Components and Devices

Wave Optics offers a unique selection of fiber optic components. Many of our products are available with specialty single-mode or polarization maintaining fiber.

We start with an idea and work to develop devices which are easy to use and functional with an emphasis on performance. Many of these devices can be cascaded, forming the basis for larger scale systems. We also develop custom variations of these products built to customer specifications.

SINGLE-MODE COUPLERS

Fiber optic couplers are used to split light from one fiber into two with low excess loss and low backreflection. Couplers can also combine signals from two fibers into one. In larger distribution schemes, couplers are cascaded creating m x n (m input and n output) configurations.These components are generally used for signal distribution, light monitoring, and measurement applications.

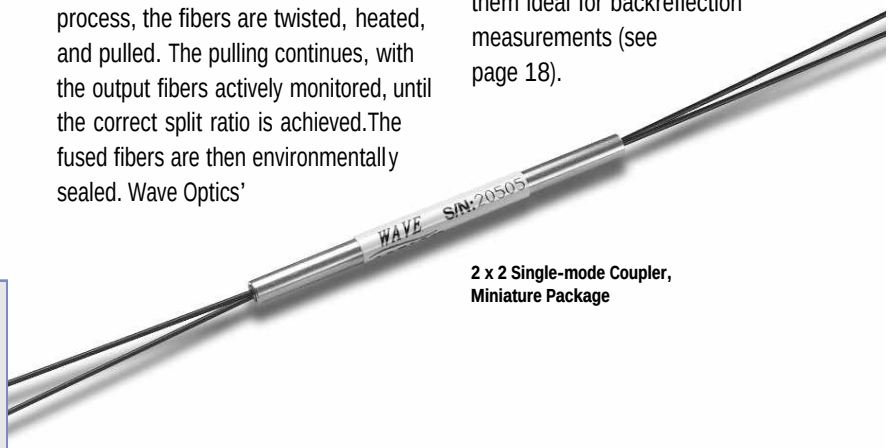
Wave Optics' Couplers.
We offer 1 x 2 and 2 x 2 fused couplers for standard single-mode fibers as well as shorter wavelength specialty fibers. Our couplers are available in bare fiber and ruggedized packaging.These passive devices are manufactured using a fused biconical taper method. In this process, the fibers are twisted, heated, and pulled. The pulling continues, with the output fibers actively monitored, until the correct split ratio is achieved.The fused fibers are then environmentally sealed. Wave Optics' fused single-mode couplers exhibit superior thermal, shock, and vibration characteristics as well as a wide operating range.

Because the fibers are never broken in our fused couplers, the backreflection remains very low (<-55 dB) making them ideal for backreflection measurements (see page 18).

TECH NOTE #10

POWER LOSS

A 1 x 2 coupler can combine the signal from two optical fibers into one,but not the power. In fact,each leg of the 1 x 2 coupler exhibits the same loss regardless of the direction of light propagation.



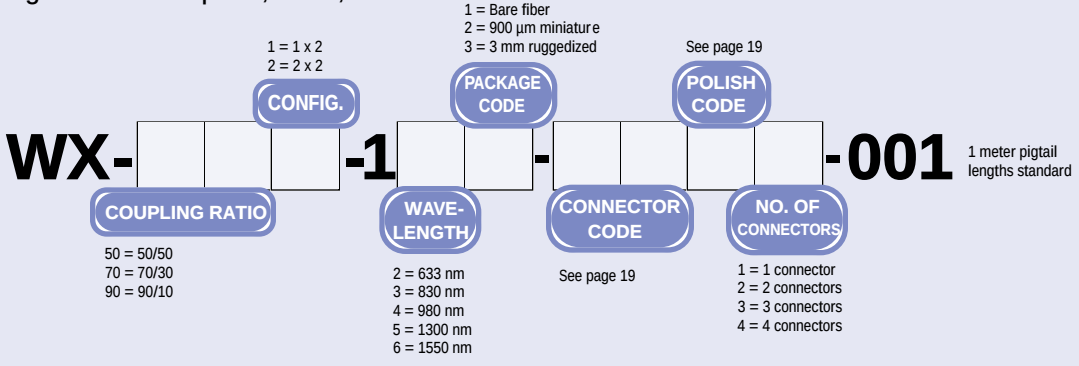
2 x 2 Single-mode Coupler, Miniature Package

Single-mode Coupler Specifications (50/50 coupling ratio)

