



## MANUALLY ADJUSTABLE POLARIZATION INSENSITIVE TUNABLE FILTERS

### Features:

- Narrow linewidth
- Polarization insensitive
- Wide wavelength range
- Singlemode, multimode, and polarization maintaining fiber versions
- High resolution

### Applications:

- Dense Wavelength Division Multiplexing (DWDM)
- Tunable sources
- Spectral analysis
- Quality control and measurement
- Product development
- Fiber optic component manufacturing

### Product Description:

Tunable filters consist of a collimating optical assembly, an adjustable narrow bandpass filter, and a focusing optical assembly to collect the light again. Tunable filters are available in three versions - a manually adjustable version, a motor driven version for OEM applications, and a digital version with a display and computer interface.

The manual tunable filter is a pigtailed component with a rotating stage that allows for the manual adjustment of the angle of incidence between the beam and the filter. The filter works based on the principle that by adjusting the angle of incidence between the filter and the incident beam one controls the wavelength at which the filter transmits.

Filter linewidths are normally defined in terms of Full Width at Half Maximum (FWHM). The standard filter used in tunable filters has a smooth, rounded transmission spectrum that is the result of a single Fabry Perot type cavity. A Fabry Perot cavity is simply made up of two reflectors separated by a fixed spacer of some thickness. Other filter designs are available. For instance, flat top bandpass filters are made by stacking multiple cavities together. By increasing the number of cavities one can increase the roll-off slope therefore improving the out-of-band rejection level. For more information on custom filters please contact OZ Optics.

OZ Optics tunable filters now utilize a new optical technique to control Polarization Dependent Losses (PDL). This new design reduces PDL to below 0.3dB, while at the same time making the spectral response polarization insensitive. This feature makes it ideal for today's DWDM system applications.

Tunable filters using singlemode, multimode and Polarization Maintaining (PM) fibers are offered. In general, OZ Optics uses polarization maintaining fibers based on the PANDA fiber structure when building polarization maintaining components and patchcords. However OZ Optics can construct devices using other PM fiber structures. We do carry some alternative fiber types in stock, so please contact our sales department for availability. If necessary, we are willing to use customer supplied fibers to build devices.



