

Modeling a Ring Resonator

Simulating resonances with FullWAVE

Introduction

Tool used: FullWAVE

A ring resonator functions as a high-Q filter for applications requiring wavelength selectivity. This device supports many resonances, allowing only resonant wavelengths to couple into the output waveguide. All other wavelengths pass uncoupled through the input waveguide, making the ring resonator an optical notch filter with numerous stop bands.

In this application example, a ring resonator is analyzed using finite-difference time-domain (FDTD) simulator **FullWAVE**. First, a pulse response determines the resonance spectrum, then a continuous wave (CW) simulation demonstrates the propagation through the device at a selected resonant wavelength.

Device Layout

The structure in this example has waveguides that are $0.2\ \mu\text{m}$ in width with a refractive index of 3. Resonances are examined around a wavelength of $2\ \mu\text{m}$, and waveguides are separated from the ring by $0.2\ \mu\text{m}$. The inner and outer radii of the ring are $R\text{-width}/2$ and $R_2 = R + \text{width}/2$, where $R = 1.7$.

The following model in Figure 1 is created by using computer-aided design (CAD) software. The RSoft CAD model shows the ring resonator structure, with green objects representing time monitors used for analysis.

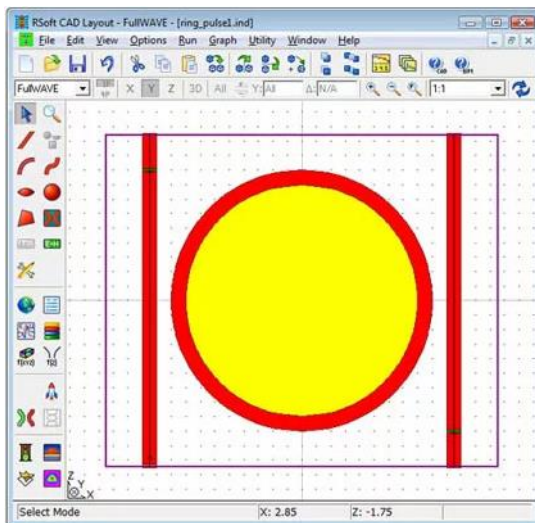


Figure 1. Simulation setup in RSoft CAD

The input signal enters the lower left port, with non-resonant wavelengths exiting from the upper left port and resonant wavelengths exiting from the lower right port.

Simulation: Pulse Excitation

To determine the wavelength/frequency spectrum for the ring resonator, a pulsed excitation is applied. The launch field corresponds to the fundamental mode of the input port, with a temporal full width at half maximum (FWHM) equal to the wavelength in μm . When the simulation is complete, a Fourier transform is performed on the time monitor data to produce the device's wavelength response.

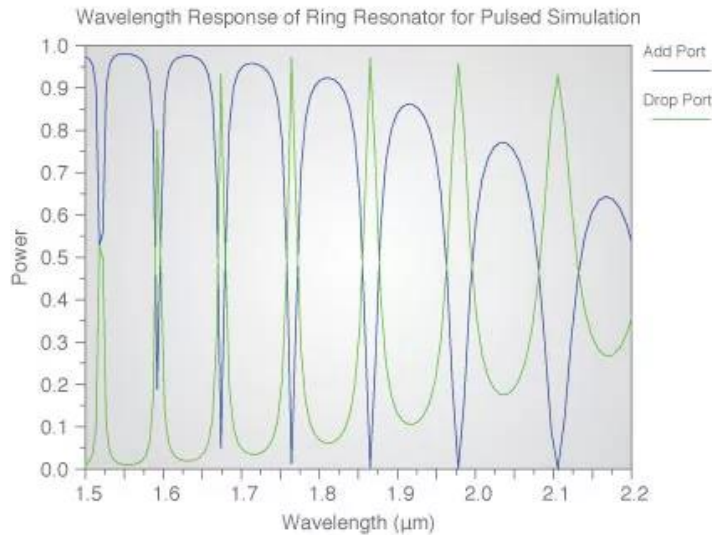


Figure 2. The green line represents the through port, and the blue line represents the drop port

Simulation: CW Excitation

With a resonance of around $1.977\text{ }\mu\text{m}$, shown from the wavelength response, set the wavelength to this value and use a CW simulation.

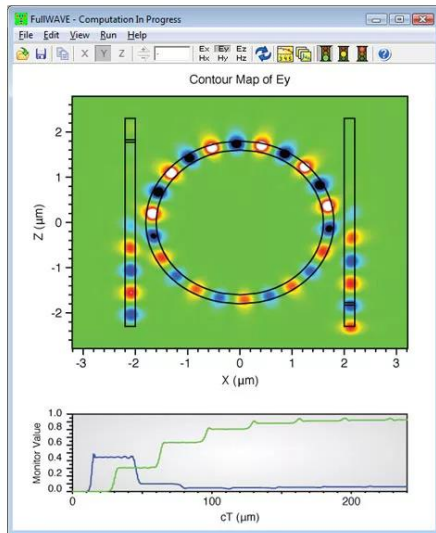


Figure 3. Steady-state CW simulation results

The lower portion of the simulation window displays the time monitor results in the time domain. In steady-state, these results show energy in the ring has built up and nearly the entire field propagates in the output waveguide. By using pulsed and CW calculations, one can calculate the spectral response of this device and illustrate the CW operation at a resonance.

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