WAVELENGTH, nm	633	830	980	1300	1550
Operating wavelength,nm	633 ± 20	830 ± 20	980 ± 20	1310 ± 50	1550 ± 50
Insertion loss*,dB,max	3.6	3.6	3.6	3.6	3.6
Uniformity, dB,max	1	1	1	0.9	0.9
Directivity**,dB,min	55	55	55	55	55
Polarization sensitivity, dB	± 0.1	± 0.1	± 0.1	± 0.1	± 0.1
Thermal stability, dB	± 0.1	± 0.1	± 0.1	± 0.1	± 0.1
Temperature	All:-20 to +70°C				
Port configuration	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2
Fiber Code (page 7)	12	13	14	15	15
Packaging:					
Miniature (length,OD)	All:65 x 4.8 mm OD				
Ruggedized (L x W x H)	All:100 x 12 x 8 mm				

** for 1x2 and 2x2 port configurations. ** 65 dB min for 2x2 port configurations.*

Ordering Information:
Single-mode Couplers, 1 x 2, 2 x 2



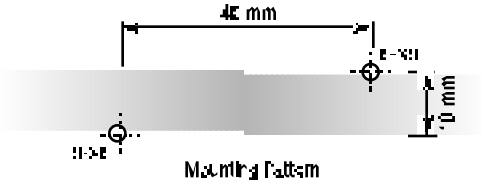
PM COUPLERS

PM couplers perform the same basic function as single-mode fiber couplers and maintain polarization.There are two common types of PM couplers: fused and polished.

Fused PM couplers are made by the heat and pull method (see page 38). Great care must be taken during the heating and pulling process to preserve the stress characteristics required for PM operation.

Polished PM couplers are made by polishing two fibers length-wise almost to the core.When the two cores are in close proximity, light will couple from one fiber to the other. This method has temperature limitations, but is suitable for indoor and lab use.

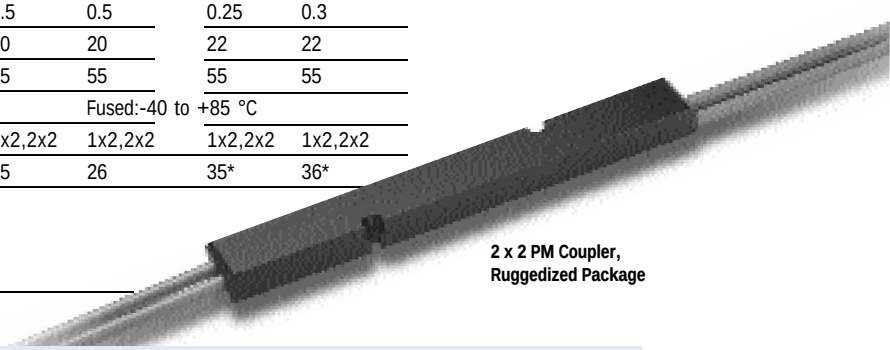
Wave Optics offers fused PM couplers for standard 1300 and 1550 nm applications. Standard and custom 2 x 2 polished PM couplers are available from 633 to 1550 nm.



PMCoupler Specifications

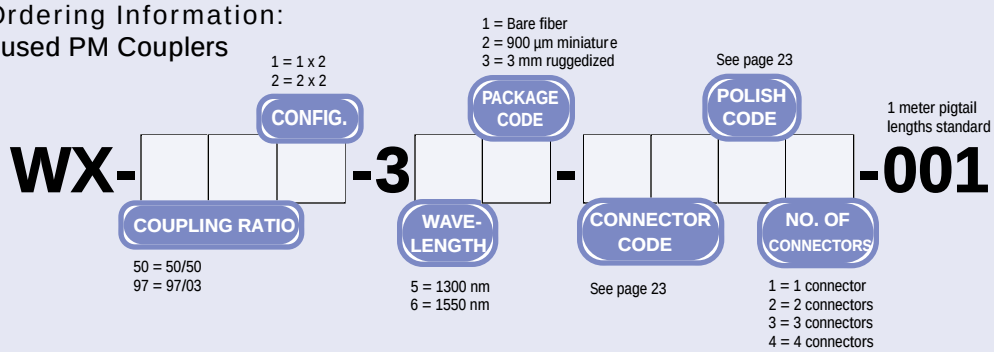
	PMPOLISHED					PM FUSED	
WAVELENGTH, nm	**633**	**830**	**1060**	**1300**	**1550**	**1300**	**1550**
Excess loss,dB,max	0.5	0.5	0.5	0.5	0.5	0.25	0.3
Polarization extinction ratio,dB,min	17	20	17	20	20	22	22
Directivity, dB,min	55	55	55	55	55	55	55
Temperature	Polished:-10 to +60 °C				Fused:-40 to +85 °C		
Port configuration	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2	1x2,2x2
Fiber Code (page 9)	72	23	74	25	26	35*	36*
Packaging:							
Miniature (length,OD)	All:65 x 4.8 mm OD (fused only)						
Ruggedized (L x W x H)	All:100 x 12 x 8 mm						

