



## DIGITAL TUNABLE FILTERS

### Features:

- Narrow linewidth
- Polarization insensitive
- Wide wavelength range
- Singlemode, multimode, and polarization maintaining fiber versions
- High resolution
- Built in computer RS232 interface
- GPIB/RS232 converter available

### Applications:

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

### 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.

The digital tunable filter is a hand held unit with a keypad, display, and computer interface. The device works 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. The digital version is calibrated such that the user directly enters the wavelength to transmit via the keypad or remotely, through the computer interface. An RS232 interface with cable is standard with GPIB to RS232 converter offered as an optional accessory.

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 profiles 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.



Digital Tunable Filter



GPIB/RS232 Converter

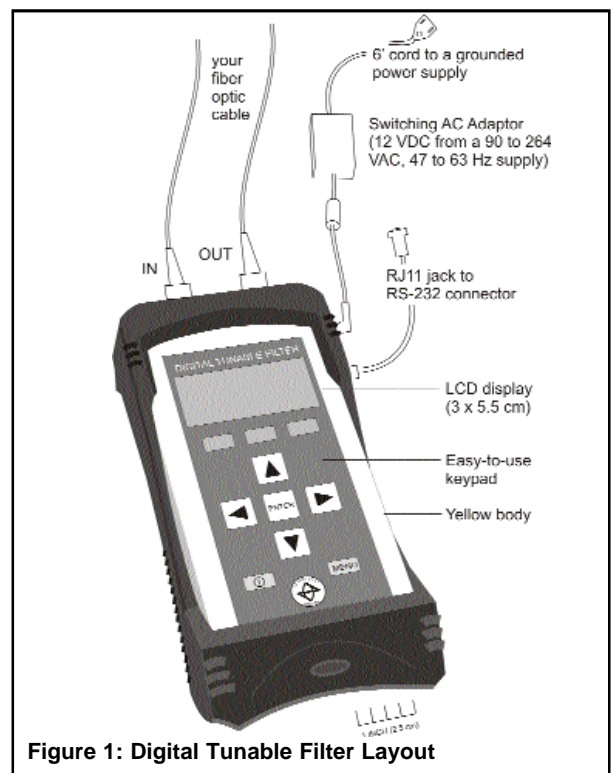


Figure 1: Digital Tunable Filter Layout

Typical Transmission Curves of 1.2 nm C band Tunable Filters

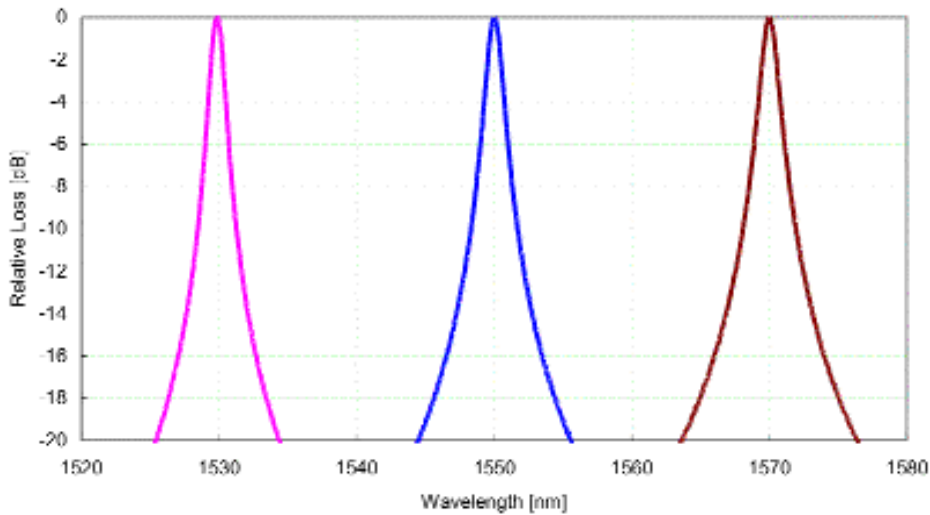


Figure 2: Typical Transmission Curve For 1.2nm C-Band Tunable Filters

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

**Standard Product Specifications:**

Power Supply:	Universal 110/220 Volt AC/DC adapter. Removable North American power cord included. Other power cords available as accessories.
Computer Interface:	RS232. External GPIB-RS232 adapters available.
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. 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.
Standard Wavelength Ranges:	S, C and L bands: 1470-1520nm, 1520-1570nm and 1570-1620nm
Power Handling:	Up to 200mW for standard package.
Response Time:	50nm change in less than 1 sec. 1nm change in less than 0.1 sec.
Dimensions:	5.9 x 3.2 x 1.8 inches (150 x 81 x 46mm)
Weight:	1lb (450g) (not including protective boot)
Repeatability	Typically better than 0.2nm

