



## POLARIZATION ROTATORS/CONTROLLERS/ANALYZERS

### Features

- User friendly lab package or compact package for inside systems
- Singlemode, multimode, and polarization maintaining (PM) fiber versions available
- Removable/replaceable optics (interchangeable)
- Wide range of available wavelengths
- High Polarization Extinction Ratio
- Convert any polarization state to any other polarization state
- Compatible with standard detector housings

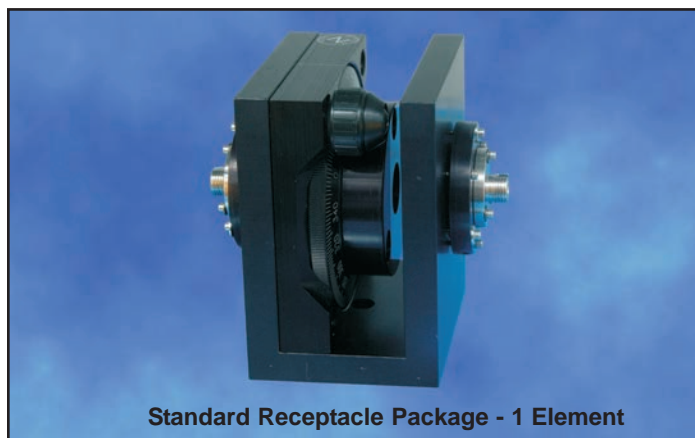
### Applications

- Laser to fiber coupling
- Polarization dependent component or PM fiber testing
- Fiber amplifiers
- Coherent communications
- Polarization ER measurements
- PM fiber axis conversion

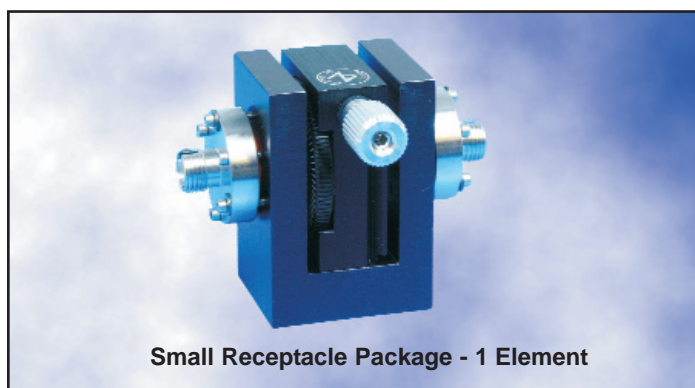
### Product Description

OZ Optics supplies a complete line of polarization rotators, controllers and analyzers to manipulate and control the state of polarization of an input beam of light and couple the adjusted light into an output fiber or detector. These systems typically consist of an input with fiber pigtail or connector receptacle, from 1 to 3 polarization optic components and an output coupler with fiber pigtail, or connector receptacle. The FPR product line uses bulk waveplates and polarizing glass to accomplish the polarization control.

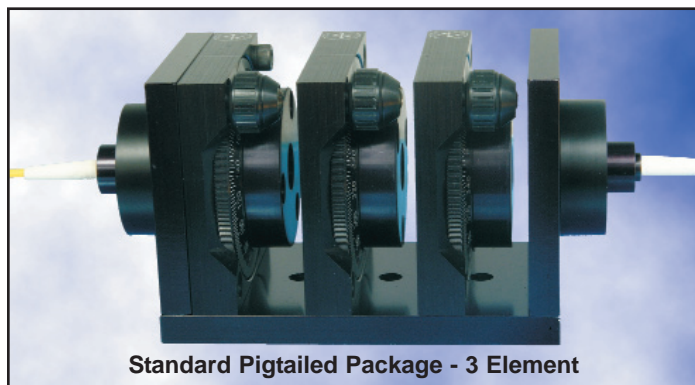
Each polarization optic stage can be removed without loss of coupling. These stages may be replaced or interchanged as the application requires. Separate stages with polarization optics mounted in a rotary platform may be purchased to allow using only one fiber optic assembly for multiple applications.