** Please verify availability before ordering.*

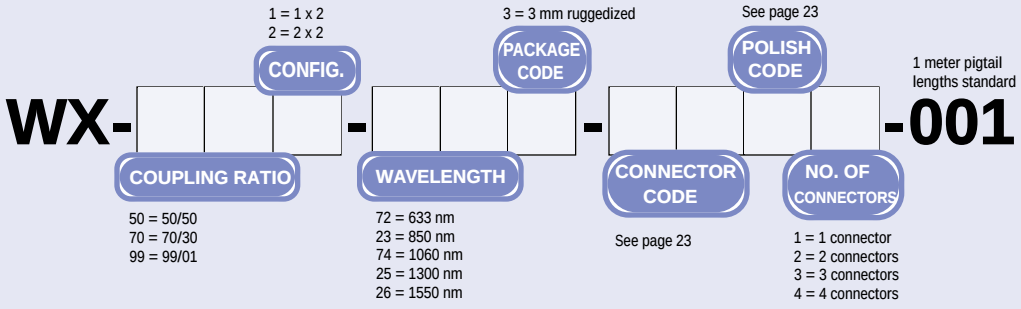


2 x 2 PM Coupler, Ruggedized Package

Ordering Information: Fused PM Couplers



Ordering Information: Polished PM Couplers

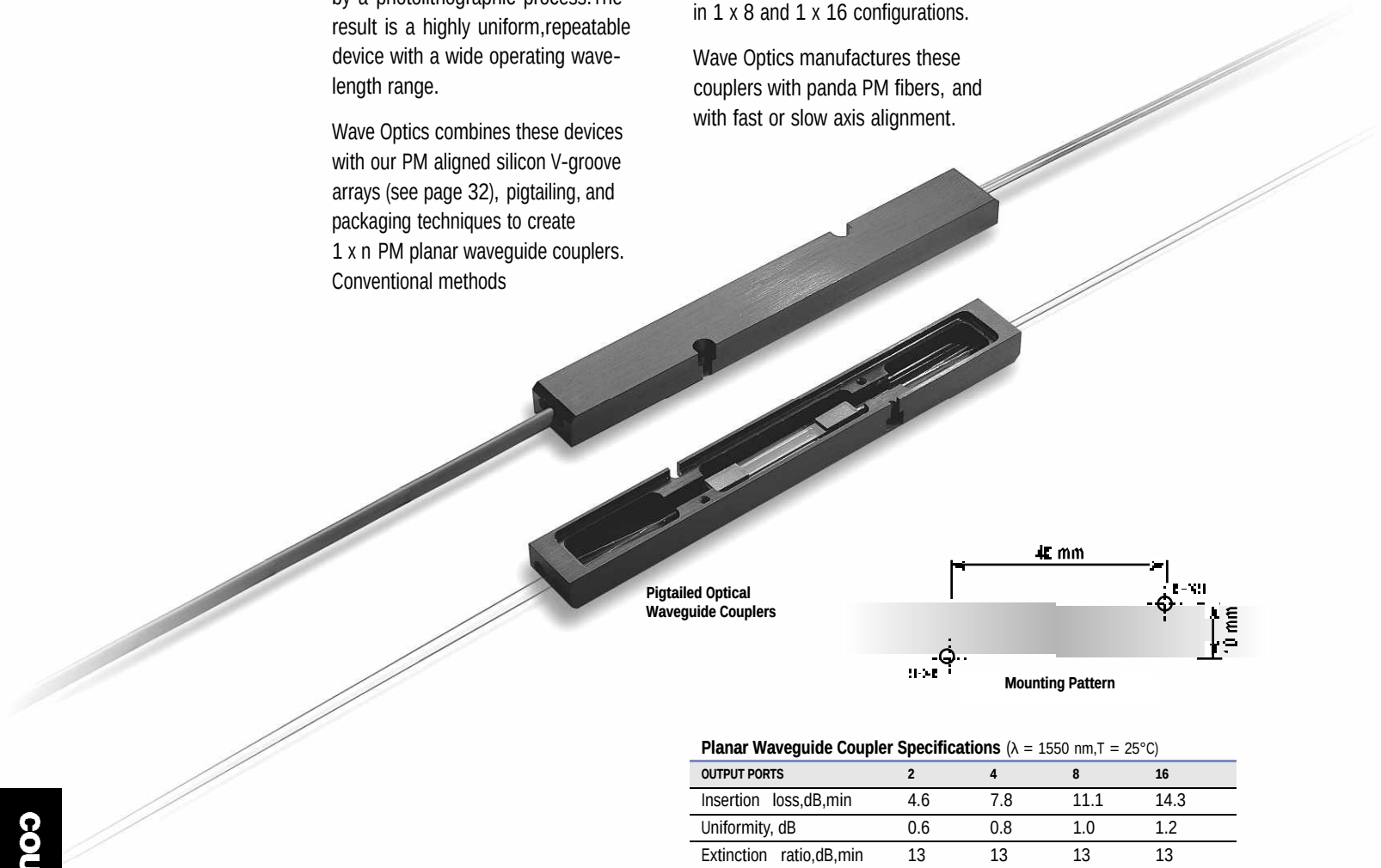


PM PLANAR WAVE-GUIDE COUPLERS

Planar waveguides are integrated optic devices containing a pattern generated by a photolithographic process.The result is a highly uniform,repeatable device with a wide operating wave-length range.

Wave Optics combines these devices with our PM aligned silicon V-groove arrays (see page 32), pigtailing, and packaging techniques to create 1 x n PM planar waveguide couplers. Conventional methods of cascading fused 1 x 2 PM couplers become complicated due to unpredictable stress patterns generated at each fusion junction.The advantage of PM planar waveguide couplers is especially evident in 1 x 8 and 1 x 16 configurations.

Wave Optics manufactures these couplers with panda PM fibers, and with fast or slow axis alignment.



Pigtailed Optical Waveguide Couplers

Mounting Pattern

Planar Waveguide Coupler Specifications (λ = 1550 nm,T = 25°C)

OUTPUT PORTS	2	4	8	16
Insertion loss,dB,min	4.6	7.8	11.1	14.3
Uniformity, dB	0.6	0.8	1.0	1.2
Extinction ratio,dB,min	13	13	13	13
Temperature	All:-10 to + 65 °C			
Operating wavelength	1310 ± 50 nm,1550 nm ± 50 nm			