Manually Adjustable Tunable Filter

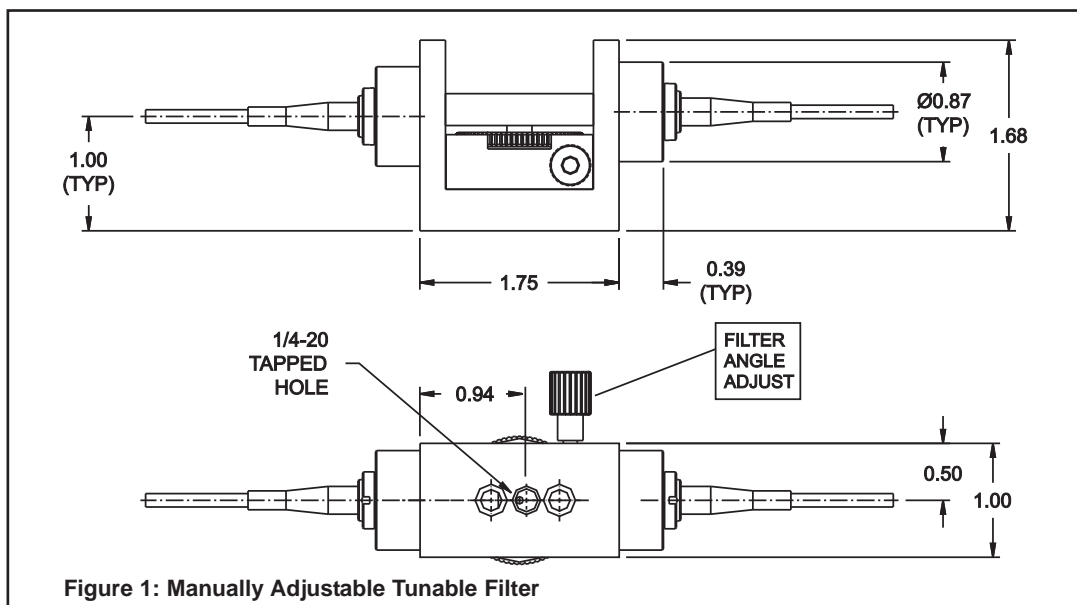


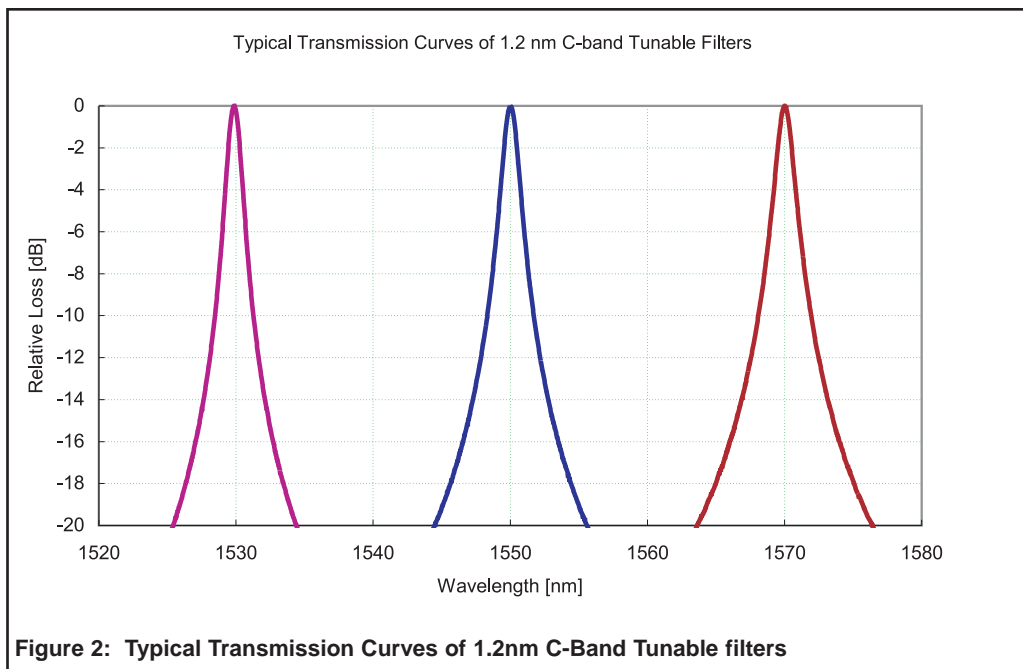
Figure 1: Manually Adjustable Tunable Filter

## Ordering Information For Standard Parts:

Bar Code	Part Number	Description
13553	TF-11-11-1520/1570-9/125-S-40-3S3S-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 40dB return loss, super FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13554	TF-11-11-1520/1570-9/125-S-50-3U3U-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss, ultra FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
14150	TF-11-11-1520/1570-9/125-S-60-3A3A-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 60dB return loss, angled FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13555	TF-11-11-1570/1620-9/125-S-40-3S3S-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 40dB return loss, super FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13556	TF-11-11-1570/1620-9/125-S-50-3U3U-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss, ultra FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13557	TF-11-11-1570/1620-9/125-S-60-3A3A-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 60dB return loss, angled FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13614	TF-11-11-1520/1570-8/125-P-60-3A3A-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1520-1570nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 60dB return loss, angled FC/PC connectors and 1.2nm FWHM Fabry Perot filter.
13613	TF-11-11-1570/1620-8/125-P-60-3A3A-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1570-1620nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 60dB return loss, angled FC/PC connectors and 1.2nm FWHM Fabry Perot filter.

## Standard Product Specifications:

Resolution:	Typically less than 0.1nm
Tuning Range:	50nm
Wavelength Range:	1520-1570 (C-band), 1570-1620 (L-band) and 1470-1520 (S-band) standard. Other ranges available on request.
Linewidth: (FWHM):	1.1 ± 0.1nm standard over tuning range. As narrow as 0.3nm is available as an option.
Wavelength/Temperature Sensitivity	Typically less than 0.002nm/°C
PDL:	Typically less than 0.3dB
Insertion Loss:	Typically less than 2.5dB for complete device over full tuning range.
Power Handling:	Up to 200mW for standard package.



### SAMPLE TEST DATA FOR TUNABLE FILTERS

Wavelength (nm)	PDL (dB)
1520.04	0.30
1530.00	0.20
1539.96	0.10
1550.04	0.15
1560.00	0.30
1569.96	0.30

## Ordering Examples For Standard Parts:

A customer wants to use a broadband source as a manual tunable source in order to test the spectral characteristics of optical components at different wavelengths. Both the light source and components have FC/PC receptacles and the wavelength region of interest for the components is throughout the C-band. The broadband source is polarized randomly and therefore the tunable source required should be polarization insensitive.

The component required for this application is a polarization insensitive manual tunable filter. With this filter connected to the broadband light source and by adjusting the angle at which the beam is incident on the filter the transmitted wavelength from the broadband source can be tuned from 1520 to 1570nm.