Standard Receptacle Package - 1 Element



Small Receptacle Package - 1 Element



Standard Pigtailed Package - 3 Element



Small Pigtailed Package - 2 Element

## Polarization Optics

Three types of polarization optics are employed. Plate polarizers are 0.5 mm thick absorbing glass polarizers with high extinction ratio and low loss. They may be used from 600 nm to 1625 nm. Due to their broadband capability, a single plate polarizer may be used for 1300 to 1550 nm. Half wave plates rotate the plane of polarization as they are rotated. They can be used to optimize the alignment between the axes of two PM fibers. Quarter wave plates change the ellipticity of the input light. They are commonly used with SM to PM applications where elliptically polarized light must be linear before launching into PM. These waveplates are typically very thin crystal quartz and zero-order plates with high extinction ratio and low loss. Waveplates are not broadband in nature and are typically recommended for use over  $\pm 25$  nm (at 1550 nm, less at shorter wavelengths). Consult OZ Optics for special component performance requirements. For extreme applications, custom achromatic waveplates can be supplied that allow operation over wider bands. These components are much more expensive than simple waveplates and detailed requirements should be supplied to ensure the proper component is supplied.

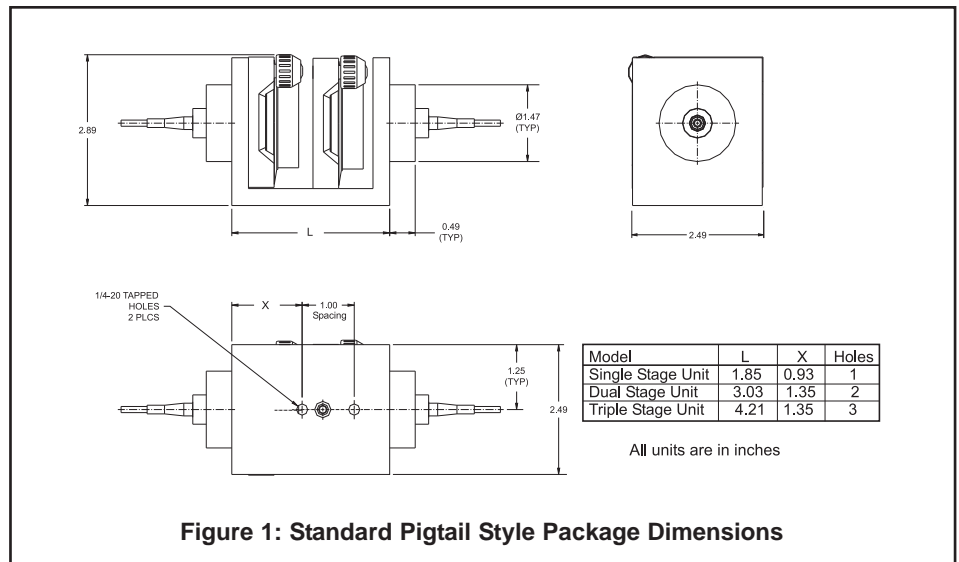


Figure 1: Standard Pigtail Style Package Dimensions

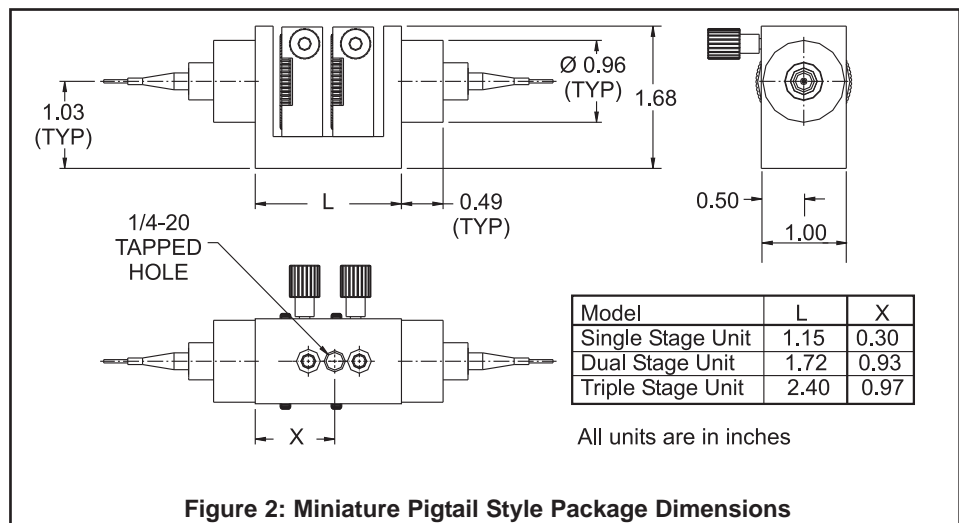


Figure 2: Miniature Pigtail Style Package Dimensions

## Standard vs Miniature Size

OZ Optics manufactures two standard sizes of FPR devices: Standard and Miniature. The standard size uses 2.5" square rotational stages with markings at 2 degree intervals for precise and repeatable polarization control. The stage can be rotated using a knob or by holding the rotating section itself. For applications where frequent adjustments must be made or repeatability is important, the standard stage is the preferred choice. The miniature stage uses 1" stages to fit into tight spaces. This package is preferred for use in equipment boxes or where a single state needs to be found and subsequent alignment is minimal.

## Standard Product Specifications

Description	Condition	Units	1 Stage	2 Stage	3 Stage
Insertion Loss <sup>1</sup>	Pigtail Style	dB	0.8	1.0	1.2
	Receptacle Style	dB	1.5	2.0	2.5
Change in loss during tuning <sup>1</sup>		dB	0.2	0.3	0.5
Available Center wavelengths		nm	440-1625		
Polarization Extinction Ratio		dB	20 (25&30 available for 1310-1550 nm)		
Return loss	Pigtail Style SM,PM fibers	dB	40 (60 available for 1310-1550 nm)		
	Pigtail Style MM fibers	dB	35		
