



## MOTOR DRIVEN 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

### Applications:

- Dense Wavelength Division Multiplexing
- 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 with a display and computer interface.

The motor driven tunable filter is a pigtailed unit with a computer interface which has options for different communication standards. 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 motor driven version is calibrated such that the user directly enters the wavelength to transmit via the computer interface. An RS232 interface with cable is standard.

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.

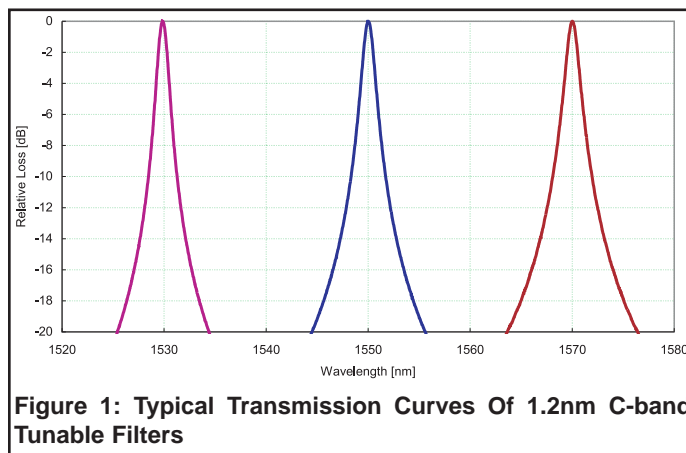
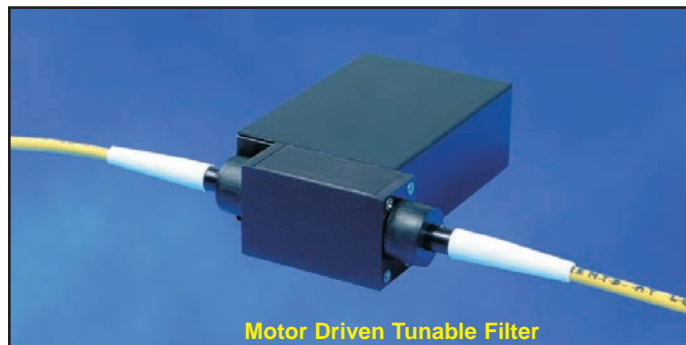


Figure 1: Typical Transmission Curves Of 1.2nm C-band Tunable Filters

## Standard Product Specifications:

Computer Interface:	RS232. Other available options include IIC and SPI.
Resolution:	As low as 0.1nm
Tuning Range:	50nm
Linewidth:	1.1 ± 0.1nm over full tuning range is standard. As low as 0.3nm as an option.
PDL:	Typically less than 0.3dB
Insertion Loss:	Typically less than 2.0dB for complete device over full tuning range.
Standard Wavelength Ranges:	S, C and L bands: 1470-1520nm, 1520-1570nm and 1570-1620nm
Power Handling <sup>1</sup> :	Up to 200mW for standard package. Up to 2Watts for high power package.
Response Time:	50nm change in less than 1 sec. 1nm change in less than 0.1 sec.
Dimensions:	0.75" x 1.5" x 3.25" (2.0 x 3.8 x 8.5cm), (not including fibers)
Weight:	0.2lb (100g)
Power Requirements:	Voltage: 5.0 volts for logic, 5 to 12 volts for motor Current: 57mA for logic supply, 160mA for motor with +12V Supply
Repeatability:	Typically better than ±0.2nm

<sup>1</sup> High power versions available upon request.

