PAF2 Series
Aspheric and Achromatic FiberPort Collimators with FC/PC, FC/APC, or SMA Bulkheads

User Guide

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Chapter 1 Description

1.1. Mechanisms of the FiberPort

The FiberPort is a fiber collimator and coupler with six degrees of freedom (5 axes, plus rotation). It uses a movable lens as the alignment mechanism while holding the fiber stationary. This provides an extremely stable and repeatable platform for coupling and collimating. All adjustments are coupled.

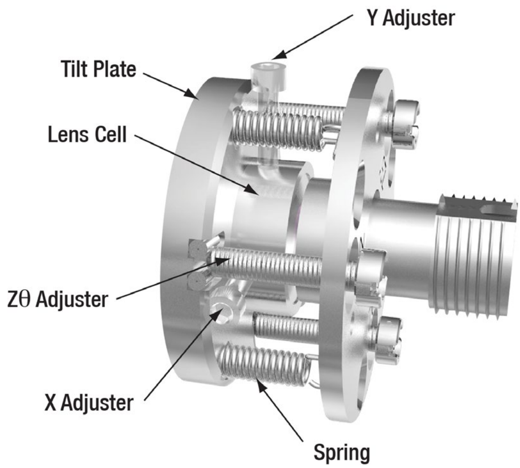

Figure 1 The Internal Mechanism of a FiberPort

The FiberPort consists of a body, a magnetic lens cell (MLC) adhered to a tilt plate, and a bulkhead with fiber connector. The bulkhead is locked onto the FiberPort body by three flat head screws and the clamp plate. By loosening the flat head screws, the fiber bulkhead can be rotated freely and can be used to coarsely align the bulkhead with polarization maintaining fiber.

1.1.1. Zθ Adjustment

The MLC is adhered to the tilt plate, which can be translated in the Z direction via equal adjustments of the three adjusters. These adjusters consist of three ball-end fine adjust screws labeled Zθ1, Zθ2, and Zθ3 which ride in ceramic ball seats. The hardened steel ball-ends and ceramic ball seats are attached with a high-temperature, low-outgassing epoxy to provide a stable, long-wearing kinematic system. The extension springs provide counterforce against the fine adjust screws. The Z (optical axis) translation range is ±1.0 mm.

1.1.2. X-Y Adjustment

The MLC can be translated in X-Y using the socket head cap screws (SHCS) in the side of the FiberPort body. The MLC rests on a leaf spring, and the X-Y screws push the cell against the leaf spring. The X-Y adjusters are stabilized by 0-80 setscrews with a 0.028" hex removing backlash. These setscrews, accessible from the top of the FiberPort, can be used to tune the feel of the X-Y screws. A third SHCS behind the leaf spring can be used for locking. The travel range of the aspheric lens in the X and Y directions is ±0.7 mm; in most cases when the FiberPort is used in a standard collimation/coupling application, only a small portion of this translation range is needed.

1.2. Location of Screws on the FiberPort

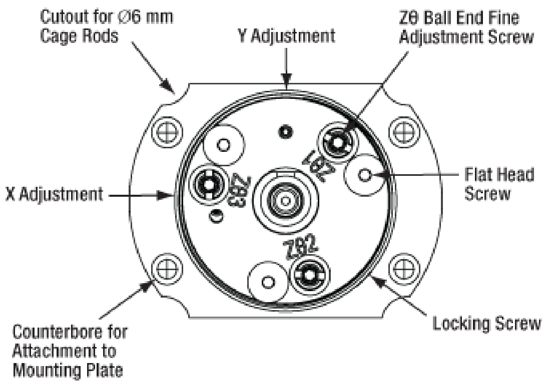

Figure 2 Location of Screws on the FiberPort

Part	Screw Size Used	Head Size (Hex)
Mounting Plate Attachment Screws	2-56	5/64"
X, Y, and Locking Screws	0-80	0.050"
Z (Tip & Tilt) Ball End Fine Adjust Screws	M2 x 0.20	0.050"
Flat Head Screws	2-56	0.050"

Chapter 2 Specifications

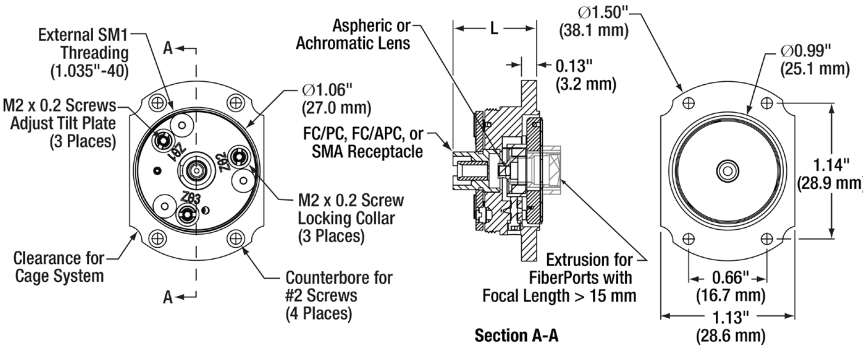

Figure 3 Schematic Diagram of the FiberPort

2.1. Achromatic FiberPorts

We offer achromatic FiberPorts as an alternative to our aspheric models. They perform similarly to our short focal length aspheric FiberPorts but have a very small focal length shift over a broad wavelength range.