	Receptacle Style	dB	14 dB for non angled connectors, 55 dB for angled connectors		
Maximum Input Power		mW	200		
Standard Bandwidth <sup>1</sup>		nm	$\pm 10$ nm		

<sup>1</sup> At 1300-1550 nm wavelengths

## Standard Parts

The following list is just a subset of available standard parts. In particular, we produce components for a variety of wavelengths. Your choice of connectors can be added to the pigtail style units.

Receptacle Style Polarization Analyzers/Rotators - Large Body		
Bar Code	Part Number	Description
10178	FPR-01-33-1550-P-P-1	Fiber Polarization Rotator for 1550 nm PM fiber with rotatable plate polarizer and receptacle for flat super, or ultra FC/PC connectors
10181	FPR-01-33-1550-P-P-2	Fiber Polarization Rotator for 1550 nm PM fiber with rotatable half wave plate and receptacle for flat super, or ultra FC/PC connectors
8936	FPR-01-33-1550-P-P-1&2	Fiber Polarization Rotator for 1550 nm PM fiber with rotatable plate polarizer and half wave plate and receptacle for flat super, or ultra FC/PC connectors
9227	FPR-01-33-1550-S-S-1&2&3	Fiber Polarization Rotator for 1550 nm SM fiber with plate polarizer, half wave and quarter wave plates and receptacle for flat super, or ultra FC/PC connectors
10774	FPR-01-33-1550-S-S-3&2&3	Fiber Polarization Rotator for 1550 nm SM fiber with quarter wave, half wave and quarter wave plates and receptacle for flat super, or ultra FC/PC connectors

Pigtail Style Polarization Analyzers/Rotators - Large Body		
Bar Code	Part Number	Description
16008	FPR-11-11-1550-9/125-S-S-1-40-XX-3-1	Fiber Polarization Rotator with 1 meter long 3 mm OD PVC cabled 1550 nm 9/125 SM fiber pigtails and rotatable plate polarizer with 40dB return loss and no connectors.
9212	FPR-11-11-1550-9/125-S-S-2-40-XX-1-1	Fiber Polarization Rotator with 1 meter long 1 mm OD cabled 1550 nm 9/125 SM fiber pigtails and rotatable half wave plate with 40dB return loss and no connectors.
15244	FPR-11-11-1550-9/125-S-S-3-40-XX-1-1	Fiber Polarization Rotator with 1 meter long 1 mm OD cabled 1550 nm 9/125 SM fiber pigtails and rotatable quarter wave plate with 40dB return loss and no connectors.
23276	FPR-11-11-1550-8/125-P-P-1-40-XX-3-1	Fiber Polarization Rotator with 1 meter long 3 mm OD PVC cabled 1550 nm 9/125 SM fiber pigtails and rotatable plate polarizer with 40dB return loss and no connectors.
23277	FPR-11-11-1550-8/125-P-P-2-40-XX-1-1	Fiber Polarization Rotator with 1 meter long 1 mm OD cabled 1550 nm 9/125 SM fiber pigtails and rotatable half wave plate with 40dB return loss and no connectors.
23278	FPR-11-11-1550-8/125-P-P-3-40-XX-1-1	Fiber Polarization Rotator with 1 meter long 1 mm OD cabled 1550 nm 9/125 SM fiber pigtails and rotatable quarter wave plate with 40dB return loss and no connectors.

