Laser Beam Couplers Series 60SMS

The Schäfter+Kirchhoff laser beam couplers launch a laser beam into, or from a polarization-maintaining single-mode fiber. This document provides assistance in installing and adjusting the laser beam couplers series 60SMS. It describes how a fiber cable is attached, and how a fiber coupling is optimized.

1. Before You Start

The laser beam coupler is shipped with a protection cap for the fiber receptacle and with a front cap.

> **Notice:** Please remove all the protection caps first and do not use them as beam dumps (risk of photo contamination).

There is a two-part protection cap on the receptacle. Please perform the following steps in order to remove this cap:

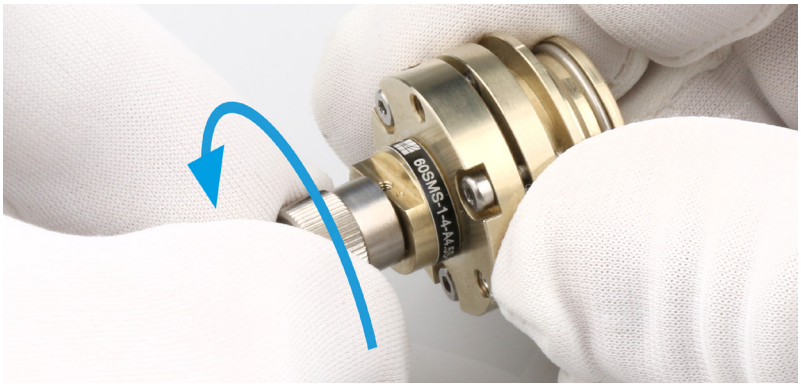

Figure 1:

First, remove the threaded cap from the fiber receptacle of the laser beam coupler.

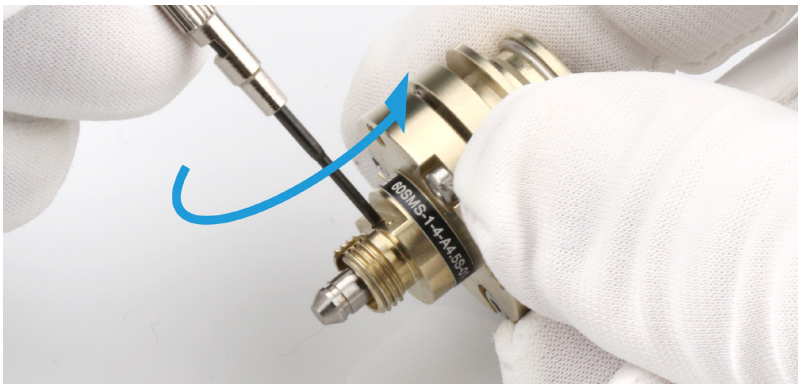

Figure 2:

Then, slightly loosen the small pin screw. Use the screwdriver 9D-12. Make sure to not loosen it too far, as it is small and easily lost.

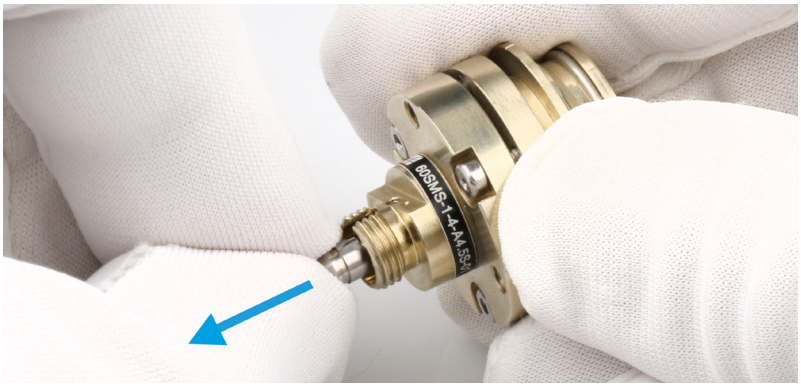

Figure 3:

Now, pull out the plug.

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Now, make sure that the connector of the fiber you want to attach matches the receptacle type of the laser beam coupler:

- Use fibers with FC-APC (8°-polish) connectors for laser beam couplers with an inclined coupling axis (60SMS-4).
- Use fibers with FC-PC (0°-polish) connectors for laser beam couplers with a coaxial axis (60SMS-0).