### 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

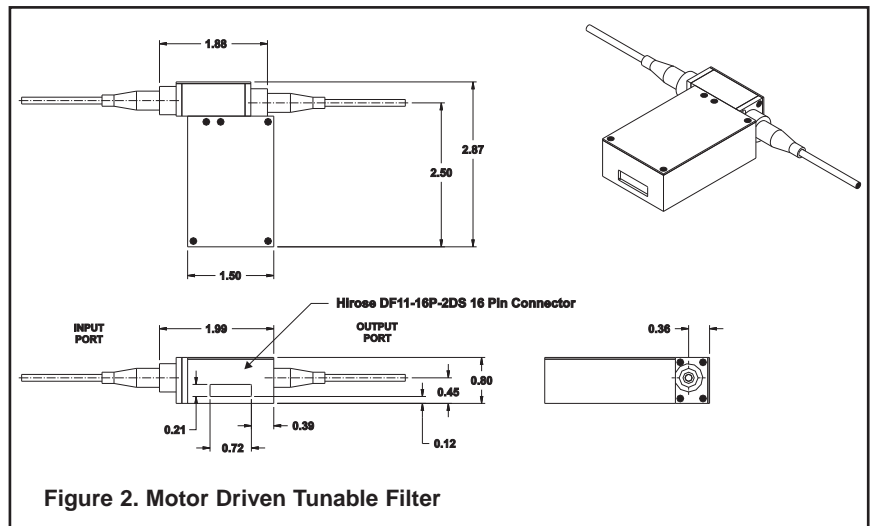


Figure 2. Motor Driven Tunable Filter

### Ordering Information For Standard Parts:

Bar Code	Part Number	Description
10528	TF-100-11-1520/1570-9/125-S-40-3S3S-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 40dB return loss, super FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13546	TF-100-11-1520/1570-9/125-S-50-3U3U-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss, ultra FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13547	TF-100-11-1520/1570-9/125-S-60-3A3A-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 60dB return loss, angled FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13548	TF-100-11-1570/1620-9/125-S-40-3S3S-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 40dB return loss, super FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.

### Ordering Information For Standard Parts (cont.):

Bar Code	Part Number	Description
13549	TF-100-11-1570/1620-9/125-S-50-3U3U-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss, ultra FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13550	TF-100-11-1570/1620-9/125-S-60-3A3A-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1570-1620nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 60dB return loss, angled FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13551	TF-100-11-1520/1570-8/125-P-60-3A3A-3-1-1.2-MC/RS232	Polarization maintaining motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 60dB return loss, angled FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.
13552	TF-100-11-1570/1620-8/125-P-60-3A3A-3-1-1.2-MC/RS232	Polarization maintaining motorized tunable filter for 1570-1620nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 60dB return loss, angled FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape filter.

### Ordering Examples For Standard Parts:

A customer wants to remotely select a channel from a 200GHz DWDM system in the C-band. All connections in the system use angled FC/PC connectors and low return loss is critical for this application. As with most DWDM systems, requirements for low PDL are strict and the components used must be polarization insensitive.

The component required for this application is an OEM style polarization insensitive motorized tunable filter. With this standard OZ Optics filter, the customer will be able to remotely select between channels on the ITU grid.

Bar Code	Part Number	Description
13547	TF-100-11-1520/1570-9/125-S-60-3A3A-3-1-1.2-MC/RS232	Polarization insensitive motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 60dB return loss, angled FC/PC connectors, built-in microcontroller with RS232 interface and 1.2nm FWHM Fabry Perot shape 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 type are you using?
7. What type of computer interface do you need?

**Motor Driven Tunable Filter: TF-100-11-W-a/b-F-LB-XY-JD-L-LW-MC/I**

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

**a/b** = Fiber core/cladding sizes in microns:  
for 1300/1550 SM fiber use 9/125  
for 1550 Panda Style PM fiber use 8/125

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

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

**I** = Computer Interface:  
RS232 for RS232  
IIC for IIC  
SPI for SPI

**LW** = Linewidth in nm. For a flat-top profile add the suffix "F" to the line width  
Example: -15F=15nm Flat Top Filter

**L** = Fiber length in meters (each side)

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

**X,Y** = Connector code:  
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 select between channels in the C-band for a metro Coarse WDM (CWDM) system. Typical channel width is 15nm and a flat top, low ripple, polarization insensitive tunable filter is needed.

Part Number	Description
TF-100-11-1520/1570-9/125-S-50-3U3U-3-1-15F-MC/RS232	Polarization insensitive motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 9/125 SM fiber pigtails, 50dB return loss, ultra FC/PC connectors and built-in microcontroller with RS232 interface and 15nm passband flat top 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 motorized tunable filter.

Part Number	Description
TF-100-11-1520/1570-8/125-P-40-3S3S-3-1-MC/RS232-0.3	Polarization maintaining motorized tunable filter for 1520-1570nm with 1 meter long, 3mm OD jacketed 8/125 PM fiber pigtails, 40dB return loss, super FC/PC connectors, built-in microcontroller with RS232 interface and 0.3nm FWHM Fabry Perot shape 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 filter can be set to operate over 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, 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 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 Fabry-Perot filters the typical linewidth 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. 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 line widths 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 and OZ Optics can work with you to build the filter that best suites your requirements.

