Entry into Optogenetics

Optogenetics Exhibit at the Science Museum, London

A few years ago, when optogenetics was an emerging field, members of Thorlabs' fiber business unit received a few atypical custom fiber patch cable orders, asking for a connector on one end and a flat cleave on the other. The customers ordering these specials from us mentioned a recently published journal article out of Stanford University in which a research group was doing research in the field of optogenetics.

Prior to these requests, we had never heard about optogenetics, but it was clearly piquing the interest of a lot of researchers in the field of neuroscience, and it captured our interest, too. While our roots are in the photonic sciences, the company had been rapidly expanding into the life science and biomedical fields for some time.

After contacting researchers at Stanford to discuss the needs of researchers utilizing this emerging technique, we gained a better understanding of the wavelengths, fiber types, and fiber core sizes that would be most desirable to those working in the field, primarily manipulating light to control neurons. Seeing this as an opportunity to utilize our internal manufacturing capabilities to assist with research endeavors, optogenetics quickly opened the door for our fiber team to step into the life science market and apply our photonics knowledge in a novel way.

Fiber Being Drawn in Our Fiber Tower

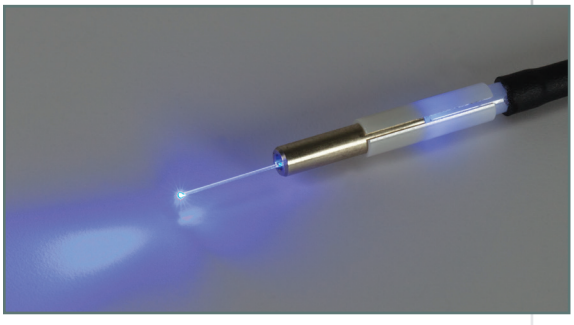
Thanks to our in-house fiber draw and connectorization capabilities, our fiber group was able to develop and manufacture fiber optic components that were optimized to the needs of the optogenetics community in just a few weeks, while maintaining short lead times and the ability to fully customize to meet particular specifications.

Looking beyond fiber patch cables at one of the cannula used in optogenetic study, we believed it would be possible to manufacture and offer these components in the same way: stock the most common configurations for same-day shipment and create a custom cannula configurator that would enable customers to request less common variations with short lead times. The result has been an affordable product family of optogenetic equipment, designed for ease of use and customization to meet the needs of a variety of institutions.

Meet the Fiber Team

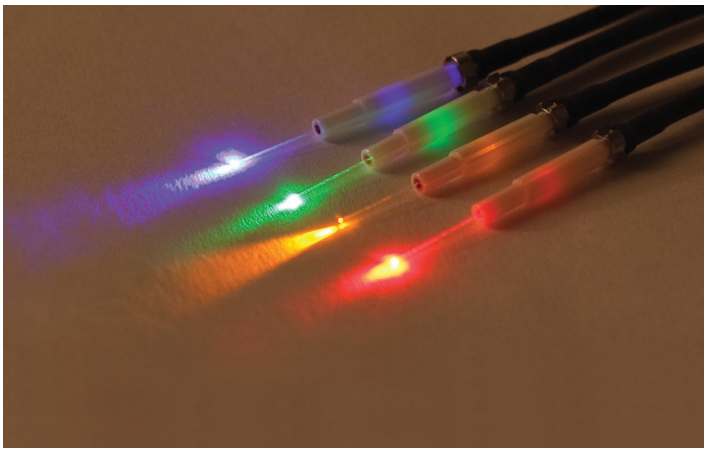
Our Fiber Business Unit is Located in Newton, NJ and produced over 50,000 fiber patch cables last year. Here, they are raising awareness in the fight against breast cancer.

Optogenetics
Selection Guide

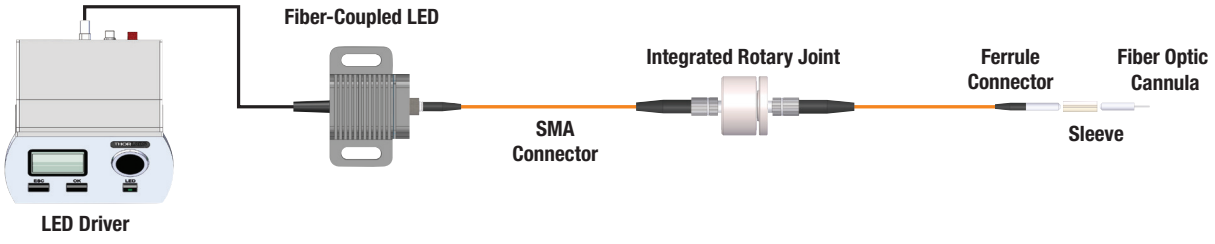


Optogenetics Overview

Thorlabs offers same-day shipping on a full line of optogenetics equipment for *in vivo* stimulation, including LED and laser light sources, fiber optic patch cables, rotary joints, and implantable fiber optic cannula. We are also well equipped to provide custom optogenetics packages, including fiber-coupled light sources and custom-made cannula, as well as next-day shipping on custom patch cable orders placed before 2 PM EST. Please contact optogenetics@thorlabs.com for assistance with optogenetics equipment selection.



Typical Optogenetics System



A typical optogenetics system requires a light source, fiber optic patch cable with optional rotary joint, mating sleeve, and fiber optic cannula. All of these items can be purchased separately or together as an Optogenetics Starter Kit (see pages 346 - 349).

Light Sources

Thorlabs offers both Fiber-Coupled LED Sources (see pages 332 - 333) and high-power Fiber-Coupled Benchtop Laser Sources (see pages 334 - 335) for *in vivo* stimulation. The latter provides higher power at the cannula tip. Both light sources are offered at the wavelengths most commonly used in optogenetics research.

Features

- Complete Systems Including Fiber Optic Cannula, Fiber Patch Cables, and Light Sources
- Allows for *In Vivo* Optical Stimulation for Neuroscience Research
- Components used Extensively in Leading Optogenetics Labs
- Quick Turnaround on Custom Orders

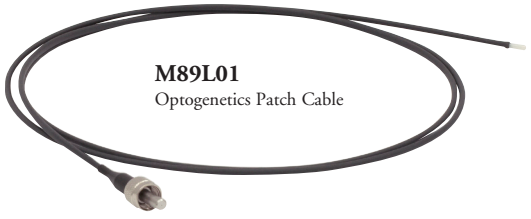
S1FC473MM
Fiber-Coupled
Benchtop Laser Source

M470F1
Fiber-Coupled
LED Source

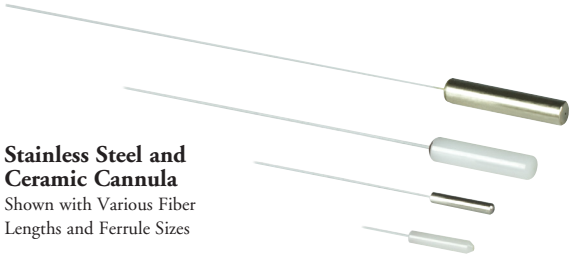
Optogenetics Overview

Fiber Optic Patch Cables

Our optogenetics patch cables (see pages 336 - 337) can be used to connect a light source to a fiber optic implantable cannula. We offer small diameter fiber that minimizes tissue damage, as well as extra lightweight cables for Ø1.25 mm cannula.



M89L01
Optogenetics Patch Cable



Stainless Steel and Ceramic Cannula
Shown with Various Fiber Lengths and Ferrule Sizes

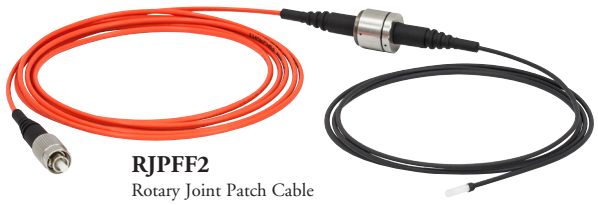
Fiber Optic Cannula and Mating Sleeves

Thorlabs offers stock and custom fiber optic cannula (see pages 340 - 345), which can be surgically mounted to the skull of the specimen using stereotactic guidance. Mating sleeves are available to connect our optogenetics patch cables with ferrule connectors to our implantable fiber optic cannula.

Custom cannula are available with a stainless steel or ceramic ferrule, as well as with an array of different fiber types, lengths, and end terminations. Contact optogenetics@thorlabs.com for information on custom orders.

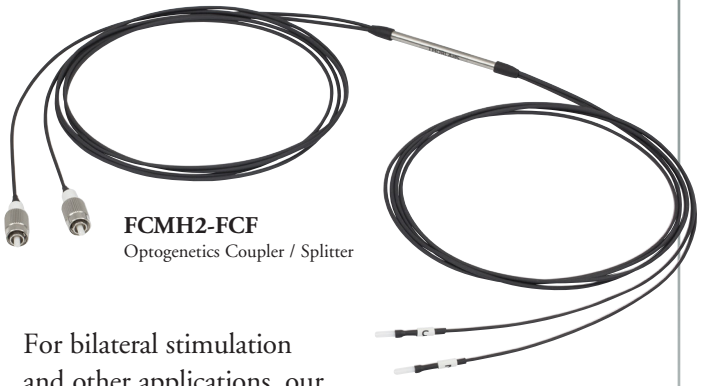
Optogenetics Starter Kits

Thorlabs' optogenetics equipment is available in a complete, ready-to-use kit (see pages 346 - 349). This kit includes a 470 nm fiber-coupled LED source, five cannula mating sleeves, 20 cannula, and either a lightweight fiber optic patch cable or a lightweight articulated fiber patch cable.



RJPFF2
Rotary Joint Patch Cable

Our articulated fiber optic patch cables (see page 338) feature a rotary joint interface that allows the cable to freely rotate, reducing damage in optogenetics experiments. These cables provide a complete solution for connecting the light source to an implanted fiber optic cannula and are compatible with all Thorlabs light sources and optogenetics equipment.

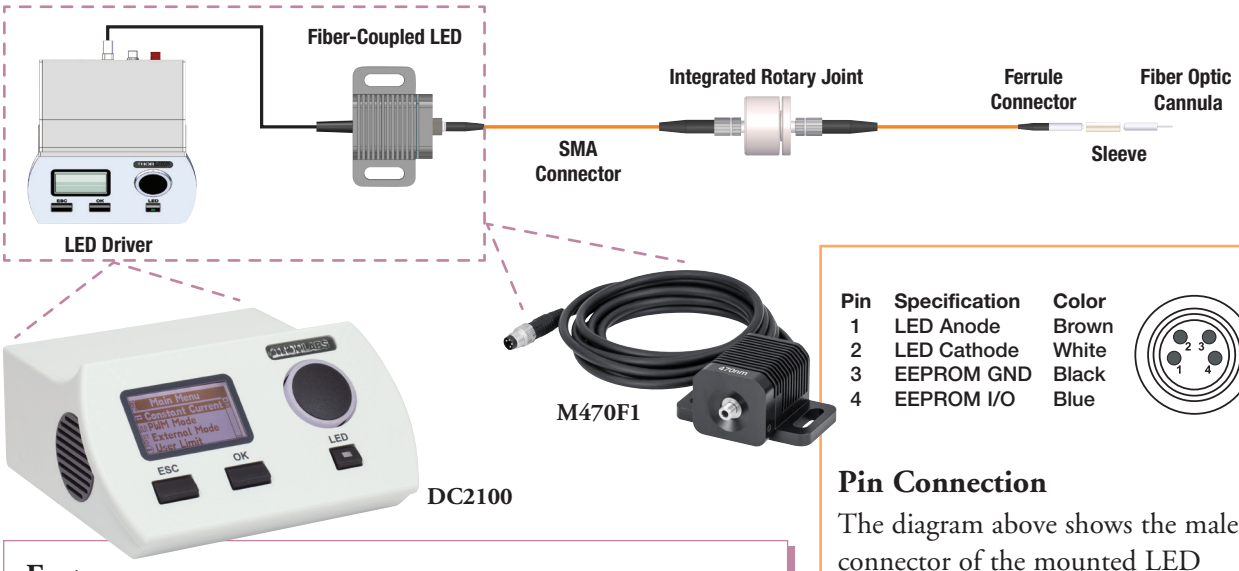


FCMH2-FCF
Optogenetics Coupler / Splitter

For bilateral stimulation and other applications, our optogenetics couplers/splitters divide light between two fiber outputs, both of which can be connected to a fiber optic implantable cannula or a patch cable. On the input side, we offer options with SMA or FC/PC connectors. On the output side, customers can choose from two Ø1.25 mm ferrules, two Ø2.5 mm ferrules, two SMA connectors, or two FC/PC connectors. Every coupler/splitter offers a 50:50 coupling/splitting ratio, which results in a typical transmission of 40% through each output leg.