Bar Code	Part Number	Description
13553	TF-11-11-1520/1570-9/125-S-40-3S3S-3-1-1.2	Polarization insensitive manual tunable filter in U-bracket for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 40dB return loss, super FC/PC connectors and standard 1.2nm FWHM Fabry Perot filter.

## Ordering Information For Custom Parts:

OZ Optics welcomes the opportunity to provide custom designed products to meet your application needs. As with most manufacturers, customized products do take additional effort so please expect some differences in the pricing compared to our standard parts list. In particular, we will need additional time to prepare a comprehensive quotation, and lead times will be longer than normal. In most cases non-recurring engineering (NRE) charges, lot charges, and a 1 piece minimum order will be necessary. These points will be carefully explained in your quotation, so your decision will be as well informed as possible. We strongly recommend buying our standard products

### Questionnaire For Custom Parts:

1. What wavelength range are you interested in?
2. What linewidth do you require?
3. What type of fiber is being used? Singlemode, multimode or PM fiber?
4. Are you using a polarized or randomly polarized light source?
5. What return losses are acceptable in your system?
6. What connector types are you using?
7. What fiber length and jacket diameter do you need?

### **TF-11-11-W-a/b-F-LB-XY-JD-L-LW**

**W:** Wavelength range in nanometers:  
Example: 1520/1570

**a/b:** Fiber core/cladding sizes in microns:  
9/125 for 1300/1550nm Corning SMF28 fiber  
8/125 for 1550nm PANDA style PM fiber

**F:** Fiber type:  
M=Multimode  
S=Singlemode  
P=Polarization Maintaining

**LB:** Backreflection level: 40, 50 or 60dB for singlemode or PM fibers only.  
(60dB for 1290 to 1620nm wavelength ranges only)  
35dB for multimode fibers

**LW:** FWHM linewidth in nm. Standard filter is a Fabry Perot. For a flat top profile filter, add the letter F to the end of the number

**L:** Fiber length in meters

**JD:** Fiber Jacket type:  
1=900 micron OD hytel jacket  
3=3mm OD Kevlar reinforced PVC cable

**X,Y:** Input & Output Connector codes:  
3S=Super NTT-FC/PC  
3U=Ultra NTT-FC/PC  
3A=Angled NTT-FC/PC  
8=AT&T-ST  
SC=SC  
SCA=Angled SC  
LC=LC  
LCA=Angled LC  
MU=MU  
X=No Connector

## Ordering Examples For Custom Parts:

### Example 1:

A customer wants to reduce the ASE noise and manually tune the transmitted wavelength for a special broadband light source between the C and L bands, 1550 to 1600nm, with a very narrow linewidth.

A custom version of the manually tunable filter will meet this requirement with a narrow linewidth custom filter used in the component.

Bar Code	Part Number	Description
N/A	TF-11-11-1550/1600-9/125-S-50-3U3U-3-1-0.3	Polarization insensitive manual tunable filter for 1550-1600nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss and ultra FC/PC connectors. Custom 0.3nm FWHM Fabry Perot filter.

### Example 2:

A customer wants to reduce the out of band noise of a polarized light source and tune the transmitted wavelength using a 0.3nm linewidth tunable filter.

The component required for this application is a polarization maintaining tunable filter.

Bar Code	Part Number	Description
N/A	TF-11-11-1520/1570-8/125-P-60-3U3U-3-1-0.3	Polarization maintaining manual tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 60dB return loss, angled FC/PC connectors and 0.3nm FWHM Fabry Perot filter.

### Frequently Asked Questions (FAQs):

**Q:** What is the filter linewidth?

**A:** The standard filter is a 1.2nm FWHM Fabry-Perot filter. This can be customized to suit the customer's requirements.

**Q:** What is the largest tuning range available?

**A:** The standard tuning range is 50nm, however the filter can be operated over a 100nm range with some effects on the linewidth and insertion loss in the shorter wavelength (high angle of incidence) region.

**Q:** What is a Fabry-Perot filter? Are there other types available?

**A:** A Fabry-Perot filter has a smooth, rounded transmission spectrum that is the result of a single Fabry Perot type cavity. This shape is known as a Lorentz profile. A Fabry Perot cavity is simply made up of two reflectors separated by a fixed spacer of some thickness. By adjusting the spacer thickness one can adjust the pass bandwidth of the filter. Other shapes of filters are available. For instance, flat top bandpass filters are made by stacking multiple cavities together. By increasing the number of cavities one can increase the roll-off slope therefore improving the out-of-band rejection level. For more information on what custom filters are available please contact OZ Optics.

