FFP-TF2
Fiber Fabry-Perot Tunable Filter
Technical Reference

MICRON OPTICS, INC.

1852 Century Place NE
Atlanta, GA 30345

Tel. (404) 325-0005
Fax. (404) 325-4082
Internet: www.micronoptics.com
Email: sales@micronoptics.com

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Rev_A

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Technical Reference

This manual describes various aspects of the FFP-TF2 Fiber Fabry-Perot Tunable Filter that are commonly encountered while developing systems based on tunable filter technology.

Before using the filter, please read the “First Time User Manual.”

If you cannot find the answers you need in this handbook, please contact us for technical support at the address listed below:

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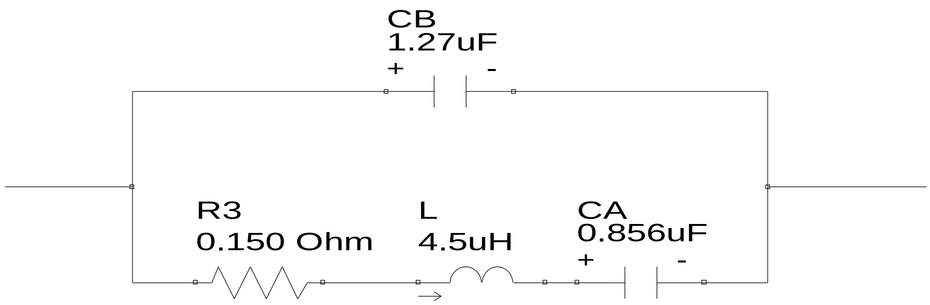
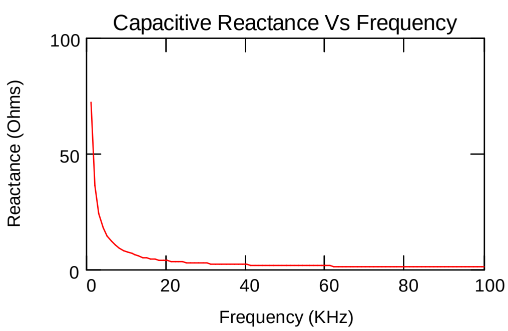
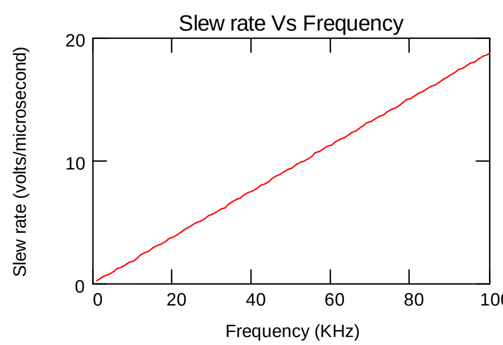
PZT Equivalent Circuit:

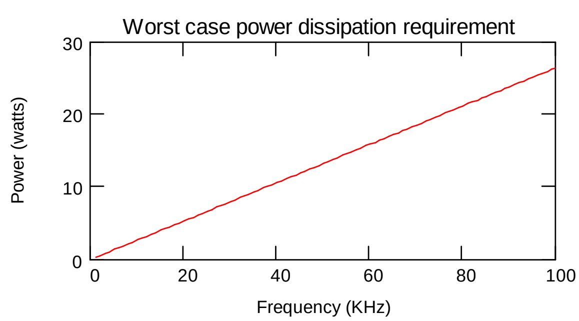
The most general equivalent circuit for the PZT alone is shown below. The resonant frequency (mechanical and electrical) is approximately 85 KHz for the bare actuator (associated with the 16 mm length dimension). The anti-resonance frequency is approximately 100 KHz, with a coupling coefficient k ~0.6. The loss tangent and the dielectric constant of the actuator at 1 Khz are 0.028 and 6200 respectively. **When the actuator is loaded with optics and end brackets, the resonance drops to approximately 48 KHz due to the extra mass loading.**



For most low frequency driver designs, the PZT actuator can be modeled as a simple ~2.2 microfarad capacitor. Recall that for a reactive load (as is the case here), the power requirements will increase with frequency for a constant amplitude AC drive signal input. The reactance, slew rate, and power dissipation charts shown below illustrate this concept for a 2.2 microfarad capacitor and a 30 volt peak-to-peak driving signal.