OGK2

Fiber-Coupled High-Power LED Sources



Pin	Specification	Color
1	LED Anode	Brown
2	LED Cathode	White
3	EEPROM GND	Black
4	EEPROM I/O	Blue

Pin Connection

The diagram above shows the male connector of the mounted LED assembly. It is a standard M8x1 sensor circular connector. Pins 1 and 2 are the connection to the LED. Pins 3 and 4 are used for the internal EEPROM. Please note that the EEPROM pins are not useable with a third-party LED driver.

Features

- Popular Wavelengths for Optogenetics
- Stable Output Intensity by Optimized Thermal Management
- Long Lifetime
- Output can be Modulated (with Suitable Controller)
- Integrated EEPROM for Automated LED Settings
- SMA Connector

Each fiber-coupled LED consists of a single, high-power LED that is coupled to the fiber using a technique called butt-coupling. During this process, the fiber connector is positioned so that the end of the fiber is as close as possible to the emitter, thereby minimizing losses at the fiber input and maximizing output power. The coupling efficiency is primarily dependent on the core diameter and the numerical aperture (NA) of the connected fiber. Larger core diameters and higher NA values give rise to reduced losses and increased output power at the end of the fiber.

Each LED is equipped with an integrated EEPROM chip that stores information about the LED (e.g., current limit, wavelength, and forward voltage) that can be read by Thorlabs' DC2100 LED Controller.

Optimized Thermal Management

These high-power, fiber-coupled LEDs possess good thermal stability properties. The large, passively cooled heat sink has direct contact to the metal core circuit board on which the LED is mounted. By doing so, the degradation of optical output power that can be attributed to increased LED junction temperature is minimized.

LED Specifications

ITEM #	COLOR[a]	NOMINAL WAVELENGTH[a, b]	MINIMUM LED OUTPUT POWER[c]	TYPICAL LED OUTPUT POWER[c]	TEST CURRENT FOR LED POWER	MAXIMUM CURRENT CW	FORWARD VOLTAGE	HALFWIDTH (FWHM)	TYPICAL LIFETIME
M470F1	Blue	470 nm	8.0 mW	10.1 mW	1000 mA	1000 mA	3.6 V	25 nm	>50,000 h
M530F1	Green	530 nm	4.0 mW	5.1 mW	1000 mA	1000 mA	3.6 V	33 nm	>50,000 h
M565F1	Green Yellow	565 nm	1.8 mW	2.0 mW	500 mA	500 mA	3.2 V	80 nm	>10,000 h
M590F1	Amber	590 nm	2.5 mW	3.2 mW	1000 mA	1000 mA	2.5 V	18 nm	>50,000 h

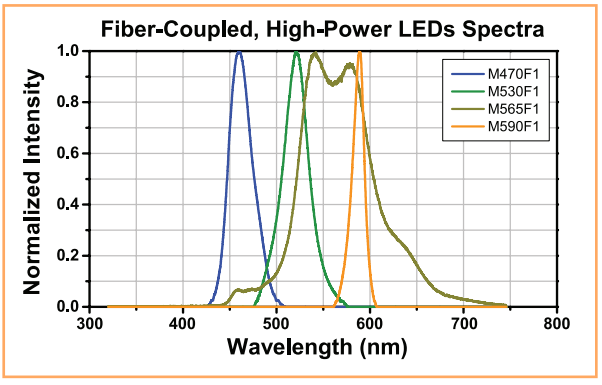
[a]Due to variations in the manufacturing process and operating parameters such as temperature and current, the actual spectral output of any given LED will vary. Output plots and center wavelength specs are only intended to be used as a guideline.

[b]The nominal wavelength indicates the wavelength at which the LED appears brightest to the human eye. This may not correspond to the peak wavelength as measured by a spectrograph.

[c]When Using Thorlabs' M28L01 1m Long MM Patch Cable, Ø400 µm Core, 0.39 NA

Fiber-Coupled High-Power LED Sources

M565F1
Shown with Ø400 µm Core Patch Cable (Not Included)



Driver Options

Each of our fiber-coupled LEDs requires a driver for operation. We offer two single-channel options: the LEDD1B T-Cube Driver with a maximum current of 1.2 A or the DC2100 LED Driver with a maximum current of 2 A.

The LEDD1B driver offers three operation modes: constant current mode, trigger mode, and modulation mode. The trigger and modulation modes are controlled by an external voltage in the 0 to 5 V range. When in the modulation mode, the LED current output exactly follows the amplitude and waveform of the input signal independent of the knob settings on the top of the T-Cube control unit. In trigger mode, the output current switches to the level that has been selected by the knob on the top of module as soon as a threshold voltage is reached. This can be used for pulse width modulation (PWM). The TPS001 power supply must be purchased separately.

More Wavelengths Available on the Web

The DC2100 driver allows the user to adjust current, pulse frequency, duty cycle, and number of pulses. The user also has the option of using an external trigger to control the LED current. The external trigger voltage frequency can be modulated up to 100 kHz. This LED driver can be remotely operated via USB2.0 by the included software package with an intuitive GUI and an extensive driver set.

LEDD1B
T-Cube Driver
(1.2 A Max)

DC2100
LED Driver
(2 A Max)

Compatible LED Drivers

ITEM #	LEDD1B	DC2100
LED Driver Current Output	1.2 A (Max)	2.0 A (Max)
Modulation Frequency Using External Input (Max)	5 kHz, Sine Wave	100 kHz, Sine Wave
Interface	Analog	USB 2.0
Main Driver Feature	Very Compact Footprint 60 mm x 73 mm x 104 mm (W x H x D)	Individual Pulse Width Control
EEPROM Compatible: Reads Out LED Data for LED Settings	No	Yes
LCD Display	No	Yes

Fiber-Coupled High-Power LEDs (Purchase Driver Separately Below)

ITEM #	PRICE	DESCRIPTION
M470F1	$ 366.00	Blue (470 nm) Fiber-Coupled High-Power LED, 1000 mA
M530F1	$ 366.00	Green (530 nm) Fiber-Coupled High-Power LED, 1000 mA
M565F1	$ 629.00	Green Yellow (565 nm) Fiber-Coupled High-Power LED, 500 mA
M590F1	$ 366.00	Amber (590 nm) Fiber-Coupled High-Power LED, 1000 mA

LED Drivers

ITEM #	PRICE	DESCRIPTION
LEDD1B	$ 284.00	T-Cube LED Driver, 1.2 A Max Drive Current (PSU Not Included)
TPS001	$ 25.00	15 V Power Supply Unit for a Single T-Cube (Purchase with LEDD1B)
DC2100	$ 1,770.00	High-Power, 1-Channel LED Driver with Pulse Modulation, 2 A, 24 V

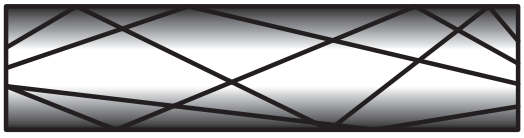
Fiber-Coupled Benchtop Laser Source

Features

- Multimode FC/PC Fiber Interface
- Adjustable Power (0 to 50 mW)
- 473 nm Wavelength for Optogenetics Applications
- Low Noise, Stable Output

S1FC473MM
Shown with M31L01
Multimode Patch Cable

The S1FC473MM Fiber-Coupled Laser provides 50 mW of output power and a wavelength of 473 nm, making it an ideal source for many Optogenetics applications. The unit's output can also be externally modulated at 5 kHz full depth/30 kHz small signal. The output is a multimode fiber terminated at an FC/PC connector.



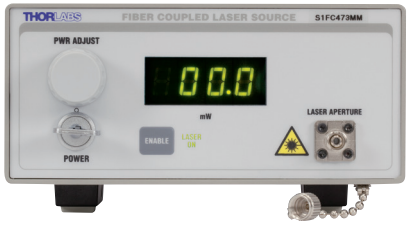
Light Propagation Down Step-Index Multimode Fiber

The front panel includes a display that shows the output power in mW, an on/off key, an enable button, and a knob to adjust the laser power. The back panel includes an input that allows the laser diode drive current to be controlled via an external voltage source and a remote interlock input. All of our fiber-pigtailed lasers utilize an angled fiber ferrule at the internal laser/fiber launch point to minimize reflections back into the laser diode, thereby increasing the stability of the laser diode's output.

SPECIFICATIONS	
Center Wavelength (Typical)	473 nm
Output Power*	50 mW (Max)
Stability	15 min: ±0.05 dB, 24 hr: ±0.1 dB (After 1 hr Warm-up at 25 ± 10 °C Ambient)
Display Accuracy (mW)	±10% of Actual
Set Point Resolution	0.1 mW
Adjustment Range	~0 mW to Full Power
Fiber Core Size	Ø105 µm
AC Input	115 / 230 VAC (Switch Selectable) 50 - 60 Hz
Modulation Input	0 - 5V = 0 - Full Power, DC or Sine Wave Input Only
Modulation Bandwidth	5 kHz Full Depth of Modulation / 30 kHz Small Signal Modulation

*Output power ranges from 0 - 50 mW. Due to variations between laser diodes, maximum output power may be higher.

S1FC473MM
Fiber-Coupled Laser with
Multimode Fiber Output



Front Panel of S1FC473MM

Back Panel of S1FC473MM

ITEM #	PRICE	DESCRIPTION
S1FC473MM	$ 6,910.00	FC/PC Fiber-Coupled Laser Source, 473 nm, 50 mW, Class 3B

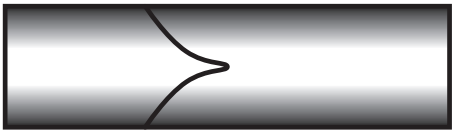
Temperature-Controlled Fiber-Coupled Benchtop Laser Source

Features

- Single Mode FC/PC Fiber Interface
- Adjustable Power (0 to 20 mW)
- Thermoelectric Temperature Stabilization
- 473 nm Wavelength for Optogenetics Applications
- Low Noise, Stable Output

S3FC473
Actively Stabilized Power and Temperature

The S3FC473 Fiber-Coupled Laser Source features an integrated TEC element that is used to stabilize the temperature of a Fabry-Perot laser diode, which in turn stabilizes the output power and wavelength of the laser diode for a given drive current. The Fabry-Perot laser diode inside each unit is pigtailed to a single mode fiber that is terminated at an FC/PC bulkhead connector (wide 2.1 mm key compatible) on the front panel.