**Q:** Is the unit calibrated?

**A:** The motorized tunable filter with microcontroller uses a stepper-motor which is calibrated to give the desired wavelength within the specified wavelength range of the unit. Units ordered without a microcontroller are not calibrated

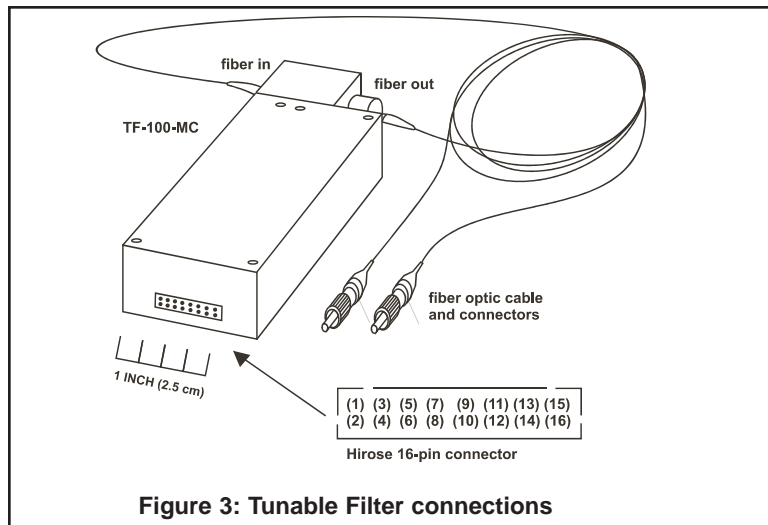
**Q:** Does any software come with the unit?

**A:** The motorized tunable filter with microcontroller does not require unique software to be operated. You can run any one of many communications programs available, e.g. HyperTerminal. All commands required to operate the filter are supplied with the operating instructions shipped with the unit. LabView, Active X and stand-alone drivers are under development.

For more information, please contact OZ Optics.

### Application Notes:

Introduction to TF-100-MC: OZ Optics' line of motor-driven components includes the TF-100-MC Tunable Filter for transmission of a well defined band of light. Wavelength selection is controlled by the angle of incidence of a collimated beam to a bandpass filter. Control of angle is accomplished with a micro-controlled stepper-motor geared to give you a balance of speed and resolution. Our versatile design lets us custom build and calibrate each unit according to the specific requirements of your fiber optic system. The OZ micro-controlled motor-driven Tunable Filter TF-100-MC comes as a calibrated unit complete with fiber optic cable and specified connectors. The Hirose 16-pin connector comes with a cable and connector (not shown) to the interface of your choice (e.g., RS-232 or I2C communications).



**Figure 3: Tunable Filter connections**

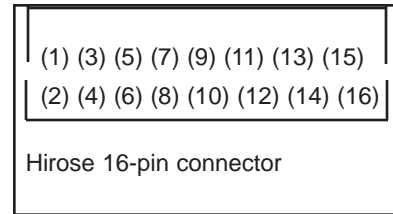
**Mounting:** The base of the TF-100-MC has three 2-56 tapped mounting holes for attachment to a rack or printed circuit board. For best results, the mounting surface should be rigid and free of vibration. Do not over-tighten the mounting screws and use screws with a threaded length no longer than 2mm.

The TF-100-MC is shipped with custom fiber optic cables attached. Both the cable and connectors (with strain-relief boot) are customer-specified. Clean the optical connectors and attach them in circuit with the input broadband optical signal.

## Electrical Connections:

The TF-100-MC has a Hirose DF11-16P-2DS 16-pin connector to a wire harness terminated by a connector of your choice. This harness carries communication signals, power and ground lines. The pin designations are given below:

Pin	Function	Comments
1	GND	common ground
2	GND	common ground
3	VDC	logic supply voltage +5 VDC
4	N/A	DO NOT USE
5	+V	motor supply voltage +12 VDC (min.+5, max.+12.25)
6	+V	motor supply voltage +12 VDC (min.+5, max.+12.25)
7	Rx	RS-232 receiver input
8	Tx	RS-232 transmitter output
9	SCK/SCL	SPI / I2C serial clock
10	-Enable (SS)	SPI enable (slave select; active low TTL input)
11	SDO	SPI serial data out
12	SDI/SDA	SPI data input / I2C data
13	N/A DO NOT USE	
14	N/A DO NOT USE	
15	N/A DO NOT USE	
16	N/A DO NOT USE	



Pins **1** and **2** connect to ground.