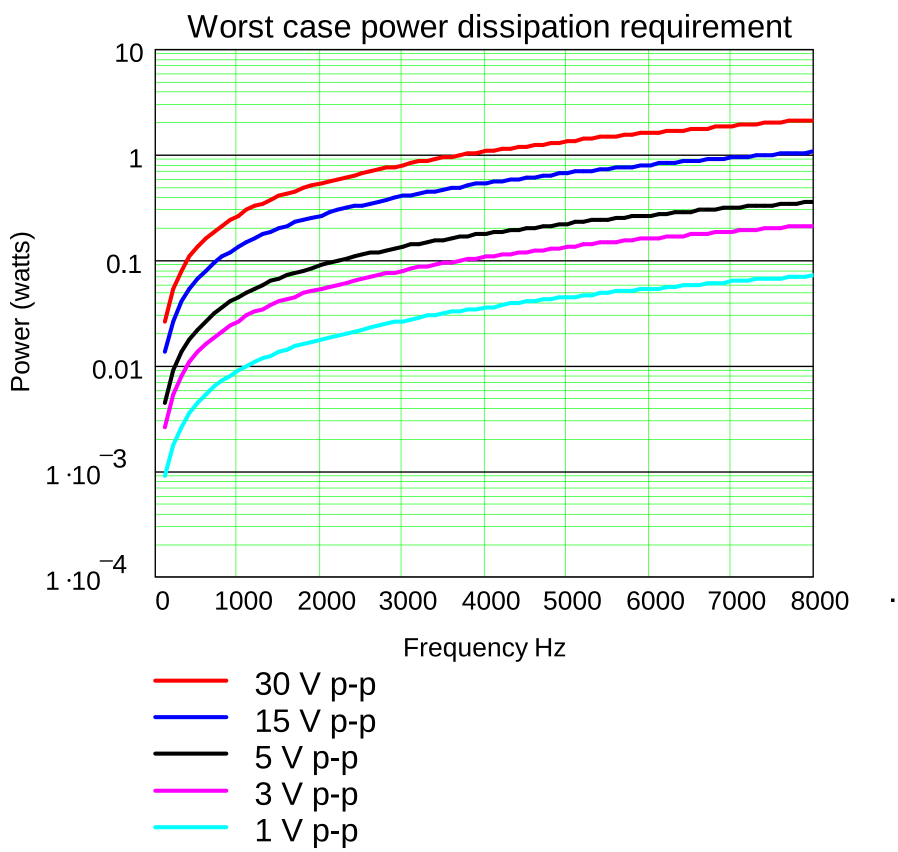
Maximum Drive Voltage:

As the voltage on the PZT increases, the PZT expands causing the optics to move closer together. It is important that the filter drive voltage remain below 60 volts to ensure that the optics are not damaged.

Maximum Drive Frequency:

To avoid overheating the PZT, and to avoid complex compensation and dampening circuitry, we recommend that the filter be driven at less than 300 Hz if using the complete voltage range (0 – 50 volts). A higher drive frequency can be utilized if the drive voltage is reduced.

For example, consider the power dissipation plots below: a 30 V p-p signal at 300 Hz will dissipate approximately 80mW of power. If the voltage is reduced to 1 V p-p, then the drive frequency can be increased to 8kHz while maintaining the same 80mW of power dissipation.