Light Propagation Down Single Mode Fiber

More Wavelengths Available on the Web

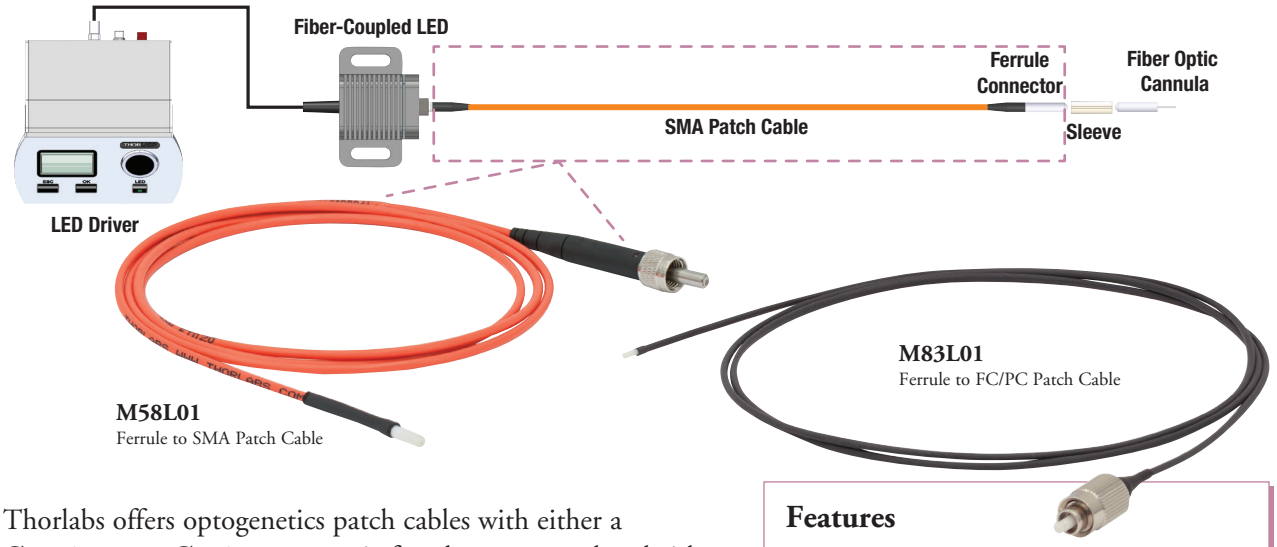
The front panel includes a display that shows the output power in mW, an on/off key, an enable button, and a knob to adjust the laser power. The back panel includes an input that allows the laser diode drive current to be controlled via an external voltage source and a remote interlock input. All of our fiber pigtailed lasers utilize an angled fiber ferrule at the internal laser/fiber launch point to minimize reflections back into the laser diode, thereby increasing the stability of the laser diode's output.

SPECIFICATIONS	
Center Wavelength (Typical)[a]	473 nm
Wavelength Range	468 – 478 nm
Output Power	20 mW (Max)
Stability	15 min: ±0.05 dB, 24 hr: ±0.1 dB (After 1 hr Warm-up at 25 ± 10 °C Ambient)
Display Accuracy (mW)	±10% of Actual
Set Point Resolution	0.01 mW
Adjustment Range	~0 mW to Full Power
TEC	
Stability	0.005 °C/ 1 °C
Set Point Accuracy	±0.25 °C
Set Point Resolution	±0.1 °C
Adjustment Range	20 ± 1 °C to 30 ± 1 °C
Environmental	
Operating Temperature	15 to 35 °C
Storage Temperature	0 to 50 °C
AC Input	115/230 VAC (Switch Selectable) 50 - 60 Hz
Modulation Input	0 - 5 V = 0 - Full Power , DC or Sine Wave Input Only
Modulation Bandwidth	5 kHz Full Depth of Modulation 30 kHz Small Signal Modulation
Fiber	S460-HP (Single Mode)
Output Fiber Connector	FC/PC, Wide 2.1 mm Key Compatible

[a]Nominal wavelength, actual wavelength may vary by ±15 nm

ITEM #	PRICE	DESCRIPTION
S3FC473	$ 7,635.92	FC/PC Fiber-Coupled Laser Source with TEC, 473 nm, 20 mW, Class 3B

Fiber Patch Cables



Thorlabs offers optogenetics patch cables with either a Ø1.25 mm or Ø2.5 mm ceramic ferrule on one end and either an FC/PC or SMA connector on the other. Both 0.5 m and 1.0 m lengths are available.

Each patch cable includes two protective caps that shield the ferrule ends from dust and other hazards when not in use. Additional caps are available on the following page. If the fiber ends become dirty from use, we offer a selection of inspection tools, as well as fiber optic cleaning products (see pages 350 - 351).

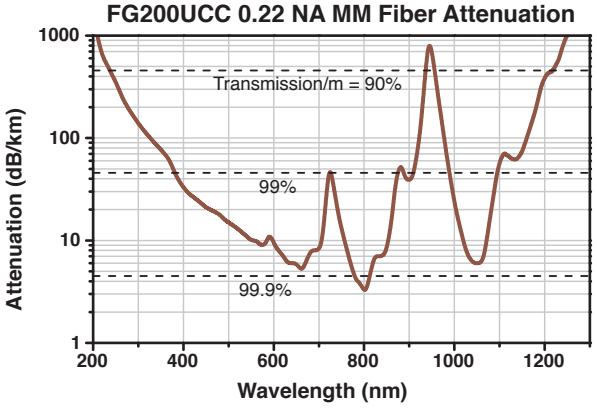
Features

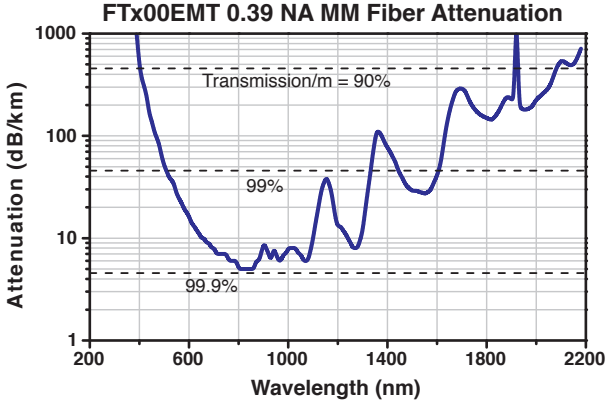
- Ferrule Material: Ceramic (Zirconia)
- Connector Options
  - FC/PC to Ferrule
  - SMA to Ferrule
- Ferrule End Integrates with an Implantable Fiber Optic Cannula
- Lightweight Protective Tubing

Ferrule Size, Fiber Core Size, and Numerical Aperture (NA)

Our lightweight, compact Ø1.25 mm ferrule end cables minimize stress on the specimen and offer the ability to implant several cannulae near the same location for applications such as bilateral stimulation. Patch cables with Ø1.25 mm ferrules also have a total mass that is almost one-third that of their Ø2.5 mm counterparts, due to the use of heat shrink tubing as a protective jacket. In contrast, the larger Ø2.5 mm ferrule end cables provide easier handling and a more robust connection to the specimen.

Smaller fiber core sizes, such as the Ø200 µm, are less invasive, making them ideal for smaller specimens. Larger core sizes, such as Ø300 µm or Ø400 µm, offer more robust solutions for larger specimens, as well as when using higher power light sources.





Fiber Patch Cables

Numerical Aperture (NA) defines the angle of the cone of light leaving the fiber tip at the end of the cannula. The 0.22 NA fibers provide a narrower cone of light at the tip, resulting in higher light intensity over a smaller area. The 0.39 NA fibers generate a wider cone of light, illuminating a larger area with lower intensity.

M83L01
Optogenetics Patch Cables Feature a Connector on One End and a Ceramic Ferrule on the Other

Component Compatibility

The diameter of the ceramic ferrule on the patch cable should be chosen to match the diameter of the ferrule on our implantable fiber optic cannulae. Cannulae and patch cables with different ferrule materials can be mixed and matched without significant additional signal losses. However, fiber core sizes, numerical aperture (NA), and ferrule diameters should match for proper connection and maximum signal strength.

Ø1.25 mm and Ø2.5 mm FC/PC and SMA Fiber Patch Cables

ITEM #	CONNECTOR	FERRULE SIZE	INCLUDED CAP ITEM #[a]	FIBER TYPE[b]	CORE SIZE	NA	LENGTH	COMPATIBLE CANNULA (ITEM # PREFIX)	PRICE
M86L005	FC/PC	Ø1.25 mm	CAPF and CAPL	FG200UCC	Ø200 µm	0.22	0.5 m	CFMLC22 (Ceramic) or CFML22 (Stainless Steel)	$ 87.92
M86L01				FG200UCC		0.22	1.0 m	CFMLC22 (Ceramic) or CFML22 (Stainless Steel)	$ 90.98
M83L01				FT200EMT		0.39	1.0 m	CFMLC12 (Ceramic) or CFML12 (Stainless Steel)	$ 90.98
M80L005		Ø2.5 mm	CAPF	FG200UCC		0.22	0.5 m	CFMC22 (Ceramic) or CFM22 (Stainless Steel)	$ 67.52
M80L01				FG200UCC		0.22	1.0 m	CFMC22 (Ceramic) or CFM22 (Stainless Steel)	$ 70.58
M81L005				FT200EMT		0.39	0.5 m	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 67.52
M81L01				FT200EMT		0.39	1.0 m	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 70.58
M56L005				FT300EMT	Ø300 µm	0.39	0.5 m	CFMC13 (Ceramic) or CFM13 (Stainless Steel)	$ 81.29
M56L01				FT300EMT		0.39	1.0 m	CFMC13 (Ceramic) or CFM13 (Stainless Steel)	$ 84.35
M82L005				FT400EMT	Ø400 µm	0.39	0.5 m	CFMC14 (Ceramic) or CFM14 (Stainless Steel)	$ 81.60
M82L01				FT400EMT		0.39	1.0 m	CFMC14 (Ceramic) or CFM14 (Stainless Steel)	$ 84.66
M87L005	SMA	Ø1.25 mm	CAPM and CAPL	FG200UCC	Ø200 µm	0.22	0.5 m	CFMLC22 (Ceramic) or CFML22 (Stainless Steel)	$ 87.92
M87L01				FG200UCC		0.22	1.0 m	CFMLC22 (Ceramic) or CFML22 (Stainless Steel)	$ 90.98
M89L01				FT200EMT		0.39	1.0 m	CFMLC12 (Ceramic) or CFML12 (Stainless Steel)	$ 90.98
M84L005		Ø2.5 mm	CAPM and CAPF	FG200UCC		0.22	0.5 m	CFMC22 (Ceramic) or CFM22 (Stainless Steel)	$ 69.51
M84L01				FG200UCC		0.22	1.0 m	CFMC22 (Ceramic) or CFM22 (Stainless Steel)	$ 72.66
M77L005				FT200EMT		0.39	0.5 m	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 69.51
M77L01				FT200EMT		0.39	1.0 m	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 72.66
M58L005				FT300EMT	Ø300 µm	0.39	0.5 m	CFMC13 (Ceramic) or CFM13 (Stainless Steel)	$ 69.56
M58L01				FT300EMT		0.39	1.0 m	CFMC13 (Ceramic) or CFM13 (Stainless Steel)	$ 72.62
M79L005				FT400EMT	Ø400 µm	0.39	0.5 m	CFMC14 (Ceramic) or CFM14 (Stainless Steel)	$ 81.60
M79L01				FT400EMT		0.39	1.0 m	CFMC14 (Ceramic) or CFM14 S(tainless Steel)	$ 84.66

[a]Cables include only one cap for each end.
[b]For an attenuation curve, please see the previous page.