Ordering Information: Planar Waveguide Couplers, 1 x N

WX-[CONFIG.][CONFIG.]-[FIBER CODE][FIBER CODE]-[WAVE-LENGTH]1-[CONNECTOR CODE][CONNECTOR CODE][POLISH CODE][POLISH CODE]-[NO. OF CONNECTORS][NO. OF CONNECTORS]-001

- WAVE-LENGTH: 5 = 1300 nm; 6 = 1550 nm
- CONFIG.: 02 = 1 x 2; 04 = 1 x 4; 08 = 1 x 8; 16 = 1 x 16
- FIBER CODE: 1 = Single-mode; 2 = Panda PM
- CONNECTOR CODE: See pages 19,23
- POLISH CODE: See pages 19,23
- NO. OF CONNECTORS: 1 = 1 connector; 2 = 2 connectors; etc.
- -001: 1 meter pigtail lengths standard

Call for availability of 2 x N Couplers

POLARIZATION BEAM SPLITTER/COMBINER

Wave Optics now offers a 1 x 2 pigtailed polarization beam splitter. A polarization splitter (or combiner) splits a light signal into two orthogonal linearly polarized signals. Signals can be combined by reversing their paths back into the crystal.

The beam splitting element is a birefringent crystal.The splitter works by taking advantage of the anisotropic structure of this crystal; that is, the crystal does not have the same optical density for the two transverse propagation vectors. When a randomly polarized signal is passed through a crystal of this kind the polarization is broken up into two components relative to the optical orientation of the crystal. Both beams will emerge linearly polarized,but with polarization orientations perpendicular to each other.