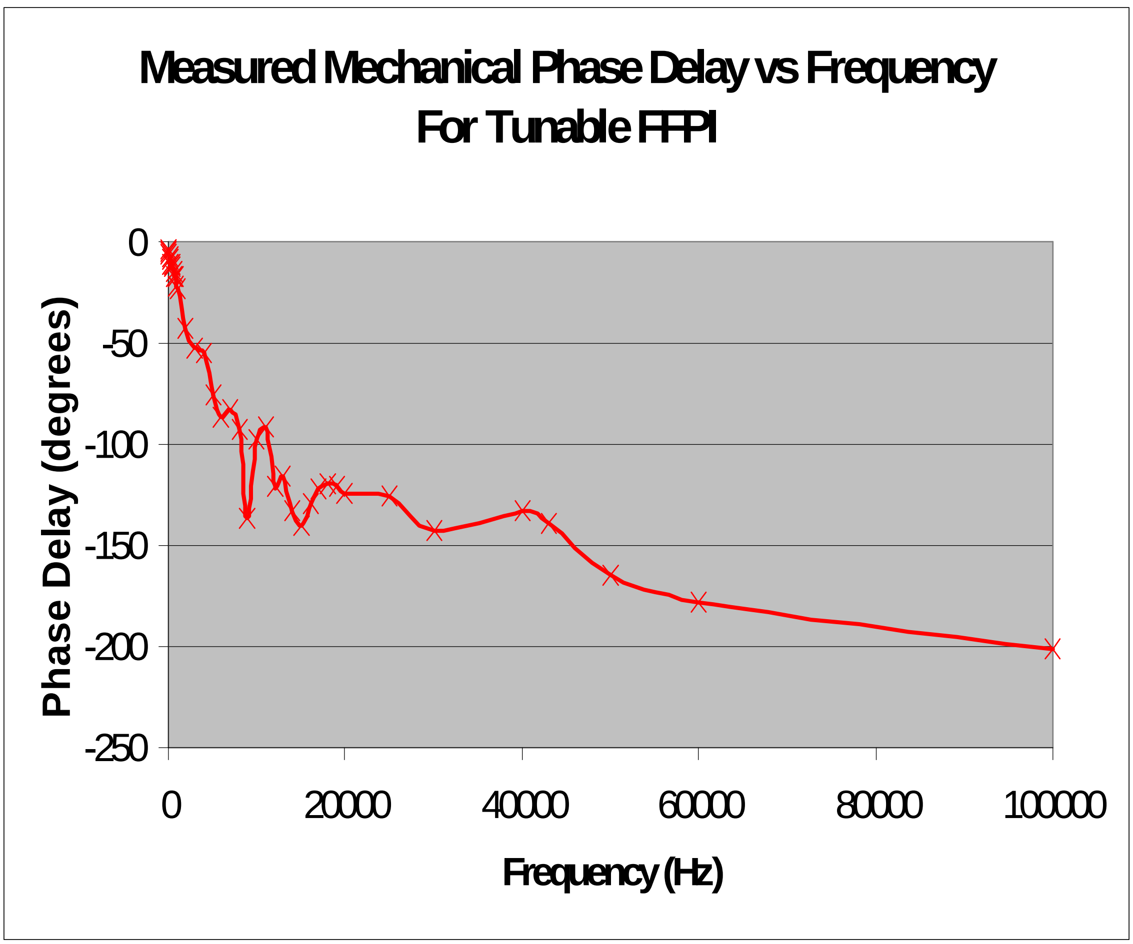
There are special cases where one may want to drive the PZT at even higher frequencies. Please keep the following information in mind:

The loaded PZT actuator has a natural mechanical resonance near 48 KHz which can cause ringing, especially if the drive signal or its overtones are near the resonance. Therefore, a good rule of thumb is to drive the PZT at a maximum frequency no greater than 1/3 of the resonance frequency to avoid ringing. For example, a 10 KHz triangular-wave drive signal is probably OK because it has a 50 KHz overtone component comprising only 3.2% of the signal power. Whereas a 10 KHz saw tooth-wave drive signal input would likely cause ringing because the power contained in the 50 KHz overtone is 12.7%.

Tuning Response Delay:

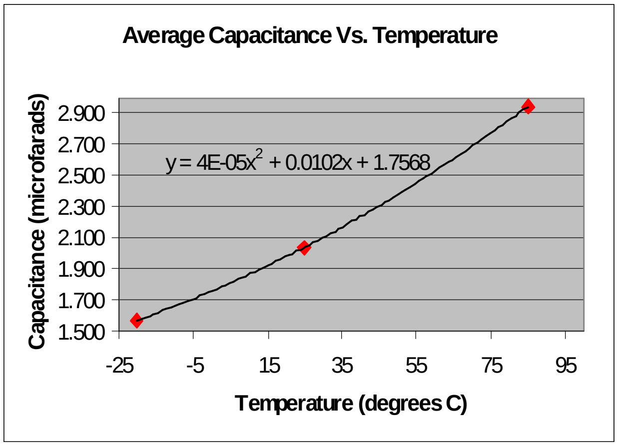
By nature of the fact that the optics are moved with the PZT (which is capacitive) there is a phase delay between the electrical signal and the mechanical action, which varies as a function of frequency.