CAPL
White Plastic Dust Cap, 25 Pack

CAPF
Clear Plastic Dust Cap, 25 Pack

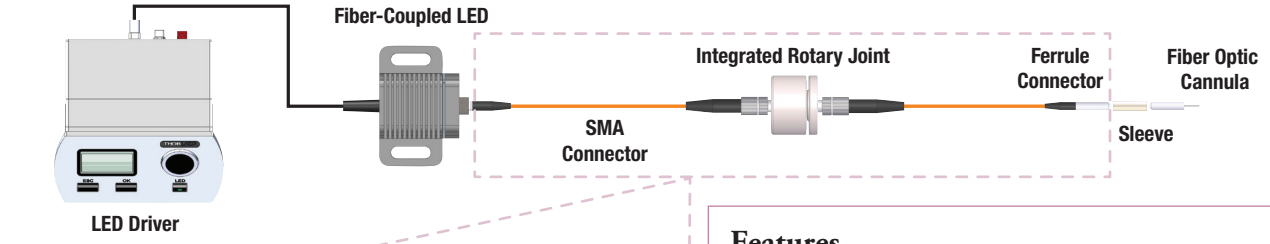
CAPM
Black Rubber Dust Cap, 10 Pack

CAPMM
Metal-Threaded Cap 4 Pack

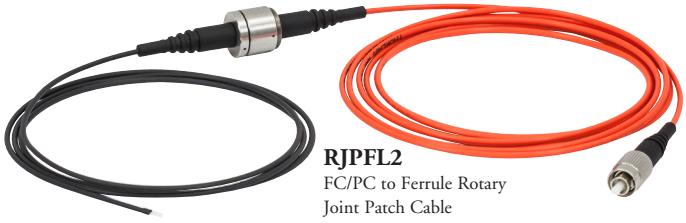
Fiber Caps

ITEM #	QTY	DESCRIPTION	PRICE
CAPL	25	White Plastic Dust Caps for Ø1.25 mm Ferrules	$ 6.60
CAPF	25	Clear Plastic Dust Caps for Ø2.5 mm Ferrules	$ 6.60
CAPFM	4	Metal-Threaded Caps for FC Connectors	$ 7.00
CAPM	10	Black Rubber Dust Caps for SMA Connectors	$ 8.80
CAPMM	4	Metal-Threaded Caps for SMA Connectors	$ 7.00

Rotary Joint Fiber Patch Cables



RJPSL2
SMA to Ferrule Rotary Joint Patch Cable



RJPFL2
FC/PC to Ferrule Rotary Joint Patch Cable

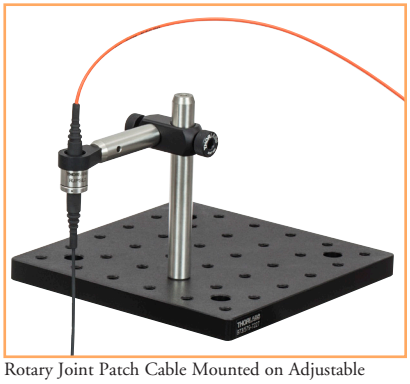
Features

- Articulated Rotary Joint Protects Against Fiber Damage Caused by Moving Specimen
- Ferrule Material: Ceramic (Zirconia)
- Connector Options
  - FC/PC to Ferrule
  - SMA to Ferrule
- Ferrule End Integrates with an Implantable Fiber Optic Cannula
- Lightweight Protective Tubing

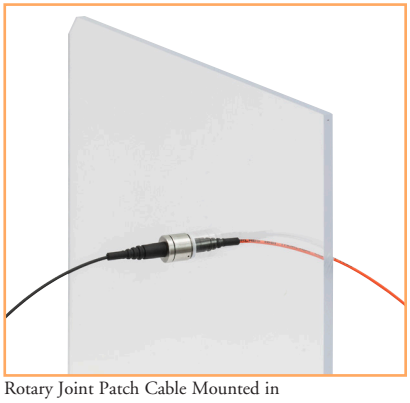
Our articulated rotary joint patch cables are a one-piece solution for optogenetics experiments. The built-in rotary joint interface allows the cable to freely rotate, reducing the risk of damage in optogenetics experiments. Rather than using two fiber patch cables with a separate rotary joint interface, the permanently attached fiber optics directly connect to the light source on one end and the specimen implant on the other. The lens-free design provides higher light transmission and less rotational transmission variation than a separate rotary joint and patch cable solution.

Two potential mounting options for these rotary joint patch cables are shown in the photos to the right. For a detailed components list and mounting instructions, as well as alternative mounting options, please visit our rotary joint patch cable presentation at www.thorlabs.com.

Each patch cable is 3 m long and comes with either a Ø1.25 mm or Ø2.5 mm ceramic ferrule on one end and either an FC/PC or SMA connector on the other end. The FC/PC cables are directly compatible with our fiber-coupled laser sources, while the SMA cables are directly compatible with our fiber-coupled LEDs.



Rotary Joint Patch Cable Mounted on Adjustable Ø1/2" Post



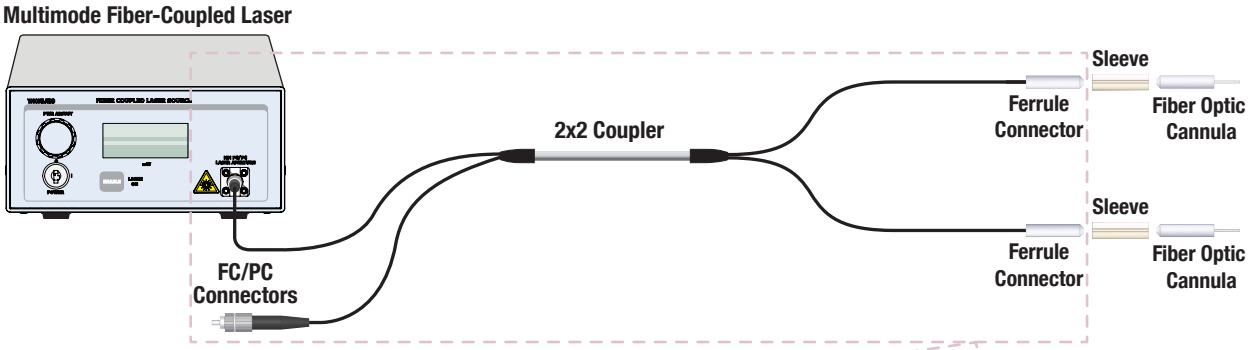
Rotary Joint Patch Cable Mounted in Custom Enclosure

Ø1.25 mm and Ø2.5 mm Rotary Joint FC/PC and SMA Fiber Patch Cables

ITEM #	CONNECTOR	FERRULE SIZE	FIBER TYPE[a]	CORE SIZE	NA	LENGTH	COMPATIBLE CANNULA (ITEM # PREFIX)	PRICE
RJPFL2	FC/PC	Ø1.25 mm	FT200EMT	Ø200 µm	0.39	3 m	CFMLC12 (Ceramic) or CFML12 (Stainless Steel)	$ 300.00
RJPFF2		Ø2.5 mm					CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 300.00
RJPFF4		Ø2.5 mm	FT400EMT	Ø400 µm			CFMC14 (Ceramic) or CFM14 (Stainless Steel)	$ 325.00
RJPSL2	SMA	Ø1.25 mm	FT200EMT	Ø200 µm			CFMLC12 (Ceramic) or CFML12 (Stainless Steel)	$ 300.00
RJPSF2		Ø2.5 mm					CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 300.00
RJPSF4		Ø2.5 mm	FT400EMT	Ø400 µm			CFMC14 (Ceramic) or CFM14 (Stainless Steel)	$ 325.00

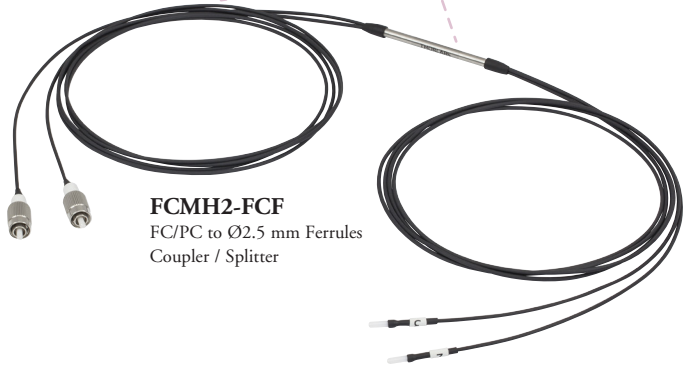
[a]For an attenuation curve, please see page 336.

2x2 Fiber Optic Couplers / Splitters



Features

- Illuminate Two Fiber Optic Implants
- Combine Two Light Sources
- 50:50 Coupling / Splitting Ratio
- Connector Options
  - SMA to Ferrule
  - FC/PC to Ferrule
  - SMA to SMA
  - FC/PC to FC/PC



FCMH2-FCF
FC/PC to Ø2.5 mm Ferrules
Coupler / Splitter

These 2x2 Multimode Fiber Optic Couplers/Splitters are built with FT200UMT 0.39 NA, Ø200 µm core multimode fiber. They are optimized for applications such as bilateral stimulation, where two fiber optic implants need to be illuminated with a single light source. A typical setup is shown in the diagram above.

Choose from either SMA or FC/PC connectors on the input legs for connection to a light source. On the output side, options are available with SMA connectors, FC/PC connectors, Ø1.25 mm ceramic ferrules, or Ø2.5 mm ceramic ferrules. The ceramic ferrule output ends, which enable direct connection to fiber optic cannulae, have Ø1/16" (Ø1.6 mm) black shrink tubing to protect the fiber and block any stray light that escapes from it. Options with either SMA or FC/PC connectors on the output legs, which have unjacketed fiber with a Ø500 µm tefzel tight buffer, allow for connection to either our optogenetics patch cables (see pages 336 - 337) or our rotary joint patch cables (see page 338) using mating sleeves.

COMMON SPECIFICATIONS[a]	
Operating Wavelength Range	400 - 600 nm[b]
Coupling Ratio	50:50 ± 3.5%
Transmission[c]	40% Typical from 400 to 600 nm 28% Min (≤5.5 dB Insertion Loss) @ 455 nm
Directivity	≥40 dB
Power Level (Max)	300 mW (CW)
Fiber Type	FT200UMT, 0.39 NA, Ø200 µm Core, High-OH
Fiber Length	1.0 +0.075/-0.0 m
Coupler Body Dimensions[d]	2.36" x Ø0.16" (60 mm x Ø4 mm)

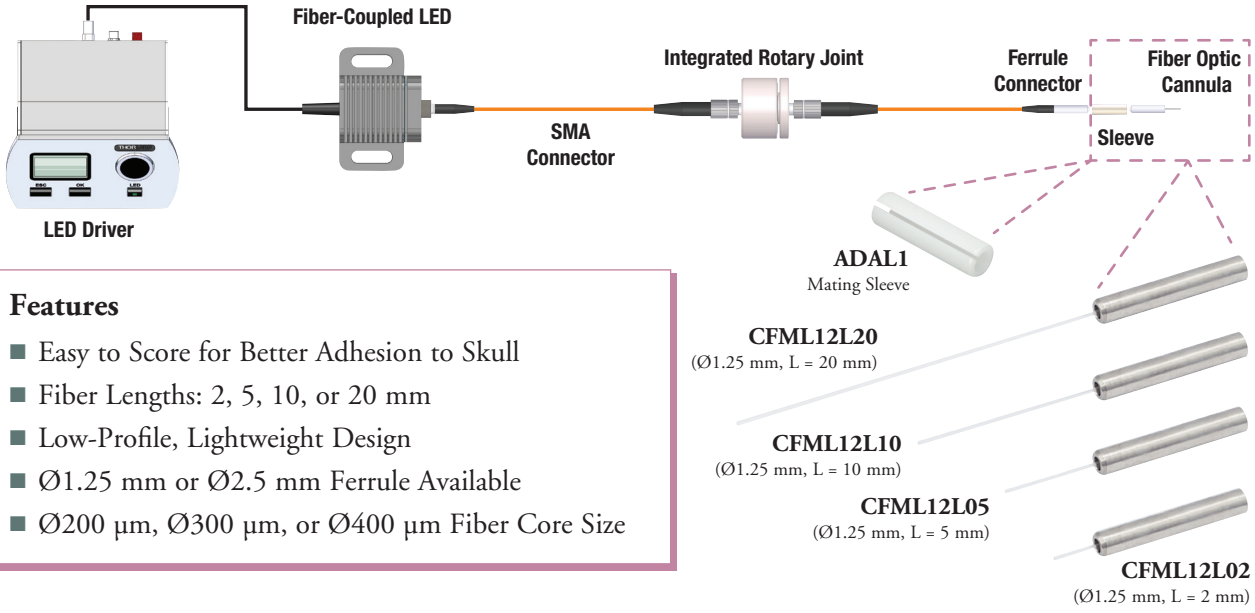
[a]All specifications are measured without connectors during the manufacturing process.
[b]All other specifications listed here are guaranteed within the 400 - 600 nm operating wavelength range. However, the couplers perform well outside of this range.
[c]Transmission is specified from any port on one side of the coupler to either port on the other side of the coupler. This specification accounts for the inherent 50% power splitting within the coupler.
[d]Dimensions of the metal coupler body not including the boots.