Pigtail Style Polarization Analyzers/Rotators - Small Body		
Bar Code	Part Number	Description
23279	FPR-12-11-1550-9/125-S-S-1-40-XX-1-1	Fiber Polarization Rotator (small housing) with 1 meter long 900 um OD jacketed 1550 nm 9/125 SM fiber pigtails and rotatable polarizer with 40dB return loss and no connectors.
17614	FPR-12-11-1550-9/125-S-S-2-40-XX-1-1	Fiber Polarization Rotator (small housing) with 1 meter long 900 um OD jacketed 1550 nm 9/125 SM fiber pigtails and rotatable half wave plate with 40dB return loss and no connectors.
17615	FPR-12-11-1550-9/125-S-S-3-40-XX-1-1	Fiber Polarization Rotator (small housing) with 1 meter long 900 um OD jacketed 1550 nm 9/125 SM fiber pigtails and rotatable quarter wave plate with 40dB return loss and no connectors.
23280	FPR-12-11-1550-9/125-S-P-1&2&3-40-XX-3-1	Fiber Polarization Rotator (small housing) with 1 meter long 3 mm OD PVC cabled 1550 nm 9/125 SM (input) 8/125 PM (output) fiber pigtails and rotatable plate polarizer, half wave and quarter wave plates with 40dB return loss and no connectors

## Ordering example for standard parts

A researcher is studying the properties of polarization maintaining fiber, and needs to take light from a polarization maintaining fiber, clean up the polarization of the light coming out, and launch it into another polarization maintaining fiber. The researcher wants to be able to rotate the polarization, so he can launch into either the slow axis or fast axis of the second fiber, depending on the experiment. A polarizer and half wave plate combination will suffice for this application. All the patchcords in the lab are terminated with Super FC/PC connectors, so the researcher wants a receptacle style setup to use these patchcords.

Bar Code	Part Number	Description
8936	FPR-01-33-1550-P-P-1&2	Fiber Polarization Rotator for 1550 nm PM fiber with rotatable plate polarizer and half wave plate and receptacles for flat, super or ultra FC/PC connectors.

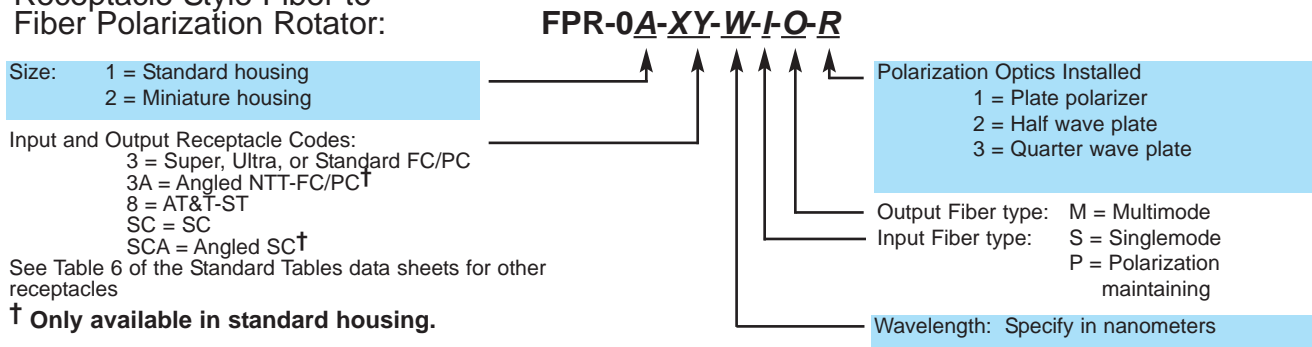
## Ordering Information

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 some cases non-recurring engineering (NRE) charges, lot charges, or 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.

