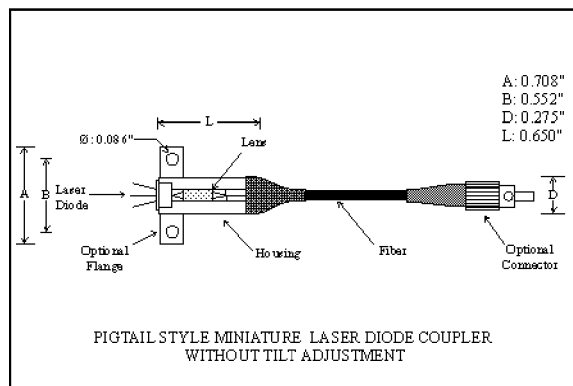




## LASER DIODE TO FIBER COUPLERS



OZ Optics offers a complete line of laser diode to fiber couplers, offering optimum coupling in a small, rugged package. They may be purchased prealigned, with the diode already in place, or as a kit that can be assembled by the customer using their own diode. The complete assembly procedure is quite straightforward, and can be done in less than twenty minutes. Assembly and operating instructions are available in a video cassette, showing the alignment process. The video is available in both North America and European (PAL) versions. In addition, a complete alignment kit is available, which includes the collimating wrench, multimode fiber assembly, centering lens, and video instructions.

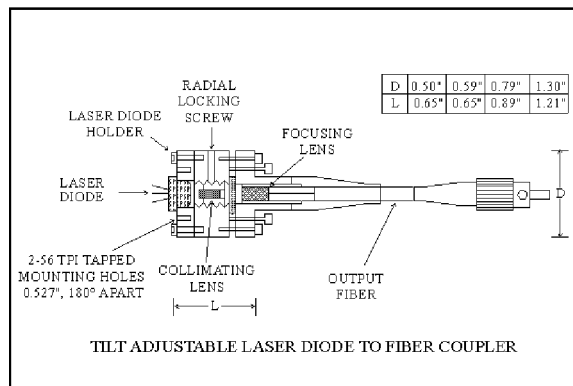
Diode source couplers are available for a variety of diode case sizes, and for diode wavelengths from less than 630nm to greater than 1550nm. These source couplers work with multimode, singlemode, and polarization maintaining fiber. Should the diode ever fail, it can be easily replaced while using the rest of the coupling optics. The source coupler can then be realigned for optimum coupling. This is one of the main advantages of using the OZ Optics tilt adjustment technique.

There are two versions of tilt adjustable laser diode to fiber couplers; receptacle style couplers, and pigtail style couplers. Connector receptacle style couplers have a

female receptacle, such as NTT-FC, or AT&T-ST, etc. at the output end. This allows the user to connect any optical fiber with a matching male connector to the diode. Pigtail style laser diode to fiber couplers are also offered, with the fiber pigtailed directly onto the coupler. Pigtail style laser diode to fiber couplers provide higher coupling efficiencies than receptacle style couplers, as well as better stability, and lower backreflection levels. The output fiber can also be terminated with different output connectors.

Laser diode to fiber couplers are available in different diameters. The standard diameter package is 0.79 inches in diameter. This size fits most diode types, and is available for both receptacle style and pigtail style couplers. For the best coupling efficiencies choose the larger, 1.3 inch diameter housing, which supports larger and higher quality lenses. This housing size is also used with large diode case sizes, such as H1 package sizes. For pigtail style source couplers, a smaller 0.59" diameter housing is available for diode can sizes 9.0mm in diameter or smaller. For diodes with can diameters of 5.6mm or less, a miniature 0.5" diameter tilt adjustable housing is possible.

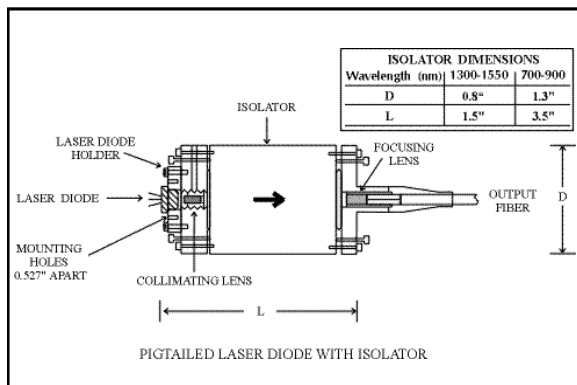
One misconception about tilt adjustable laser diode couplers is the belief that the number of tilt and lockingscrews make the coupler sensitive to temperature