**Q:** How do you define your linewidths?

**A:** Standard filters are specified by their Full Width Half Maximum (FWHM). This is the transmitted linewidth at -3dB from the peak transmission. For custom filters linewidths such as the passband at -0.3dB and -25dB can be specified.

**Q:** Is the shape of the transmission curve affected by polarization?

**A:** No, OZ Optics tunable filters utilize an optical technique to control Polarization Dependent Losses (PDL). This design reduces PDL to minimal levels, while at the same time making the spectral response polarization insensitive.

**Q:** How well does the filter block unwanted wavelengths?

**A:** For standard single cavity Fabry Perot filters the typical linewidth at -20dB is ~12nm. This type of filter is good for selecting specific channels in a DWDM system or cleaning up the ASE noise from a broadband source. The filter may transmit light at specific wavelengths. Significantly outside the operating wavelength range. For custom applications requiring different out-of-band isolation please contact OZ Optics.

**Q:** What linewidth do I need in a 200GHz DWDM system? 100GHz? 50GHz?

**A:** Typical linewidths associated with these frequencies are 1.2, 0.8 and 0.3nm respectively. This ultimately depends on the channel width and isolation levels required for the system in question. OZ Optics can work with you to build the filter that best suits your requirements.

**Q:** Is the unit calibrated?

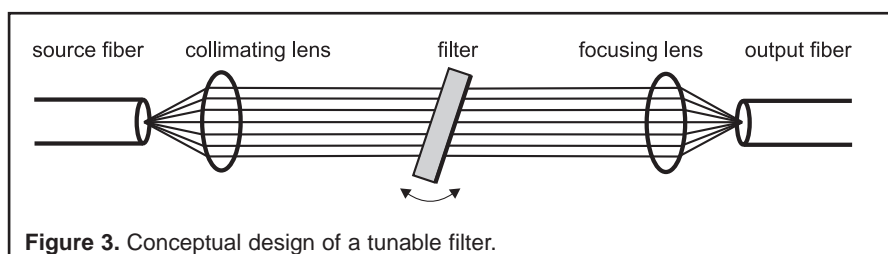
**A:** No, the manual tunable filter is a low cost, flexible solution to tunable filter needs and is not calibrated due to its manual use. However, OZ Optics does take great care in the production of these units in order to meet or exceed the optical properties required by the customer.

### Application Notes

#### Introduction To Thin Film Filters:

In many fiber-optic applications we need to use light with a specific frequency or wavelength ( $\lambda$ ). Although a laser may be an excellent source of monochromatic radiation, we might need a source of light providing controlled, variable wavelength. Bandpass filters provide an effective means of transmitting a well-defined band of light while blocking unwanted wavelengths emanating from a broadband source.

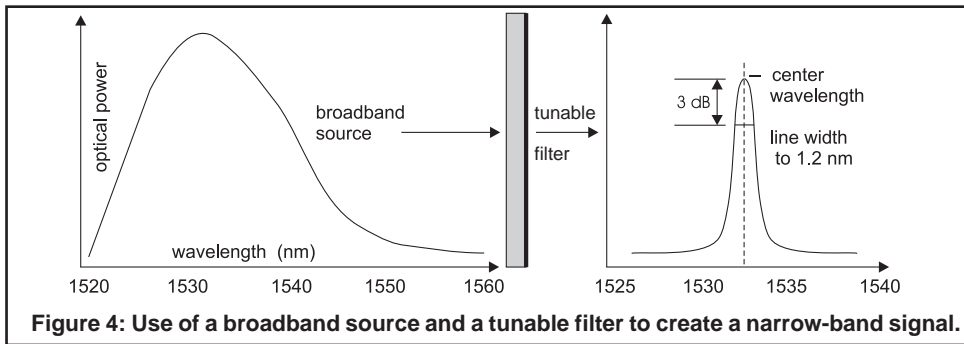
OZ Optics' Tunable Filter uses a narrow wavelength bandpass filter. With increased angle of incidence, the filter transmits light of decreased wavelength (Figure 3)



