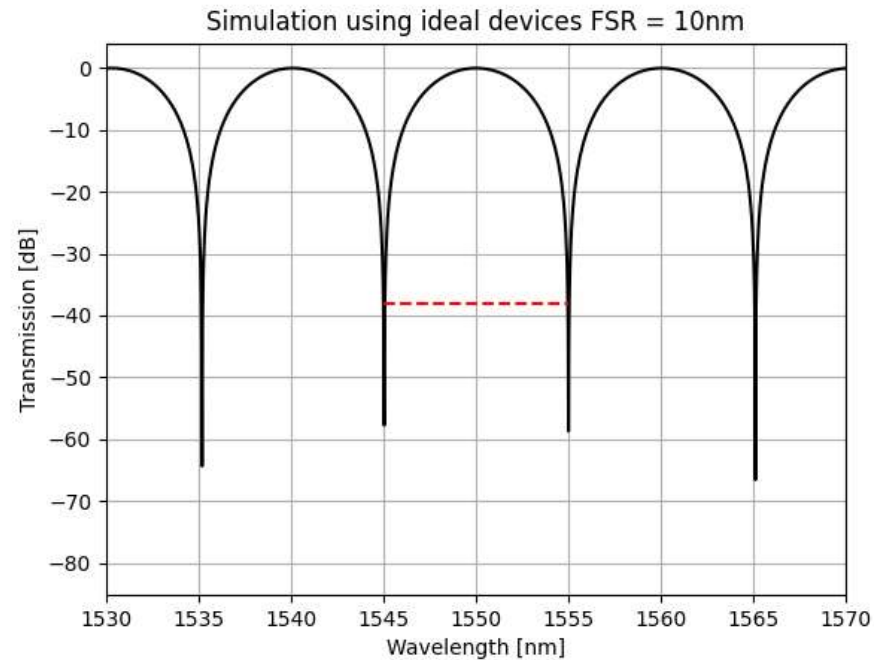
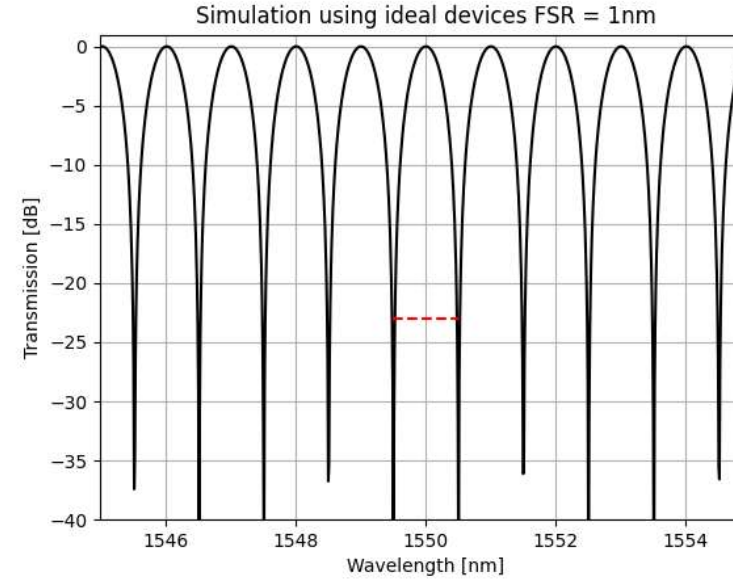
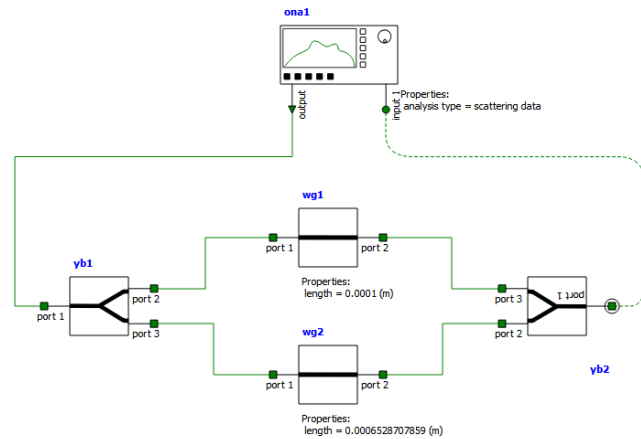