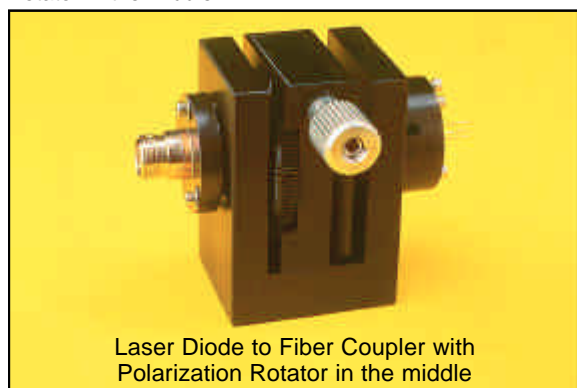
or vibration. In fact, tilt adjustable source couplers can be used over a temperature range of -25°C to 60°C, and have been vibration tested. Higher temperature versions are available on request.

OZ Optics also offers a special, **low cost, miniature pigtail** style laser diode to fiber couplers for OEM applications. These packages use just a single lens to couple light from the laser diode into the fiber. They do not use OZ Optics tilt adjustment technique. This package features a compact, rugged housing, at a significantly lower cost. The housing diameter is typically 10mm. Coupling efficiency into singlemode and multimode fibers is typically 10 percent and 35 percent, respectively.

A variety of options are available for laser diode to fiber couplers. One such option is a coupler with a built in isolator. Isolators can reduce the effects of backreflection by up to 60dB. This is done by using coated optics and angled polished fibers. This is very useful for applications where the intensity and wavelength stability of the output light from the diode is critical.



Another option for laser diode to fiber couplers is a blocking screw to attenuate the output beam. This allows the user to precisely control the output power entering the fiber, without having to change the diode current. Another option is laser diode to fiber couplers with polarizer or polarization rotator in the middle.



Laser Diode to Fiber Coupler with Polarization Rotator in the middle

## LIGHT SOURCES

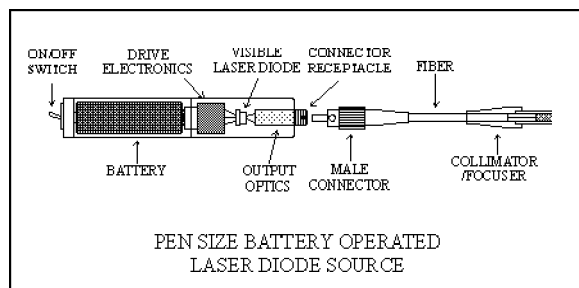
OZ Optics also has available self contained laser diode to fiber delivery systems, with battery operated power supplies. AC to DC converters are also available. These systems provide a compact, portable source of light to attach to an optical fiber for test and measurement systems. They are used in a variety of applications, including fault detection, laser acupuncture, fluorescence measurements, etc.



Self contained systems are available in both a pocket size casing, as well as a miniature pen size housing. Both receptacle style and pigtail style systems are available. OZ Optics can also provide fiber pigtailed collimators for your system.

OZ Optics has in stock a selection of laser diodes. In addition we can package customer specified laser diodes. OZ Optics also provides laser diode power supplies and drivers, as well a thermoelectric Peltier coolers. Please refer to the Fiber Optic Stable Source & TE Cooled Laser Diode Housing Data Sheet.

## OPERATING PRINCIPLE



Laser diode to fiber couplers with tilt adjustment use a two stage process to couple light from the laser diode into the fiber. In the first stage, the output light from the diode is collimated with a collimating lens. The distance between the diode and the collimating lens is easily adjusted with a collimator wrench, then locked with a radial set screw. The collimated beam is then coupled into the fiber with a second lens, using OZ Optics' patented tilt alignment technique. The focal lengths of the collimating and coupling lenses are carefully selected to transform the mode field pattern of the fiber as closely as possible. Coupling efficiencies of over 50 percent into singlemode fiber, and 80 percent into multimode fibers, can be achieved with certain diodes with the correct choice of lenses. Coupling efficiencies into singlemode fibers better than 80% are possible with certain diodes by correcting the diode astigmatism and the ellipticity of the diode output with a miniature cylindrical type lens. Contact OZ Optics for further information about this technique.

Before building a laser diode to fiber coupler, OZ Optics has to choose an appropriate lens combination to maximize coupling efficiency. To do so, we need to know the following laser diode characteristics: (1) Diode wavelength (2) Output power (3) Diode can size (4) Emitter dimensions (5) Far field divergence angles (6) Astigmatism. In addition, the diode selected should exhibit good pointing stability over time.