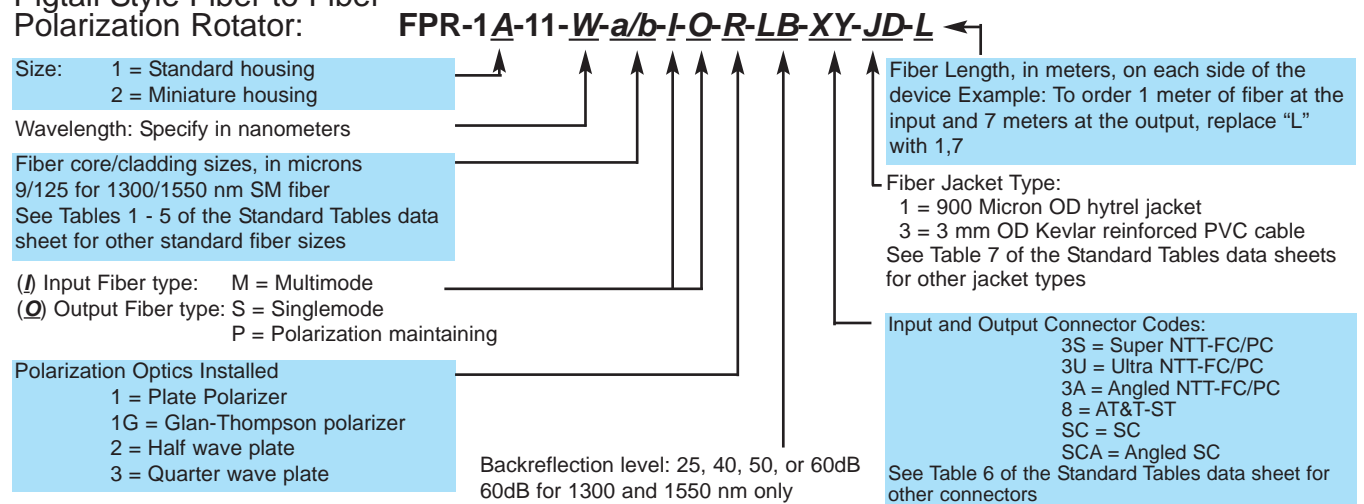
## Questionnaire

1. What is the operating wavelength for your system?
2. What type of fiber are you using on the input and output?
3. What combination of polarizers, halfwave plate, and quarterwave plates do you need?
4. Which of the following statements apply?
  - a. I need a miniature device. A readout of the angle is not required.
  - b. I need to record the alignment of the optical elements. Size is not required.
5. Do you need a device with receptacles, or a unit with the fibers?
6. Is return loss an issue with your application?
7. What connectors are you using on the fiber ends?
8. What is the intensity of your signal?
9. What is the input signal polarization, and the desired output polarization?

### Receptacle Style Fiber to Fiber Polarization Rotator:



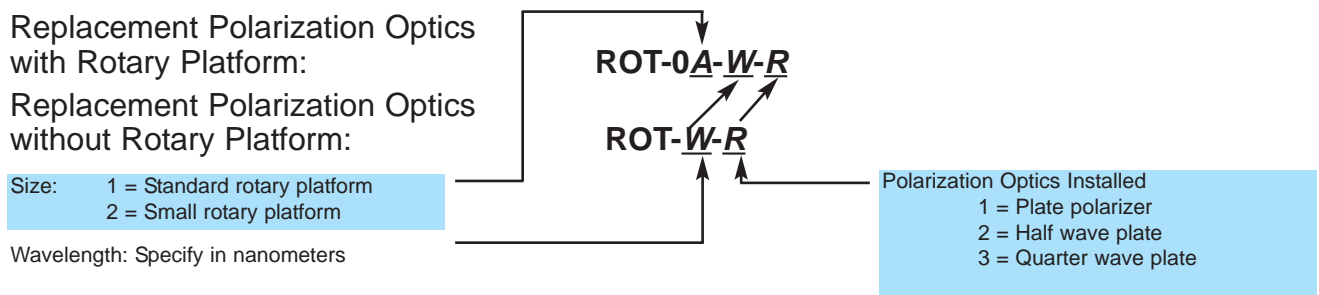
### Pigtail Style Fiber to Fiber Polarization Rotator:



Add "-ER=25", "-ER=30" to the part number for 25dB and 30dB extinction ratios. Use 1 & 2 & 3 for multiple polarization optics.