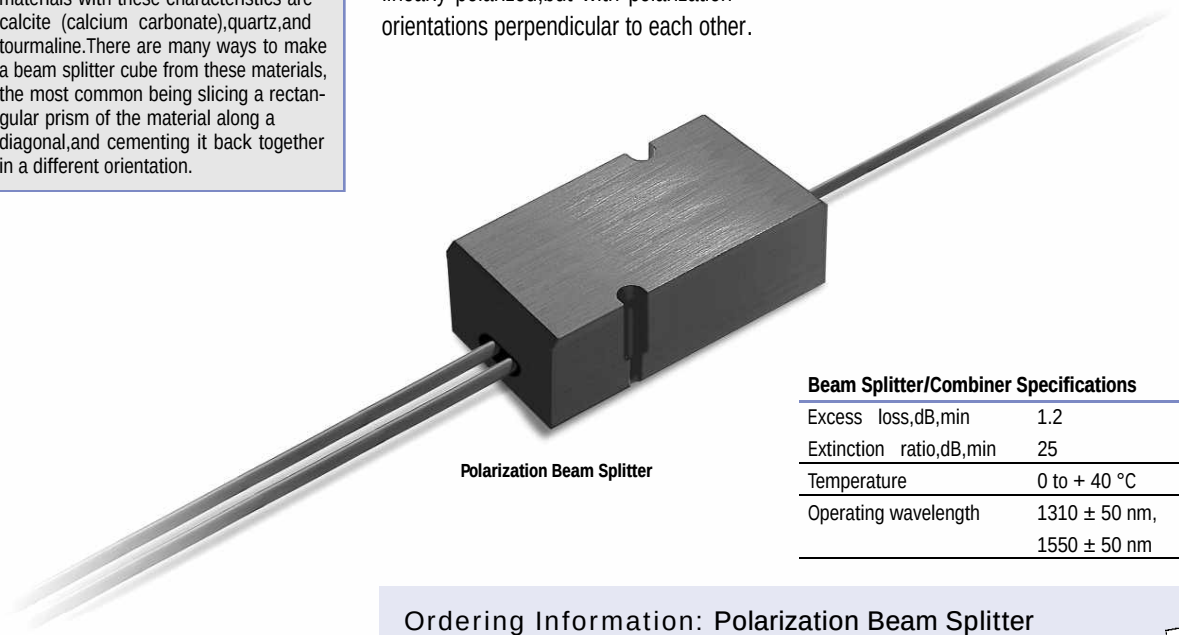
Wave Optics' splitter/combiner is designed for maximum coupling efficiency, stability, and extinction ratio. All optical surfaces are anti-reflection coated for the peak wavelength specified, and the fiber ends are angle polished. Since these components combine light through a free space beam, they can also be used as power combiners, unlike conventional fused couplers (see page 38). This splitter/combiner also has a much higher power capability than common waveguide devices (up to 1 W), making it ideal for higher power applications.

All devices are delivered with panda PM fiber in a ruggedized housing.

TECH NOTE #11

BIREFRINGENT CRYSTALS

Only certain types of crystals will exhibit birefringent behavior. Crystals must have hexagonal,tetragonal,or trigonal lattice structures to allow the light to encounter an asymmetric structure.Some common materials with these characteristics are calcite (calcium carbonate),quartz,and tourmaline.There are many ways to make a beam splitter cube from these materials, the most common being slicing a rectangular prism of the material along a diagonal,and cementing it back together in a different orientation.

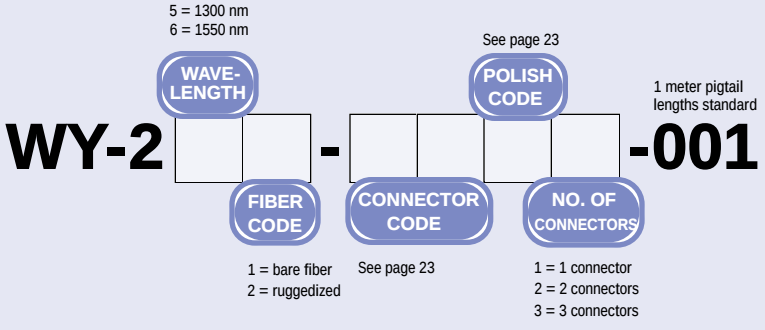


Polarization Beam Splitter

Beam Splitter/Combiner Specifications

Excess loss,dB,min	1.2
Extinction ratio,dB,min	25
Temperature	0 to + 40 °C
Operating wavelength	1310 ± 50 nm, 1550 ± 50 nm

Ordering Information: Polarization Beam Splitter



Other fibers and wavelengths are available on special orders. Call for details.