Item #	EFL (mm)	Input MFD[1] (µm)	Output Waist Dia. $(1/e^2)$[1] (mm)	Max Waist Dist.[1,2] (mm)	Diverg.[1] (mrad)	Focal Length Shift[3] (µm)	Lens Characteristics			Length L (in/mm)
							CA[4] (mm)	NA	AR Range[5] (nm)	
FC/PC and FC/APC Compatible										
PAF2-A4A	4.0	3.5	0.65	378	0.875	34.3	1.8	0.22	350 - 700	0.70/17.7
PAF2-A4B	4.0	5.0	0.87	350	1.250	6.9	1.8	0.22	600 - 1050	0.70/17.7
PAF2-A4C	4.0	10.4	0.76	150	2.600	14.8	1.8	0.22	1050 - 1620	0.70/17.7
PAF2-A7A	7.5	3.5	1.23	1323	0.467	32	4.5	0.30	400 - 700	0.70/17.7
PAF2-A7B	7.5	5.0	1.62	1225	0.667	43	4.5	0.30	650 - 1050	0.70/17.7
PAF2-A7C	7.5	10.4	1.42	521	1.387	78	4.5	0.30	1050 - 1700	0.70/17.7
FC/PC Compatible										
PAF2P-A10A	10.0	3.5	1.64	2349	0.350	56	>4.5	0.23	400 - 700	0.87/22.2
PAF2P-A10B	10.0	5.0	2.16	2175	0.500	19	>4.5	0.23	650 - 1050	0.87/22.2
PAF2P-A10C	10.0	10.4	1.99	922	0.990	96	>4.5	0.23	1050 - 1700	0.87/22.2
PAF2P-A15A	15.0	3.5	2.46	5277	0.233	56	>4.5	0.15	400 - 700	0.87/22.2
PAF2P-A15B	15.0	5.0	3.25	4885	0.333	24	>4.5	0.15	650 - 1050	0.87/22.2
PAF2P-A15C	15.0	10.4	2.85	2068	0.693	1.23	>4.5	0.15	1050 - 1700	0.87/22.2

[1] *These values are calculated using the following fibers at the specified wavelengths: -AxA: 460HP at 450 nm, -AxB: 780HP at 850 nm, -AxC: SMF-28-J9 at 1550 nm.*
[2] *The max distance from the lens a Gaussian beam's waist can be placed.*
[3] *Focal length shift is defined over the entire AR coating range.*
[4] *Clear Aperture*
[5] *Wavelength Range of the Antireflection Coating*

Item #	EFL (mm)	Input MFD[1] (µm)	Output Waist Dia. $(1/e^2)$[1] (mm)	Max Waist Dist.[1,2] (mm)	Diverg.[1] (mrad)	Focal Length Shift[3] (µm)	Lens Characteristics			Length L (in/mm)
							CA[4] (mm)	NA	AR Range[5] (nm)	
FC/APC Compatible										
PAF2A-A10A	10.0	3.5	1.64	2349	0.350	56	>4.5	0.23	400 - 700	0.88/22.4
PAF2A-A10B	10.0	5.0	2.16	2175	0.500	19	>4.5	0.23	650 - 1050	0.88/22.4
PAF2A-A10C	10.0	10.4	1.99	922	0.990	96	>4.5	0.23	1050 - 1700	0.88/22.4
PAF2A-A15A	15.0	3.5	2.46	5277	0.233	56	>4.5	0.15	400 - 700	0.88/22.4
PAF2A-A15B	15.0	5.0	3.25	4885	0.333	24	>4.5	0.15	650 - 1050	0.88/22.4
PAF2A-A15C	15.0	10.4	2.85	2068	0.693	1.23	>4.5	0.15	1050 - 1700	0.88/22.4
SMA Compatible										
PAF2S-A4A	4.0	3.5	0.65	378	0.875	34.3	1.8	0.22	350 - 700	0.87/22.0
PAF2S-A4B	4.0	5.0	0.87	350	1.250	6.9	1.8	0.22	600 - 1050	0.87/22.0
PAF2S-A4C	4.0	10.4	0.76	150	2.600	14.8	1.8	0.22	1050 - 1620	0.87/22.0
PAF2S-A7A	7.5	3.5	1.23	1323	0.467	32	4.5	0.30	400 - 700	0.87/22.0
PAF2S-A7B	7.5	5.0	1.62	1225	0.667	43	4.5	0.30	650 - 1050	0.87/22.0
PAF2S-A7C	7.5	10.4	1.42	521	1.387	78	4.5	0.30	1050 - 1700	0.87/22.0

[1] *These values are calculated using the following fibers at the specified wavelengths: -AxA: 460HP at 450 nm, -AxB: 780HP at 850 nm, -AxC: SMF-28-J9 at 1550 nm.*
[2] *The max distance from the lens a Gaussian beam's waist can be placed.*
[3] *Focal length shift is defined over the entire AR coating range.*
[4] *Clear Aperture*
[5] *Wavelength Range of the Antireflection Coating*

2.2. Aspheric FiberPorts

Our aspheric lens FiberPorts are available with a variety of focal length and coating options. The first table details all of our SMA-compatible FiberPorts. FiberPorts in the second table have a straight FC bulkhead which will work with FC/PC and FC/APC connectors. The FiberPorts in the last table come with either FC/PC- or FC/APC-compatible bulkheads.