### Ordering Information For Standard Parts:

Bar Code	Part Number	Description
10176	TF-100-3S3S-1520/1570-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1520-1570nm 9/125 SM fiber with 40dB return loss, super FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
10021	TF-100-3U3U-1520/1570-9/125-S-50-1.2	Polarization insensitive digital tunable filter for 1520-1570nm 9/125 SM fiber with 50dB return loss, ultra FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13746	TF-100-3A3A-1520/1570-9/125-S-60-1.2	Polarization insensitive digital tunable filter for 1520-1570nm 9/125 SM fiber with 60dB return loss, angled FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
7760	TF-100-SCSC-1520/1570-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1520-1570nm 9/125 SM fiber with 40dB return loss, SC receptacles and 1.2nm FWHM Fabry Perot filter.
13747	TF-100-3S3S-1570/1620-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1570-1620nm 9/125 SM fiber with 40dB return loss, super FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13748	TF-100-3U3U-1570/1620-9/125-S-50-1.2	Polarization insensitive digital tunable filter for 1570-1620nm 9/125 SM fiber with 50dB return loss, ultra FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13749	TF-100-3A3A-1570/1620-9/125-S-60-1.2	Polarization insensitive digital tunable filter for 1570-1620nm 9/125 SM fiber with 60dB return loss, angled FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13750	TF-100-SCSC-1570/1620-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1570-1620nm 9/125 SM fiber with 40dB return loss, SC receptacles and 1.2nm FWHM Fabry Perot filter.
10628	TF-100-3S3S-1290/1330-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1290-1330nm 9/125 SM fiber with 40dB return loss, super FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13751	TF-100-3A3A-1520/1570-8/125-P-60-1.2	Polarization maintaining digital tunable filter for 1520-1570nm 8/125 PM fiber with 60dB return loss, angled FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
13752	TF-100-3A3A-1570/1620-8/125-P-60-1.2	Polarization maintaining digital tunable filter for 1570-1620nm 8/125 PM fiber with 60dB return loss, angled FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
4572	GPIB-RS232	GPIB/RS232 Converter
4571	GPIB-CABLE-2	GPIB cable, 2m long
13397	CASE-03	Ruggedized, waterproof carrying case
2736	POWER CORD-UK	IEC Power Cord - UK, 2.5m, Black
2737	POWER CORD-EUROPE	Power Cord - European 4mm Round Pin

## Ordering Examples For Standard Parts:

A customer in Europe wants to use a broadband source as a 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 customer would like to be able to adjust the wavelength at the workstation as well as remotely from a computer. He is using a GPIB control interface.

The component required for this application is a polarization insensitive digital tunable filter. With this unit connected to the broadband light source and by directly entering the wavelength to transmit via the keypad or remotely, through the computer interface, the transmitted wavelength from the broadband source can be tuned from 1520 to 1570nm.

Bar Code	Part Number	Description
10176	TF-100-3S3S-1520/1570-9/125-S-40-1.2	Polarization insensitive digital tunable filter for 1520-1570nm 9/125 SM fiber with 40dB return loss, super FC/PC receptacles and 1.2nm FWHM Fabry Perot filter.
4572	GPIB-RS232	GPIB/RS232 Converter
4571	GPIB-CABLE-2	GPIB cable, 2m long
2737	POWER CORD-EUROPE	Power Cord - European 4mm Round Pin

## 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 transmission profile do you require?
4. What type of fiber is being used? Singlemode, Multimode or PM?
5. Are you using a polarized or randomly polarized light source?
6. What return losses are acceptable in your system?
7. What connector type are you using?