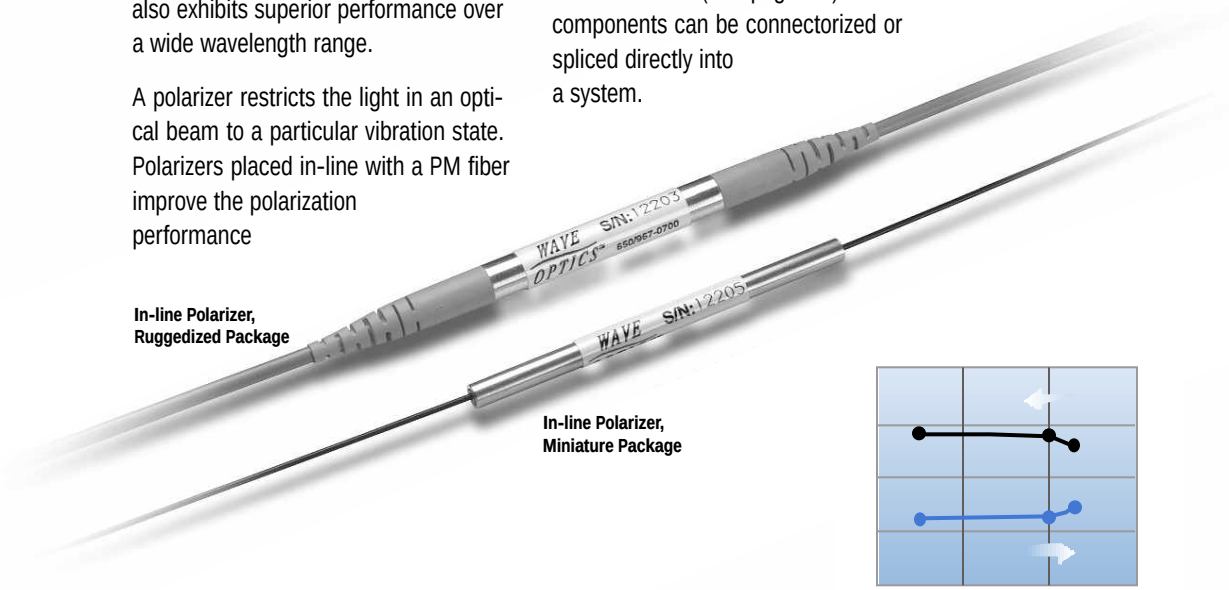
IN-LINE POLARIZERS

Wave Optics offers an in-line polarizer to improve extinction characteristics in PM fiber applications.

The Wave Optics polarizer design ensures maximum performance regardless of fiber length. Our in-line polarizer also exhibits superior performance over a wide wavelength range.

A polarizer restricts the light in an optical beam to a particular vibration state. Polarizers placed in-line with a PM fiber improve the polarization performance of the fiber. Some devices require highly polarized light to work efficiently. A degradation in polarization extinction can cause noise and limit system performance.

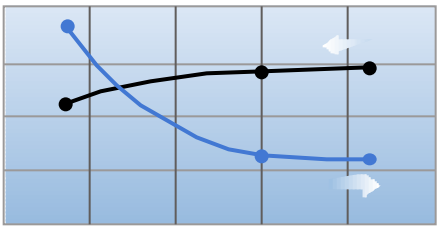
We fabricate our polarizer by aligning a linearly polarized material with the stress axis of the fiber (see page 12).These components can be connectorized or spliced directly into a system.



In-line Polarizer, Ruggedized Package

In-line Polarizer, Miniature Package

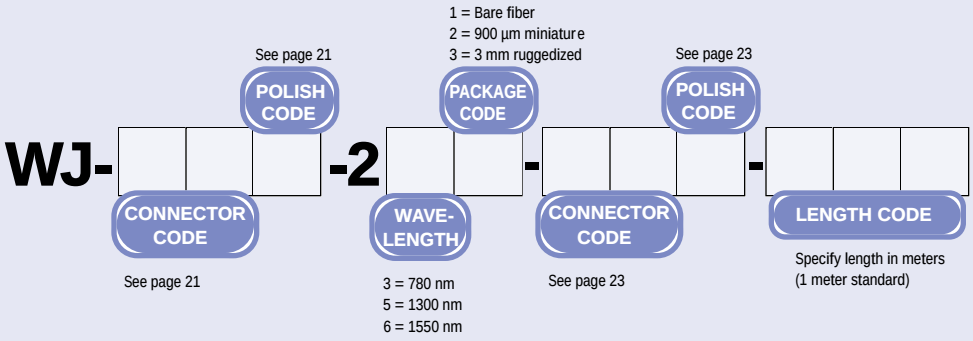
Wavelength Performance of Polarizing Material,780-830 nm



Wavelength Performance of Polarizing Material,1300-1550 nm

In-line Polarizer Specifications	
Excess loss (no connectors,slow axis launch)	
Typical	1.0 dB
Maximum	1.5 dB
Backreflection,dB	-40 typical
Extinction ratio (no connectors),fiber output,T=25°C	
Typical	30 dB
Minimum	23 dB
Package dimensions	
Miniature (length,OD)	64 mm x 4.8 mm OD
Ruggedized (length,OD)	120 mm x 7.4 mm OD
Temperature	-20 to + 70°C

Ordering Information: In-line Polarizers



PACKAGED LASER DIODES

Laser diodes are used in a wide variety of applications from laser pointers and CD players to long distance communications and laser welding. One of the limitations in working with laser diodes is that they are extremely sensitive to electrical spikes and static discharge.

To avoid damaging the lasers, they must be operated with power supplies specifically designed for this purpose.