2.2.1. All Focal Lengths, SMA Compatible

Item #	EFL (mm)	Input MFD[1] (µm)	Output Waist Dia. ($1/e^2$)[1] (mm)	Max Waist Dist.[1,2] (mm)	Diverg.[1] (mrad)	Lens Characteristics			Length L (in/mm)
						CA[3] (mm)	NA	AR Range[4] (nm)	
SMA Compatible									
PAF2S-2A	2.0	3.5	0.33	96	1.750	2.0	0.50	350 - 700	0.87/22.0
PAF2S-2B	2.0	5.0	0.43	89	2.500	2.0	0.50	600 - 1050	0.87/22.0
PAF2S-2C	2.0	10.4	0.38	38	5.200	2.0	0.50	1050 - 1620	0.87/22.0
PAF2S-4E	4.0	14.8	1.17	162	3.700	5.0	0.56	2000 - 5000	0.87/22.0
PAF2S-5A	4.6	3.5	0.75	499	0.761	4.9	0.53	350 - 700	0.87/22.0
PAF2S-5B	4.6	5.0	1.00	463	1.087	4.9	0.53	600 - 1050	0.87/22.0
PAF2S-5C	4.6	10.4	0.87	198	2.261	4.9	0.53	1050 - 1620	0.87/22.0
PAF2S-5D	4.6	13.0	0.90	164	2.826	4.9	0.53	1800 - 2400	0.87/22.2
PAF2S-7A	7.5	3.5	1.23	1323	0.467	4.5	0.30	350 - 700	0.87/22.0
PAF2S-7B	7.5	5.0	1.62	1225	0.667	4.5	0.30	600 - 1050	0.87/22.0
PAF2S-7C	7.5	10.4	1.42	521	1.387	4.5	0.30	1050 - 1620	0.87/22.0
PAF2S-11A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	1.04/26.5
PAF2S-11B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	1.04/26.5
PAF2S-11C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	1.04/26.5
PAF2S-11D	11.0	13.0	2.15	921	1.182	4.4	0.20	1800 - 2400	1.04/26.5
PAF2S-11E	11.0	14.8	3.21	1203	1.345	4.0	0.18	2000 - 5000	1.04/26.5
PAF2S-15A	15.3	3.5	2.52	5490	0.227	5.0	0.16	350 - 700	1.04/26.5
PAF2S-15B	15.3	5.0	3.33	5082	0.325	5.0	0.16	600 - 1050	1.04/26.5
PAF2S-15C	15.3	10.4	2.92	2151	0.675	5.0	0.16	1050 - 1620	1.04/26.5
PAF2S-15D	15.3	13.0	3.00	1775	0.850	5.0	0.16	1800 - 2400	1.04/26.5
PAF2S-18A	18.4	3.5	3.01	7936	0.190	5.5	0.15	350 - 700	1.04/26.5
PAF2S-18B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	1.04/26.5
PAF2S-18C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	1.04/26.5
PAF2S-18D	18.4	13.0	3.60	2564	0.707	5.5	0.15	1800 - 2400	1.04/26.5

[1] *These values are calculated using the following fibers at the specified wavelengths: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28-J9 at 1550 nm, -D: SM2000 at 1996 nm, -E: ZrF_4 Fiber at 3.39 µm.*

[2] *The max distance from the lens a Gaussian beam's waist can be placed.*

[3] *Clear Aperture*

[4] *Wavelength Range of the Antireflection Coating*

2.2.2. Short Focal Length, FC/PC and FC/APC Compatible

Item #	EFL (mm)	Input MFD[1] (µm)	Output Waist Dia. ($1/e^2$)[1] (mm)	Max Waist Dist.[1,2] (mm)	Diverg.[1] (mrad)	Lens Characteristics			Length L (in/mm)
						CA[3] (mm)	NA	AR Range[4] (nm)	
FC/PC and FC/APC Compatible									
PAF2-2A	2.0	3.5	0.33	96	1.750	2.0	0.50	350 - 700	0.70/17.7
PAF2-2B	2.0	5.0	0.43	89	2.500	2.0	0.50	600 - 1050	0.70/17.7
PAF2-2C	2.0	10.4	0.38	38	5.200	2.0	0.50	1050 - 1620	0.70/17.7
PAF2-4E	4.0	14.8	1.17	162	3.700	5.0	0.56	2000 - 5000	0.70/17.7
PAF2-5A	4.6	3.5	0.75	499	0.761	4.9	0.53	350 - 700	0.70/17.7
PAF2-5B	4.6	5.0	1.00	463	1.087	4.9	0.53	600 - 1050	0.70/17.7
PAF2-5C	4.6	10.4	0.87	198	2.261	4.9	0.53	1050 - 1620	0.70/17.7
PAF2-5D	4.6	13.0	0.90	164	2.826	4.9	0.53	1800 - 2400	0.70/17.7
PAF2-7A	7.5	3.5	1.23	1323	0.467	4.5	0.30	350 - 700	0.70/17.7
PAF2-7B	7.5	5.0	1.62	1225	0.667	4.5	0.30	600 - 1050	0.70/17.7
PAF2-7C	7.5	10.4	1.42	521	1.387	4.5	0.30	1050 - 1620	0.70/17.7
FC/APC Compatible									
PAF2A-2A	2.0	3.5	0.33	96	1.750	2.0	0.50	350 - 700	0.70/17.9
PAF2A-2B	2.0	5.0	0.43	89	2.500	2.0	0.50	600 - 1050	0.70/17.9
PAF2A-2C	2.0	10.4	0.38	38	5.200	2.0	0.50	1050 - 1620	0.70/17.9
PAF2A-5A	4.6	3.5	0.75	499	0.761	4.9	0.53	350 - 700	0.70/17.9
PAF2A-5B	4.6	5.0	1.00	463	1.087	4.9	0.53	600 - 1050	0.70/17.9
PAF2A-5C	4.6	10.4	0.87	198	2.261	4.9	0.53	1050 - 1620	0.70/17.9
PAF2A-7A	7.5	3.5	1.23	1323	0.467	4.5	0.30	350 - 700	0.70/17.9
PAF2A-7B	7.5	5.0	1.62	1225	0.667	4.5	0.30	600 - 1050	0.70/17.9
PAF2A-7C	7.5	10.4	1.42	521	1.387	4.5	0.30	1050 - 1620	0.70/17.9

[1] *These values are calculated using the following fibers at the specified wavelengths: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28-J9 at 1550 nm, -D: SM2000 at 1996 nm, -E: ZrF_4 Fiber at 3.39 µm.*