Pin **3** supplies voltage (+5 VDC) for the logic circuits. The typical current is ~57 mA.

Pin **4** OZ Optics use only.

Pins **5** and **6** supply power to the motor (typically +12 VDC; up to +12.25 VDC; as low as +5 VDC). The motor runs fastest with a +12 VDC power supply, drawing ~160 mA. But with a +5 VDC voltage, the typical current is ~57 mA.

Pins **7** to **12** are for data communications. Pins **7** and **8** are used for RS-232 communications.

Pins **9** to **12** are used for I2C or SPI communications.

Pins **13** to **16** are reserved for OZ Optics factory use only (do not connect).

When you first connect the wire harness to the 16-pin port, make sure that the power is off. Before turning the power on, make sure that your connections have the correct voltage levels and polarity (given above). If you have ordered an RS-232 interface, the harness comes terminated with a DB9 connector that plugs directly into your computer's serial port. For special applications, the harness is left without a connector and must be terminated by the user for the communications type of their choice.

## 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 4)

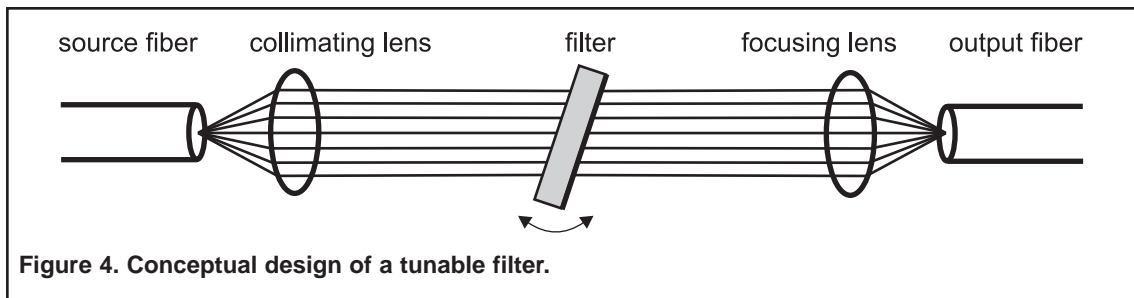
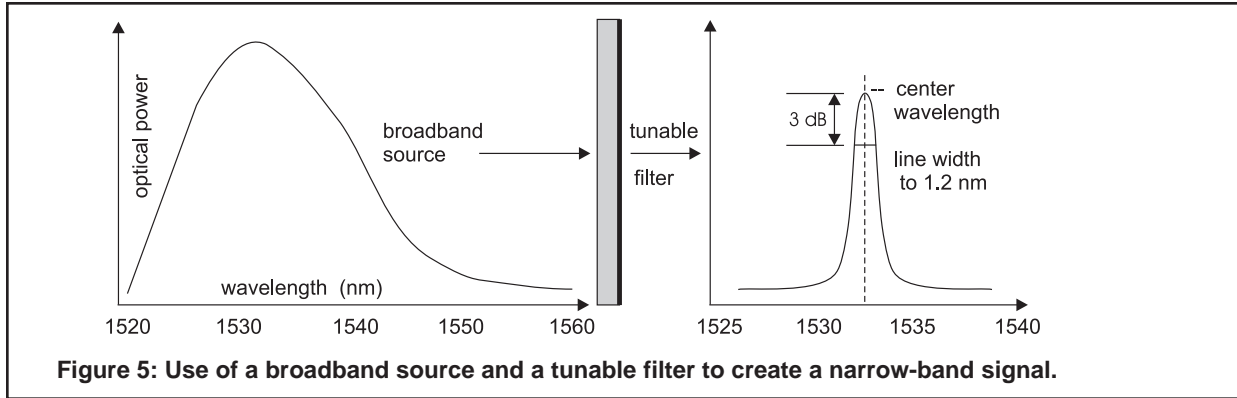


Figure 4. Conceptual design of a tunable filter.