Wave Optics has developed a series of fiber pigtailed laser diodes packaged with the drive electronics. Operation is as simple as plugging the device into an AC outlet and turning it on. These Fabry-Perot lasers are factory set and need no adjustments.The minimum output of all units is one milliwatt of continuous wave (CW) power.

We manufacture these packaged diodes with a variety of connector interfaces and in custom configurations with multiple outputs.

Packaged Laser Diode (cable assembly optional,see page 19)

Packaged Laser Diode Specifications

WAVELENGTH,nm	635	780	830	980	1310	1550
Wavelength range,nm	± 30	± 30	± 30	± 30	± 30	± 30
Minimum output power, mW	1	1	1	1	1	1
Fiber type,SM (see page 7)	WF-12	WF-13	WF-13	WF-14	WF-15	WF-15
Power requirements	All:120 VAC,500 mA					
Connector interface	All: Female adapter (FC/PC,FC/APC)					
Package dimensions (L x W x H)	All:5 x 3 x 2" (130 x 80 x 50 mm)					
Temperature	All:-20 to + 70°C					

Ordering Information: Packaged Laser Diodes

WL- [ ][ ][ ] - [ ][ ][ ]

WAVELENGTH

635 = 635 nm
780 = 780 nm
830 = 830 nm
980 = 980 nm
131 = 1310 nm
155 = 1550 nm

CONNECTOR INTERFACE

10B = FC/PC
10D = FC/APC

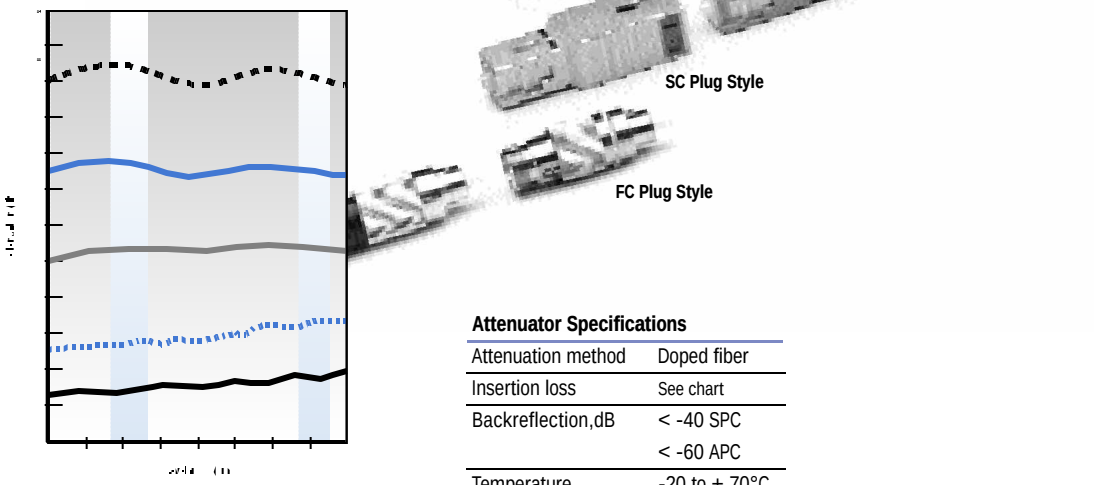
Ask about our **polarization maintaining fiber packaged laser diodes.**

PLUG STYLE ATTENUATORS

Wave Optics' new doped-fiber attenuators are male-to-female assemblies used to reduce the optical power transmitted through a fiber. The most common uses include equalizing power between fibers in multifiber systems and reducing receiver saturation, which can limit system performance.

These "plug-style" attenuators work via a small section of doped fiber placed in-line with the female and male sides of the device.The dopant is a transition metal in the internal fiber, which absorbs optical energy in a predictable and gradual way, and gradually disperses the energy as heat.The metal appears opaque to light in the operational range, and continually reduces the power along its' length.The fiber is also quite durable, withstanding 100-hour exposure tests to 100 mW light, with a variation in attenuation of only ±0.1 dB.The polarization dependent loss (PDL) is generally 0.1 dB.

We believe that the capabilities of this type of fiber, together with the convenience of the plug style, allow our attenuators to achieve performance superior to that of regular filter-style attenuators. Filter based products reduce the power at a single point limiting power handling capability. This type of attenuation also tends to have higher wavelength dependence limiting the operational wavelength range. Wave Optics plug style doped fiber attenuators are available in FC and SC styles with SPC and APC polishes at 1300 and 1550 nm.