[2] *The max distance from the lens a Gaussian beam's waist can be placed.*

[3] *Clear Aperture*

[4] *Wavelength Range of the Antireflection Coating*

2.2.3. Long Focal Length, FC/PC or FC/APC Compatible

Item #	EFL (mm)	Input MFD[1] (µm)	Output Waist Dia. ($1/e^2$)[1] (mm)	Max Waist Dist.[1,2] (mm)	Diverg.[1] (mrad)	Lens Characteristics			Length L (in/mm)
						CA[3] (mm)	NA	AR Range[4] (nm)	
FC/PC Compatible									
PAF2P-11A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.87/22.0
PAF2P-11B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.87/22.0
PAF2P-11C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.87/22.0
PAF2P-11D	11.0	13.0	2.15	921	1.182	4.4	0.20	1800 - 2400	0.87/22.0
PAF2P-11E	11.0	14.8	3.21	1203	1.345	4.0	0.18	2000 - 5000	0.87/22.0
PAF2P-15A	15.3	3.5	2.52	5490	0.227	5.0	0.16	350 - 700	0.87/22.0
PAF2P-15B	15.3	5.0	3.33	5082	0.325	5.0	0.16	600 - 1050	0.87/22.0
PAF2P-15C	15.3	10.4	2.92	2151	0.675	5.0	0.16	1050 - 1620	0.87/22.0
PAF2P-15D	15.3	13.0	3.00	1775	0.850	5.0	0.16	1800 - 2400	0.87/22.0
PAF2P-18A	18.4	3.5	3.01	7936	0.190	5.5	0.15	350 - 700	0.87/22.0
PAF2P-18B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.87/22.0
PAF2P-18C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.87/22.0
PAF2P-18D	18.4	13.0	3.60	2564	0.707	5.5	0.15	1800 - 2400	0.87/22.0
FC/APC Compatible									
PAF2A-11A	11.0	3.5	1.80	2841	0.318	4.4	0.20	350 - 700	0.88/22.4
PAF2A-11B	11.0	5.0	2.38	2630	0.455	4.4	0.20	600 - 1050	0.88/22.4
PAF2A-11C	11.0	10.4	2.09	1115	0.945	4.4	0.20	1050 - 1620	0.88/22.4
PAF2A-11D	11.0	13.0	2.15	921	1.182	4.4	0.20	1800 - 2400	0.88/22.4
PAF2A-11E	11.0	14.8	3.21	1203	1.345	4.0	0.18	2000 - 5000	0.88/22.4
PAF2A-15A	15.3	3.5	2.52	5490	0.227	5.0	0.16	350 - 700	0.88/22.4
PAF2A-15B	15.3	5.0	3.33	5082	0.325	5.0	0.16	600 - 1050	0.88/22.4
PAF2A-15C	15.3	10.4	2.92	2151	0.675	5.0	0.16	1050 - 1620	0.88/22.4
PAF2A-15D	15.3	13.0	3.00	1775	0.850	5.0	0.16	1800 - 2400	0.88/22.4
PAF2A-18A	18.4	3.5	3.01	7936	0.190	5.5	0.15	350 - 700	0.88/22.4
PAF2A-18B	18.4	5.0	3.98	7347	0.272	5.5	0.15	600 - 1050	0.88/22.4
PAF2A-18C	18.4	10.4	3.49	3107	0.565	5.5	0.15	1050 - 1620	0.88/22.4
PAF2A-18D	18.4	13.0	3.60	2564	0.707	5.5	0.15	1800 - 2400	0.88/22.4

[1] *These values are calculated using the following fibers at the specified wavelengths: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28-J9 at 1550 nm, -D: SM2000 at 1996 nm, -E: ZrF_4 Fiber at 3.39 µm.*
[2] *The max distance from the lens a Gaussian beam's waist can be placed.*
[3] *Clear Aperture*
[4] *Wavelength Range of the Antireflection Coating*

2.3. Lens Materials

Item #	Material(s)	Lens Type
PAF2-A4A	N-SK16/N-LASF9	Cemented Achromatic Doublet
PAF2-A4B	N-LAK22/N-SF6HT	
PAF2-A4C	N-SF66/N-LASF41	
PAF2-A7A	N-BAF10/N-SF6HT	
PAF2-A7B	N-BAF10/N-SF6HT	
PAF2-A7C	N-LAK22/N-SF6	
PAF2x-A10A	N-BAK4/SF5	
PAF2x-A10B	N-LAK22/N-SF6HT	
PAF2x-A10C	N-LAK22/N-SF6	
PAF2x-A15A	N-BK7/SF2	
PAF2x-A15B	N-LAK22/N-SF6HT	
PAF2x-A15C	N-BAF10/N-SF6	
PAF2S-A4A	N-SK16/N-LASF9	
PAF2S-A4B	N-LAK22/N-SF6HT	
PAF2S-A4C	N-SF66/N-LASF41	
PAF2S-A7A	N-BAF10/N-SF6HT	
PAF2S-A7B	N-BAF10/N-SF6HT	
PAF2S-A7C	N-LAK22/N-SF6	
PAF2-2x	ECO-550	Molded Aspheric Lens
PAF2A-2x	ECO-550	
PAF2-4E	Black Diamond-2	
PAF2-5x	H-LAK54	
PAF2A-5x	H-LAK54	
PAF2-7x	H-LAK54	
PAF2A-7x	H-LAK54	
PAF2x-11x	H-LAK54	
PAF2x-11E	Black Diamond-2	
PAF2x-15x	ECO-550	
PAF2x-18x	ECO-550	
PAF2S-2x	ECO-550	
PAF2S-4E	Black Diamond-2	
PAF2S-5x	H-LAK54	
PAF2S-7x	H-LAK54	

Chapter 3 FiberPort Guide

3.1. Selection Table

The table below can be used as a selection guide to determine which FiberPort would best suit your needs. The values below are all nominal values. The *x* in the item numbers below apply to A - D versions.