FSR em função do comprimento de onda com  $\Delta L$  fixo

$$FSR [m] = \frac{\lambda^2}{n_g \Delta L}$$

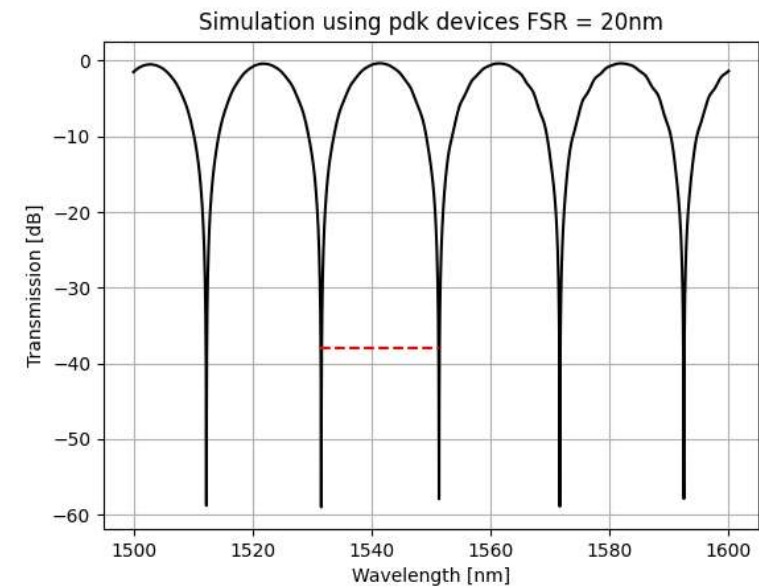