## SPECIFICATIONS

<b>Coupling Efficiency:</b>	75% to 85% for multimode fibers, 35%-55% for singlemode (SM) or polarization maintaining (PM) fibers. Coupling efficiencies greater than 75% into SM or PM fibers are also possible for certain diodes.
<b>Backreflection levels:</b>	Typically -15dB for receptacle style versions, and either -25dB, -40dB, or -60dB for pigtail style versions. (-60dB is available for 1300nm and 1550nm only.)
<b>Wavelength range:</b>	600nm to 1600nm.
<b>Operating temperature:</b>	-20°C to +60°C.
<b>Output extinction ratios:</b>	Typically greater than 20dB for PM fibers. 30dB versions are available on request for 1300 and 1550nm only

## ORDERING INFORMATION

When ordering laser diode to fiber couplers, please specify the laser diode characteristics (diode type, angular beam profile, housing dimensions, etc.). If possible, please fax us the diode manufacturer's specification sheet before ordering. For pigtail style laser diode to PM fiber couplers please indicate whether you wish to align the slow axis or the fast axis of the PM fiber with respect to the diode output. The OZ Optics standard is to align the PM fiber such that the diode output is transmitted along the slow axis of the fiber.

<b>Part Number</b>	<b>Description</b>
<b>HULD-<u>AX</u>-<u>W</u>-<u>F</u>-<u>C</u></b>	Laser diode to fiber source coupler with connector receptacle.
<b>LDPC-0<u>A</u>-<u>W</u>-<u>a/b</u>-<u>F</u>-<u>LB</u>-<u>X</u>-<u>JD</u>-<u>L</u>-<u>C</u></b>	Pigtail style laser diode to fiber source coupler.
<b>VIDEO-01-NTSC (or PAL)</b>	Video instructions for using OZ Optics' components. Please indicate whether an American (NTSC) or European (PAL) standard video is required.
<b>MMJ-<u>X</u>1-50/125-3-0-1</b>	One meter long multimode jumper assembly for performing initial alignment of singlemode laser to fiber couplers.
<b>LDC-21 (or LDC-21A)</b>	Alignment wrench for adjusting the laser diode collimation.
<b>ALIGN-0<u>X</u>-NTSC (or PAL)</b>	Alignment kit for laser diode to singlemode fiber source couplers, containing a collimating wrench, a multimode jumper assembly, written instructions, and instructional video. Please indicate whether an American (NTSC) or European (PAL) standard video is required.

Where: A is the diameter of the diode package. (Use 1 for the standard 0.79" diameter package size, 2 for the higher performance 1.3" diameter package, 3 for compact 0.59" diameter, and 4 for the miniature 0.50" diameter. Note that due to limitations in the size of the diode being used, not all package sizes are available for every diode.)

X is the receptacle type for connector style laser diode to fiber source couplers. For pigtail style laser diode to fiber couplers, it refers to the male connector on the fiber end (3 for FC, 5 for SMA 905, 8 for AT&T-ST, SC for SC connectors, etc. Use X for unterminated fibers for pigtail style laser diode to fiber couplers.)

W is the laser diode wavelength in nm;

a/b are the fiber core and cladding diameters, respectively, in microns;

F is the type of fiber being used (S for singlemode, M for multimode, P for polarization maintaining fiber);

C is the desired coupling efficiency (35%, 45% or 75% typical efficiencies for singlemode couplers, 75% typically for multimode fibers). Note that due to limitations in the diode optical characteristics, not all of the coupling efficiencies listed are possible with every diode. Contact OZ Optics for further technical help.

LB is the desired backreflection level for pigtail style laser diode to fiber couplers. (25, 40 or 60 dB typically);

JD is the fiber jacket type (1 for uncabled fiber, 3 for 3 mm OD loose tube kevlar, 3A for 3mm OD armored cable, and 5A for 5mm armored cable);

L is the fiber length in meters;

**Options:** If OZ Optics is to supply the laser diode, then add the term "-LD" to the part number. If you require a power supply as well, then add the term "-PS" to the part number. For a blocking screw, add the term "-BL" to the part number. Add "-PO" to the part number for parts only, if customer wants to do the alignment. Add "-DR" to the part number for laser diode driver circuit.