Attenuator Wavelength Dependence

Attenuator Specifications

Attenuation method	Doped fiber
Insertion loss	See chart
Backreflection,dB	< -40 SPC < -60 APC
Temperature	-20 to + 70°C

Ordering Information: Plug Style Attenuators

WU- [ ][ ] -PLG-164- [ ][ ][ ]

- ATTENUATION: 03 = 3 dB, 05 = 5 dB, 10 = 10 dB, 15 = 15 dB, 20 = 20 dB
- CONNECTOR CODE: 10 = FC, 40 = SC
- POLISH CODE: C = SPC, D = APC

IN-LINE ATTENUATORS

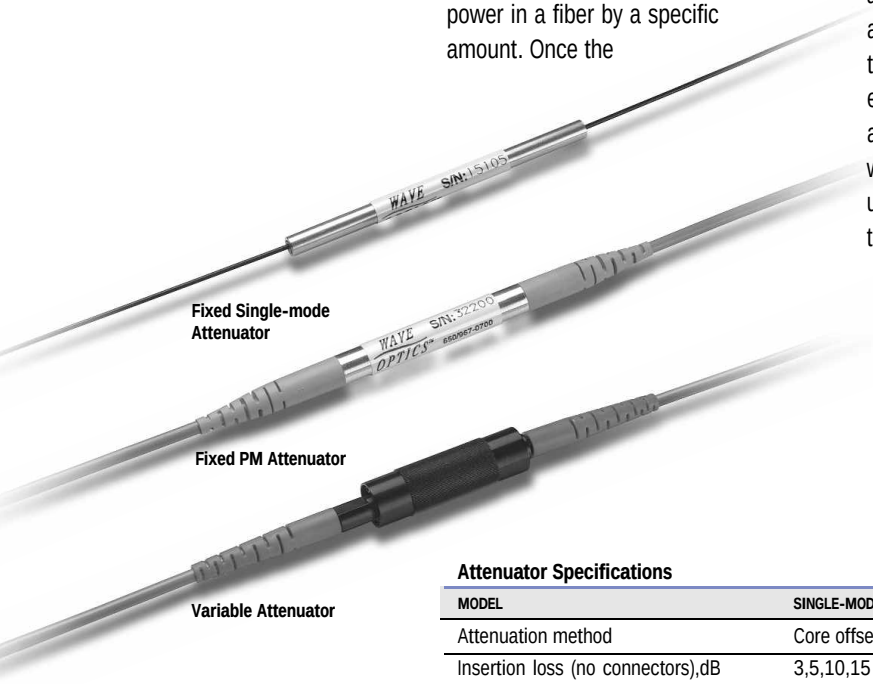
Wave Optics manufactures in-line attenuators with most of our standard single-mode or PM fibers.These attenuators are ideal for fusion splicing into a system, or as adjustment patch-cords.These products are available with bare fiber, protective tubing and ruggedized jacketing.

Fixed Attenuators.

Fixed attenuators decrease the optical power in a fiber by a specific amount. Once the optimal attenuation is determined, fixed attenuators can be built into systems with a high level of confidence. Our fiber attenuators use a core offset method and exhibit excellent temperature stability and low backreflection. PM fixed attenuators are designed to provide consistent attenuation levels as well as maintain polarization characteristics.

Variable Attenuators.

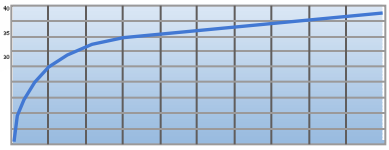
Variable attenuators are used in the same applications as fixed attenuators, with the added flexibility of adjustment. By turning the outer housing, the attenuation can be easily modified.These devices are ideal for adjusting OEM systems in production as well as laboratory applications.These products also exhibit low backreflection and good temperature stability.



Fixed Single-mode Attenuator

Fixed PM Attenuator

Variable Attenuator



Variable Attenuator, 1300 nm

Attenuator Specifications

MODEL	SINGLE-MODE	PM	VARIABLE (SM & PM)
Attenuation method	Core offset	Core offset	Variable air gap
Insertion loss (no connectors),dB	3,5,10,15 ± 10%	3,5,10,15 ± 10%	1 to 35
Backreflection,dB	< -55	< -55	< -55
Extinction ratio (PM only),dB	-	18 Minimum	20 Minimum
Package dimensions:			
Miniature (length,OD)	64 x 4.8 mm OD	64 x 4.8 mm OD	95 x 11 mm OD
Ruggedized (length,OD)	64 x 4.8 mm OD	120 x 7.4 mm OD	115 x 11 mm OD
Temperature	All:-40 to + 85°C SM,-20 + 70°C PM		
Resolution	-	-	0.25 dB (1 to 5 dB)
	-	-	0.1 dB (5 to 35 dB)

Ordering Information:
In-Line Attenuators