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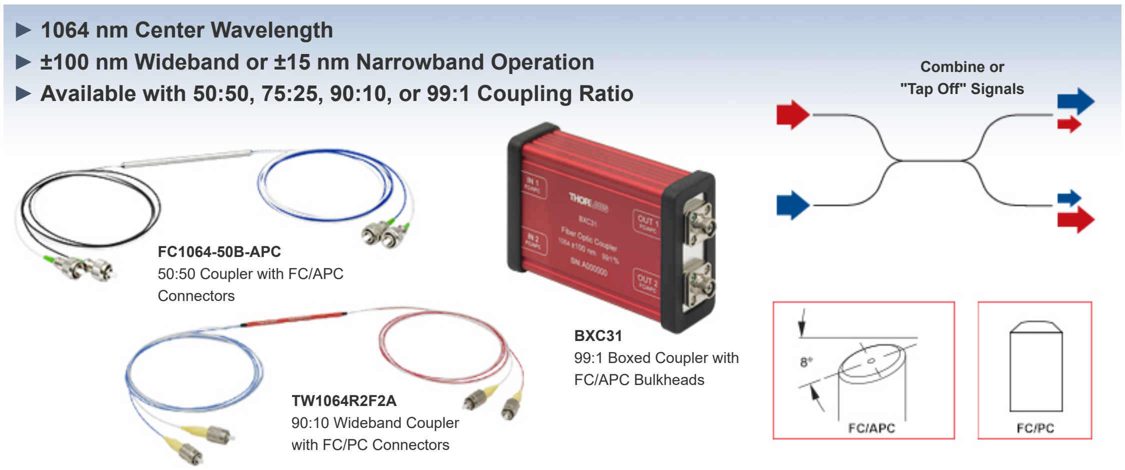
FC1064-90B-APC - JUN 03, 2021

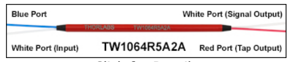
Item # FC1064-90B-APC was discontinued on JUN 03, 2021. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

1064 NM, SINGLE MODE FUSED FIBER OPTIC COUPLERS / TAPS



OVERVIEW

Features



Click for Details
A coupler in a standard stainless steel tube housing is shown above, while an example aluminum box housing is shown to the lower right. Specifications below are given for the case where the white (standard housing) or IN 1 (box housing) port is used as the input.

- 1064 nm Fiber Couplers with 50:50, 75:25, 90:10, or 99:1 Split Ratio
- Two Wavelength Ranges Available:
  - ±100 nm Wideband with 0.14 NA or 0.22 NA Fiber
  - ±15 nm Narrowband with 0.14 NA or 0.22 NA Fiber
- Bidirectional Coupling (Either End Can Be Used as an Input)
- Versions Contained in Durable Aluminum Boxes Available
- Couplers Shipped with Individual Test Reports (See the *Coupler Verification* Tab for Details on Wideband Coupler Testing)
- Contact Us for Custom Wavelength, Coupling Ratio, and Connector Options

Animated example of 90:10 splitting and 50:50 mixing.

2x2 SM Fiber Optic Couplers			
Center Wavelength	**Bandwidth**	**Center Wavelength**	**Bandwidth**
405 nm	±5 nm	930 nm	±100 nm
470 nm	±40 nm		
488 nm	±15 nm	980 nm	±15 nm
532 nm	±15 nm	1064 nm	±100 nm
560 nm	±50 nm		±15 nm
	±15 nm	1300 nm	±100 nm
630 nm	±50 nm	1310 nm	±15 nm
632 nm	±15 nm	1430 nm	±100 nm
670 nm	±75 nm	1550 nm	±100 nm
785 nm	±15 nm		±15 nm
805 nm	±75 nm	1650 nm	±100 nm
808 nm	±15 nm	2000 nm	±200 nm
830 nm	±15 nm	1310 nm/ 1550 nm	±40 nm
850 nm	±100 nm		

Boxed Options

Click to Enlarge
Any of our couplers can be packaged in an aluminum housing such as the one shown here for a 1064 nm coupler. Contact Tech Support with inquiries.

Thorlabs offers a wide range of wideband and narrowband single mode 2x2 fused fiber optic couplers, as highlighted in the table to the right. Couplers featuring a center wavelength of 1064 nm are available below. All the couplers on this page are bidirectional, allowing any port to be used as an input (refer to the *2x2 Coupling Examples* tab above).

These couplers are available with a coupling ratio of 50:50, 75:25, 90:10, or 99:1 and are available with HI1060 or HI1060 FLEX fiber. HI1060 fiber offers a Ø5.3 µm core size and a 0.14 NA, while HI1060 FLEX fiber offers a Ø3.4 µm core size, a 0.22 NA, and reduced bending loss relative to HI1060.

Our wideband couplers are designed for a flat spectral response over a ±100 nm operating range. In particular, wideband couplers with a center wavelength of 1064 nm are ideal for use in optical coherence tomography (OCT) applications. Narrowband couplers have a smaller operating range, but offer improved coupling ratio tolerance at the center wavelength relative to wideband couplers.

Thorlabs provides an individual test data sheet with each coupler. Our wideband couplers feature a detailed test report that includes coupling data and performance graphs that extend outside of the specified bandwidth, covering the wavelength range where the coupling ratio remains within the specified tolerance. Details of our wideband coupler testing procedures are provided on the *Coupler Verification* tab and sample data sheets for our 1064 nm standard wideband, boxed wideband, and narrowband couplers are available. Our couplers have undergone extensive testing to ensure they meet or surpass Telcordia requirements; please see the *Reliability Testing* tab for details.

Standard Couplers are offered from stock with 2.0 mm narrow key FC/PC or FC/APC connectors. These couplers can accept up to 1 W of power (total power passing through the component) when connectors or bare fiber are used at the inputs and outputs or up to 5 W when spliced into a setup; if higher power operation is needed, single mode couplers for 970 to 1070 nm that can handle up to 50 W of total power are also available. Fiber leads on our standard couplerps are 0.8 m long and jacketed in Ø900 µm Hytrel® tubing. When the white port is used as the input, the coupling ratios listed below correspond to the ratio of the output power from the white port (signal output) to the red port (tap output), as shown in the image above.

Boxed couplers are available in a durable aluminum housing with 2.0 mm narrow-key FC/APC bulkheads and can accept up to 1 W of total power. The housings can be stacked using the EPS225 plastic clamp, or mounted to a Ø1/2" post using ECM100 or ECM225 aluminum clamps sold below. For boxed couplers, when the IN 1 port is used as the input, the coupling ratios listed below correspond to the ratio of the output power from OUT 1 (signal output) to OUT 2 (tap output).

Custom coupler configurations with other wavelengths, fiber types, coupling ratios, port configurations, or housing options are also available. Please contact Tech Support for inquiries.

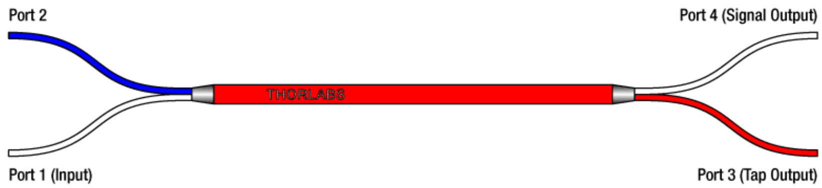
Our complete selection of 2x2 SM couplers is outlined in the table to the right and on the *SM Coupler Guide* tab. Thorlabs also offers fiber optic couplers for 1064 nm in a 1x2 configuration; they can be found here.