## APPLICATION EXAMPLES

1. A pigtail style laser diode to fiber coupler is needed to couple light from a 1300nm laser diode into a PM fiber. The output fiber is to be one meter long, cabled with 3.0mm kevlar cable, and with an NTT-FC connector on the end. The backreflection level is to be less than 40dB. A coupling efficiency of 45% is desired. The slow axis of the fiber is to be aligned with the polarization axis of the output light from the diode. The customer wants OZ Optics to supply the laser diode and a power supply for the diode. OZ Optics' part number: **LDPC-01-1300-9/125-P-40-3-3.0-1-45-LD-PS.**

## QUESTIONS AND ANSWERS

**Q: What type of laser diode should I choose for my application?**

A: Normally, the choice of laser diode wavelength, output power, line width, and modulation rate will drive your choice in choosing a laser diode. The remaining information can be found from the diode manufacturer's data sheets. In choosing between similar diodes, keep the following points in mind:

**Diode can size: Ideally,** the can dimensions should be as small as possible. The critical dimension is the distance between the laser diode chip and the outside of the optical window on the can. For maximum flexibility, this distance should be less than or equal to 1.1mm. Diodes with longer separations can be used, but this means using longer focal length lenses, which will affect the package size.

**Emitter Dimensions:** The smaller the emitter area is, the easier it is to couple the light into a fiber. Most diodes have emitting areas of the order of one to three microns in size. It is usually easy to get good coupling efficiency into a singlemode fiber with this chip size. However some diodes, particularly very high power diodes, have much larger dimensions (100 microns, for instance). These diodes can only be efficiently coupled to multimode fibers with similar core sizes.

**Far field divergence angles/Astigmatism:** These two properties are closely related. Ideally, the divergence angles should be as small as possible. Typical divergence angles are about 10° by 30°. Furthermore, the difference between the two angles, which is limited by the diode's astigmatism, should be as little as possible.

**Pointing Stability:** Some diodes show changes in the pointing direction of their output over time. This could be a serious problem when coupling the laser diode output into a singlemode fiber. Contact the diode manufacturer for information about their diode's specifications.

**Q: If the diode fails, do I have to throw out the whole assembly?**

A: No. This is one of the main advantages of the OZ Optics adjustable tilt design. The lenses and optical fibers can be easily reused. Simply put the new diode into a new laser diode holder, collimate it using the old collimating lens assembly, and focus the collimated beam into the fiber using the old focusing optics.

**Q: Can the level of backreflected light going back into the laser diode cavity be reduced without having to use an isolator?**

A: Yes. First, the laser diode chip should be positioned slightly off center with respect to the collimating lens assembly. This prevents reflections from traveling straight back into the cavity. Secondly, The input end of the fiber can be polished at an angle. Finally, the output end of the fiber can be angle polished, or index matching gel can be used on the output end of the fiber. By combining these techniques, typical backreflection levels of up to -40dB can be achieved. In addition, backreflection levels as low as -60 dB are possible by applying an AR coating to the fiber tips.

**Q: Does the diode chip have to be centered with respect to the outer diode housing?**

A: No. This is one of the advantages of the OZ Optics design. There is no need for tight tolerances on the diode chip location. Any offset in the lateral position of the laser diode chip can be easily compensated for at the focusing optics, using the patented tilt adjustment technique.

**Q: Is there any way to achieve greater than the 45% coupling efficiency normally specified for a singlemode laser diode to fiber coupler?**

A: Yes. In certain cases a cylindrical microlens can be added to the laser diode to reduce the astigmatism and aspect ratio. Coupling efficiencies of up to 80 percent have been achieved using this method. However, this usually means removing the diode can from the diode. The can is then soldered back on. Contact OZ Optics for more information on this technique.

**Q: I have a laser diode mounted on an open chip carrier. How can I use a laser diode to fiber coupler with it?**

A: The laser diode chip must first be attached to a laser diode holder. The laser diode and laser diode holder can then be attached to the collimating lens assembly and focusing optics.

OZ Optics has several different type of laser diode holders already in stock, and custom diode holders can be manufactured to meet your needs. Contact OZ Optics for further information.

**Q: I want to convert the output from a laser diode into a Gaussian beam. Can I do this without using cylindrical lenses or anamorphic prisms?**

A: Yes. Couple the light into a singlemode or polarization maintaining fiber using a laser diode to fiber coupler. The fiber acts as an excellent spatial filter, giving an almost ideal Gaussian output beam. Wavefront distortion can be as low as 1/50. The fiber output can then be easily collimated using a lens. OZ Optics offers a wide variety of fiber optic collimators for this purpose.

**Q: Can optical amplifiers be pigtailed as well as laser diodes?**

A: Yes. Optical amplifiers emit a little light in both directions when operated at low currents. This light can be collimated, then coupled into an optical fiber. By doing this on both sides of the coupler, the amplifier can be pigtailed.