Combining Signals

While these couplers are primarily designed to split a signal from a single light source between two cannulae, they can also be used to combine the signals from two light sources into one cannula. This can be useful when illuminating an implant with two different wavelengths of light. However, both signals will experience approximately a 40% typical transmission, as each input signal will be evenly split between the two output ports, plus a small percentage of light will be attenuated within the coupler.

ITEM #	CONNECTORS (SIDE ONE)	CONNECTORS (SIDE TWO)	COMPATIBLE CANNULA (ITEM # PREFIX)	PRICE
FCMH2-SMAL	SMA	Ø1.25 mm Ceramic Ferrule	CFMLC12 (Ceramic) or CFML12 (Stainless Steel)	$ 520.00
FCMH2-FCL	FC/PC	Ø1.25 mm Ceramic Ferrule	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 520.00
FCMH2-SMAF	SMA	Ø2.5 mm Ceramic Ferrule	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 520.00
FCMH2-FCF	FC/PC	Ø2.5 mm Ceramic Ferrule	CFMC12 (Ceramic) or CFM12 (Stainless Steel)	$ 520.00
FCMH2-SMA	SMA	SMA	N/A	$ 500.00
FCMH2-FC	FC/PC	FC/PC	N/A	$ 500.00

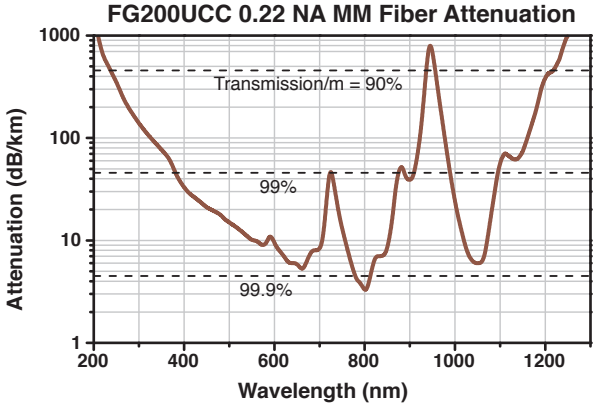
Implantable Fiber Optic Cannula: Stainless Steel Ferrule

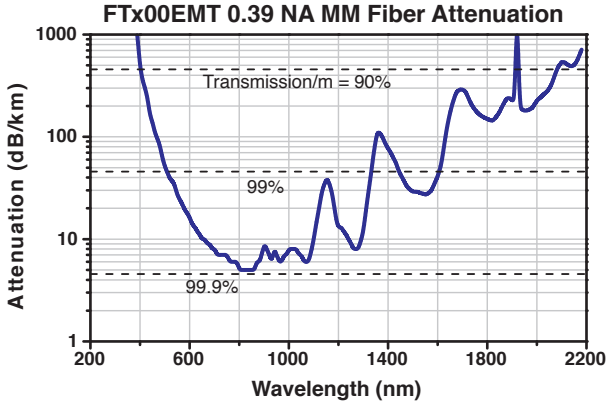


Features

- Easy to Score for Better Adhesion to Skull
- Fiber Lengths: 2, 5, 10, or 20 mm
- Low-Profile, Lightweight Design
- Ø1.25 mm or Ø2.5 mm Ferrule Available
- Ø200 µm, Ø300 µm, or Ø400 µm Fiber Core Size

Thorlabs' Stainless Steel Fiber Optic Cannula can be surgically implanted using stereotactic guidance and offer better glue adhesion than ceramic. The Ø1.25 mm ferrules minimize pressure on the specimen and allow several cannulae to be implanted near the same location. In contrast, the larger Ø2.5 mm ferrules provide easier handling and a stronger mating force, which prevents disconnections caused by specimen motion.





Ø1.25 mm Ferrule, Ø200 µm Core

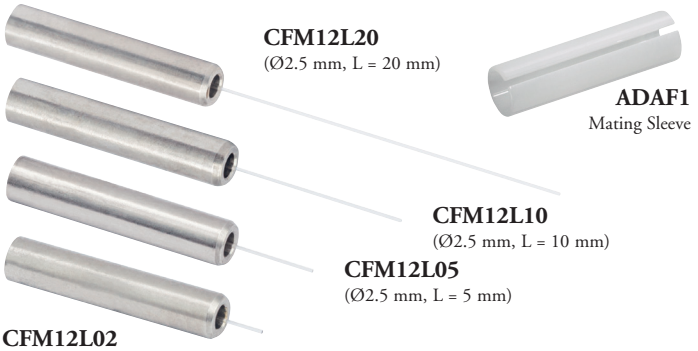
ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFML22L02	Ø1.25 mm	Ø200 ± 8 µm	0.22	FG200UCC	2 mm	$ 43.86
CFML22L05					5 mm	$ 45.90
CFML22L10					10 mm	$ 47.94
CFML22L20					20 mm	$ 51.00
CFML12L02		Ø200 ± 5 µm	0.39	FT200EMT	2 mm	$ 43.86
CFML12L05					5 mm	$ 45.90
CFML12L10					10 mm	$ 47.94
CFML12L20					20 mm	$ 51.00

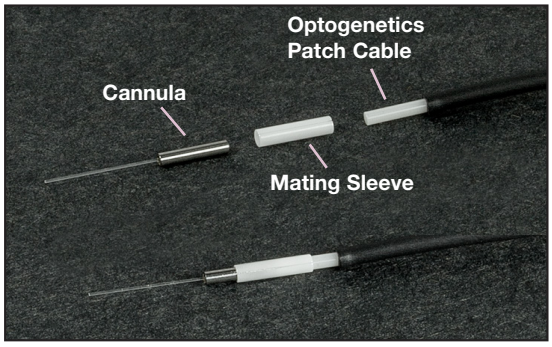
Compatible Mating Sleeves for Ø1.25 mm Ferrule

ITEM #	COMPATIBLE FERRULE SIZE	INSERTION LOSS	LENGTH	CONNECTION FORCE	MATERIAL	QUANTITY	PRICE
ADAL1	Ø1.25 mm	<1.0 dB Typical (Multimode Fiber)[a]	6.8 mm	11.4 N (2.6 lbf) Max[b] 7.2 N (1.6 lbf) Typical[b]	Ceramic (Zirconia)	1	$ 5.00
ADAL1-5						5	$ 20.00

[a]Tested using Ø200 µm core, 0.39 NA multimode fiber with LC connectors, and an LED source at 617 nm.
[b]Tested using an LC-type ferrule.

Implantable Fiber Optic Cannula: Stainless Steel Ferrule





Cannula, Mating Sleeve, and Patch Cable Shown Separated (Above) and Assembled (Below)

Ø2.5 mm Ferrule, Ø200 µm Core

ITEM #	QUANTITY	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFM22L02	1	Ø2.5 mm	Ø200 ± 8 µm	0.22	FG200UCC	2 mm	$ 38.76
CFM22L05	1					5 mm	$ 40.80
CFM22L10	1					10 mm	$ 42.84
CFM22L20	1					20 mm	$ 45.90
CFM12L02	1		Ø200 ± 5 µm	0.39	FT200EMT	2 mm	$ 38.76
CFM12L02-10	10						$ 348.84
CFM12L05	1					5 mm	$ 40.80
CFM12L05-10	10						$ 367.20
CFM12L10	1					10 mm	$ 42.84
CFM12L10-10	10						$ 385.56
CFM12L20	1					20 mm	$ 45.90
CFM12L20-10	10						$ 413.10

Ø2.5 mm Ferrule, Ø300 µm Core

ITEM #	QUANTITY	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFM13L02	1	Ø2.5 mm	Ø300 ± 6 µm	0.39	FT300EMT	2 mm	$ 40.80
CFM13L05	1					5 mm	$ 42.84
CFM13L10	1					10 mm	$ 44.88
CFM13L20	1					20 mm	$ 47.94

Ø2.5 mm Ferrule, Ø400 µm Core

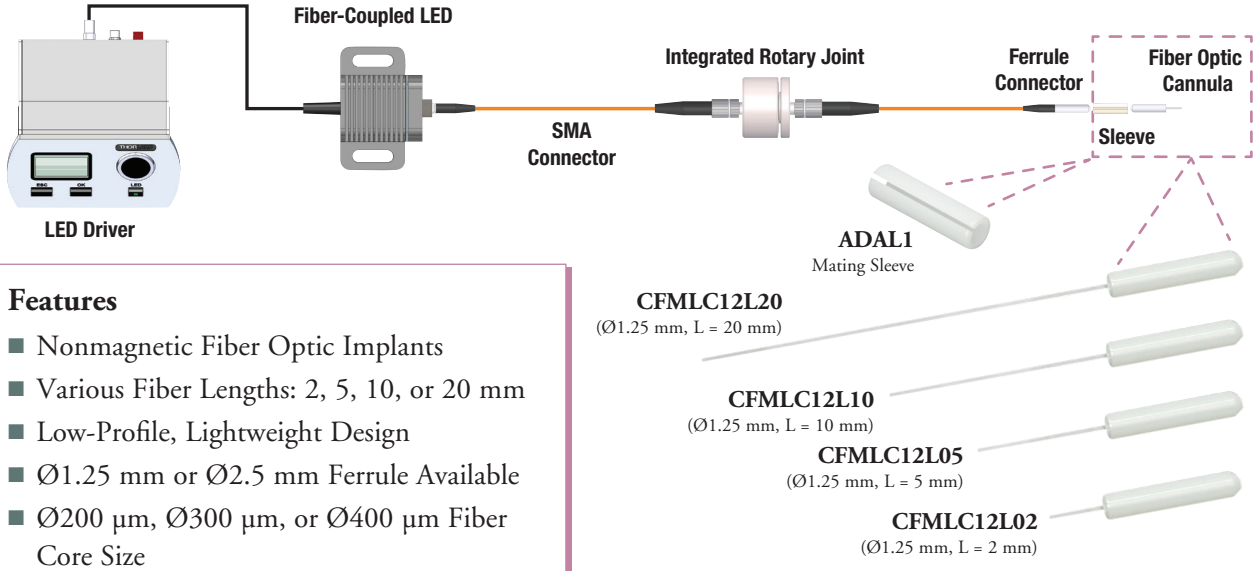
ITEM #	QUANTITY	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFM14L02	1	Ø2.5 mm	Ø400 ± 8 µm	0.39	FT400EMT	2 mm	$ 41.82
CFM14L02-10	10						$ 376.38
CFM14L05	1					5 mm	$ 43.86
CFM14L05-10	10						$ 394.74
CFM14L10	1					10 mm	$ 45.90
CFM14L10-10	10						$ 413.10
CFM14L20	1					20 mm	$ 48.96
CFM14L20-10	10						$ 440.64

Compatible Mating Sleeve for Ø2.5 mm Ferrule

ITEM #	COMPATIBLE FERRULE SIZE	INSERTION LOSS	LENGTH	CONNECTION FORCE	MATERIAL	QUANTITY	PRICE
ADAF1	Ø2.5 mm	<1.0 dB Typical (Multimode Fiber)[a]	11.4 mm	53 N (12 lbf) Max[b] 25 N (5.6 lbf) Typical[b]	Ceramic (Zirconia)	1	$ 5.00
ADAF1-5						5	$ 20.00

[a]Tested using Ø200 µm core, 0.39 NA multimode fiber with FC/PC connectors, and an LED source at 617 nm.
[b]Tested using an FC-type ferrule.