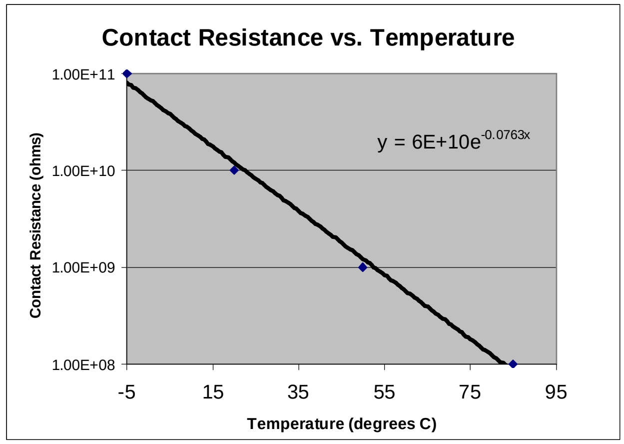
The chart below indicates the measured electrical-to-mechanical delay for a typical loaded filter with a 15 V p-p drive signal, varying from 0 to 100 kHz.
Phase delay is calculated as the 360* delay (sec) * frequency (1/sec)



PZT Capacitance/Resistance Change vs. Temperature:

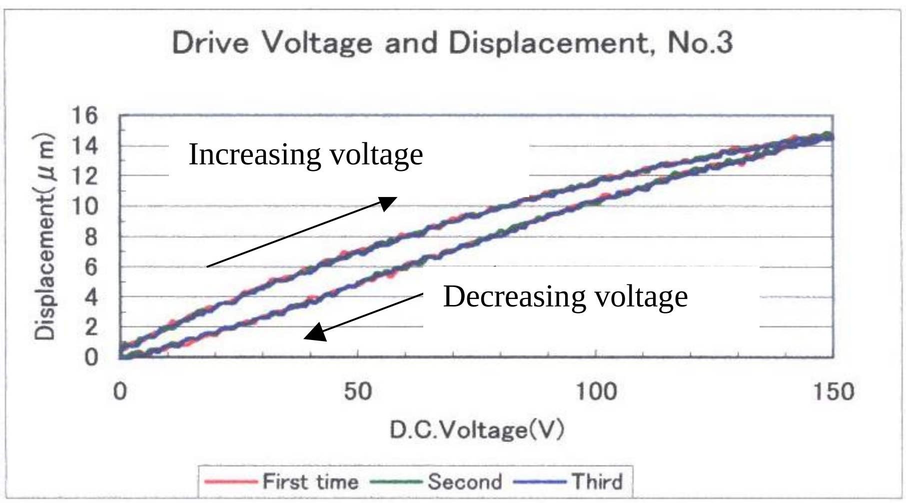
As shown in the two graphs below, the average DC capacitance increases with temperature while the contact resistance decreases with temperature.



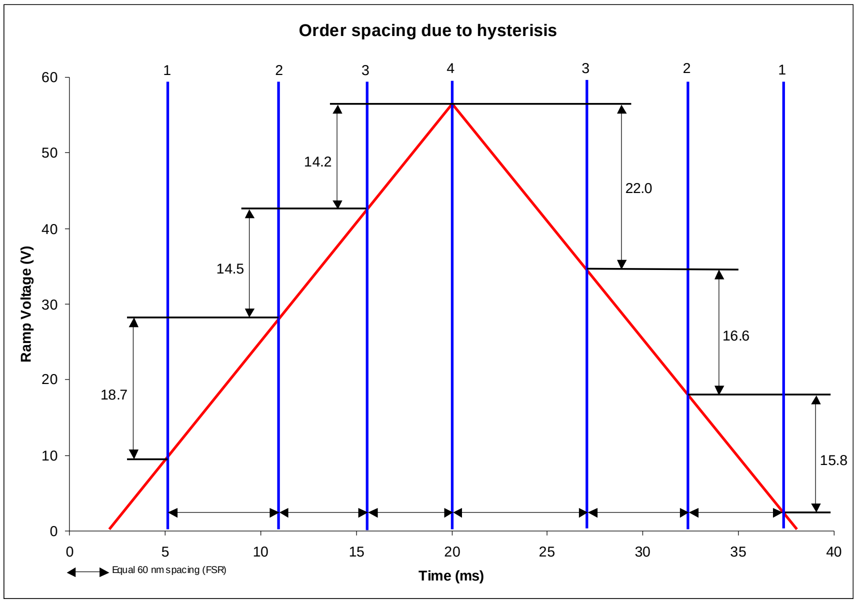


Hysteresis:

As shown below, the displacement for a given voltage is different on the up-cycle (increasing voltage) than it is on the down-cycle (decreasing voltage). Therefore, this device is inherently non-linear. Measurements and calibration can be simplified by only analyzing data on either the up or down cycle.



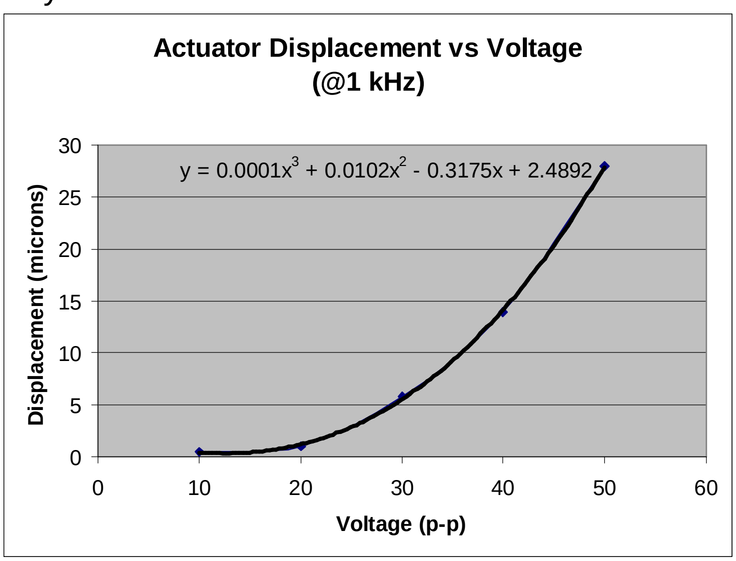
The diagram below shows the response to a single laser line input at 1550 nm when a typical filter (finesse = 200 and FSR = 60 nm) is swept through 3 FSR's



The filter resonance matches the input wavelength at each blue vertical line.

<u>PZT Displacement vs. Input Voltage:</u>

A good "rule of thumb" to keep in mind is 18-20 volts per FSR for most of our optical filters. In other words, it takes an increase (or decrease) of 18-20 volts on the actuator to move the optical resonance peak through one FSR. Keep in mind that the actual maximum displacement is not linear with applied voltage. Shown below is the measured bare actuator displacement vs peak-to-peak AC voltage at 1 kHz frequency.



Polarization Dependent Loss:

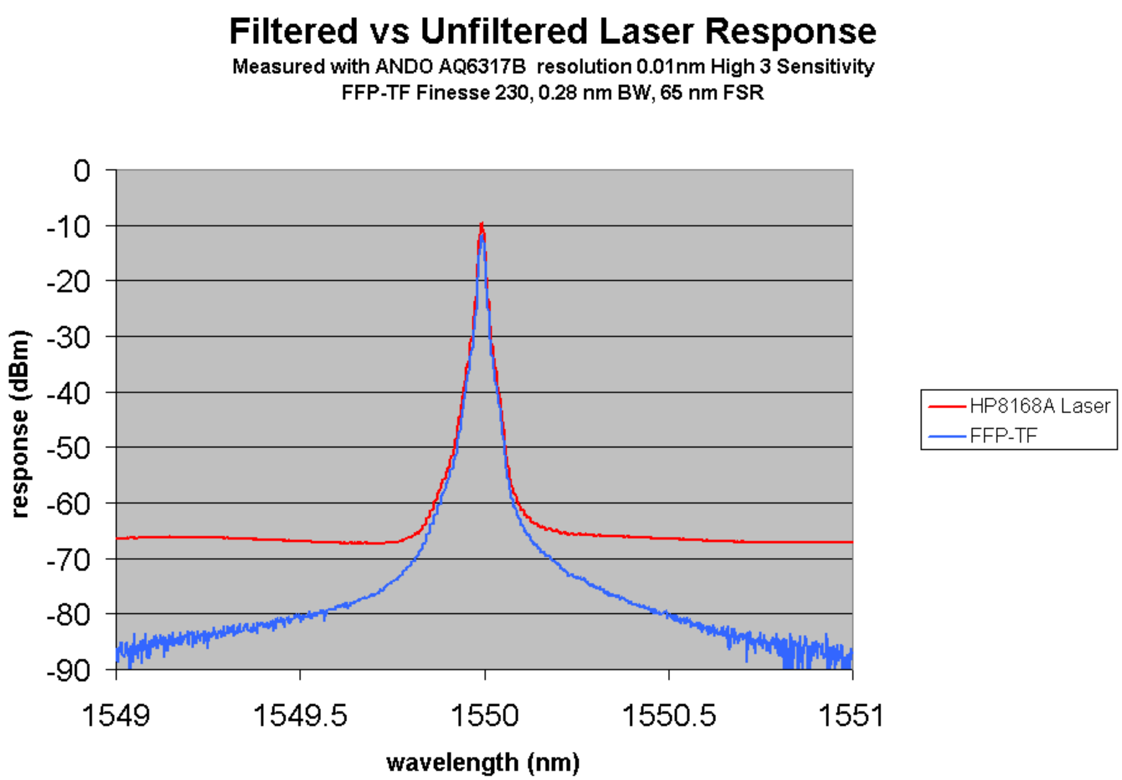
The polarization sensitivity of some of Micron Optics' filters is due to the birefringence inside the etalon. The end result is that one input mode of polarization becomes more sensitive to loss, and the other mode becomes less sensitive to loss.

The total power transmission (or total loss) of the filter is constant. The difference in polarization loss can be evenly split between the two modes (each one showing 50% of the total loss), or it can increase one of the modes to as much as 100% of the total loss of the filter, with the other being 0%.

This polarization sensitivity mostly affects the longer cavity lengths, or the smaller FSR filters. Controlling the polarization of the input signal to the filter can control this polarization sensitivity. If the polarization mode of the input signal is controlled there is no mode coupling and no variation of the loss between polarization modes.

Laser Noise-Floor Suppression:

Use a FFP-TF in combination with a FFP-C to lock-onto the peak wavelength of the laser. A typical example of noise-floor suppression is shown below.



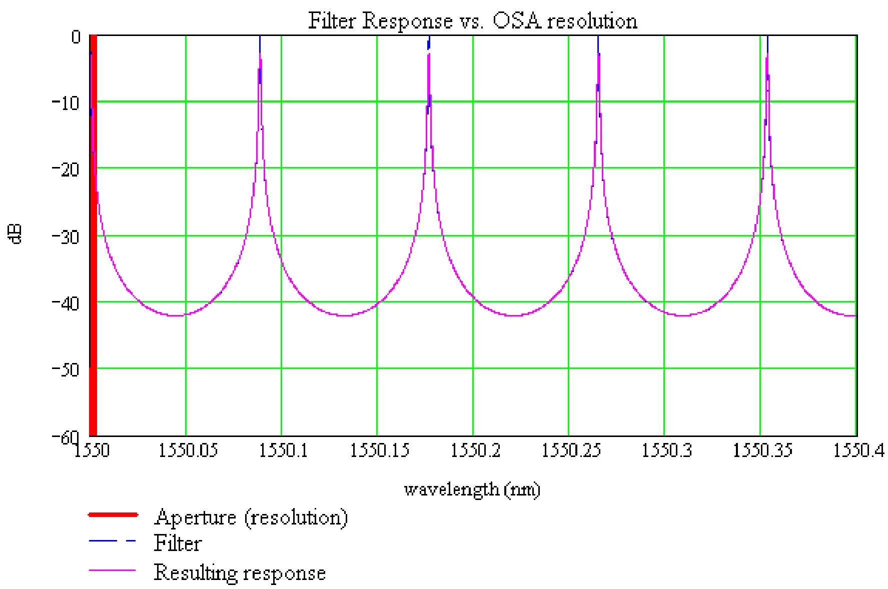
Optical Spectrum Analyzer (OSA) Measurement Issues:

You may experience excessive insertion loss when measuring a filter with a broadband source and an optical spectrum analyzer (OSA).