Item#	EFL (mm)	Coupling Input Beam Diameter (mm)	Collimated Output Beam Diameter[1] (mm)	Best Collimation Distance at	Connector Compatibility[2]
PAF2-2x	2.0	0.3 - 0.8	0.33 - 0.43	1 - 20 cm	All FC
PAF2A-2x	2.0	0.3 - 0.8	0.33 - 0.43	1 - 20 cm	FC/APC
PAF2S-2x	2.0	0.3 - 0.8	0.33 - 0.43	1 - 20 cm	SMA
PAF2-A4x	4.0	0.8 - 1.2	0.65 - 0.87	10 cm & Beyond	All FC
PAF2S-A4x	4.0	0.8 - 1.2	0.65 - 0.87	10 cm & Beyond	SMA
PAF2-4E	4.0	1.35 - 2.1	1.17	10 cm & Beyond	All FC
PAF2S-4E	4.0	1.35 - 2.1	1.17	10 cm & Beyond	SMA
PAF2-5x	4.6	0.8 - 1.4	0.75 - 1.00	10 cm & Beyond	All FC
PAF2A-5x	4.6	0.8 - 1.4	0.75 - 1.00	10 cm & Beyond	FC/APC
PAF2S-5x	4.6	0.8 - 1.4	0.75 - 1.00	10 cm & Beyond	SMA
PAF2-7x	7.5	1.2 - 2.0	1.23 - 1.62	20 cm & Beyond	All FC
PAF2A-7x	7.5	1.2 - 2.0	1.23 - 1.62	20 cm & Beyond	FC/APC
PAF2-A7x	7.5	1.2 - 2.0	1.23 - 1.62	20 cm & Beyond	All FC
PAF2S-A7x	7.5	1.2 – 2.0	1.23 – 1.62	20 cm & Beyond	SMA
PAF2S-7x	7.5	1.2 - 2.0	1.23 - 1.62	20 cm & Beyond	SMA
PAF2P-11x	11.0	1.9 - 3.0	1.80 - 2.38	20 cm & Beyond	FC/PC
PAF2A-11x	11.0	1.9 - 3.0	1.80 - 2.38	20 cm & Beyond	FC/APC
PAF2S-11x	11.0	1.9 - 3.0	1.80 – 2.38	20 cm & Beyond	SMA
PAF2P-11E	11.0	3.7 - 5.8	3.21	20 cm & Beyond	FC/PC
PAF2A-11E	11.0	3.7 - 5.8	3.21	20 cm & Beyond	FC/APC
PAF2S-11E	11.0	3.7 - 5.8	3.21	20 cm & Beyond	SMA
PAF2P-A15x	15.0	2.8 - 4.0	2.50 - 3.31	30 cm & Beyond	FC/PC
PAF2A-A15x	15.0	2.8 - 4.0	2.50 - 3.31	30 cm & Beyond	FC/APC
PAF2P-15x	15.3	2.8 - 4.0	2.50 - 3.31	30 cm & Beyond	FC/PC
PAF2A-15x	15.3	2.8 - 4.0	2.50 - 3.31	30 cm & Beyond	FC/APC
PAF2S-15x	15.3	2.8 - 4.0	2.50 - 3.31	30 cm & Beyond	SMA
PAF2P-18x	18.4	3.4 - 4.7	3.01 - 3.98	30 cm & Beyond	FC/PC
PAF2A-18x	18.4	3.4 - 4.7	3.01 - 3.98	30 cm & Beyond	FC/APC
PAF2S-18x	18.4	3.4 - 4.7	3.01 - 3.98	30 cm & Beyond	SMA

[1] *These values are calculated using the following fibers at the specified wavelengths: -A: 460HP at 450 nm, -B: 780HP at 850 nm, -C: SMF-28-J9 at 1550 nm, -D: SM2000 at 1996 nm, -E: ZrF_4 Fiber at 3.39 µm.*

[2] *The PAF2-2x, PAF2-4x, PAF2-5x, PAF2-7x, PAF2-A4x, and PAF2-A7x FiberPorts have a straight FC bulkhead that will work with FC/PC and FC/APC connectors.*

3.2. Selection Example

The example presented here details the steps needed to ensure proper selection of a FiberPort to match the requirements of a particular fiber. For specific recommendations, please contact techsupport@thorlabs.com.

- Fiber: P1-630A-FC-2
- Collimated Beam Diameter Prior to Lens: Ø3 mm
- Wavelength: 633 nm

The specifications for the P1-630A-FC-2, 633 nm, FC/PC single mode patch cable indicate that the mode field diameter (MFD) is 4.3 µm at 633 nm. The MFD should be matched to the diffraction-limited spot size Φ_{spot}, which is given by the following equation:

$$\phi_{spot} = \frac{4\lambda f}{\pi D}$$

Here, *f* is the focal length of the lens, λ is the wavelength of the input light, and *D* is the diameter of the collimated beam incident on the lens. Solving for the desired focal length of the collimating lens yields:

$$f = \frac{\pi D(\mathrm{MFD})}{4\lambda} = \frac{\pi(0.003\ \mathrm{m})(4.3\times10^{-6}\ \mathrm{m})}{4(633\times10^{-9}\ \mathrm{m})} = 0.016\ \mathrm{m} = 16\ \mathrm{mm}$$

Thorlabs offers a large selection of FiberPorts. Of our available FiberPorts, note that Item # PAF2P-15A features a focal length closest to 16 mm while also fulfilling fiber connector and AR coating range requirements, as specified in Chapter 2. This FiberPort also has a clear aperture that is larger than the collimated beam diameter. Therefore, this is the best option given the initial parameters (*i.e.*, a P1-630A-FC-2 single mode fiber and a collimated beam diameter of 3 mm).

Remember, for optimum coupling the spot size of the focused beam must be less than the MFD of the single mode fiber. As a result, if a FiberPort is not available that provides an exact match, then choose the FiberPort with a focal length that is shorter than the calculation above yields. Alternatively, if the clear aperture of the lens is large enough, the beam can be expanded before the lens to reduce the spot size of the focused beam.

Please note that the NA listed in Section 2.1 and Section 2.2 is the NA of the lens, not the required numerical aperture of the fiber you are using. As long as the effective lens NA (calculated from the lens EFL and incoming beam diameter) is smaller than the NA of your fiber, you should be able to maximize the light coupled into your fiber. For best results, Thorlabs recommends using the equations above when choosing a FiberPort.