The laser beam couplers are compatible to all fiber connectors type FC, including fiber connectors with end caps.

Notice:
- Do not touch either the optical surface of the lens or the fiber end-face.
- If the coupler is not in use, reattach both rear and front protection caps.

Caution! **Refer to the laser instruction manual for all instructions regarding laser safety!**
- Do not stare directly into the laser beam (which can cause permanent damage to the eyes).
- Do not stare at the reflected beam from reflective objects.
- Do not point the laser beam to other individuals.

2. Attaching a Fiber Cable to the Laser Beam Coupler

For attaching a fiber cable to the laser beam coupler perform the following steps:

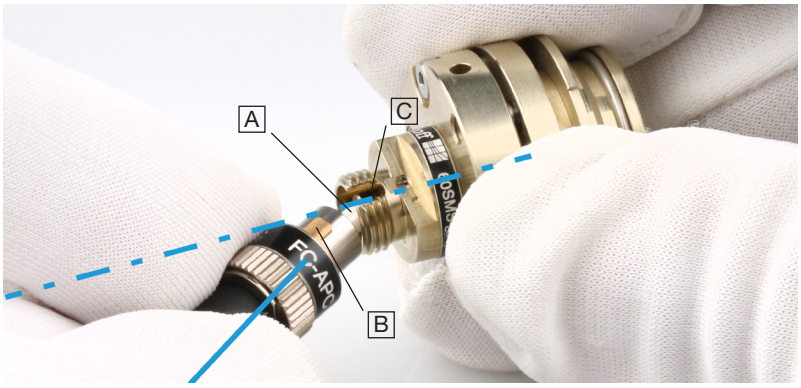

Figure 4:

To prevent damage to the sensitive fiber end-face, always insert the fiber connector`s ferrule A at an angle, with the connector key B properly aligned to the receptacle notch C.

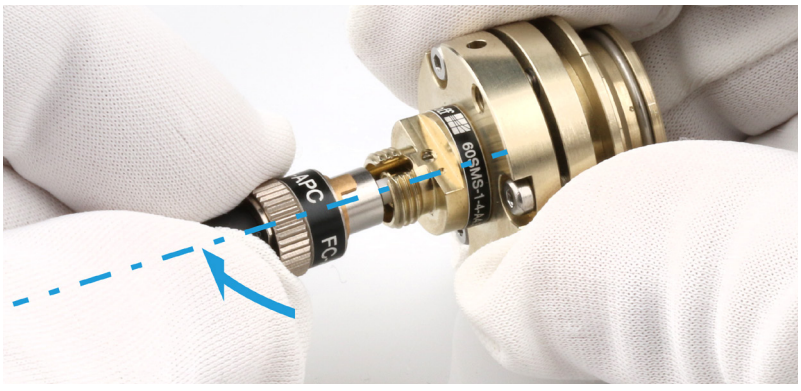

Figure 5:

When the ferrule tip is safely located in the inner cylinder of the receptacle, align the connector to the receptacle axis and carefully introduce the connector into the laser beam coupler.

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Figure 6:

Then, orient the connector key in a way that it is pressed gently onto the right-hand side of the receptacle notch.

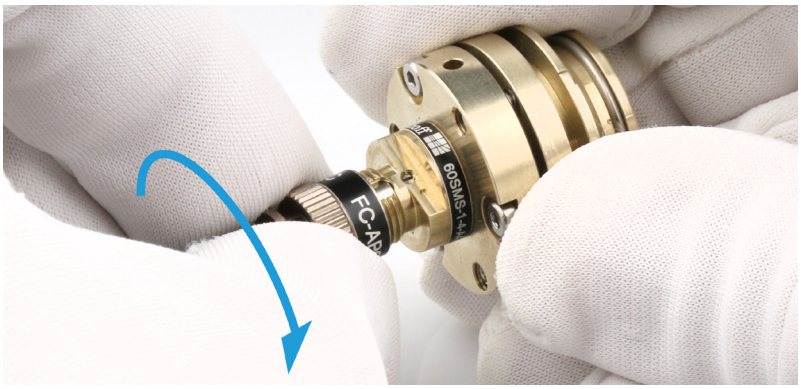

Figure 7:

Gently screw on the connector cap nut onto the receptacle until it is finger-tight.