### Replacement Polarization Optics with Rotary Platform:

### Replacement Polarization Optics without Rotary Platform:



## Ordering example for custom parts

A laser diode manufacturer needs to test the output polarization extinction ratio of polarization maintaining fiber pigtailed 980nm laser diodes. The fibers on these units are terminated with SC connectors. To evaluate their performance, the manufacture decides to use a receptacle style polarization rotator with SC receptacles on both sides. On the input side he will plug in the device to be tested, while on the other side he will plug in a multimode fiber. In the middle will be a plate polarizer. To ensure accurate measurements of the polarization, the engineer wants a unit with the polarizer capable of extinction ratios better than 30dB.

Part Number	Description
FPR-01-SCSC-980-P-M-1	Fiber Polarization Analyzer for 980 nm, with a rotatable plate polarizer and receptacles SC connectors. The input fiber is a polarization maintaining fiber, while the output fiber is a multimode fiber.

## Application Notes

Polarization Controllers may also be supplied for fiber to fiber, fiber to detector and source to fiber applications. For use with a source, please submit a Laser to Fiber Delivery System Questionnaire (for collimated sources) or Laser Diode to Fiber Delivery Questionnaire. Fiber-to-Fiber pigtailed systems provide the most stable and repeatable coupling. Connections to existing system fibers may be made via sleeve through adapters. Receptacle systems will have varying loss depending on connector tolerances. Angled connectors have particular problems due to the variation in ferrule geometry among manufactures. OZ Optics supplies a special flat angled connector for reliable coupling. In situations where other cables will be used, OZ Optics recommends the customer supply a sample set of cables for the alignment of the collimators. For bare fiber testing, OZ Optics can supply a bare fiber adapter and, upon request, leave the alignment screws of the coupler exposed so the customer may do fine adjustment if necessary. Receptacle systems are recommended for multimode systems or for patchcord testing. Fiber to detector systems may be used for manual polarization extinction ratio measurement. A detector can be supplied by the customer or by OZ Optics and will be mounted on the output. Light from fiber connected to an input receptacle is collimated and passes through a rotatable plate polarizer. The PER is determined by taking a ratio of the minimum to maximum signals as the polarizer is turned. For an automated PER measurement, please see the OZ Optics polarization extinction ratio meter data sheet. Additional PER measurement information is available on the polarization measurement systems application note available on our website or in our catalog.

### Polarization Extinction Ratio Testing

A thorough description of PER testing for patchcords is included in our Application notes section.

### Launching from Single Mode (SM) Fiber to Polarization Maintaining (PM) Fiber

For this application, two or three stages are suggested. The output PM fiber should have its output light collimated through a polarizer of known transmission axis. The power through the polarizer should be monitored as the waveplates are adjusted. When the signal is a minimum, the light is launched with highest extinction ratio down the fiber axis opposite to the polarizer axis. This can also be done using the OZ Optics Polarization Extinction Ratio Meter. The minimum is to have a quarter wave plate and a half wave plate. The half wave plate is used to get the azimuth of the light aligned as closely to the proper PM fiber axis as possible. The quarter wave plate is used to convert the input light from some kind of elliptical polarization to linear. It may be necessary to iteratively adjust the two plates for maximum performance. By including a polarizer in the FPR, one can just monitor output power rather than need a collimator and external polarizer.

### Changing Axes in PM fiber

Some applications require light to be launched down the two different axes of a PM fiber on different occasions. This can be accomplished using a single stage FPR with a half wave plate. If the plate is properly aligned to pass the light down one axis, then it is rotated 45 degrees to change the polarization plane by 90 degrees. Output signal should be monitored to ensure optimal alignment.