**Figure 3.** Conceptual design of a tunable filter.

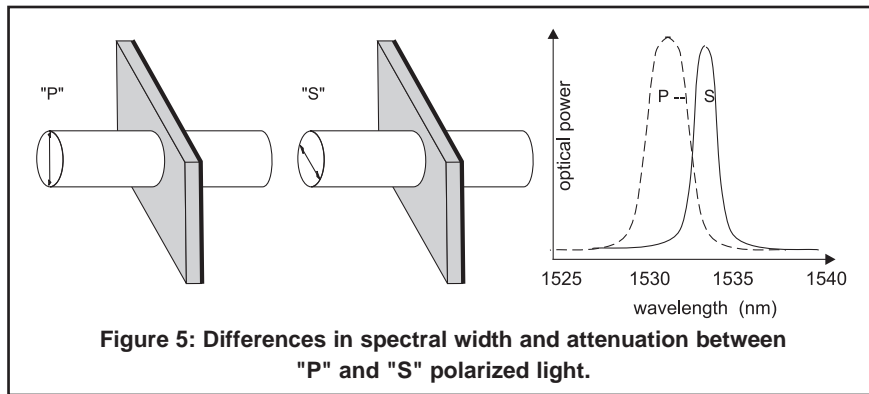
**Application Notes:** (cont'd)

The typical output wavelength distribution is demonstrated in Figure 4.



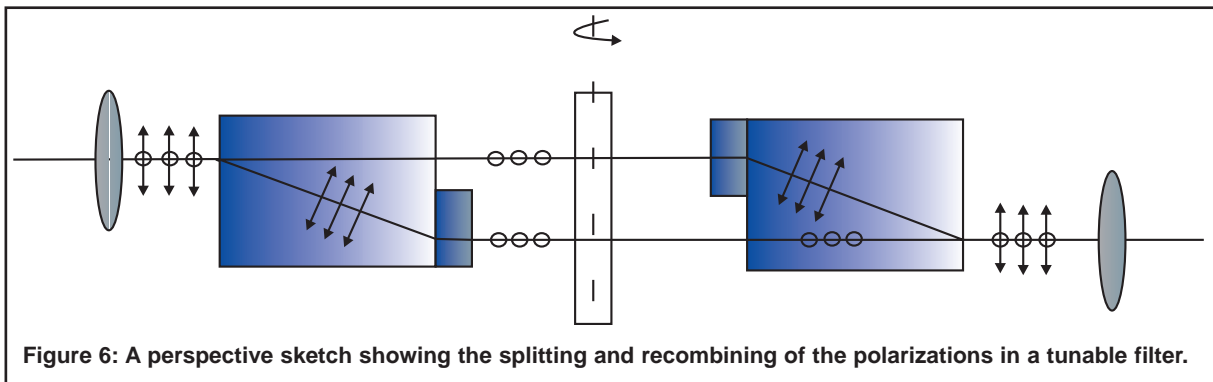
**Figure 4: Use of a broadband source and a tunable filter to create a narrow-band signal.**

The main problem with typical tunable filters that has been solved by OZ Optics is their polarization sensitivity. As the angle of incidence increases, the sensitivity to polarized light also increases. (See Figure 5) This is a very important point in optical systems as the separation of the S and P polarizations causing large PDL can have detrimental effects on the system.

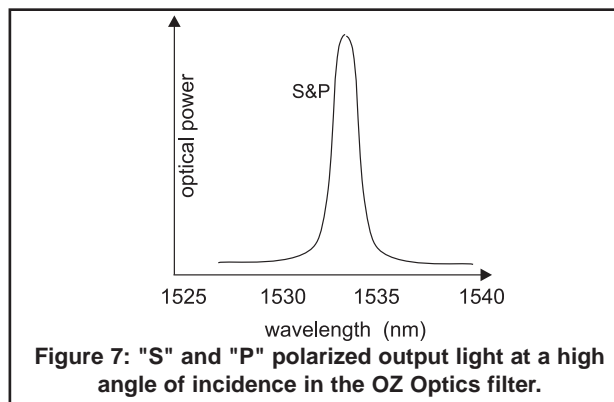


**Figure 5: Differences in spectral width and attenuation between "P" and "S" polarized light.**

OZ Optics' tunable filters utilize an optical technique to control PDL making the spectral response polarization insensitive. The polarization insensitivity is accomplished through the precision alignment of optical components on both the input and output side of the filter. As demonstrated in Figure 6, below, the light is first split into its respective polarizations and then one of the polarizations is rotated such that the light incident on the filter is all the same polarization. After passing through the filter the other polarization is rotated and then the beams are combined for the final focusing and collection into the fiber. By rotating the light and having a common polarization pass through the filters the PDL effect of the filter at high angles of incidence is avoided. Therefore, the spectral response of S and P polarizations remain the same for increasing angles of incidence. See figure 7.



**Figure 6: A perspective sketch showing the splitting and recombining of the polarizations in a tunable filter.**



**Figure 7: "S" and "P" polarized output light at a high angle of incidence in the OZ Optics filter.**