Alternative Fiber Coupler & Splitter Options											
Double-Clad Couplers	**Single Mode Couplers**			**Single Mode PLC Splitters**		**Multimode Couplers**		**Polarization-Maintaining Couplers**			**Wavelength Division Multiplexers (WDM)**
2x2	1x2	2x2	1x4	1x8	1x16	1x2	2x2	1x2	2x2	1x4	

2X2 COUPLER TUTORIAL

Definition of 2x2 Fused Fiber Optic Coupler Specifications

This tab provides a brief explanation of how we determine several key specifications for our 2x2 couplers. The ports of the coupler are defined as shown in the coupler schematic below. In the sections below, the light is input into port 1. Port 3 and port 4 would then be considered the signal and tap outputs, respectively.



Excess Loss

Excess loss in dB is determined by the ratio of the total input power to the total output power:

$$\text{Excess Loss}(dB) = 10\log\frac{P_{port1}(mW)}{P_{port3}(mW) + P_{port4}(mW)}$$

P_{port1} is the input power at port 1 and $P_{port3}+P_{port4}$ is the total output power from ports 3 and 4, assuming no input power at port 2. All powers are expressed in mW.

Polarization Dependent Loss (PDL)

The polarization dependent loss is defined as the ratio of the maximum and minimum transmissions due to polarization states in couplers. This specification pertains only to couplers not designed for maintaining polarization. PDL is always specified in decibels (dB), and can be calculated with the following equation:

$$\text{Polarization Dependent Loss}(dB) = 10\log\frac{P_{max}(mW)}{P_{min}(mW)}$$

where P_{max} is the maximum power able to be transmitted through the coupler when scanning across all possible polarization states. P_{min} is the minimum transmission across those same states.

Optical Return Loss (ORL) / Directivity

The directivity refers to the fraction of input light that exits the coupler through an input port (i.e., light exiting at port 2) instead of the intended output port. It can be calculated in units of dB using the following equation:

$$\text{Directivity}(dB) = 10\log\frac{P_{port1}(mW)}{P_{port2}(mW)}$$

where P_{port1} and P_{port2} are the optical powers (in mW) in port 1 and port 2, respectively. This output is the result of back reflection at the junction of the legs of the coupler and represents a loss in the total light output at ports 3 and 4. For a 50:50 coupler, the directivity is equal to the optical return loss (ORL).

Insertion Loss

The insertion loss is defined as the ratio of the input power to the output power at one of the output legs of the coupler (signal or tap). Insertion loss is always specified in decibels (dB). It is generally defined using the equation below:

$$\text{Insertion Loss}(dB) = 10\log\frac{P_{in}(mW)}{P_{out}(mW)}$$

where P_{in} and P_{out} are the input and output powers (in mW). For our 2x2 couplers, the insertion loss specification is provided for both signal and tap outputs; our specifications always list insertion loss for the signal output first. To define the insertion loss for a specific output (port 3 or port 4), the equation is rewritten as:

$$\text{Insertion Loss}_{port1\rightarrow port3}(dB) = 10\log\frac{P_{port1}(mW)}{P_{port3}(mW)}$$

$$\text{Insertion Loss}_{port1\rightarrow port4}(dB) = 10\log\frac{P_{port1}(mW)}{P_{port4}(mW)}$$

A similar equation can be used to define the insertion loss at port 2 for input at port 1. However, as seen above, this is already defined as the directivity of the coupler.

Insertion loss inherently includes both coupling (e.g., light transferred to the other output leg) and excess loss (e.g., light lost from the coupler) effects. The maximum allowed insertion loss for each output, signal and tap, are both specified. Because the insertion loss in each output is correlated to light coupled to the other output, no coupler will ever have the maximum insertion loss in both outputs simultaneously.

Calculating Insertion Loss using Power Expressed in dBm
Insertion loss can also be easily calculated with the power expressed in units of dBm. The equation below shows the relationship between power expressed in mW and dBm:

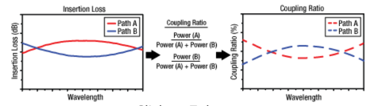
$$P(dBm) = 10\log P(mW)$$

Then, the insertion loss in dB can be calculated as follows:

$$\text{Insertion Loss}(dB) = P_{in}(dBm) - P_{out}(dBm)$$

Coupling Ratio

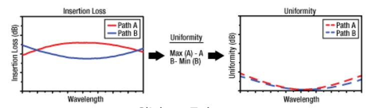
Insertion loss (in dB) is the ratio of the input power to the output power from each leg of the coupler as a function of wavelength. It captures both the coupling ratio and the excess loss. The coupling ratio is calculated from the measured insertion loss. Coupling ratio (in %) is the ratio of the optical power from each output port (A and B) to the sum of the total power of both output ports as a function of wavelength. It is not impacted by spectral features such as the water absorption region because both output legs are affected equally.



Click to Enlarge
A graphical representation of the coupling ratio calculation.

Uniformity

The uniformity is also calculated from the measured insertion loss. Uniformity is the variation (in dB) of the insertion loss over the bandwidth. It is a measure of how evenly the insertion loss is distributed over the spectral range. The uniformity of Path A is the difference between the value of highest insertion loss and the solid red insertion loss curve (in the Insertion Plot above). The uniformity of Path B is the difference between the solid blue insertion loss curve and the value of lowest insertion loss.



Click to Enlarge
A graphical representation of the Uniformity calculation.

2X2 COUPLING EXAMPLES

General Coupling Examples

Animated example of 90:10 splitting and 50:50 mixing.

2x2 fused fiber optic couplers can split or mix light between two optical fibers with minimal loss and at a specified coupling ratio. Thorlabs' couplers are available from stock in one of four ratios: 50:50, 75:25, 90:10, or 99:1. All of our fused fiber optic couplers are bidirectional, meaning that all ports can be used as an input. The animation to the right shows several simple coupling examples.

The terms "Signal Output" and "Tap Output" refer to the higher and lower power outputs, respectively. To illustrate this, if light is input into the white port of the TW1064R1A2A coupler (99:1 coupling ratio), 99% of the transmitted light is coupled into the white port on the other side of the coupler while the other 1% is coupled into the red port. In this example, the second white port is referred to as the signal output port, and the red port is referred to as a tap output port. For a 50:50 coupler, the signal and tap ports would have the same power output.

In our couplers with a red housing, the signal always propagates from blue to red or white to white, while the tap always propagates from blue to white or white to red. For other couplers, please refer to the datasheet included with the coupler to determine signal and tap propagation paths.

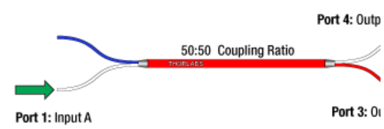
Specific Coupling Examples

In the examples below, two 2x2 1300 nm Wideband Fiber Optic Couplers (50:50 and 90:10 coupling ratios) are used with input signals A and B. The table to the right lists typical insertion loss (signal and tap outputs) for each coupler. To calculate the power at any given output, subtract the insertion loss for the signal or tap output from the input power (in dBm).