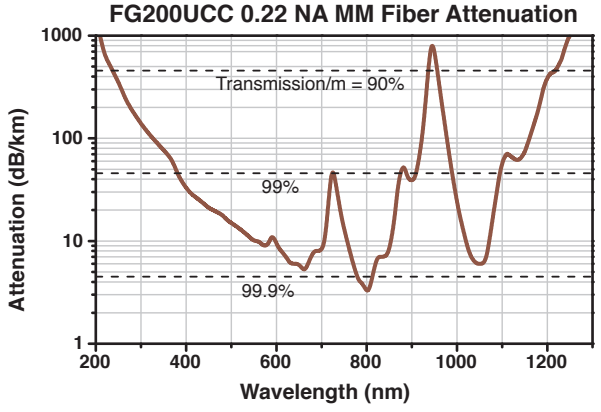
Implantable Fiber Optic Cannula: Ceramic Ferrule

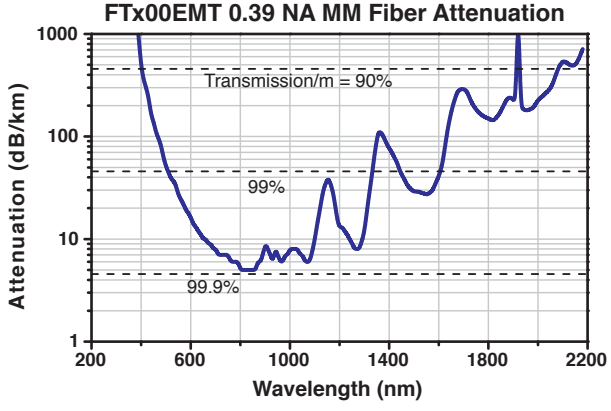


Features

- Nonmagnetic Fiber Optic Implants
- Various Fiber Lengths: 2, 5, 10, or 20 mm
- Low-Profile, Lightweight Design
- Ø1.25 mm or Ø2.5 mm Ferrule Available
- Ø200 µm, Ø300 µm, or Ø400 µm Fiber Core Size

Thorlabs' Ceramic Fiber Optic Cannula can be surgically implanted using stereotactic guidance and provide a completely nonmagnetic cannula and interconnection when used with a patch cable with a ceramic ferrule. The Ø1.25 mm ferrules minimize pressure on the specimen and allow several cannulae to be implanted near the same location. In contrast, the larger Ø2.5 mm ferrules provide easier handling and a stronger mating force, which prevents disconnections caused by specimen motion.





Ø1.25 mm Ferrule, Ø200 µm Core

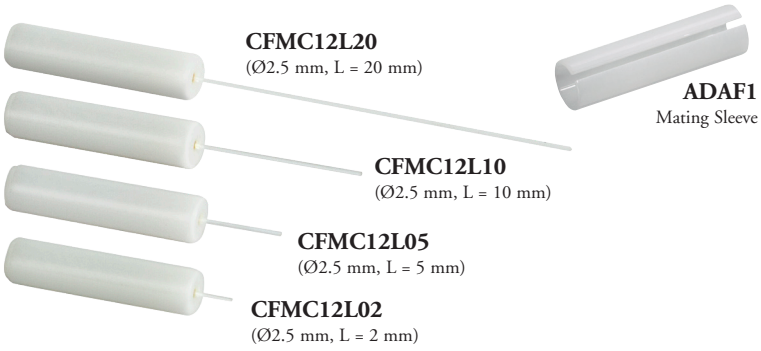
ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFMLC22L02	Ø1.25 mm	Ø200 ± 8 µm	0.22	FG200UCC	2 mm	$ 43.86
CFMLC22L05					5 mm	$ 45.90
CFMLC22L10					10 mm	$ 47.94
CFMLC22L20					20 mm	$ 51.00
CFMLC12L02		Ø200 ± 5 µm	0.39	FT200EMT	2 mm	$ 43.86
CFMLC12L05					5 mm	$ 45.90
CFMLC12L10					10 mm	$ 47.94
CFMLC12L20					20 mm	$ 51.00

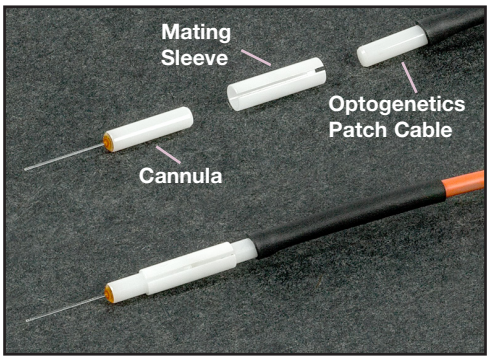
Compatible Mating Sleeves for Ø1.25 mm Ferrule

ITEM #	COMPATIBLE FERRULE SIZE	INSERTION LOSS	LENGTH	CONNECTION FORCE	MATERIAL	QUANTITY	PRICE
ADAL1	Ø1.25 mm	<1.0 dB Typical (Multimode Fiber)[a]	6.8 mm	11.4 N (2.6 lbf) Max[b] 7.2 N (1.6 lbf) Typical[b]	Ceramic (Zirconia)	1	$ 5.00
ADAL1-5						5	$ 20.00

[a]Tested using Ø200 µm core, 0.39 NA multimode fiber with LC connectors, and an LED source at 617 nm.
[b]Tested using an LC-type ferrule.

Implantable Fiber Optic Cannula: Ceramic Ferrule





Cannula, Mating Sleeve, and Patch Cable Shown Separated (Above) and Assembled (Below)

Ø2.5 mm Ferrule, Ø200 µm Core

ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFMC22L02	Ø2.5 mm	Ø200 ± 8 µm	0.22	FG200UCC	2 mm	$ 38.76
CFMC22L05					5 mm	$ 40.80
CFMC22L10					10 mm	$ 42.84
CFMC22L20					20 mm	$ 45.90
CFMC12L02		Ø200 ± 5 µm	0.39	FT200EMT	2 mm	$ 38.76
CFMC12L05					5 mm	$ 40.80
CFMC12L10					10 mm	$ 42.84
CFMC12L20					20 mm	$ 45.90

Ø2.5 mm Ferrule, Ø300 µm Core

ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFMC13L02	Ø2.5 mm	Ø300 ± 6 µm	0.39	FT300EMT	2 mm	$ 40.80
CFMC13L05					5 mm	$ 42.84
CFMC13L10					10 mm	$ 44.88
CFMC13L20					20 mm	$ 47.94

Ø2.5 mm Ferrule, Ø400 µm Core

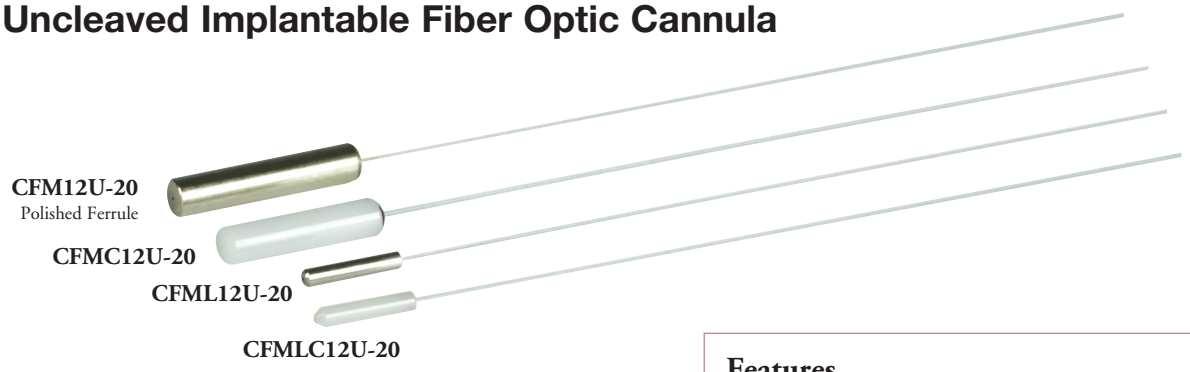
ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	PRICE
CFMC14L02	Ø2.5 mm	Ø400 ± 8 µm	0.39	FT400EMT	2 mm	$ 41.82
CFMC14L05					5 mm	$ 43.86
CFMC14L10					10 mm	$ 45.90
CFMC14L20					20 mm	$ 48.96

Compatible Mating Sleeves for Ø2.5 mm Ferrule

ITEM #	COMPATIBLE FERRULE SIZE	INSERTION LOSS	LENGTH	CONNECTION FORCE	MATERIAL	QUANTITY	PRICE
ADAF1	Ø2.5 mm	<1.0 dB Typical (Multimode Fiber)[a]	11.4 mm	53 N (12 lbf) Max[b] 25 N (5.6 lbf) Typical[b]	Ceramic (Zirconia)	1	$ 5.00
ADAF1-5						5	$ 20.00

[a]Tested using Ø200 µm core, 0.39 NA multimode fiber with FC/PC connectors, and an LED source at 617 nm.
[b]Tested using an FC-type ferrule.

Uncleaved Implantable Fiber Optic Cannula



Our Uncleaved Fiber Optic Cannula can be surgically implanted using stereotactic guidance. Stainless steel ferrules offer better glue adhesion while ceramic ferrules provide a completely nonmagnetic cannula and interconnection when used with a patch cable with a ceramic ferrule. Please note that the fiber end on our uncleaved cannula must be cleaved, or precision cut, before use. This can be accomplished easily using the procedure outlined on the next page.

Features

- Long Scissor-Cut Fiber End Designed for Custom Cleaving
- Ferrule Varieties
  - Stainless Steel or Ceramic
  - Ø1.25 mm or Ø2.5 mm
- 0.22 or 0.39 Numerical Aperture (NA)
- Sold in Packages of 20

Stainless Steel Ferrules*

ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	COMPATIBLE PATCH CABLES	PRICE
CFML22U-20	Ø1.25 mm x 6.4 mm	Ø200 ± 8 µm	0.22	FG200UCC	50 ± 2.5 mm (Scissor Cut)	M86 and M87	$ 459.00
CFML12U-20	Ø1.25 mm x 6.4 mm	Ø200 ± 5 µm	0.39	FT200EMT		M83, M89, RJPFL2, and RJPSL2	$ 408.00
CFM22U-20	Ø2.5 mm x 12.7 mm	Ø200 ± 8 µm	0.22	FG200UCC		M80 and M84	$ 408.00
CFM12U-20	Ø2.5 mm x 12.7 mm	Ø200 ± 5 µm	0.39	FT200EMT		M81, M77, RJPFF2, and RJPSF2	$ 408.00

*Sold in Packs of 20

Ceramic Ferrules*

ITEM #	FERRULE SIZE	CORE SIZE	NA	FIBER	FIBER LENGTH	COMPATIBLE PATCH CABLES	PRICE
CFMLC22U-20	Ø1.25 mm x 6.4 mm	Ø200 ± 8 µm	0.22	FG200UCC	50 ± 2.5 mm (Scissor Cut)	M86 and M87	$ 459.00
CFMLC12U-20	Ø1.25 mm x 6.4 mm	Ø200 ± 5 µm	0.39	FT200EMT		M83, M89, RJPFL2, and RJPSL2	$ 408.00
CFMC22U-20	Ø2.5 mm x 10.5 mm	Ø200 ± 8 µm	0.22	FG200UCC		M80 and M84	$ 408.00
CFMC12U-20	Ø2.5 mm x 10.5 mm	Ø200 ± 5 µm	0.39	FT200EMT		M81, M77, RJPFF2, and RJPSF2	$ 408.00

*Sold in Packs of 20

Cleaving Procedure

Materials Necessary

- Uncleaved Fiber Optic Cannula
- S90R Fiber Scribe
- BFG1 Bare Fiber Gripper
- KW32 Kimwipes™ Lint-Free Wipes
- Isopropyl Alcohol
- JEL10 Eye Loupe or Microscope
- FTDU Fiber Optic Disposal Unit