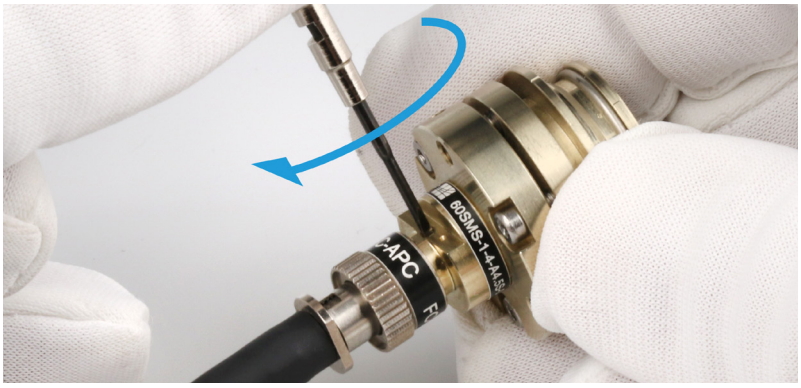

Figure 8:

Finally, gently tighten the fiber grub screw to reduce the free play of the ferrule in the receptacle.

The free play in between the connector ferrule and receptacle is only a few microns, but necessary for inserting the ferrule without force.

The tightened grub screw and the right-hand orientation rule for the connector, ensure a high reproducibility in mode field position and angle, which is especially important for attaching and reattaching polarization-maintaining fibers reproducibly.

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3. Adjusting the Focus Setting

Focus adjustment (adjustment of the coupling lens in z-direction) is a demanding task and should be performed preferably using a collimating telescope.

Notice: The laser beam coupler is shipped pre-adjusted for the labeled wavelength and, often, it is not necessary for the customer to readjust the coupling lens position. This is why you can skip this step in most cases.

A fine-adjustment of the focus setting of a laser beam coupler already installed and adjusted is described in Chapter 10.

To check the collimation setting of the laser beam coupler, couple a radiation source of appropriate wavelength into the fiber connected to the laser beam coupler. Direct the beam to a target about half a Rayleigh length z_R away:

$$\frac{z_R}{2} = \frac{\pi \cdot \varnothing^2_{beam}}{\lambda \cdot 8}$$

Here λ is the optical wavelength and $\varnothing_{beam}$ the collimated beam diameter ($1/e^2$ level).

Caution! **Refer to the laser instruction manual for all instructions regarding laser safety!**

- Do not stare directly into the laser beam (which can cause permanent damage to the eyes).
- Do not stare at the reflected beam from reflective objects.
- Do not point the laser beam to other individuals.

When correctly collimated, the laser spot diameter on a target about $z_R/2$ away must have approximately the same diameter such as the beam directly behind the laser beam coupler. Additionally, make sure that there is no focused spot between the laser beam coupler and the target at $z_R/2$.

The lens position is adjusted by means of an eccentric key. The eccentric key type 60EX-4 is used for laser beam couplers with focal lengths ≤ 11 mm. For laser beam couplers with focal lengths ≥ 12 mm please use the eccentric key type 60EX-5.

For adjusting the lens position perform the following steps:

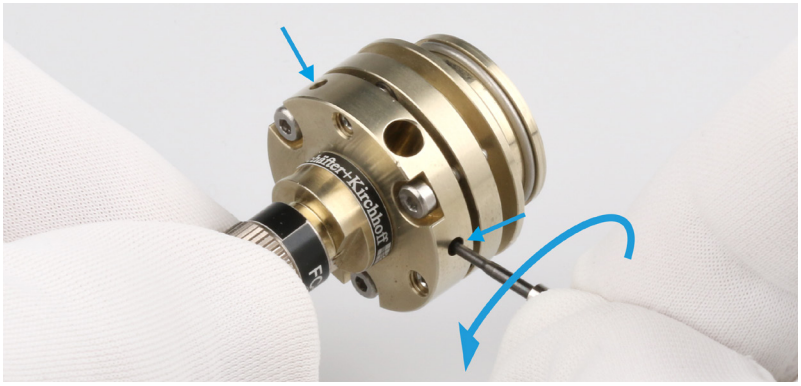

Figure 9:

Loosen the two grub screws fixing the lens position by means of a screwdriver type 9D-12.