Coupling Ratio	Insertion Loss (Signal)	Insertion Loss (Tap)
90:10	0.6 dB	10.1 dB
50:50	3.2 dB	3.2 dB

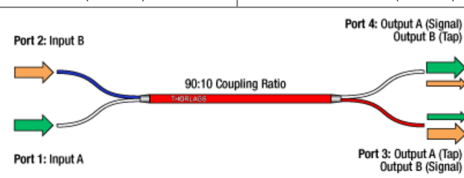
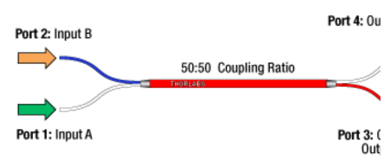
Example 1: Splitting Light from a Single Input

For this example, the couplers are used to split light from a single input into the signal and tap outputs as indicated in the diagrams below. In the table below, the output ports are highlighted in green.

	90:10 Coupling Ratio	50:50 Coupling Ratio
Port	**Signal A**	**Signal A**
1 (Input)	10 dBm (10 mW)	10 dBm (10 mW)
2 (Not Used)	-	-
3 (Tap Output)	-0.1 dBm (1.0 mW)	6.8 dBm (4.8 mW)
4 (Signal Output)	9.4 dBm (8.7 mW)	6.8 dBm (4.8 mW)
Click on the Diagram for Power Distributions at Each Port		

Example 2: Mixing Two Signals from Two Inputs

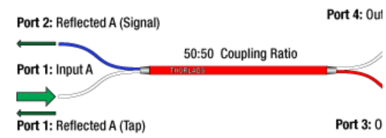
In this example, the couplers are used to mix light from two inputs, designated Signal A and Signal B. The outputs contain a mixed signal composed of both Signal A and Signal B in ratios depending on the coupling ratio. All ports are indicated in the diagrams below. In the table below, the output ports are highlighted in green.

	90:10 Coupling Ratio		50:50 Coupling Ratio	
Port	**Signal A**	**Signal B**	**Signal A**	**Sig**
1 (Input A)	5 dBm (3.2 mW)	-	5 dBm (3.2 mW)	
2 (Input B)	-	8 dBm (6.3 mW)	-	8 dBm
3 (Output)	-5.1 dBm (0.3 mW)	7.4 dBm (5.5 mW)	1.6 dBm (1.4 mW)	4.8 dBm
4 (Output)	4.4 dBm (2.8 mW)	-2.1 dBm (0.6 mW)	1.6 dBm (1.4 mW)	4.8 dBm
Click on the Diagram for Power Distributions at Each Port				

Example 3: Coupling a Return Signal with a Reflector on Port 3

Here, the couplers are used to split light from a single input, however, in this example there is a 100% reflector on port 3, as shown in the diagrams below. As a result, the light is reflected back into the coupler and split again. The ports are indicated in the diagrams below. In the table below, the output ports for the initial pass are highlighted in green.

	90:10 Coupling Ratio		50:50 Coupling Ratio	
Port	**Signal A**	**Reflected Signal A**	**Signal A**	**Refle**
1 (Input)	6 dBm (4.0 mW)	-14.2 dBm (0.04 mW)	6 dBm (4.0 mW)	-0.4
2 (No Input)	-	-4.7 dBm (0.34 mW)	-	-0.4
3 (Reflected Output)	-4.1 dBm (0.39 mW) Reflected	-	2.8 dBm (1.9 mW) Reflected	
4 (Signal Output)	5.4 dBm (3.5 mW)	-	2.8 dBm (1.9 mW)	

	90:10 Coupling Ratio	50:50 Coupling Ratio
Click on the Diagram for Power Distributions at Each Port		

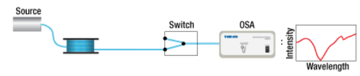
COUPLER VERIFICATION

Fiber Coupler Testing and Verification Procedure

During Thorlabs' coupling manufacturing process, the coupling ratio and bandwidth of each coupler is monitored as the two branches are fused together. This ensures that each coupler meets the stated specifications over the bandwidth. Each coupler is shipped with an individualized data sheet providing a summary of the results of these tests. Click for a sample data sheet for our 1064 nm wideband and narrowband couplers is available.

Step 1

The fiber to create the first branch (Path A) of the coupler is connected to a source on one side and a switch leading to an Optical Spectrum Analyzer (OSA) on the other.



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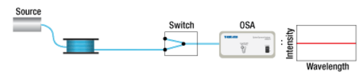
Step 2

The spectrum of the source through the fiber and switch is measured using the OSA and zeroed.



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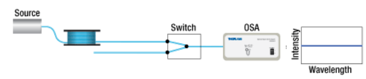
Step 3

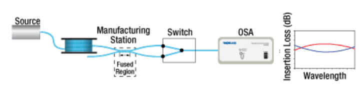
The fiber to form the second branch (Path B) of the coupler is connected to the source and to the second port of the switch leading to the OSA. The spectrum of the source through the fiber and switch is also measured and zeroed.



Click to Enlarge

Step 4

The two fibers are fused on a manufacturing station to create the coupler structure. During the fusing process, the output from both legs of the coupler is monitored on the OSA. Coupler fusing stops once the coupler reaches the desired coupling ratio, excess loss, and insertion loss specifications.



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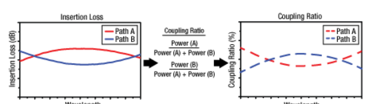
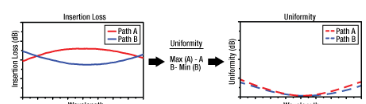
For 1x2 couplers, one of the fiber ends is terminated within the coupler housing. The termination is done in a manner that minimizes back reflections from this output.



Click to Enlarge

Insertion loss (in dB) is the ratio of the input power to the output power from each leg of the coupler as a function of wavelength. It captures both the coupling ratio and the excess loss. The coupling ratio is calculated from the measured insertion loss. Coupling ratio (in %) is the ratio of the optical power from each output port (A and B) to the sum of the total power of both output ports as a function of wavelength. It is not impacted by spectral features such as the water absorption region because both output legs are affected equally. Persistence plots showing the coupling ratio of our wideband couplers can be viewed by clicking on the blue info icons below.



Click to Enlarge

The uniformity is also calculated from the measured insertion loss. Uniformity is the variation (in dB) of the insertion loss over the bandwidth. It is a measure of how evenly the insertion loss is distributed over the spectral range. The uniformity of Path A is the difference between the value of highest insertion loss and the solid red insertion loss curve (in the Insertion Plot above). The uniformity of Path B is the difference between the solid blue insertion loss curve and the value of lowest insertion loss. Persistence plots showing the uniformity of our wideband couplers can be viewed by clicking on the blue info icons below.

RELIABILITY TESTING

GR-1221-CORE Testing

Our 2x2 1300 nm Single Mode Fused Fiber Optic Couplers have undergone a reliability testing program inspired by GR-1221-CORE (Generic Reliability Assurance Requirements for Passive Optical Components, Issue 2). The selected test conditions are for uncontrolled environments and are some of the most stringent test conditions for passive components. The results of this testing program qualify these couplers and their manufacturing process for volume production and use in uncontrolled environments. To download a PDF of this test report, please click here.