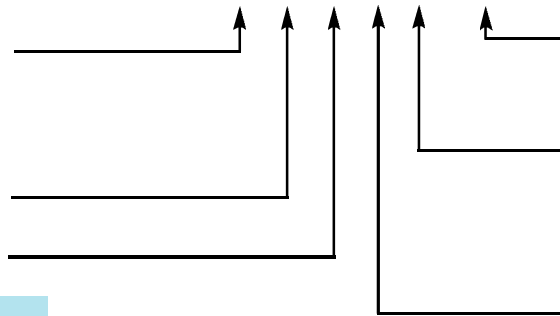
**XY** = Input & Output Connector codes:

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 LCA

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

**a/b** = Fiber core/cladding sizes in microns:  
 9/125 for 1300/1550nm Corning SMF 28 fiber  
 8/125 for 1550nm PANDA style PM fiber

**TF-100-XY-W-a/b-F-LB-LW**



**LW** = Linewidth in nm:

Standard filter is Fabry Perot. For a flat top profile filter, add the letter **F** to the end of the number.

**LB** = Backreflection Level:

40, 50 or 60dB for singlemode or polarization maintaining fibers only (60dB for 1290 to 1620nm wavelength ranges only)  
 35dB for multimode fibers

**F** = Fiber type:

M=Multimode  
 S=Singlemode  
 P=Polarization Maintaining

## Ordering Examples For Custom Parts:

### Example 1:

A customer in North America has a specialty polarized light source between the C and L bands and wants to use it as a tunable source while maintaining the extinction ratio. The source is used between 1550 and 1600nm and is pigtailed with a super FC/PC connector.

A custom version of the digital tunable filter with a narrow linewidth made for PM fiber will meet this requirement custom filter.

Part Number	Description
TF-100-3S3S-1550/1600-8/125-P-40-0.3	Polarization maintaining digital tunable filter for 1550-1600nm 8/125 PM fiber with 40dB return loss, super FC/PC receptacles and a custom 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:** How do you define your linewidths?

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

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

**A:** The standard tuning range is 50nm, however the filters can be made operational for a 100nm tuning range with some effects on the linewidth and insertion loss in the lower 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. 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 example, 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 are filters available please contact OZ Optics.

**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 filters the typical line width at -20dB is ~10nm. 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 suites your requirements.

**Q:** Is the unit calibrated?

**A:** YES, the Digital Tunable Filter uses a stepper-motor which is calibrated to give the desired wavelength within the specified wavelength range of the unit.

**Q:** Does the device operate at 220V as well as 110V?

**A:** Yes, the universal power adapter works for both voltages but you have to use the appropriate power cord. A North American style power cord is included with the unit. Other types of power cords may be ordered separately.

## Application Notes:

### Introduction:

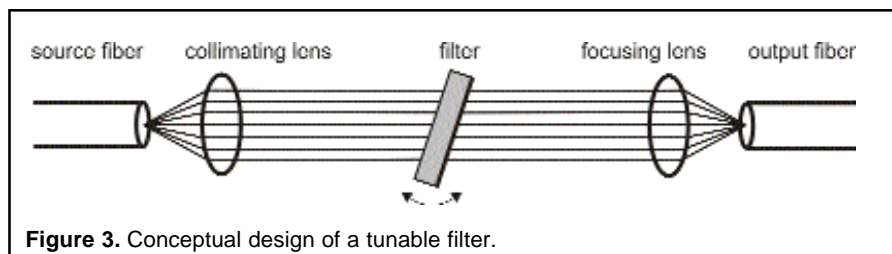
OZ Optics' family of hand-held test equipment includes the Digital Tunable Filter for transmission of a well-defined band of light. Wavelength selection is controlled by angle of incidence of a collimated beam to a bandpass filter. Control of angle is accomplished with a micro-controlled stepper motor geared for an optimal balance of speed and resolution.

The OZ Digital Tunable Filter TF-100 system includes the handheld unit with impact-absorbing blue rubber boot, RS-232 cable, AC/DC power supply with cord.

### Introduction To Thin Film Filters:

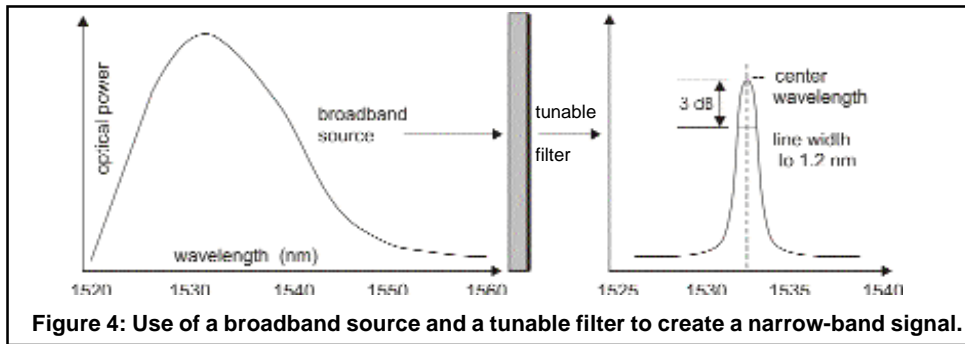
In many fiber-optic applications we need to use light with a specific frequency or wavelength ( $\lambda$ ). Although a laser may be an excellent source of monochromatic radiation, we might need a source of light providing controlled, variable wavelength. Bandpass filters provide an effective means of 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)