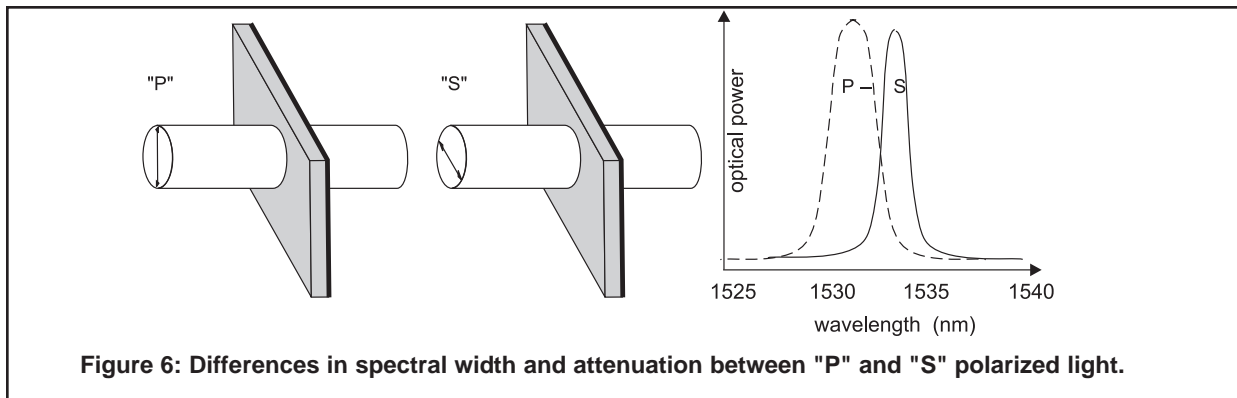
**Application Notes: (cont'd)**

The typical output wavelength distribution is demonstrated in Figure 5.



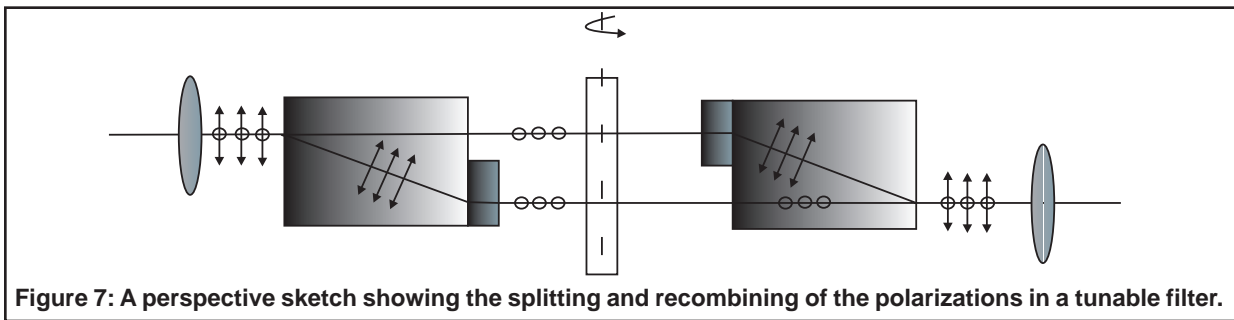
**Figure 5: Use of a broadband source and a tunable filter to create a narrow-band signal.**

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 6) 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.

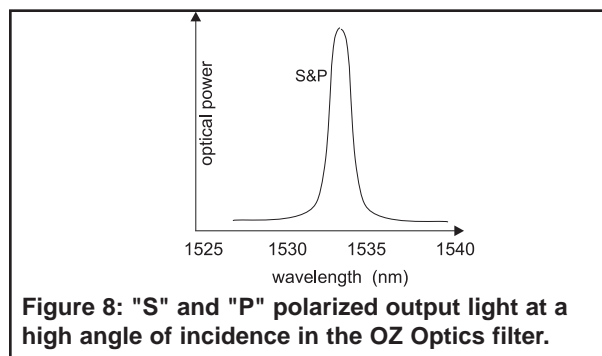


**Figure 6: Differences in spectral width and attenuation between "P" and "S" polarized light.**

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 7, 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 8.



**Figure 7: A perspective sketch showing the splitting and recombining of the polarizations in a tunable filter.**



**Figure 8: "S" and "P" polarized output light at a high angle of incidence in the OZ Optics filter.**