Figure 1

Figure 2

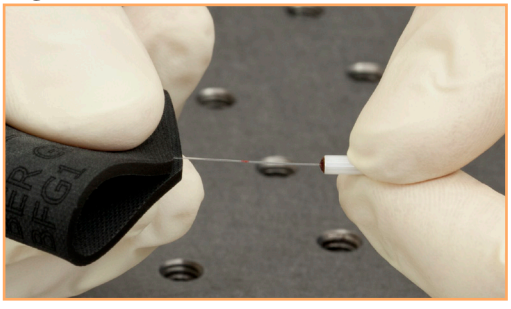


Figure 3

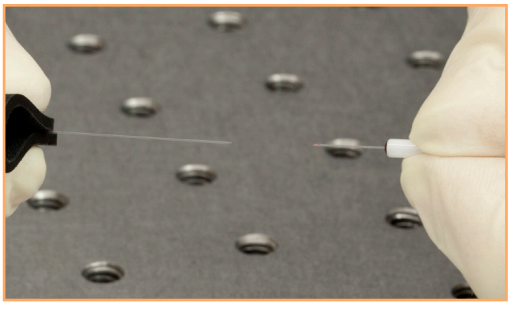
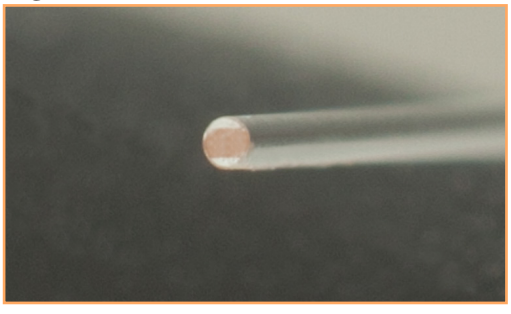


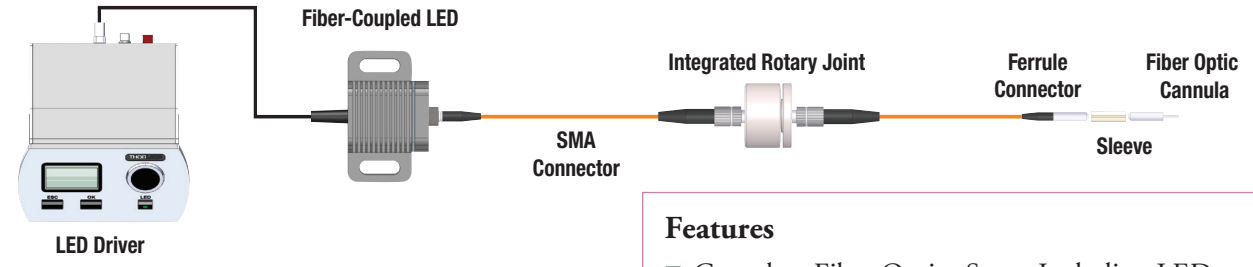
Figure 4



1. Clean the fiber end of the cannula using a lint-free wipe and isopropyl alcohol. Do not use acetone, as this will damage the TEQS cladding on the exposed fiber.
2. Measure the desired length of fiber from the end of the ferrule. Mark this length on the fiber with a marker.
3. Place the cannula on a hard surface and secure the fiber end with a finger or tape, as shown in Figure 1.
4. Hold the cleaving tool perpendicular to the fiber and gently score the fiber as shown in Figure 1. Do not apply excessive pressure. The fiber should not break off at this point. This step is critical in obtaining a good cleave. If the scribe is made too hard, the fiber will break instead of cleaving. If the scribe is too light, the fiber will not cleave.
5. Hold the cannula in one hand, and grip the fiber end with a bare fiber gripper in the other end as shown in Figure 2.
6. Pull the fiber straight back until the fiber cleaves as shown in Figure 3. Dispose of the scrap fiber end in the FTDU or any medical or fiber sharps container.
7. If the fiber does not break with a moderate amount of tension, repeat steps 4 through 6 applying slightly more pressure when scoring. Inspect the cleave using an eye loupe or microscope. A good cleave will be flat across the fiber and perpendicular to the optic axis. There should be no 'tag' (i.e., protrusion) from the edge of the fiber. The region where the initial scribe was made may be visible. It should be less than 5% of the core diameter. Be patient as this process takes a little practice. Please be aware that it will be more difficult to achieve a high-quality cleave in large-core-diameter fibers compared to smaller-core-diameter fibers. A view of a properly cleaved fiber end as seen through a Thorlabs JEL10 eye loupe is shown in Figure 4.

ITEM #	DESCRIPTION	PRICE
S90R	Fiber Scribe	$ 49.00
BFG1	Bare Fiber Gripper	$ 5.00
KW32	Kimwipes™ Lint-Free Wipes (12 Boxes Per Case)	$ 44.60
JEL10	Eye Loupe	$ 23.26
FTDU	Fiber Optic Disposal Unit (Recommended)	$ 6.95

Optogenetics Starter Kits



Features

- Complete Fiber Optics Setup Including LED, Patch Cable, Cannula, and Accessories
- Ferrule Options
  - Ø1.25 mm Ferrules (Ø200 µm Core Fiber)
  - Ø2.5 mm Ferrules (Ø200 µm or Ø400 µm Core Fiber)
- 20 Cannula Included (Five Each of Four Different Lengths)
- Five Mating Sleeves Included

With a 470 nm Fiber-Coupled LED, a lightweight patch cable with optional rotary joint, five mating sleeves, and 20 stainless steel ferrule cannula, our optogenetics kit includes all the necessary components for a full, ready-to-use system. Each kit is available with Ø200 µm or Ø400 µm core fiber components with 0.39 NA. The Ø200 µm core size cables are less invasive, making them ideal for smaller animals, while the Ø400 µm core size cables offer a stiffer more robust solution for larger animals and higher power light sources. These kits are offered at a 10% discount over the individual component pieces.

ITEM #	OGKL2	OGKRL2	OGK2	OGKR2	OGK4	OGKR4
Light Source	Item # M470F1 (470 nm Fiber-Coupled LED)					
LED Driver	Item # DC2100 (LED Driver with Pulse Modulation)					
Patch Cable	Item # M89L01 (1 m Long)	Item # RJPSL2 (3 m Long with Rotary Joint)	Item # M77L01 (1 m Long)	Item # RJPSF2 (3 m Long with Rotary Joint)	Item # M79L01 (1 m Long)	Item # RJPSF4 (3 m Long with Rotary Joint)
Fiber Core Size	Ø200 µm				Ø400 µm	
Cannula (Quantity: 5)	Item # CFML12L02 (L = 2 mm) Item # CFML12L05 (L = 5 mm) Item # CFML12L10 (L = 10 mm) Item # CFML12L20 (L = 20 mm)		Item # CFM12L02 (L = 2 mm) Item # CFM12L05 (L = 5 mm) Item # CFM12L10 (L = 10 mm Item # CFM12L20 (L = 20 mm)		Item # CFM14L02 (L = 2 mm) Item # CFM14L05 (L = 5 mm) Item # CFM14L10 (L = 10 mm) Item # CFM14L20 (L = 20 mm)	
Cannula Ferrule Size	Ø1.25 mm		Ø2.5 mm			
Approximate Output Power	2.3 mW	1.5 mW	2.6 mW	1.6 mW	10.8 mW	6.8 mW
Output Power Variation	N/A	±7%	N/A	±7%	N/A	±7%
Cannula Mating Sleeve (Quantity: 5)	Item # ADAL1		Item # ADAF1			

ITEM #	DESCRIPTION	PRICE
OGKL2	Optogenetics Kit with Ø200 µm Core Fiber, Ø1.25 mm Cannula Ferrules, and a Lightweight Patch Cable	$ 2,848.68
OGKRL2	Optogenetics Kit with Ø200 µm Core Fiber, Ø1.25 mm Cannula Ferrules, and a Rotary Joint Patch Cable	$ 3,038.40
OGK2	Optogenetics Kit with Ø200 µm Core Fiber, Ø2.5 mm Cannula Ferrules, and a Lightweight Patch Cable	$ 2,729.25
OGKR2	Optogenetics Kit with Ø200 µm Core Fiber, Ø2.5 mm Cannula Ferrules, and a Rotary Joint Patch Cable	$ 2,948.40
OGK4	Optogenetics Kit with Ø400 µm Core Fiber, Ø2.5 mm Cannula Ferrules, and a Lightweight Patch Cable	$ 2,798.55
OGKR4	Optogenetics Kit with Ø400 µm Core Fiber, Ø2.5 mm Cannula Ferrules, and a Rotary Joint Patch Cable	$ 3,002.40

Optogenetics Starter Kits: Quick-Start Guide

The ADAF1 Mating Sleeve should be inserted one half to two thirds of the way onto the patch cable before cannula connection.

LED and Driver

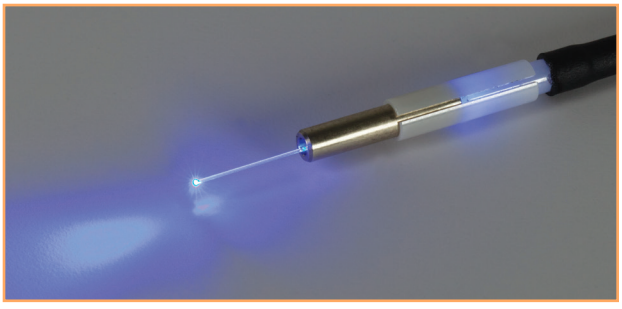
All Optogenetics Starter Kits include a 470 nm LED and LED Driver. Connect the LED to the "LED" jack in the back of the driver. The power supply for the driver should be plugged into the unit as well. The driver can then be powered on using the rocker switch on the back of the unit.

After the device is powered up, the display will show a "Welcome" screen for a few seconds. Although the driver is immediately ready for use after turning it on, the rated accuracy requires a warm-up period of 10 minutes.

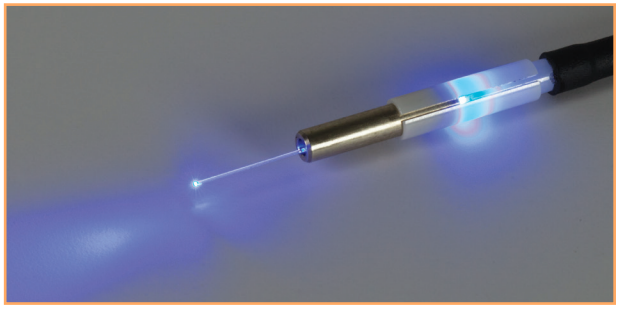
Patch Cable and Cannula

Insert the patch cable's SMA connector into the LED unit by threading the connector's rotating barrel onto the LED unit's housing. Then, place the ADAL1 (Ø1.25 mm ferrules) or ADAF1 (Ø2.5 mm ferrules) mating sleeve onto the ferrule end of the patch cable. Leave approximately one third of the mating sleeve length exposed for the cannula connection (as shown in the photo above). Then, connect the mating sleeve to the cannula. Note: To disconnect the cannula, grip the patch cable by the ferrule and mating sleeve (not the heat shrink tubing) and use a twisting motion.

It is very important that the ends of the patch cable's ferrule and the cannula's ferrule are in physical contact. If they are not, the output power at the cannula tip will decrease significantly, as shown in the photos to the right.



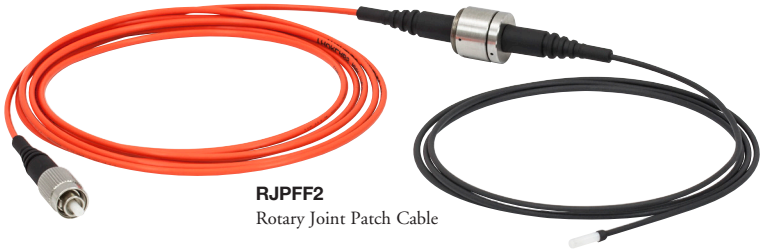
Properly connected cannula and patch cable, with the cannula and patch cable in physical contact.



Improperly connected cannula and patch cable, showing an air gap and light leakage.

Rotary Joint Patch Cables

The OGKRL2, OGKR2, and OGKR4 kits include rotary joint patch cables, which operate exactly the same way as the standard patch cables included in the other kits but have an articulated joint that prevents tangling from specimen movement. SM05 (0.535"-40) mounting threads are present on the light source side of the joint, allowing it to be mounted using Thorlabs' extensive line of SM05-compatible optomechanics hardware such as the LMR05 lens mount. Alternatively, the rotary joint can be mounted directly to the wall or ceiling of a specimen enclosure by creating an SM05-tapped hole using Thorlabs' 83373 SM05 tap. The joint can also be glued into an approximately Ø1/2" hole.