Requirement Limits	
Parameter	**Limit**
Change in Insertion Loss (ΔIL)	≤0.2 dB
Coupling Ratio	±1.5%


Click To Enlarge
Close-Up of Mechanical Shock Test Setup

Click To Enlarge
SM-105 Mechanical Shock Test Machine


Click To Enlarge
Vibration Test Setup


Click To Enlarge
Damp Heat Testing Setup

Testing Conditions

This test program consisted of five test groups with a sample size of 11 per group. Testing was conducted with a 1310 nm laser source input into 1310 tap couplers using a 1x16 waveguide coupler. The two outputs of every coupler were measured by a PM100USB power meter with an S154C sensor head.

Testing Conditions		
Mechanical Testing (Group 1)		
These fused couplers with a tap ratio of 10% underwent three mechanical tests; the mechanical shock and vibration tests were conducted by the NTS Environmental and Mechanical Testing Laboratory while the fiber side pull tests were performed in-house. In one test, the couplers were induced with mechanical shock using an Avex SM-105 mechanical shock test machine with a 3200B4 accelerometer. In another, they were induced with vibration using a Dynamic Solutions DS-2200VH/8-19 vibration system with a VT1436 vibration controller and a 356A01 accelerometer. The couplers also underwent a fiber side pull in two directions with a weight of 0.23 kg at 90° for 5 seconds.		
Test Parameter	**Conditions**	**Reference**
Mechanical Shock	Acceleration: 500 g Pulse Width: 1 ms Pulse Shape: Half-Sine # of Directions: 6 # of Shocks/Direction: 5	MIL-STD-993 Method 2002
Vibration	Acceleration: 20 g Frequency Range: 20 Hz to 2000 Hz Duration: 4 min/cycle Number of Cycles/Axis: 4 Axes: X, Y, Z	MIL-STD-883 Method 2007 Condition A
Fiber Side Pull	0.23 kg, 90°, 5 sec, 2 directions	GR-1209-CORE
		Click for Graphs: More [+]
Damp Heat Storage (Group 2)		
The performance of these couplers was tested in damp heat at a Thorlabs facility. A Test Equity Model 115A Temperature Chamber was used to maintain an 85 °C ± 2 °C temperature with 85% ± 5% relative humidity for 2000 hours.		
Test Parameter	**Conditions**	**Reference**
Damp Heat	85 °C (±2 °C) 85% (±5%) Relative Humidity 2000 Hours	MIL-STD-883 Method 103
		Click for Graphs: More [+]
High Temperature Storage (Group 3)		
The performance of these couplers was tested in dry high temperatures in a Thorlabs facility. A Test Equity Model 115A Temperature Chamber was used to maintain an 85 °C ± 2 °C temperature with <40% Relative Humidity for 2000 hours.		
Test Parameter	**Conditions**	**Reference**
High Temperature Storage (Dry Heat)	85 °C (±2 °C) <40% Relative Humidity 2000 Hours	EIA/TIA-455-4A
		Click for Graphs: More [+]
Low Temperature Storage (Group 4)		
The performance of these couplers was tested in low temperatures at a Thorlabs facility. A Test Equity Model 115A Temperature Chamber was used to maintain a -40 °C ± 5 °C temperature with uncontrolled relative humidity for 2000 hours.		
Test Parameter	**Conditions**	**Reference**
Low Temperature Storage	-40 °C (±5 °C) Uncontrolled Relative Humidity 2000 Hours	EIA/TIA-455-4A
		Click for Graphs: More [+]

Testing Conditions		
Temperature Cycling (Group 5)		
At a Thorlabs facility, the performance of these couplers was tested during temperature cycling of their environment. The temperature varied from -40 °C to 85 °C (±2 °C) through 400 cycles with a 10 minutes pause at room temperature at each cycle.		
Test Parameter	**Conditions**	**Reference**
Temperature Cycling	-40 °C to 85 °C (±2 °C) 400 Cycles with 10 Minute Pause at Room Temperature	MIL-STD-883 Method 1010
		Click for Graphs: More [+]

DAMAGE THRESHOLD

Laser-Induced Damage in Silica Optical Fibers

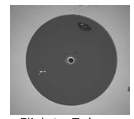
Quick Links
Damage at the Air / Glass Interface
Intrinsic Damage Threshold
Preparation and Handling of Optical Fibers

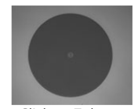
The following tutorial details damage mechanisms relevant to unterminated (bare) fiber, terminated optical fiber, and other fiber components from laser light sources. These mechanisms include damage that occurs at the air / glass interface (when free-space coupling or when using connectors) and in the optical fiber itself. A fiber component, such as a bare fiber, patch cable, or fused coupler, may have multiple potential avenues for damage (e.g., connectors, fiber end faces, and the device itself). The maximum power that a fiber can handle will always be limited by the lowest limit of any of these damage mechanisms.

While the damage threshold can be estimated using scaling relations and general rules, absolute damage thresholds in optical fibers are very application dependent and user specific. Users can use this guide to estimate a safe power level that minimizes the risk of damage. Following all appropriate preparation and handling guidelines, users should be able to operate a fiber component up to the specified maximum power level; if no maximum is specified for a component, users should abide by the "practical safe level" described below for safe operation of the component. Factors that can reduce power handling and cause damage to a fiber component include, but are not limited to, misalignment during fiber coupling, contamination of the fiber end face, or imperfections in the fiber itself. For further discussion about an optical fiber's power handling abilities for a specific application, please contact Thorlabs' Tech Support.

Damage at the Air / Glass Interface

There are several potential damage mechanisms that can occur at the air / glass interface. Light is incident on this interface when free-space coupling or when two fibers are mated using optical connectors. High-intensity light can damage the end face leading to reduced power handling and permanent damage to the fiber. For fibers terminated with optical connectors where the connectors are fixed to the fiber ends using epoxy, the heat generated by high-intensity light can burn the epoxy and leave residues on the fiber facet directly in the beam path.


Click to Enlarge
Damaged Fiber End


Click to Enlarge
Undamaged Fiber End

Damage Mechanisms on the Bare Fiber End Face

Damage mechanisms on a fiber end face can be modeled similarly to bulk optics, and industry-standard damage thresholds for UV Fused Silica substrates can be applied to silica-based fiber. However, unlike bulk optics, the relevant surface areas and beam diameters involved at the air / glass interface of an optical fiber are very small, particularly for coupling into single mode (SM) fiber. therefore, for a given power density, the power incident on the fiber needs to be lower for a smaller beam diameter.

The table to the right lists two thresholds for optical power densities: a theoretical damage threshold and a "practical safe level". In general, the theoretical damage threshold represents the estimated maximum power density that can be incident on the fiber end face without risking damage with very good fiber end face and coupling conditions. The "practical safe level" power density represents minimal risk of fiber damage. Operating a fiber or component beyond the practical safe level is possible, but users must follow the appropriate handling instructions and verify performance at low powers prior to use.

Estimated Optical Power Densities on Air / Glass Interface[a]

Type	Theoretical Damage Threshold[b]	Practical Safe Level[c]
CW (Average Power)	~1 MW/cm^2	~250 kW/cm^2
10 ns Pulsed (Peak Power)	~5 GW/cm^2	~1 GW/cm^2

- All values are specified for unterminated (bare) silica fiber and apply for free space coupling into a clean fiber end face.
- This is an estimated maximum power density that can be incident on a fiber end face without risking damage. Verification of the performance and reliability of fiber components in the system before operating at high power must be done by the user, as it is highly system dependent.
- This is the estimated safe optical power density that can be incident on a fiber end face without damaging the fiber under most operating conditions.