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Figure 10:

Insert the eccentric key type 60EX-4 or type 60EX-5 into the large hole.

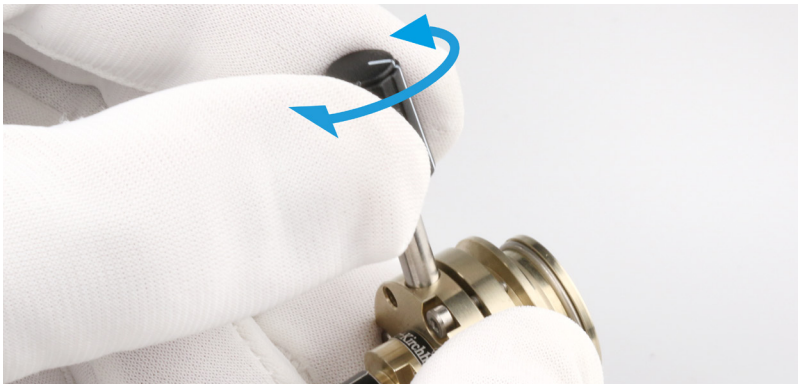

Figure 11:

Now, adjust the focus setting by rotating the eccentric key. Adjust the collimation by minimizing the size of the laser spot on the target about half the Rayleigh length z_R away.

Figure 12:

Finally, fix the two grub screws in order to lock the focus setting.

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4. Adapter for the Lateral Adjustment

The laser beam coupler can be connected to your laser system or optical bench by using an adapter flange or it can be attached directly to a multicube element from Schäfter+Kirchhoff.

It is very important for an efficient coupling that the laser beam passes the aperture of the laser beam coupler centrally.

Many lasers, such as HeNe lasers or DPSS lasers, have a 1˝ x 1˝ drilling pattern around the beam exit. For these lasers, Schäfter+Kirchhoff offers an adapter flange which can be moved laterally in oversized holes in order to center the adapter flange to the laser beam (Figure 13). Always attach the flange with the recommended washers and spring washers.

Figure 13:

DPSS laser with a 1˝ x 1˝ drilling pattern and attached adapter type 60A19.5-F.

The proper centering of the beam can be tested by attaching an aperture type 13H or a variable iris diaphragm type 13BL1-13 instead of the laser beam coupler (Figure 14).

For centering the adapter flange, perform the following steps:

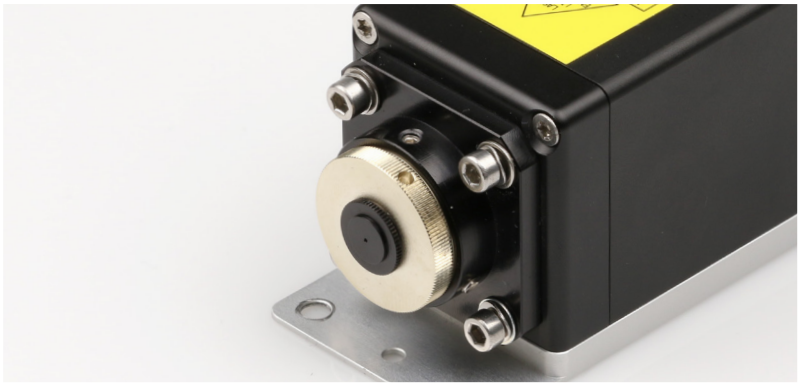

Figure 14:

Instead of a 60SMS laser beam coupler, an aperture 13H is attached.

Measure the power transmitted by this aperture. Maximize the transmitted power by laterally shifting the adapter. The adjustment is most sensitive if the aperture diameter is chosen to be about 70% of the collimated beam diameter ($1/e^2$).