3.3. AR Coatings

Thorlabs offers FiberPort models with our -A (350 - 700 nm), -B (600 - 1050 nm), -C (1050 - 1620 nm), -D (1800 - 2400 nm), or -E (2000 - 5000 nm) AR coatings. The plot below shows the typical per-surface reflectance of each AR coating. Each coating is available in FC/PC-, FC/APC-, and SMA-terminated versions, except for the E coating, which is available in FC/PC- and SMA-terminated versions. Care should be taken in selecting a FiberPort to make sure the correct fiber/connector/FiberPort combination is selected. If you need assistance, please contact techsupport@thorlabs.com.

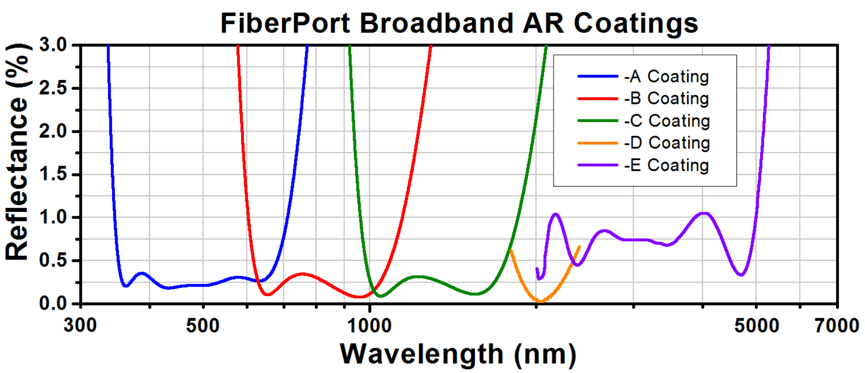

Figure 4 Available FiberPort AR Coatings

Chapter 4 Pre-Alignment

Note: A new FiberPort comes pre-aligned with no additional pre-alignment necessary for collimation. Each FiberPort is aligned for the wavelength that is specified in its mechanical drawing, available on the web. The following instructions should be followed if the FiberPort has been adjusted since purchase, or if you are operating under different conditions than the intended collimation provides (such as a different input wavelength than the factory alignment). Before attempting to collimate or couple fiber with your FiberPort, it is crucial to ensure that the FiberPort is properly aligned. If your FiberPort has been adjusted since purchase, please follow the steps below to provide the best performance.

4.1. Aligning the Tilt Plate

With the laser off, center the lens by eye in the tilt plate aperture by turning the X and Y adjustment screws. Turn the Zθ adjusters counter-clockwise until the tilt plate is flat against the FiberPort body and orthogonal to the beam axis. This must be done fairly precisely and can be achieved one of the following ways:

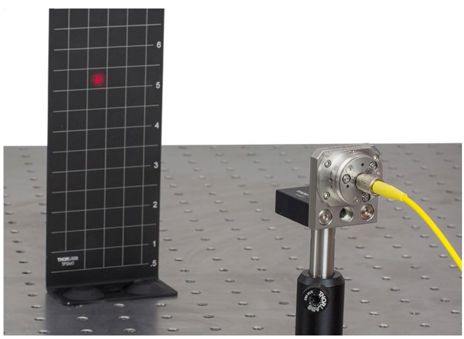

Figure 5 Aligning the Tilt Plate by Utilizing an Alignment Grid

4.1.1. Using Input Laser (Recommended)

1. Securely mount the FiberPort so it does not move during alignment.
2. Turn the Zθ adjusters counter-clockwise until it is clear that they are no longer translating the tilt plate.
3. Insert a visible fiber laser.
4. Aim the beam at an alignment screen.
5. Turn each Zθ adjuster clockwise until the beam position is affected. Once each adjuster has just begun to affect position, the adjusters are in contact with the tilt plate. If done carefully, the tilt plate is still flush against the body of the FiberPort and is orthogonal to the optical axis.

4.1.2. With No Input Laser

1. If you are familiar with FiberPorts, or if you are using a FiberPort with a 2.0 - 5.0 µm coating, it is possible to align the tilt plate by feel alone.
2. Turn the Zθ adjusters counter-clockwise until it is clear that they are no longer translating the tilt plate.
3. Carefully turn the Zθ adjusters clockwise until the resistance on the turn increases.
4. The adjusters are contacting the tilt plate when resistance is first met. If done carefully, the tilt plate is still flush against the body of the FiberPort and orthogonal to the optical axis.

Chapter 5 Collimating Out of Fiber

1. Start with a pre-aligned FiberPort, as discussed in Chapter 4.
2. Measure the beam diameter, once from close to your source, and once downstream to check your collimation. The further from the source you measure, the easier it is to view the difference in beam diameter. Uniformly turn the Zθ adjusters clockwise by aligning your ball driver with the adjusters so that the number of rotations can be counted. Each adjuster must receive the same number of rotations to ensure the lens remains orthogonal to the beam axis and beam quality is preserved.

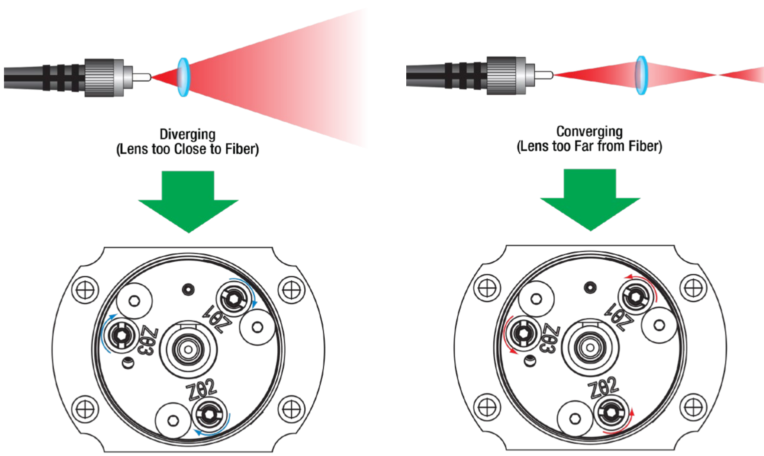

Figure 6 If the beam is diverging, the lens is too close to the fiber, and the Zθ adjusters should be turned clockwise. If the beam is converging, the lens is too far from the fiber, and the Zθ adjusters should be turned counterclockwise.