Calculating the Effective Area for Single Mode and Multimode Fibers

The effective area for single mode (SM) fiber is defined by the mode field diameter (MFD), which is the cross-sectional area through which light propagates in the fiber; this area includes the fiber core and also a portion of the cladding. To achieve good efficiency when coupling into a single mode fiber, the diameter of the input beam must match the MFD of the fiber.

As an example, SM400 single mode fiber has a mode field diameter (MFD) of ~Ø3 µm operating at 400 nm, while the MFD for SMF-28 Ultra single mode fiber operating at 1550 nm is Ø10.5 µm. The effective area for these fibers can be calculated as follows:

SM400 Fiber: Area = Pi x $(\text{MFD}/2)^2$ = Pi x $(1.5\ \mu\text{m})^2$ = 7.07 µm^2 = 7.07 x 10^{-8} cm^2

SMF-28 Ultra Fiber: Area = Pi x $(\text{MFD}/2)^2$ = Pi x $(5.25\ \mu\text{m})^2$ = 86.6 µm^2 = 8.66 x 10^{-7} cm^2

To estimate the power level that a fiber facet can handle, the power density is multiplied by the effective area. Please note that this calculation assumes a uniform intensity profile, but most laser beams exhibit a Gaussian-like shape within single mode fiber, resulting in a higher power density at the center of the beam compared to the edges. Therefore, these calculations will slightly overestimate the power corresponding to the damage threshold or the practical safe level. Using the estimated power densities assuming a CW light source, we can determine the corresponding power levels as:

SM400 Fiber: 7.07 x 10^{-8} cm^2 x 1 MW/cm^2 = 7.1 x 10^{-8} MW = 71 mW (Theoretical Damage Threshold)
7.07 x 10^{-8} cm^2 x 250 kW/cm^2 = 1.8 x 10^{-5} kW = 18 mW (Practical Safe Level)

SMF-28 Ultra Fiber: 8.66 x 10^{-7} cm^2 x 1 MW/cm^2 = 8.7 x 10^{-7} MW = 870 mW (Theoretical Damage Threshold)
8.66 x 10^{-7} cm^2 x 250 kW/cm^2 = 2.1 x 10^{-4} kW = 210 mW (Practical Safe Level)

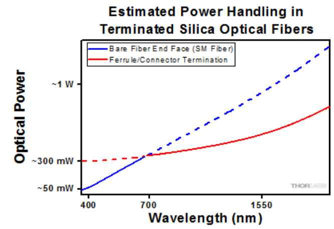
The effective area of a multimode (MM) fiber is defined by the core diameter, which is typically far larger than the MFD of an SM fiber. For optimal coupling, Thorlabs recommends focusing a beam to a spot roughly 70 - 80% of the core diameter. The larger effective area of MM fibers lowers the power density on the fiber end face, allowing higher optical powers (typically on the order of kilowatts) to be coupled into multimode fiber without damage.

Damage Mechanisms Related to Ferrule / Connector Termination

Fibers terminated with optical connectors have additional power handling considerations. Fiber is typically terminated using epoxy to bond the fiber to a ceramic or steel ferrule. When light is coupled into the fiber through a connector, light that does not enter the core and propagate down the fiber is scattered into the outer layers of the fiber, into the ferrule, and the epoxy used to hold the fiber in the ferrule. If the light is intense enough, it can burn the epoxy, causing it to vaporize and deposit a residue on the face of the connector. This results in localized absorption sites on the fiber end face that reduce coupling efficiency and increase scattering, causing further damage.

For several reasons, epoxy-related damage is dependent on the wavelength. In general, light scatters more strongly at short wavelengths than at longer wavelengths. Misalignment when coupling is also more likely due to the small MFD of short-wavelength SM fiber that also produces more scattered light.

To minimize the risk of burning the epoxy, fiber connectors can be constructed to have an epoxy-free air gap between the optical fiber and ferrule near the fiber end face. Our high-power multimode fiber patch cables use connectors with this design feature.



Click to Enlarge

Plot showing approximate input power that can be incident on a single mode silica optical fiber with a termination. Each line shows the estimated power level due to a specific damage mechanism. The maximum power handling is limited by the lowest power level from all relevant damage mechanisms (indicated by a solid line).

Determining Power Handling with Multiple Damage Mechanisms

When fiber cables or components have multiple avenues for damage (e.g., fiber patch cables), the maximum power handling is always limited by the lowest damage threshold that is relevant to the fiber component. In general, this represents the highest input power that can be incident on the patch cable end face and not the coupled output power.

As an illustrative example, the graph to the right shows an estimate of the power handling limitations of a single mode fiber patch cable due to damage to the fiber end face and damage via an optical connector. The total input power handling of a terminated fiber at a given wavelength is limited by the lower of the two limitations at any given wavelength (indicated by the solid lines). A single mode fiber operating at around 488 nm is primarily limited by damage to the fiber end face (blue solid line), but fibers operating at 1550 nm are limited by damage to the optical connector (red solid line).

In the case of a multimode fiber, the effective mode area is defined by the core diameter, which is larger than the effective mode area for SM fiber. This results in a lower power density on the fiber end face and allows higher optical powers (on the order of kilowatts) to be coupled into the fiber without damage (not shown in graph). However, the damage limit of the ferrule / connector termination remains unchanged and as a result, the maximum power handling for a multimode fiber is limited by the ferrule and connector termination.

Please note that these are rough estimates of power levels where damage is very unlikely with proper handling and alignment procedures. It is worth noting that optical fibers are frequently used at power levels above those described here. However, these applications typically require expert users and testing at lower powers first to minimize risk of damage. Even still, optical fiber components should be considered a consumable lab supply if used at high power levels.

Intrinsic Damage Threshold

In addition to damage mechanisms at the air / glass interface, optical fibers also display power handling limitations due to damage mechanisms within the optical fiber itself. These limitations will affect all fiber components as they are intrinsic to the fiber itself. Two categories of damage within the fiber are damage from bend losses and damage from photodarkening.

Bend Losses

Bend losses occur when a fiber is bent to a point where light traveling in the core is incident on the core/cladding interface at an angle higher than the critical angle, making total internal reflection impossible. Under these circumstances, light escapes the fiber, often in a localized area. The light escaping the fiber typically has a high power density, which burns the fiber coating as well as any surrounding furcation tubing.

A special category of optical fiber, called double-clad fiber, can reduce the risk of bend-loss damage by allowing the fiber's cladding (2nd layer) to also function as a waveguide in addition to the core. By making the critical angle of the cladding/coating interface higher than the critical angle of the core/clad interface, light that escapes the core is loosely confined within the cladding. It will then leak out over a distance of centimeters or meters instead of at one localized spot within the fiber, minimizing the risk of damage. Thorlabs manufactures and sells 0.22 NA double-clad multimode fiber, which boasts very high, megawatt range power handling.

Photodarkening

A second damage mechanism, called photodarkening or solarization, can occur in fibers used with ultraviolet or short-wavelength visible light, particularly those with germanium-doped cores. Fibers used at these wavelengths will experience increased attenuation over time. The mechanism that causes photodarkening is largely unknown, but several fiber designs have been developed to mitigate it. For example, fibers with a very low hydroxyl ion (OH) content have been found to resist photodarkening and using other dopants, such as fluorine, can also reduce photodarkening.