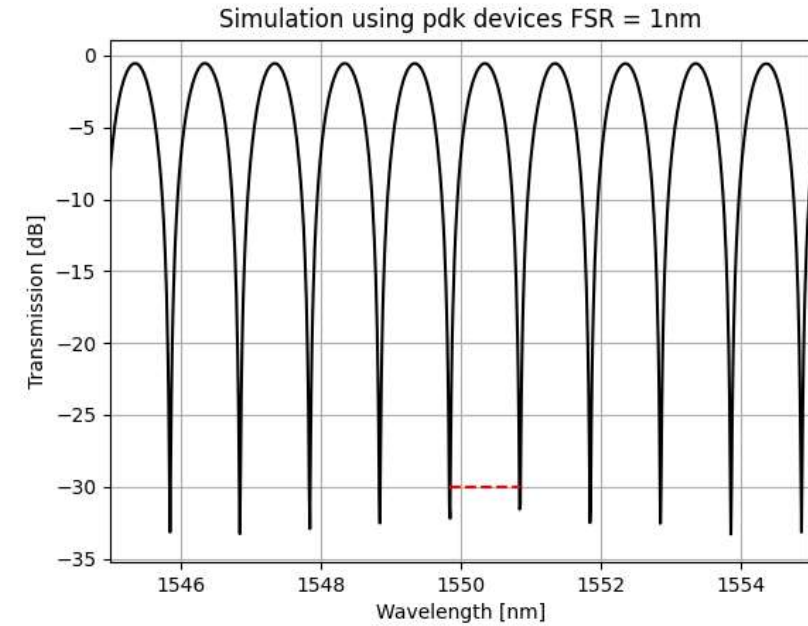
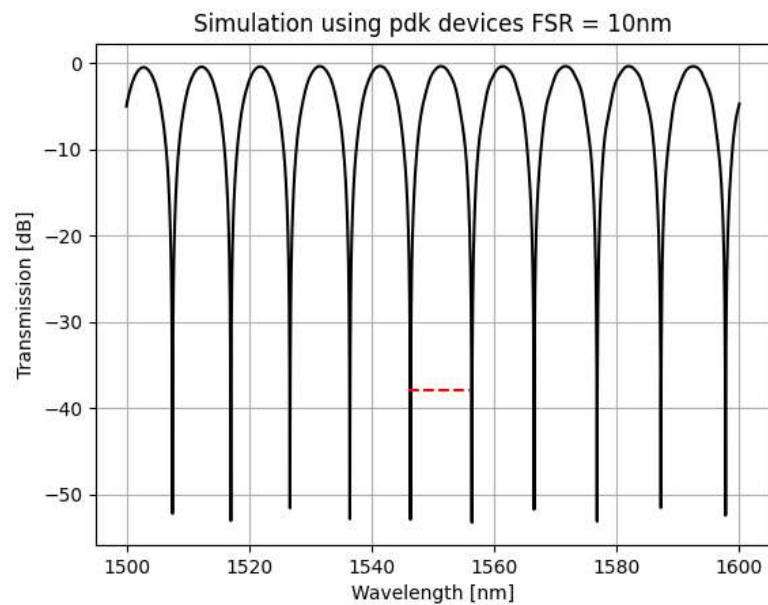
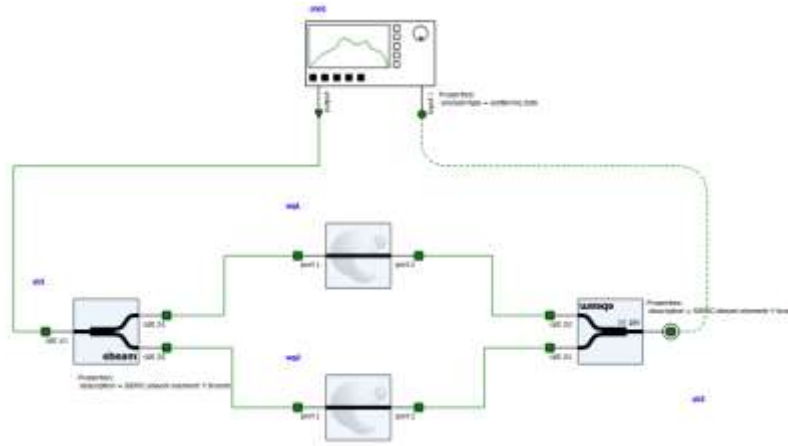