3. After each set of adjustments, measure the beam diameter from the same locations in step 2. If the beam is converging, the lens is too far away from the fiber. If the beam is diverging, the lens is too close to the fiber. Adjust the Zθ adjusters according to the diagram above. Once the downstream beam diameter is approximately equal to the beam's diameter near the source, your beam is collimated and ready for the next alignment steps.

Chapter 6 Coupling into a Fiber

6.1. Principle

While translation in the X-direction and Y-direction can be directly made by using their respective adjusters, translation in the Z-direction must be made by incremental tip/tilt adjustments. As a result, the beam's path as the adjusters are turned may not be intuitive. Equal rotations to each of the Zθ adjusters result in the beam spot tracing a triangle around the core of the fiber, as illustrated below. Once some measureable output exists, a typical alignment strategy would consist of turning each screw to maximize the output, and then continuing to turn slightly beyond maximum (about 95% of your local max). The maximum seen in passing will continue to increase until lens-to-fiber spacing is optimized (spot size is minimized). This strategy has the effect of translating the beam in a triangle of decreasing width with each set of adjustments. The beam's path is shown with the point of view of the fiber that is being coupled into.

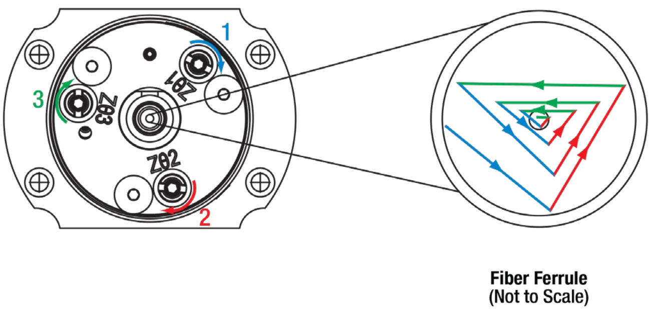

Figure 7 When turning each Zθ adjuster by equal increments, the beam traces a triangular pattern of changing width. The maximum power is seen not at either end of each turn's travel range, but in the middle when the beam is closest to the fiber's core.

Note that the typical maximum coupling efficiency is highly dependent on the system configuration and setup. A perfect system and setup can yield efficiencies up to ~90% with fibers that are not AR coated. Slight system alignment error and/or less than ideal system components that are common in most configurations make 70% - 80% coupling efficiency the typical value. Efficiencies below 50% may indicate significant component mismatch or alignment error.

6.2. Fiber Coupling

1. Start with a pre-aligned FiberPort, as discussed in Chapter 4. With the system turned on, the laser should be visible through the connector end of the FiberPort (if using a visible laser).
2. Insert a multimode (MM) fiber that is compatible with your system. Plug the fiber that is being coupled into a power meter. First maximize the X and Y positions by adjusting the X and Y adjusters and observing where the intensity peaks for each position. If large adjustments (>1 turn) are necessary, check incoming beam alignment. Once a maximum is reach, these adjusters should not be changed unless SM fiber is later used.
3. Turn each Z adjuster clockwise to maximize the output, then continue to turn slightly beyond maximum (to about 95% of your local maximum). If turning an adjuster clockwise decreases output, skip that adjuster for that round of adjustments. Repeat.
4. Once the local maxima values begin to decrease, reverse the direction, and turn each adjuster to maximize the output, and not beyond.
5. If coupling into a SM fiber, exchange the MM fiber with a SM fiber. The intensity measured by the power meter will likely drop significantly.
6. Repeat Steps 3 and 4. The adjustments will be smaller and more sensitive. If adjustment of all screws in either direction lowers the output, the beam spot may be centered on the fiber core, but improperly focused. Turn each adjuster a small amount (1/8th turn) in the same direction, then maximize each Zθ adjuster. If the new maximum is lower than the previous, turn each Zθ adjuster a small amount in the other direction and maximize. Repeat until absolute maximum is found.
7. (Optional) If desired, the adjusters can be locked via the locking collars by the use of the included SPW403 spanner wrench. Additionally, the lens cell can be locked in place by installing the included 0-80 screw located in the 4:30 position of the front face of the FiberPort. See Chapter 8 for detailed instructions.

6.3. Coupling Light from a HeNe Laser

To couple light from a HeNe laser into a FiberPort using an HCL adapter, first attach the HCL to the HeNe laser using the 4-40 (M4) cap screws provided but do not fully tighten the screws. Next, attach the FiberPort to the HCL, and again, do not fully tighten the screws. Maximum coupling can be achieved by adjusting these screws to center the beam into the FiberPort, while monitoring the output from the FiberPort (with no fiber attached). After the FiberPort is attached to the HeNe laser, the alignment procedure from Section 6.2 should be followed.

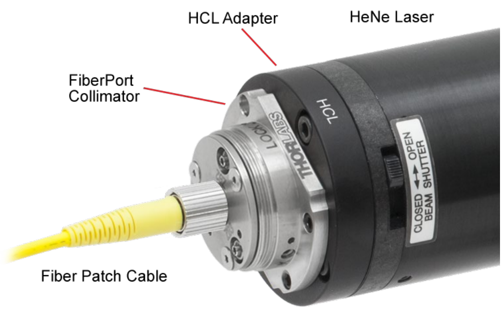

Figure 8 HCL Adapter Used to Connect the FiberPort to a HeNe Laser

When using the HNLS008 series of self-contained HeNe lasers, the HCL2 adapter should be used instead. This adapter attaches to the front of the HeNe using the 5/8”-32 threaded aperture. However, the HCL2 also features the slip-plate design of the HCL, and so the coupling procedure is similar. Simply thread the adapter onto the front of the HeNe, and then follow the procedures outlined above.

Figure 9 HCL2 Adapter Used to Connect the FiberPort to the HNLS008L Laser

Chapter 7 FiberPort and FiberBench Example

This chapter provides an example of how to collimate light between two FiberPorts when mounted to a single-axis FiberBench.