Even with the above strategies in place, all fibers eventually experience photodarkening when used with UV or short-wavelength light, and thus, fibers used at these wavelengths should be considered consumables.

Preparation and Handling of Optical Fibers

General Cleaning and Operation Guidelines

These general cleaning and operation guidelines are recommended for all fiber optic products. Users should still follow specific guidelines for an individual product as outlined in the support documentation or manual. Damage threshold calculations only apply when all appropriate cleaning and handling procedures are followed.

1. All light sources should be turned off prior to installing or integrating optical fibers (terminated or bare). This ensures that focused beams of light are not incident on fragile parts of the connector or fiber, which can possibly cause damage.

2. The power-handling capability of an optical fiber is directly linked to the quality of the fiber/connector end face. Always inspect the fiber end prior to connecting the fiber to an optical system. The fiber end face should be clean and clear of dirt and other contaminants that can cause scattering of coupled light. Bare fiber should be cleaved prior to use and users should inspect the fiber end to ensure a good quality cleave is achieved.

3. If an optical fiber is to be spliced into the optical system, users should first verify that the splice is of good quality at a low optical power prior to high-power use. Poor splice quality may increase light scattering at the splice interface, which can be a source of fiber damage.

4. Users should use low power when aligning the system and optimizing coupling; this minimizes exposure of other parts of the fiber (other than the core) to light. Damage from scattered light can occur if a high power beam is focused on the cladding, coating, or connector.

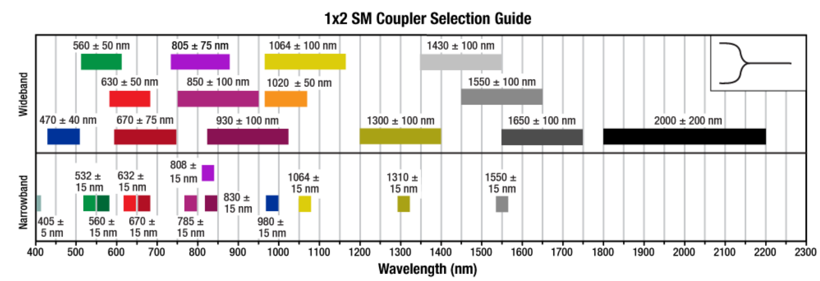
Tips for Using Fiber at Higher Optical Power

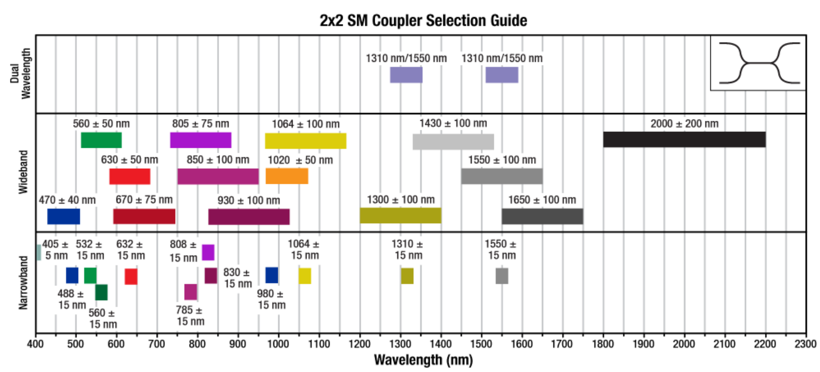
Optical fibers and fiber components should generally be operated within safe power level limits, but under ideal conditions (very good optical alignment and very clean optical end faces), the power handling of a fiber component may be increased. Users must verify the performance and stability of a fiber component within their system prior to increasing input or output power and follow all necessary safety and operation instructions. The tips below are useful suggestions when considering increasing optical power in an optical fiber or component.

1. Splicing a fiber component into a system using a fiber splicer can increase power handling as it minimizes possibility of air/fiber interface damage. Users should follow all appropriate guidelines to prepare and make a high-quality fiber splice. Poor splices can lead to scattering or regions of highly localized heat at the splice interface that can damage the fiber.
2. After connecting the fiber or component, the system should be tested and aligned using a light source at low power. The system power can be ramped up slowly to the desired output power while periodically verifying all components are properly aligned and that coupling efficiency is not changing with respect to optical launch power.
3. Bend losses that result from sharply bending a fiber can cause light to leak from the fiber in the stressed area. When operating at high power, the localized heating that can occur when a large amount of light escapes a small localized area (the stressed region) can damage the fiber. Avoid disturbing or accidently bending fibers during operation to minimize bend losses.
4. Users should always choose the appropriate optical fiber for a given application. For example, large-mode-area fibers are a good alternative to standard single mode fibers in high-power applications as they provide good beam quality with a larger MFD, decreasing the power density on the air/fiber interface.
5. Step-index silica single mode fibers are normally not used for ultraviolet light or high-peak-power pulsed applications due to the high spatial power densities associated with these applications.

SM COUPLER GUIDE

Our 1x2 and 2x2 Single Mode Coupler offerings are outlined in the graphs below. Click on the colored bars to visit the web presentation for each coupler. Note that the 1020 nm ± 50 nm (orange bars) option is designed for high power applications up to 50 W.





50:50 Fiber Optic Couplers

Thorlabs offers both narrowband and wideband fiber optic couplers. All specifications are measured without connectors during the manufacturing process. Additional information on the testing process for our wideband couplers can be found on the *Coupler Verification* tab above. Our wideband couplers are highlighted green in the table below.

Item #	Info	Center Wavelength	Bandwidth	Coupling Ratio[a]	Coupling Ratio Tolerance	Insertion Loss[a]	Excess Loss[a]	Uniformity[a]	Fiber Type[b]	Termination	Housing
BXC35[c]		1064 nm	±100 nm[d]	50:50 (Click for Plot)	±5.0%	≤3.7 dB / ≤3.7 dB	≤0.2 dB	≤0.5 dB (Click for Plot)	HI1060 (0.14 NA)	FC/APC Bulkheads	Boxed
TW1064R5F2A[c]										FC/PC Connectors	Standard
TW1064R5A2A[c]										FC/APC Connectors	
TW1064R5F2B[c]		1064 nm	±100 nm[d]	50:50 (Click for Plot)	±5.0%	≤3.7 dB / ≤3.7 dB	≤0.2 dB	≤0.5 dB (Click for Plot)	HI1060 FLEX (0.22 NA)	FC/PC Connectors	Standard
TW1064R5A2B[c]										FC/APC Connectors	
TN1064R5F2A[c]		1064 nm	±15 nm	50:50 (Click for Plot)	±3.0%	≤3.5 dB / ≤3.5 dB	≤0.2 dB	-	HI1060 (0.14 NA)	FC/PC Connectors	Standard
TN1064R5A2A[c]										FC/APC Connectors	
FC1064-50B-APC		1064 nm	±15 nm	50:50	-	3.5 dB / 3.5 dB (Typ.)	0.12 dB (Typ.)	-	HI1060 FLEX (0.22 NA)	FC/APC Connectors	Standard

- Please see the *2x2 Coupler Tutorial* tab for more information on these terms.
- Other fiber types may be available upon request. Please contact Tech Support with inquiries.
- All values are specified at room temperature over the bandwidth. Values are measured with IN 1 (boxed couplers) or the white input port (standard couplers, see diagram above) used as the input; similar performance is achieved (≤0.05 dB difference) when IN 2 (boxed couplers) or the blue input port (standard couplers, see diagram above) is used as the input.
- Below the cut-off wavelength, single mode operation is not guaranteed (click on the blue info icon for more information).

