

## Optical Filters

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1. Filters are used for wavelength division multiplexing and to reduce noise. You'd like your filter to have a large tuning range, small channel width, and narrow channel spacing.

2. One of the important things you need to watch out for is crosstalk.

Would like to have 30 dB sidelobe suppression (want 99% of signal in primary channel width and only 1% in neighboring channels)

Filter function is like a Lorentzian which never goes to zero so to find channel spacing or bandwidth, use

$$.01 = \frac{1}{1 + \{2(\text{chan sp})\}^2}$$

filter B/W

You can also find crosstalk level by integrating filter function from 0 to lambda and multiplying by 2; then set area = .99 and solve.

3. Specifics on Fabry-Perot:

### Fabry-Perot Interferometer

- a. transmission adds constructively when in phase; only in phase when  $2d = m \lambda$
- b. tuning accomplished via changing effective cavity length (move or tilt mirrors) or changing index of refraction (can chg # of carriers by pumping)
- c. advantages: commercially available
- d. disadvantages: slow tuning speed (ms)

4. Specifics on Acousto-Optic

### Acousto-Optic Tunable Filters (AOTF)

- a. wavelength selective Bragg grating formed on birefringent crystal substrate by inducing radio frequency (RF) acoustic wave in material (birefringent means 2 different indices of refraction depending on propagation direction)
- b. RF wave forces lattice spacing to expand and contract proportional to its wavelength; this changes the effective index of refraction in that region
- c. optical wave passes through perpendicular to optical axis; light is diffracted by grating and polarization shifts if wavelength matches Bragg grating wavelength
- d. polarizing beam splitter at output filters out wavelength that's had its polarization changed (it's perpendicular to incident polarization)
- e. two waveguides on same substrate with recombiner at end gets rid of polarization sensitivity
- f. tuning accomplished via changing RF wavelength
- g. advantages: large tuning range (>60 nm), tuning speed (microsecs)
- h. disadvantages: can have problems with crosstalk

5. Features to consider

- a. low insertion loss
- b. narrow bandwidth
- c. high sidelobe suppression
- d. large, dynamic range
- e. fast tuning speed
- f. simple control mechanism
- g. small size
- h. cost effectiveness

6. Advantages/Disadvantages

- a. Fiber Bragg Gratings and Fabry-Perot: most commercialized/limited in dynamic speed
- b. Micromachined and Acousto-Optic: high demanding dynamics
- c. Microresonators, electro-optic, active DBR: faster tunable devices perhaps
- d. lowest insertion loss: fiber Bragg gratings, .1 dB
- e. least space needed between channels with best isolation: cascaded MZI (.4 nm/22 dB)
- f. and arrayed waveguide grating (.8 nm/30 dB)
- g. tuning range: micromachined FP and AOTF (60 nm)
- h. tuning speed: cascaded MZI (50 ns) and EOTF (ns)

7. Types

- a. Fabry-Perot Interferometer
- b. Acousto-Optical
- c. Liquid Crystal Fabry-Perot
- d. Micromachined Device
- e. Mach-Zehnder Interferometer (MZI)
- f. Fiber Bragg Gratings
- g. Electro-Optical
- h. Arrayed Waveguide Grating
- i. Active Filters
- j. Ring Resonator

8. What's the future of optical filters?

- a. Active Filters--possibly
- b. possible gain (no insertion loss)
- c. lowest channel spacing/best isolation (<.1 nm/30 dB)
- d. bandwidth (<.1 nm)
- e. tuning range (<5 nm)
- f. tuning speed (ns)
- g. difficulty in wavelength stabilization
- h. suffer from mode hopping problems