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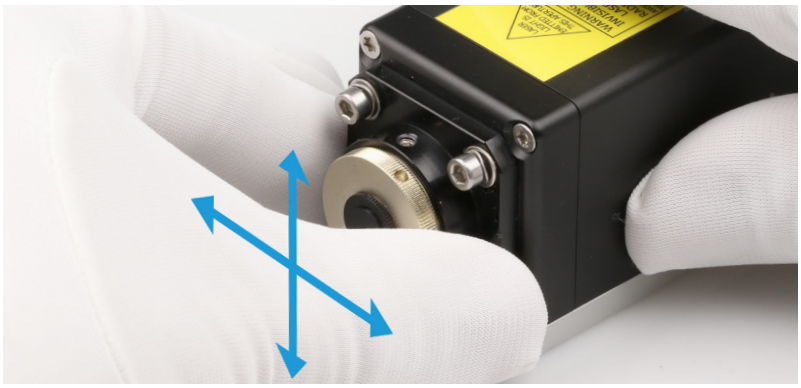

Figure 15:

Laterally shift the adapter in order to maximize the radiation that is transmitted by the aperture.

Only a coarse alignment is necessary, which can be done by hand (Figure 15), as the positioning accuracy must only be a fraction (7 - 10 %) of the collimated beam diameter.

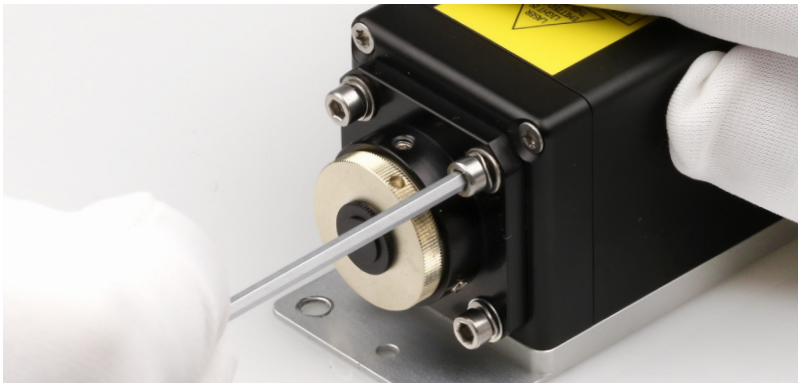

Figure 16:

Finally, fix the adapter and remove the aperture.

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5. Connecting the Laser Beam Coupler to Your System

Before you install the laser beam coupler we recommend to measure the output power of the laser as a reference for the next steps.

Now, perform the following steps:

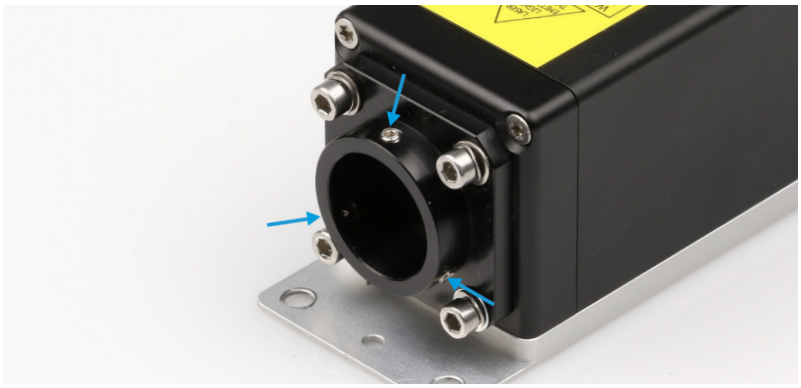

Figure 17:

Locate the three radially arranged tapered pin screws in the adapter flange (Figure 18) and loosen them using the hex screwdriver 50HD-15.

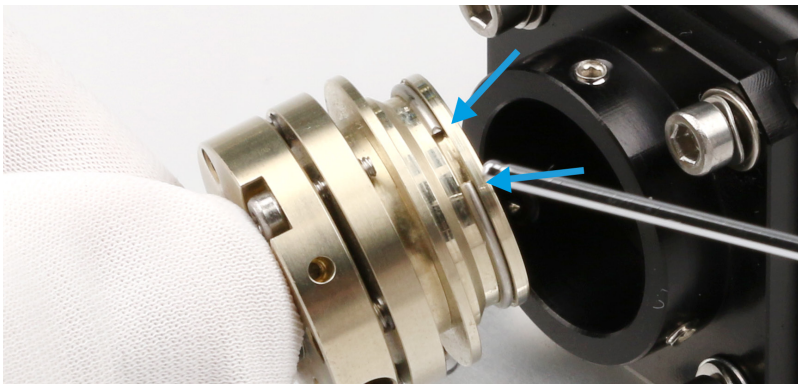

Figure 18:

Gently introduce the laser beam coupler into the vacant aperture. Make sure that none of the tapered pin screws are located in the gap.