# Transmissão do MZI – Caso ideal

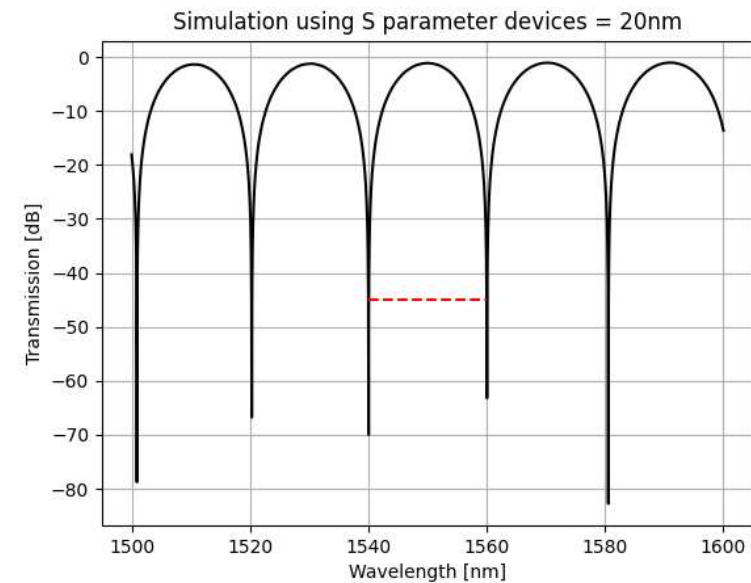
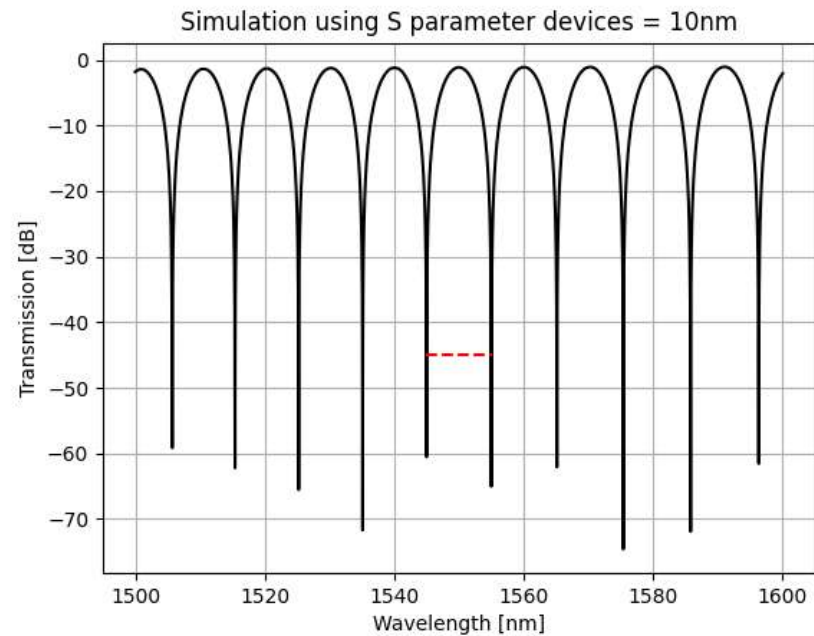
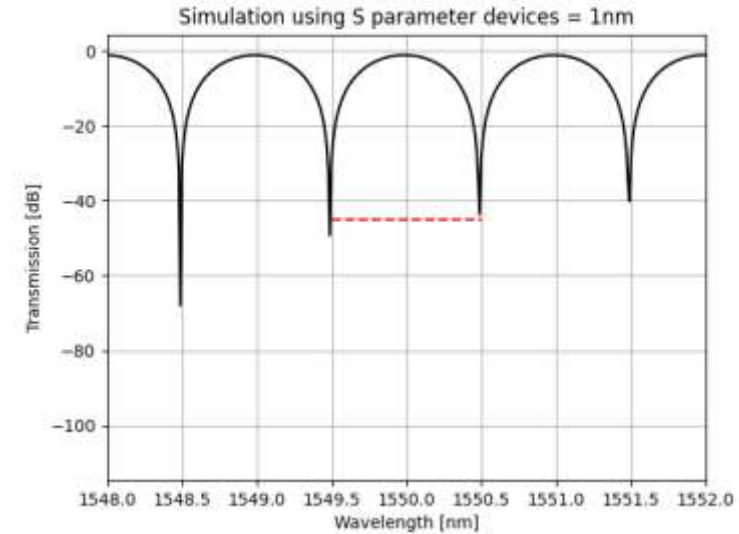
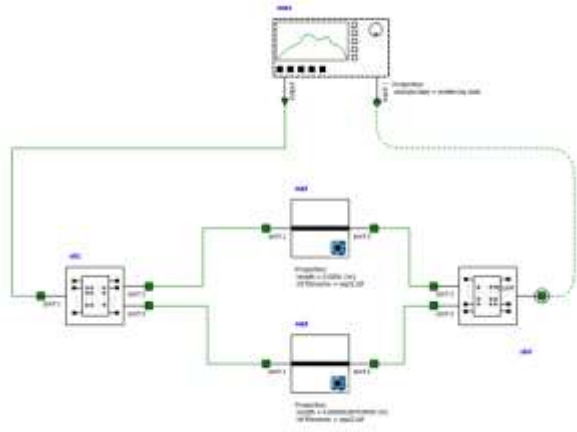