RJPFF2
Rotary Joint Patch Cable

Optogenetics Starter Kits: Quick-Start Guide

DC2100
LED Driver
(2 A Max)

Power Supply

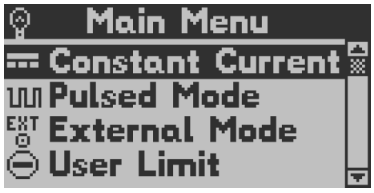


Figure 1. The DC2100 Driver's main menu allows the user to choose one of three possible operating modes.

DC2100 LED Driver

The LED in the Optogenetics Starter Kit can be operated using the front panel controls of the DC2100 LED Driver or remotely via PC. Use the scroll wheel, "OK" button, and "ESC" button to navigate through the driver's menus. The DC2100 can operate in three different modes as shown in Figure 1 to the left: 'PWM Mode' (Pulse-Width Modulation), 'Constant Current Mode', or 'External Control Mode'. It can also be operated remotely via USB.

Note that the LED must be switched off when switching between modes. Use the "ESC" button to display the main menu (see Figure 1), and then use the scroll wheel and "OK" button to select an operating mode.

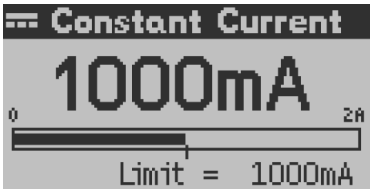
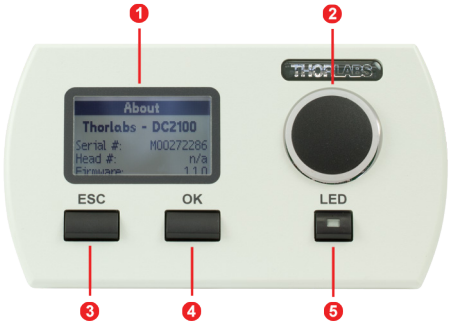


Figure 2. In constant current mode, the drive current is limited by the unit to 1000 mA.

Constant Current Mode

While operating in constant current mode (see Figure 2), the scroll wheel controls the LED's power (limited to 1 A by the LED unit), and the "LED" button toggles the LED on/off.

DC2100 Front Panel



CALLOUT	CONNECTION
1	Display
2	Display Control Knob
3	Escape Button
4	OK Button
5	LED On/Off Button

DC2100 Back Panel

CALLOUT	CONNECTION
1	Serial Number of the Unit
2	Power Switch
3	LED Connector
4	External Trigger Input (BNC)
5	USB Connector
6	Voltage Supply Connector

Optogenetics Starter Kits: Quick-Start Guide

External Control Mode

This mode allows the user to control the DC2100 LED Driver by an external signal. The 'External Control Mode' has no parameter settings. The LED can only be controlled via the BNC connector on the rear panel. The applied voltage corresponds to the LED current. When using this setting, 1 V is equivalent to an LED current of 200 mA. A maximum voltage of 10 V can be applied, resulting in a current of 2000 mA.

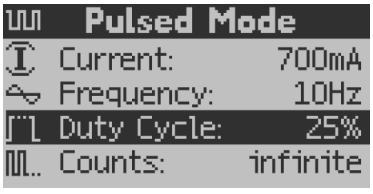


Figure 3. When the DC2100 LED Driver is in the Pulse Width Modulation Mode, the frequency, amplitude, duty cycle, and number of pulses can be defined.

Pulse Width Modulation (PWM) Mode

In Pulse Width Modulation mode, the frequency, amplitude, duty cycle (pulse width), and number of pulses can all be defined as shown to the left in Figure 3. The main Pulsed Mode screen displays each parameter. To edit the parameters, highlight that line using the scroll wheel, press "OK," edit the value using the scroll wheel, and press "OK" again to save that parameter. Again, the "LED" button toggles the LED on/off. With the LED switched off, press "ESC" to return to the main menu.

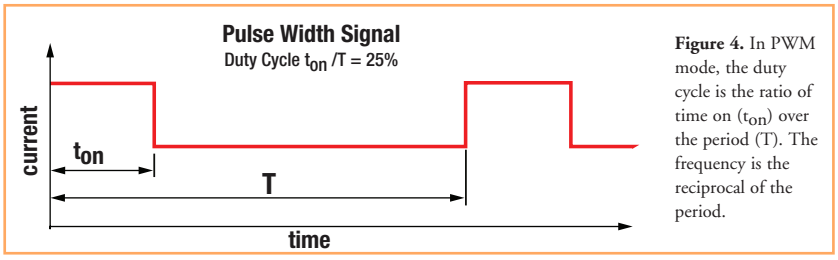


Figure 4. In PWM mode, the duty cycle is the ratio of time on (t_{on}) over the period (T). The frequency is the reciprocal of the period.

Remote Control via a PC

The LED Driver can be controlled remotely by a Windows-based PC using the included software. All controls available on the front panel of the driver are also available using this application. Additionally, the front panel controls can also be used when the driver is connected to a PC, and the DC2100 display will automatically update when changes are made in the software.

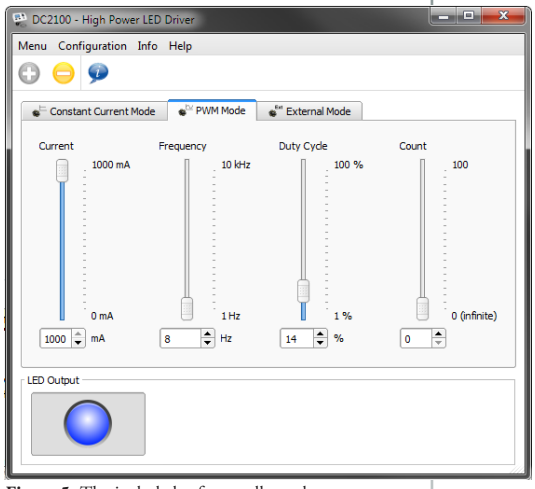


Figure 5. The included software allows the user to control the DC2100 LED driver from a Windows PC.

Further Reading

1. Aravanis A, Wang LP, Zhang F, Meltzer L, Mogri M, Schneider MB, Deisseroth K. An optical neural interface: *in vivo* control of rodent motor cortex with integrated fiberoptic and optogenetic technology. J. Neural Eng. 2007 Sept; **4**:S143-S156.
2. Gradinaru V, Thompson KR, Zhang F, Mogri M, Kay K, Schneider MB, Deisseroth K. Targeting and readout strategies for fast optical neural control *in vitro* and *in vivo*. J Neurosci. 2007 Dec 26; **27** (52):14231-8.
3. Zhang F, Gradinaru V, Adamantidis AR, Durand R, Airan RD, de Lecea L, Deisseroth K. Optogenetic interrogation of neural circuits: technology for probing mammalian brain structures. Nat Protoc. 2010; **5** (3):439-56. Epub 2010 Feb 18.
4. Yizhar O, Fenno LE, Davidson TJ, Mogri M, Deisseroth K. Optogenetics in Neural Systems. Neuron. 2011 July; **72** 9-34.

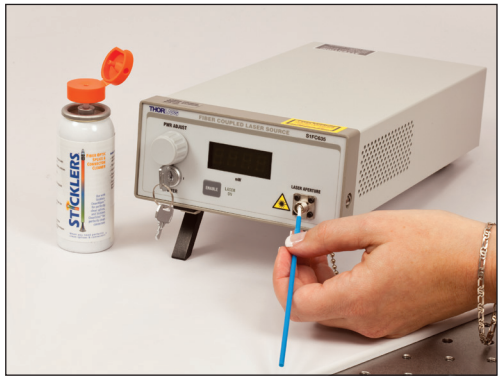
Fiber Cleaning Tutorial

Cleaning a Fiber Bulkhead

For this task, you will need the FCS3 Fiber Connector Cleaner and the MCC25 Connector Cleaning Sticks. Both of these items are available individually on page 567 or as part of the CKF Fiber Connector Cleaning Kit sold at the end of this presentation.

Step 1
Push down on the top of the FCS3 can to fill the shallow reservoir with the connector cleaner.

Step 2
Immerse the tip of an MCC25 stick into the cleaning solution.



Step 3
Use the stick to clean the fiber bulkhead (connector) on the fiber-coupled laser source as shown above or any other device with a fiber bulkhead.

Cleaning Fiber Patch Cable Connectors

Before cleaning and prior to each use, Thorlabs recommends using an inspection scope, such as the FS-200 available at the end of this presentation, to inspect each fiber endface. Every fiber optic connector should be cleaned every time it is mated, tested, or reconfigured. "Wet-Dry" cleaning as described below improves performance. For this task, you will need FCS3 Fiber Connector Cleaner and LFW90 Lint-Free Wipes. Both of these items are available individually on page 567 or as part of the CKF Fiber Connector Cleaning Kit sold at the end of this presentation.

Step 1
Pull a clean wipe out of the LFW90 mini-tub. Stop pulling when the next wipe is exposed. Pinch the next wipe against the opening in the mini-tub with your thumb. Pull sideways to remove.

Step 2
Lay the wipe across the palm of your hand. Hold it in place with your thumb.

Step 3
Place the wipe on top of the open FCS3 solvent container. Push down to dampen it. Note: Normally, only one pump is necessary.

Step 4
Place the connector on the moistened area of the wipe. Drag the connector down to the dry area. Discard the wipe. Inspect the endface with the FS-200 inspection scope to verify cleanliness.

Fiber Cleaning Tutorial

Cleaning Unterminated Fiber

For this task, you need FCS3 Fiber Cleaner and LFW90 Lint-Free Wipes. Both of these are available individually on page 567 or as part of the CKF Fiber Connector Cleaning Kit sold below.

Step #1
Pull a clean wipe out of the LFW90 mini-tub. Stop pulling when the next wipe is exposed. Pinch the next wipe against the opening in the mini-tub with your thumb. Pull sideways to remove.

Step #2
Fold the wipe in half, so it is square.

Step #3
Place the wipe on top of the open FCS3 solvent container. Push down to dampen it. Note: Normally, only one pump is necessary.

Step #4
Wrap the damp wipe around the fiber. Squeeze gently. Slide the wipe towards the end of the fiber once or twice until it squeaks, indicating the fiber is clean.

Fiber Optic Cleaning Kit

MCC25
Connector Cleaning Sticks

FCC-7021
Replacement for FCC-7020 Reel

FCC-7020
Handheld Connector Cleaner

FCS3
Fiber Connector Cleaner

LFW90
Lint-Free Wipes

Kit Contents

ITEM #	DESCRIPTION
MCC25	Connector Cleaning Sticks
FCC-7021	Replacement Reel for Handheld Connector Cleaner (FCC-7020)
FCC-7020	Handheld Connector Cleaner
FCS3	3 oz Can of Fiber Connector Cleaner
LFW90	Tub of Lint-Free Wipes

The CKF Fiber Optic Cleaning Kit includes all the necessary items for cleaning connectorized and bare fiber. The contents of the CKF kit are shown above and described in the table.

ITEM #	PRICE	DESCRIPTION
CKF	$ 77.93	Fiber Optic Cleaning Kit

Fiber Inspection Scope

The FS200 Fiber Inspection Scope produces a high-quality, low-distortion image of both the fiber end and surrounding ferrule. With a high-intensity illumination system and 200X magnification, this microscope is powerful enough to offer a clear image of the fiber core as well as the surrounding cladding. The FS200 includes adapters for fibers with FC/PC, FC/APC, ST, SC, and SMA connectors.

- Critically Examine Fiber Polish Quality
- Adapters for Ø2.5 mm and Ø3 mm Ferrules Included

In order to see the entire field of view, the rubber eyepiece should be as close as possible to the operator's eye. Operators who normally wear eyeglasses should remove them to fully inspect the fiber. Please note that under normal operation, the focus adjustment knob should not be rotated to its limits. If used improperly, the unit can fail over time.

ITEM #	PRICE	DESCRIPTION
FS200	$ 202.00	Fiber Microscope Compatible with FC, ST, SC, APC, and SMA Connectors