Attention: The ∅ 19.5 mm system mount of the 60SMS laser beam coupler has a steel ring. This steel ring has a gap of approx. 2 mm, see Figure 18. Please make sure that none of the three pin screw is located in the gap of the steel ring. Otherwise the connection in between the adapter and the laser beam coupler and therefore the alignment is not long-term stable.

If a polarization-maintaining single-mode fiber is attached to the laser beam coupler, the laser beam coupler needs to be aligned correctly to the polarization axis of the laser source. In this case, locate the flat part of the connector receptacle of the laser beam coupler and coarsely rotate the laser beam coupler so that the flat surface is perpendicular to the polarization axis of the source. (Figure 19).

A fine-adjustment of the polarization axis is performed in a later step, see Chapter 11.

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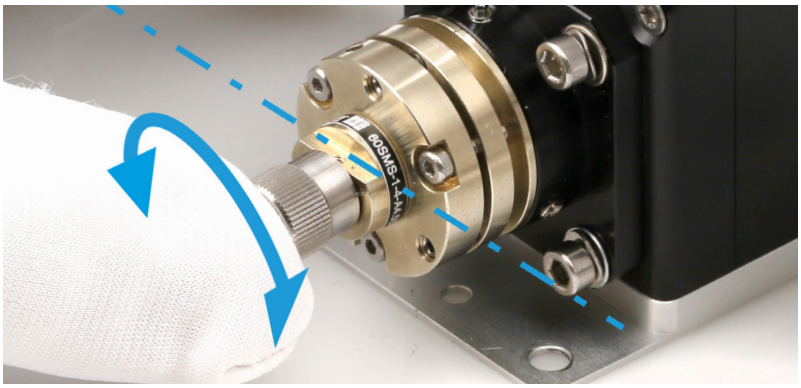

Figure 19:

The flat part (dashed line) has to be perpendicular to the polarization axis of the laser.

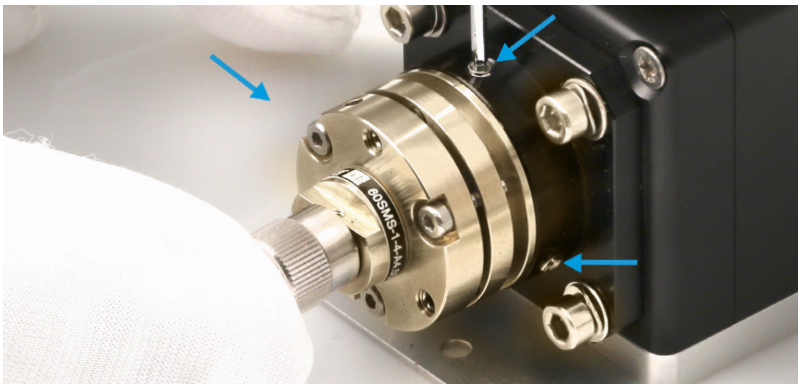

Figure 20:

Now fix the three tapered pin screws at the adapter flange. please use the same torque of about 0.48 Nm for all three pin screws, respectively.

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6. Tilt Adjustment: Finding a Signal

When coupling into single-mode fibers, the laser beam couplers should produce a diffraction-limited spot at the fiber end-face that matches the mode field diameter and - at the same time - the divergence of the fiber. Fiber-coupling with high coupling efficiency can only be achieved when this condition is met. Thus, coupling a laser beam into a single-mode fiber requires precise adjustment and needs some patience.

Caution! **Refer to the laser instruction manual for all instructions regarding laser safety!**

- Do not stare directly into the laser beam (which can cause permanent damage to the eyes).
- Do not stare at the reflected beam from reflective objects.
- Do not point the laser beam to other individuals.