Figure 10 Two FiberPorts Mounted on a Single-Axis

Rough Alignment

1. Ensure your FiberPorts are aligned. Please see Chapter 4.
2. Assemble the FiberBench with both ports on the FiberBench facing each other as shown to the right. FiberBenches are designed to provide precisely aligned mounts ready to accept FiberPorts. Ensure your system is aligned before continuing.
3. **Collimate beam from input FiberPort:** Attach an optical fiber to the input FiberPort in order to launch light into the FiberBench. Adjust the three Z adjuster screws in **equal amounts** to collimate the beam out of the fiber (see Chapter 5). It may only require very small adjustments. A mirror can be used to direct the beam off the FiberBench for more precise collimation.
4. **Center Beam on Output FiberPort:** Once collimation is achieved, use X-Y screws to steer the beam to the center of the output FiberPort. An iris or pinhole attached to the output FiberPort mount can be used to ensure alignment to the system optical axis.
5. **Center Output FiberPort:** Repeat Step 4 for the output FiberPort, launching light backward through the output fiber.

Fine Tuning

1. **Start with a Multimode Fiber for Coarse Alignment (see 6.2, step 2):** The large core, relative to single mode fiber, allows for easy coupling and good practice for the feel of the FiberPort. This also helps to understand how quickly one can go out of alignment. *Note:* It does not help to use multimode fiber on the input port.
2. **Check Output Power:** Connect the output fiber to a suitable detector to monitor the power coupled into the output fiber. Some power should be present (possibly only 10 - 250 nW). If there is no measurable power, make small adjustments to the X-Y screws (<1 turn). If large adjustments are necessary, check incoming beam alignment.
3. **Optimize Coupling (see 6.2 step 3):** Once you have a measurable signal from the output fiber, you can improve the alignment/coupling by making Z adjustments and monitoring the power level on the detector.
4. **Switch to SM Fiber (see 6.2 steps 4 & 5):** Once the alignment is optimized for MM, you can switch to using SM fiber on the output FiberPort.

Chapter 8 Locking the FiberPort

CAUTION

Most applications DO NOT require locking.

If you are leaving the FiberPort on a table, it does not need to be locked. Typically, an aligned FiberPort can be hand carried and moved without causing alignment changes. The locking process can cause a shift in the alignment of the FiberPort. For situations where the FiberPort might undergo large vibrations or shock, such as shipping, we recommend locking or potting the FiberPort. Locking the FiberPort is an iterative process requiring patience. The locking screw pushes the lens cell firmly against the X and Y screws. If the locking screw is tightened too quickly, the alignment of the FiberPort magnetic lens cell (MLC) will be shifted.

When locking the position of the MLC using the procedure below, monitor the position of the beam if the FiberPort is being used as a collimator. If the FiberPort is being used to couple light into a fiber, attach a suitable optical detector to the output end of the fiber and monitor the output signal of the detector during the locking process. In either case, make sure that the locking process does not change the alignment of the MLC.

1. Carefully thread the small locking screw into the FiberPort at the 7:30 o'clock position on the outer diameter.
2. As you slowly tighten the locking screw, adjust the X-Y screws as required to maintain the alignment. DO NOT torque down any of the screws. Applying too much pressure with the screws can permanently damage the magnet/lens assembly, the 0-80 screws, and/or destroy the alignment. When the X,Y, and locking screws are just snug, the lens is locking in place.
3. To prevent accidental changes with the Zθ adjusters, carefully tighten the locking collars with the spanner wrench (Item # SPW403) while holding each adjuster with the 0.050" hex key/ball driver. Make minor adjustments to the adjusters as necessary to maintain the alignment of the MLC. DO NOT torque down any of the screws.
4. If optimal alignment is lost when locking, first loosen the locking collars ½ turn, then loosen the adjuster screws ¼ turn each. The less the locking collars have to travel to be locked, the better. Now adjust the X-Y screws to regain optimal alignment. Repeat Steps 2 and 3.

Chapter 9 Other Accessories

HCL and HCL2 HeNe Laser Adapters

The HCL and HCL2 adapters allow a FiberPort to attach directly to the front of a HeNe laser utilizing a HeNe industry-standard four-bolt pattern, or the 5/8"-32 thread on Thorlabs' self-contained HeNe. This adapter includes the necessary 4-40 (M4) cap screws for attaching to a HeNe as well as four cap screws to attach a FiberPort. For added mounting options, the HCL features internal C-Mount threading, which is utilized on some lasers.

HCP L-Bracket Mount

The L-Bracket FiberPort mount has four 2-56 threaded holes for securing a FiberPort to the front plate. The bottom of the L-bracket can be easily attached to an optical table, a breadboard, or a post since it has 8-32 and M4 threaded holes as well as a counterbored through hole for a 1/4"-20 or an M6 cap screw.

CP08FP 30 mm Cage Mount

The CP08FP is designed to center a FiberPort inside a 30 mm cage system. The CP08FP secures to the four ER rods of a 30 mm cage assembly. Four #2-56 stainless steel socket head screws are included to secure a FiberPort to the adapter. The CP08FP has internal SM1 threading, enabling it to be used with our extensive line of lens tubes. This plate features an 8-32 tapped hole for post mounting, while the CP08FP/M has an M4 tapped hole for metric compatibility.

Multi-Axis FiberBenches

The FiberBench product selection offers platforms with support for three or more wall plates. Each table is designed so that multiple PAF2 series FiberPort fiber couplers/collimators can be used to assemble complex systems. An array of holes are positioned on the top surface to allow for the mounting of wave plates, polarizers, beamsplitters, and other optical components without the need for alignment and adjustment. The tables provide a common, compact, and stable platform for optical system designs with parallel and perpendicular beam propagation paths.

Chapter 10 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out "wheelie bin" logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility
If you do not return an "end of life" unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background
It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 11 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at **www.thorlabs.com/contact** for our most up-to-date contact information.

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