Part Number	Description	Price	Availability
BXC35	**2x2 Boxed Wideband Fiber Optic Coupler, 1064 ± 100 nm, 50:50 Split, FC/APC Bulkheads**	**$450.13**	**Today**
TW1064R5F2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 50:50 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R5A2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 50:50 Split, FC/APC Connectors**	**$386.31**	**Today**
TW1064R5F2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 50:50 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R5A2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 50:50 Split, FC/APC Connectors**	**$386.31**	**Today**
TN1064R5F2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 50:50 Split, FC/PC Connectors**	**$188.28**	**Today**
TN1064R5A2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 50:50 Split, FC/APC Connectors**	**$232.66**	**Today**
FC1064-50B-APC	**2x2 Fiber Optic Coupler, 1064 ± 15 nm, 0.22 NA, 50:50 Split, FC/APC Connectors**	**$232.66**	**Lead Time**

75:25 Fiber Optic Couplers

All specifications are measured without connectors during the manufacturing process. Additional information on the testing process for our wideband couplers can be found on the *Coupler Verification* tab above. Our wideband couplers are highlighted green in the table below.

Item #	Info	Center Wavelength	Bandwidth	Coupling Ratio[a,b]	Coupling Ratio Tolerance	Insertion Loss[a,b]	Excess Loss[a,b]	Uniformity[a,b]	Fiber Type[c]	Termination	Housing
BXC33		1064 nm	±100 nm[d]	75:25 (Click for Plot)	±3.5%	≤1.7 dB / ≤6.9 dB	≤0.2 dB	≤0.6 dB (Click for Plot)	HI10600 (0.14 NA)	FC/APC Bulkheads	Boxed
TW1064R3F2A										FC/PC Connectors	Standard
TW1064R3A2A										FC/APC Connectors	
TW1064R3F2B		1064 nm	±100 nm[d]	75:25 (Click for Plot)	±3.5%	≤1.7 dB / ≤6.9 dB	≤0.2 dB	≤0.6 dB (Click for Plot)	HI1060 FLEX (0.22 NA)	FC/PC Connectors	Standard
TW1064R3A2B										FC/APC Connectors	
TN1064R3F2A		1064 nm	±15 nm	75:25 (Click for Plot)	±3.0%	≤1.6 dB / ≤6.8 dB	≤0.2 dB	-	HI1060 (0.14 NA)	FC/PC Connectors	Standard
TN1064R3A2A										FC/APC Connectors	
TN1064R3F2B		1064 nm	±15 nm	75:25 (Click for Plot)	±3.0%	≤1.6 dB / ≤6.8 dB	≤0.2 dB	-	HI1060 FLEX (0.22 NA)	FC/PC Connectors	Standard
TN1064R3A2B										FC/APC Connectors	

- Please see the *2x2 Coupler Tutorial* tab for more information on these terms.
- Specified at room temperature over the bandwidth. Values are measured with IN 1 (boxed couplers) or the white input port (standard couplers, see diagram above) used as the input; similar performance is achieved (≤0.05 dB difference) when IN 2 (boxed couplers) or the blue input port (standard couplers, see diagram above) is used as the input.
- Other fiber types may be available upon request. Please contact Tech Support with inquiries.
- Below the cut-off wavelength, single mode operation is not guaranteed (click on the blue info icon for more information).

Part Number	Description	Price	Availability
BXC33	**2x2 Boxed Wideband Fiber Optic Coupler, 1064 ± 100 nm, 75:25 Split, FC/APC Bulkheads**	**$450.13**	**Today**
TW1064R3F2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 75:25 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R3A2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 75:25 Split, FC/APC Connectors**	**$386.31**	**Lead Time**
TW1064R3F2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 75:25 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R3A2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 75:25 Split, FC/APC Connectors**	**$386.31**	**Lead Time**
TN1064R3F2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 75:25 Split, FC/PC Connectors**	**$188.28**	**Today**
TN1064R3A2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 75:25 Split, FC/APC Connectors**	**$232.66**	**Today**
TN1064R3F2B	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.22 NA, 75:25 Split, FC/PC Connectors**	**$188.28**	**Today**
TN1064R3A2B	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.22 NA, 75:25 Split, FC/APC Connectors**	**$232.66**	**Today**

90:10 Fiber Optic Couplers

Thorlabs offers both narrowband and wideband fiber optic couplers. All specifications are measured without connectors during the manufacturing process. Additional information on the testing process for our wideband couplers can be found on the *Coupler Verification* tab above. Our wideband couplers are highlighted green in the table below.

Item #	Info	Center Wavelength	Bandwidth	Coupling Ratio[a]	Coupling Ratio Tolerance	Insertion Loss[a]	Excess Loss[a]	Uniformity[a]	Fiber Type[b]	Termination	Housing
BXC32[c]		1064 nm	±100 nm[d]	90:10 (Click for Plot)	±2.5%	≤0.8 dB / ≤11.4 dB	≤0.2 dB	≤0.6 dB (Click for Plot)	HI1060 (0.14 NA)	FC/APC Bulkheads	Boxed
TW1064R2F2A[c]										FC/PC Connectors	Standard
TW1064R2A2A[c]										FC/APC Connectors	
TW1064R2F2B[c]		1064 nm	±100 nm[d]	90:10 (Click for Plot)	±2.5%	≤0.8 dB / ≤11.4 dB	≤0.2 dB	≤0.7 dB (Click for Plot)	HI1060 FLEX (0.22 NA)	FC/PC Connectors	Standard
TW1064R2A2B[c]										FC/APC Connectors	
TN1064R2F2A[c]		1064 nm	±15 nm	90:10 (Click for Plot)	±2.0%	≤0.8 dB / ≤11.2 dB	≤0.2 dB	-	HI1060 (0.14 NA)	FC/PC Connectors	Standard
TN1064R2A2A[c]										FC/APC Connectors	
FC1064-90B-FC		1064 nm	±15 nm	90:10	-	0.7 dB / 10.5 dB (Typ.)	0.12 dB (Typ.)	-	HI1060 FLEX (0.22 NA)	FC/PC Connectors	Standard
FC1064-90B-APC										FC/APC Connectors	

- Please see the *2x2 Coupler Tutorial* tab for more information on these terms.
- Other fiber types may be available upon request. Please contact Tech Support with inquiries.
- Specified at room temperature over the bandwidth. Values are measured with IN 1 (boxed couplers) or the white input port (standard couplers, see diagram above) used as the input; similar performance is achieved (≤0.05 dB difference) when IN 2 (boxed couplers) or the blue input port (standard couplers, see diagram above) is used as the input.
- Below the cut-off wavelength, single mode operation is not guaranteed (click on the blue info icon for more information).