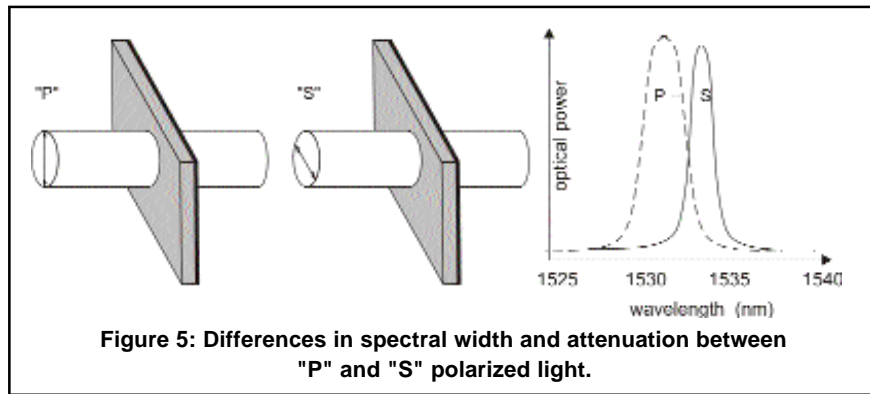
**Application Notes:** (cont'd)

The typical output wavelength distribution is demonstrated in Figure 4.



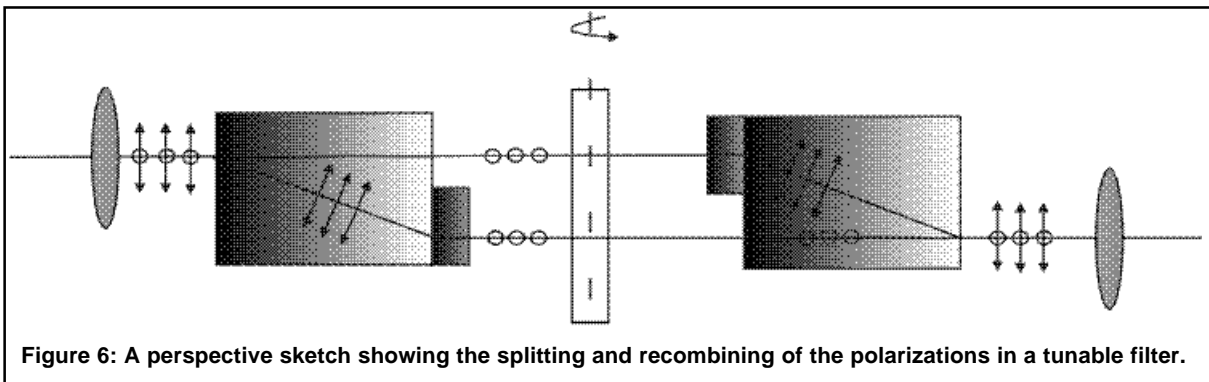
**Figure 4: Use of a broadband source and a tunable filter to create a narrow-band signal.**

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 affects on the system.

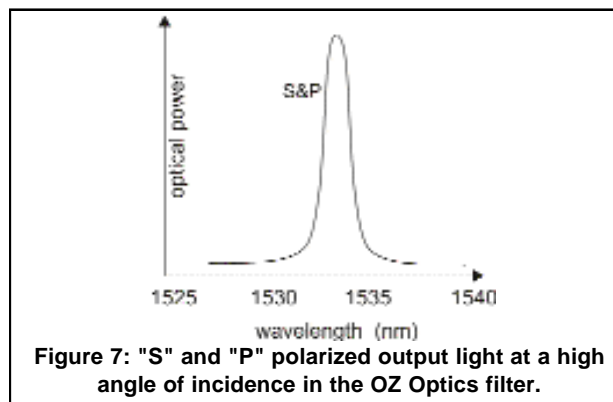


**Figure 5: Differences in spectral width and attenuation between "P" and "S" polarized light.**

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.**