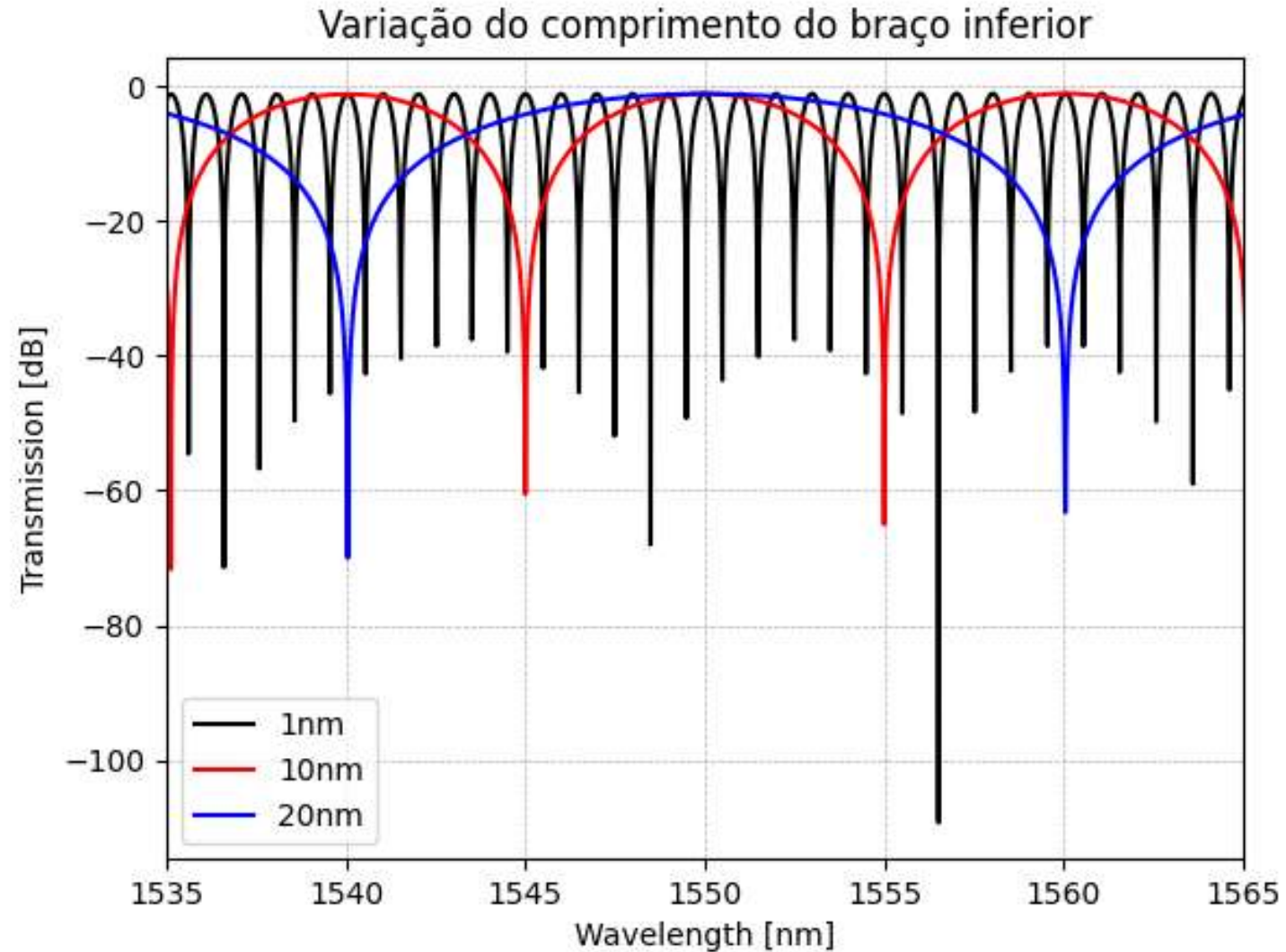
# Transmissão do MZI – PDK SiePic



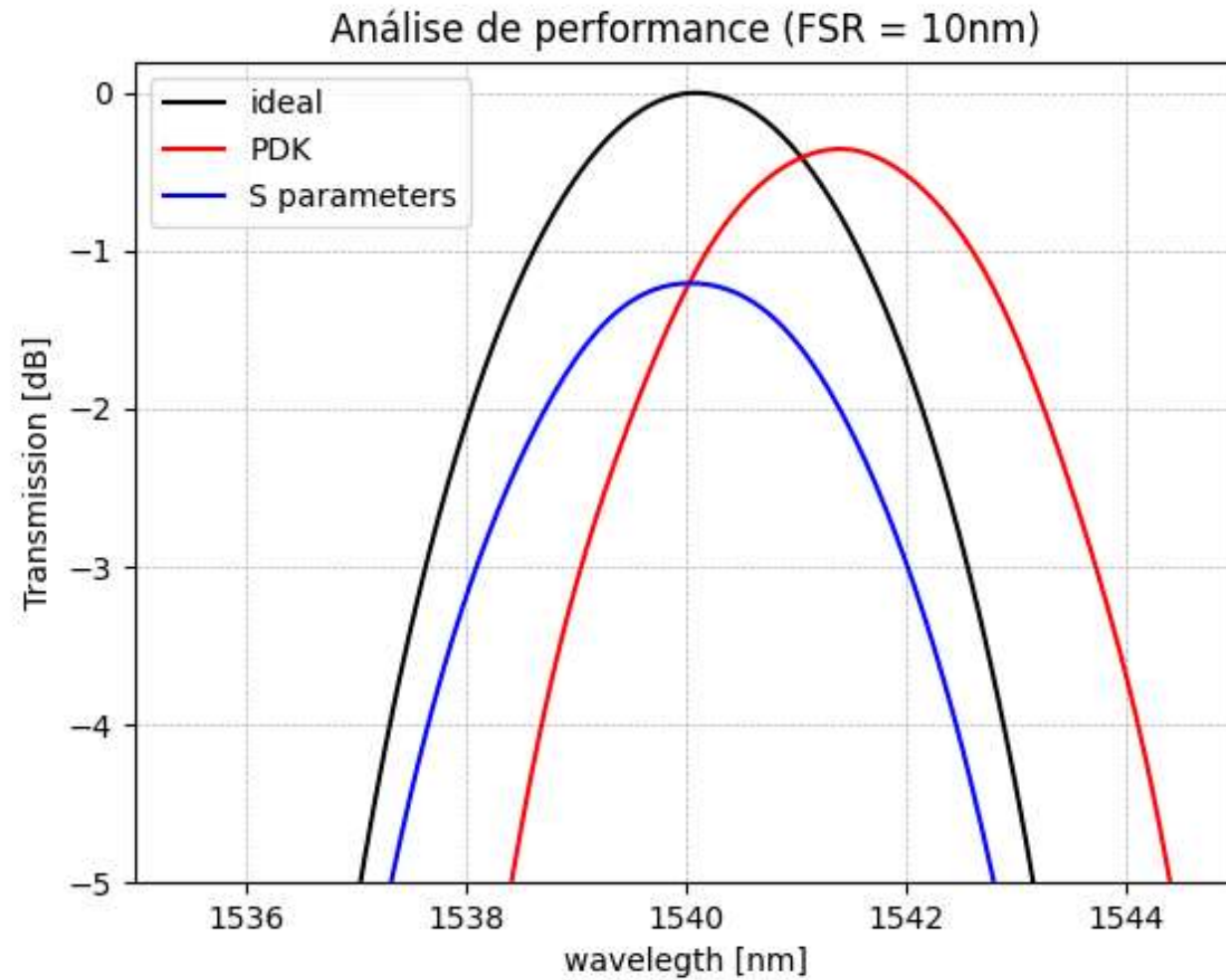
# Transmissão do MZI – Parâmetros S



## Variação do braço inferior – MZI caso ideal



# Comparação: Ideal, PDK e Parâmetros S



# Referências



CHROSTOWSKI, Lukas; HOCHBERG, Michael E. *Silicon photonics design*. Cambridge: Cambridge University Press, 2015.

OKAMOTO, Katsunari. *Fundamentals of optical waveguides*. 3rd ed. [S.l.]: Academic Press/Elsevier, 2022.  
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