Part Number	Description	Price	Availability
BXC32	**2x2 Boxed Wideband Fiber Optic Coupler, 1064 ± 100 nm, 90:10 Split, FC/APC Bulkheads**	**$450.13**	**Today**
TW1064R2F2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 90:10 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R2A2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 90:10 Split, FC/APC Connectors**	**$386.31**	**5-8 Days**
TW1064R2F2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 90:10 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R2A2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 90:10 Split, FC/APC Connectors**	**$386.31**	**Today**
TN1064R2F2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 90:10 Split, FC/PC Connectors**	**$188.28**	**Today**
TN1064R2A2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 90:10 Split, FC/APC Connectors**	**$232.66**	**Today**
FC1064-90B-FC	**2x2 Fiber Optic Coupler, 1064 ± 15 nm, 0.22 NA, 90:10 Split, FC/PC Connectors**	**$188.28**	**Lead Time**
FC1064-90B-APC	**2x2 Fiber Optic Coupler, 1064 ± 15 nm, 0.22 NA, 90:10 Split, FC/APC Connectors**	**$232.66**	**Lead Time**

99:1 Fiber Optic Couplers

Thorlabs offers both narrowband and wideband fiber optic couplers. All specifications are measured without connectors during the manufacturing process. Additional information on the testing process for our wideband couplers can be found on the *Coupler Verification* tab above. Our wideband couplers are highlighted green in the table below.

<table>
<tr><th>Item #</th><th>Info</th><th>Center Wavelength</th><th>Bandwidth</th><th>Coupling Ratio[a]</th><th>Coupling Ratio Tolerance</th><th>Insertion Loss[a]</th><th>Excess Loss[a]</th><th>Uniformity[a]</th><th>Fiber Type[b]</th><th>Termination</th><th>Housing</th></tr>
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<tr><td>TW1064R1F2B[c]</td><td></td><td rowspan="2">1064 nm</td><td rowspan="2">±100 nm[d]</td><td rowspan="2">99:1 (Click for Plot)</td><td rowspan="2">±0.6%</td><td rowspan="2">≤0.3 dB / ≤24.2 dB</td><td rowspan="2">≤0.2 dB</td><td rowspan="2">≤1.0 dB (Click for Plot)</td><td rowspan="2">HI1060 FLEX (0.22 NA)</td><td>FC/PC Connectors</td><td rowspan="2">Standard</td></tr>
<tr><td>TW1064R1A2B[c]</td><td></td><td>FC/APC Connectors</td></tr>
<tr><td>TN1064R1F2A[c]</td><td></td><td rowspan="2">1064 nm</td><td rowspan="2">±15 nm</td><td rowspan="2">99:1 (Click for Plot)</td><td rowspan="2">±0.3%</td><td rowspan="2">≤0.3 dB / ≤21.7 dB</td><td rowspan="2">≤0.2 dB</td><td rowspan="2">-</td><td rowspan="2">HI1060 (0.14 NA)</td><td>FC/PC Connectors</td><td rowspan="2">Standard</td></tr>
<tr><td>TN1064R1A2A[c]</td><td></td><td>FC/APC Connectors</td></tr>
<tr><td>FC1064-99B-FC</td><td></td><td rowspan="2">1064 nm</td><td rowspan="2">±15 nm</td><td rowspan="2">99:1</td><td rowspan="2">-</td><td rowspan="2">0.35 dB / 22 dB (Typ.)</td><td rowspan="2">0.12 dB (Typ.)</td><td rowspan="2">-</td><td rowspan="2">HI1060 FLEX (0.22 NA)</td><td>FC/PC Connectors</td><td rowspan="2">Standard</td></tr>
<tr><td>FC1064-99B-APC</td><td></td><td>FC/APC Connectors</td></tr>
</table>

- Please see the *2x2 Coupler Tutorial* tab for more information on these terms.
- Other fiber types may be available upon request. Please contact Tech Support with inquiries.
- Specified at room temperature over the bandwidth. Values are measured with IN 1 (boxed couplers) or the white input port (standard couplers, see diagram above) used as the input; similar performance is achieved (≤0.05 dB difference) when IN 2 (boxed couplers) or the blue input port (standard couplers, see diagram above) is used as the input.
- Below the cut-off wavelength, single mode operation is not guaranteed (click on the blue info icon for more information).

Part Number	Description	Price	Availability
BXC31	**2x2 Boxed Wideband Fiber Optic Coupler, 1064 ± 100 nm, 99:1 Split, FC/APC Bulkheads**	**$450.13**	**Today**
TW1064R1F2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 99:1 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R1A2A	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.14 NA, 99:1 Split, FC/APC Connectors**	**$386.31**	**Today**
TW1064R1F2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 99:1 Split, FC/PC Connectors**	**$343.03**	**Today**
TW1064R1A2B	**2x2 Wideband Fiber Optic Coupler, 1064 ± 100 nm, 0.22 NA, 99:1 Split, FC/APC Connectors**	**$386.31**	**Today**
TN1064R1F2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 99:1 Split, FC/PC Connectors**	**$188.28**	**Today**
TN1064R1A2A	**2x2 Narrowband Fiber Optic Coupler, 1064 ± 15 nm, 0.14 NA, 99:1 Split, FC/APC Connectors**	**$232.66**	**Today**
FC1064-99B-FC	**2x2 Fiber Optic Coupler, 1064 ± 15 nm, 99:1 Split, FC/PC Connectors**	**$188.28**	**Lead Time**
FC1064-99B-APC	**2x2 Fiber Optic Coupler, 1064 ± 15 nm, 99:1 Split, FC/APC Connectors**	**$232.66**	**5-8 Days**

Clamps for Fiber Component Housings

These clamps can be used to mount the boxed couplers sold above.

The ECM100 and ECM225 anodized aluminum clamps are designed to snap onto the 1" or 2.25" wide sides of the boxed coupler housings, respectively. Each clamp has a flexure lock with a 2 mm (5/64") hex locking screw. #8 (M4) counterbores (one on the ECM100 or three on the ECM225) allow the clamps to be mounted on a Ø1/2" post or any surface with an 8-32 (M4) tap. The clamp must be mounted via the counterbore before the boxed coupler housing is attached, as the counterbore will not be accessible once the housing is secured in the clamp.

The EPS225 plastic clamp is double-sided and designed to attach two of the boxed couplers. The clamp easily snaps onto either of the 2.25" wide sides of the housing. These clamps are sold in pairs.

Part Number	Description	Price	Availability
ECM100	**Aluminum Clamp for Compact Device Housings, 1.00"**	**$17.75**	**Today**
ECM225	**Aluminum Clamp for Compact Device Housings, 2.25"**	**$19.37**	**Today**
EPS225	**Double-Sided Plastic Clamp for Compact Device Housings, 2.25", Qty. 2**	**$6.90**	**Today**

Visit the *1064 nm, Single Mode Fused Fiber Optic Couplers / Taps* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=8465

FC1064-90B-APC - 2x2 SM Coupler, 1064 ± 15 nm, 90:10 Split, FC/APC

Specs

Specifications[a]	
Coupling Ratio	90:10
Center Wavelength	1064 nm
Bandwidth	±15 nm
Insertion Loss	0.7 dB / 10.5 dB (Typ.)
Excess Loss	0.12 dB (Typ.)
Polarization-Dependent Loss (PDL)	<0.2 dB
Directivity	>55 dB
Fiber Type	HI1060FLEX
Port Configuration	2x2
Fiber Lead Length and Tolerance	0.8 m +0.075 m/-0 m
Termination	2.0 mm Narrow Key FC/APC
Package Size	Ø0.15" x 2.60" (Ø3.8 mm x 66.0 mm)
Jacket	Ø900 µm Loose Furcation Tubing
Operating Temperature	-40 to 85 °C

a. All specifications are measured without connectors during the manufacturing process.