### Source to Fiber Launching

Most lasers are polarized. To use a source with patchcords with varying axis angles, a half wave plate can be incorporated into a laser to fiber coupler in the same way that the light is controlled between two PM fibers (above). OZ Optics has detailed questionnaires for source to fiber delivery systems to streamline the quotation process and ensure that all system requirements are met.

## Frequently Asked Questions (FAQs)

- Q.** Why can't I go from multimode to singlemode or polarization maintaining fiber?
- A.** This is a very common question which has an unpopular answer. Multimode fiber has a much larger core size and numerical aperture than single mode or polarization maintaining fiber. This means that coupling losses could be 20-40dB, which is typically unacceptable for most applications.
- Q.** Can I use angle polish connectors with my controller?
- A.** Angled connectors can give varying coupling losses. See the Application Notes for a description of the issues involved for angled connectors. Typically, it is better to use a fiber pigtailed device terminated with angled connectors rather than a device with receptacles.
- Q.** Should I use the FPR style controller or an all -fiber version polarization controller?
- A.** The FPR style controller is useful for accurate and repeatable control of polarization state. Because they are built from bulk optics, there will be variations in insertion loss as the stages are rotated. These variations are typically larger than what is required for Polarization Dependent Loss (PDL) measurements. When PDL measurements are the application, then the All Fiber Polarization Controllers are recommended due their very low loss variation during manipulation.
- Q.** What is the operating bandwidth of the unit?
- A.** Bandwidth is determined by a specific Polarization Extinction Ratio and by wavelength. The shorter the wavelength, the smaller the wavelength range that the Waveplate will maintain a retardance. For 1550 nm, typical ranges for 20dB extinction ratio are  $\pm 10$  to 15 nm. For high extinction ratios, this range can be smaller. It is important to be sure of the range of wavelengths to be used and the required extinction ratio required. For application where one is simply adjusting the polarization for maximum transmission through a polarization sensitive device, then 20dB ER should be sufficient. For converting light from SM fiber to PM fiber, a higher ER might be required.
- Q.** Which size should I choose, the standard size or miniature size?
- A.** In general, the standard size is easier to manipulate and has angle readout. The small size is preferred for set-it-and-forget-it applications
- Q.** Aren't Glan-Thompson or Calcite based polarizers better than plate polarizers?
- A.** The plate polarizers used by OZ Optics exceed the minimum 20dB extinction ratio specification and routinely are much better. Calcite based polarizers are much larger and much more expensive than plate polarizers. These longer, more complex polarizers create greater beam displacement and deviation as the light travels through it. This translates to higher loss variation as the polarizer is turned. OZ Optics has discontinued the use of Glan Thompson polarizers except for highly specialized applications.
- Q.** Why is the receptacle style loss specification higher?
- A.** All connectors have mechanical tolerances. Even a tolerance of 1  $\mu\text{m}$  can cause variations in loss. Considering that the mode field diameter of a single mode fiber for 800 nm is 5  $\mu\text{m}$ , a 1  $\mu\text{m}$  tolerance is huge. This is why OZ Optics typically recommends pigtails style couplers. Losses between two mated connectors are much lower and much more repeatable than connector to receptacle.
- Q.** Why do the losses change when you change patch cords?
- A.** For the same reason that receptacle style losses are specified as higher. Each patchcord can have a slightly different size and seat differently.
- Q.** What are the replacement options and restrictions?
- A.** Any optic for the original design wavelength can be interchanged as long as it is in the same size housing. For certain applications, slightly different center wavelength optics can be used. For example, a 750 nm Waveplate will work in a FPR originally aligned for 780 nm. Besides alignment, one must remember that the collimating optics are AR coated for certain wavelength ranges and are not achromatic. Please consult OZ Optics if you are planning to use different wavelength components in the same FPR assembly.
- Q.** Can I use one controller for 1300 nm and 1550 nm?
- A.** Because collimating optics and coatings operate relatively uniformly over 1300 to 1550 nm, a polarizer plate FPR can be used over this range. It should be specified by the customer when requesting a quote or ordering so that alignment can be optimized for the entire range. Most wave-plates will not work over such a broad wavelength range.