The problem is due to the OSA's limited resolution. The OSA essentially convolves the aperture spectrum (~0.01 nm - 1 nm, depending on the OSA design and the resolution setting) with the spectrum of the input light. Therefore, there is no way to resolve features in the measurement input if these features are smaller than the resolution of the OSA.

For example, consider the following filter: FSR = 0.082 nm (11.3 GHz), BW = 0.0004 nm (50 MHz). The 3 dB bandwidth of the Airy function peaks are only 0.0004 nm wide, so when the filter spectrum is measured with a 0.01 nm resolution OSA, the peaks get averaged and suppressed (see the graphs below).

The correct way to characterize the filter is with a swept laser source and a detector. In such a configuration, the narrow line-width of the laser acts as the aperture, and measurement artifacts due to limited resolution are eliminated.



FILTER CHARACTERISTICS

Resolution = $1 \cdot 10^{-3} \cdot nm$

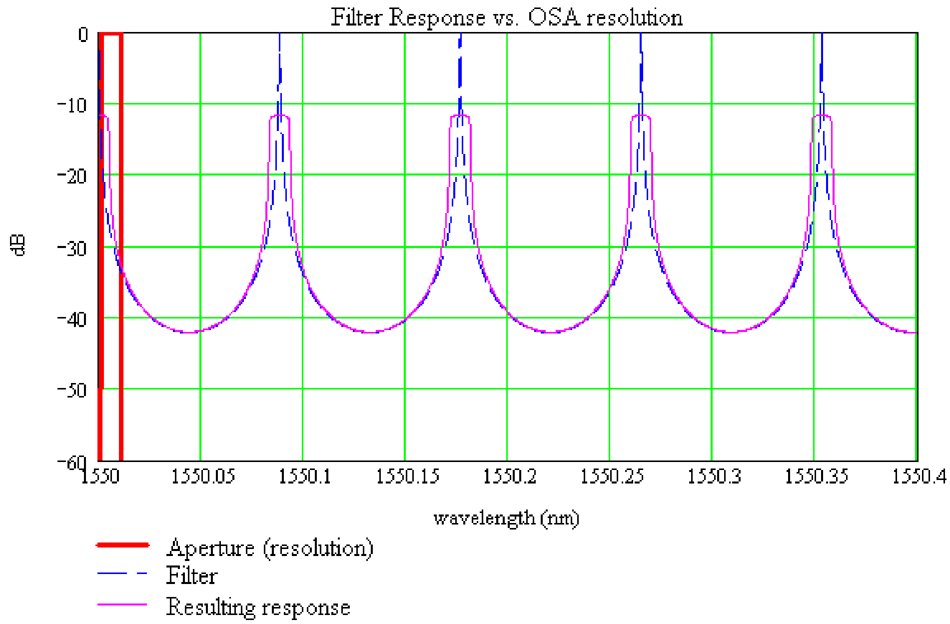
FSRfreq = $11.01 \cdot GHz$

BWfreq = $0.055 \cdot GHz$

Finesse = 200

FSRwavelength = $0.088 \cdot nm$

BWwavelength = $4.38 \cdot 10^{-4} \cdot nm$



FILTER CHARACTERISTICS   Resolution = 0.01·nm

FSRfreq = 11.01·GHz   BWfreq = 0.055·GHz   Finesse = 200

FSRwavelength = 0.088·nm   BWwavelength = $4.38 \cdot 10^{-4}$·nm

Optical instabilities due to reflections from the FFP-TF:
Place an optical isolator between the laser and the FFP-TF to avoid reflection instabilities in the light source. Recall that all out-of-band (non resonant) energy is reflected back to the source and can damage a laser if not properly isolated.

Maximum optical power:
Our Finesse-200 filters have been tested to 200 mW (23 dBm) of average power without any damage to the optical coatings. Since the damage threshold scales inversely with finesse rating of the filter; the lower finesse filters can withstand higher optical power. Non-linear behavior begins to appear above 7dBm (average power) for the Finesse-2000 filters.

For more information on this or any other Micron Optics product, please contact us at:

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