Measure the coupled light at the opposite end of the fiber cable using a light detector or power meter. The detector may have to be adjusted to maximum sensitivity in order to detect a low transmission level possible in the first few coupling steps.

Perform the following steps:

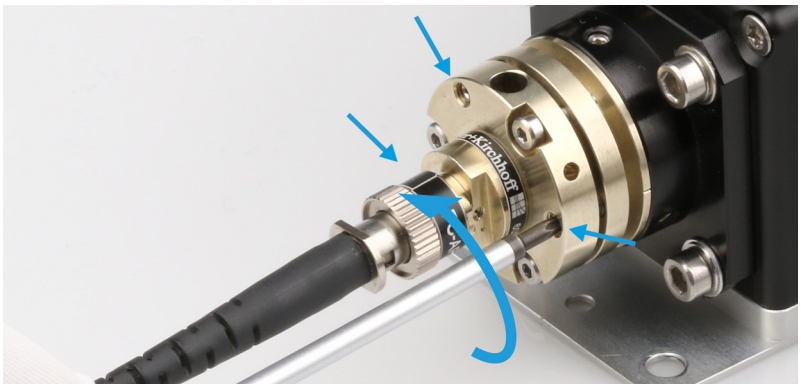

Figure 21:

Loosen the locking screws (grub screws) by 2 - 3 turns.

The adjustment screws (hex with head, Figure 22, D) now are turned in a way that each possible adjustment point is met once. Use hex screwdriver 50HD-15. For example, turn one of the screws just a little. Then, turn the next adjustment screw in a large range back and forth. Repeat the procedure by turning the first screw a litter further and the next adjustment screw again in a large range. Go on, until the detector shows a reaction and the beam is found.

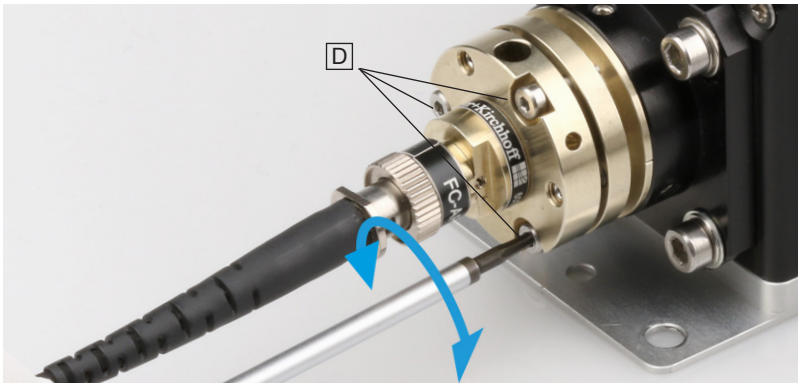

Figure 22:

Coarse adjustment of the laser beam coupler with the three adjustment screws D (hex with head).

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If no signal at all is found then the signal area can be increased by slightly loosening the threaded collar of the FC connector and slightly pulling back the fiber connector. This increases the diameter of the laser spot at the fiber end-face. Finding the first signal becomes easier. Once a signal is found then gently tighten the collar and the connector again, remembering to locate the connector key positively against the right-hand side of the groove in the laser beam coupler, as described in Chapter 2.

7. Tilt Adjustment: Adjustment Procedure, Coarse Adjustment

Once a signal is found, tighten one of the three headed screws (Figure 22), so that the signal is maximized. Adjust the detector sensitivity as required.

Move on to the next headed screw clockwise (or anti-clockwise) and proceed as described before. After two or three complete cycles of adjusting all headed screws the last screw is tightened and maximum power at fiber end is achieved. The adjustment should be now at optimum.

The fine-adjustment to provide the maximum coupling efficiency is done by the locking screws in the next step.

Notice: From now on, the headed adjustment screws are not used anymore.

8. Tilt Adjustment: Fine-Adjustment and Locking

Now, the locking screws are used to fine-adjust and lock the setting. First, fasten the three locking screws (grub screws, Figure 23, E) equally with very gentle force until you feel some resistance. Use the hex key 50HD-15. The detector at the fiber end now shows a signal, but it usually differs from the maximum signal seen before. The three locking screws are now tightened one after another, e.g. in a clockwise direction. Each screw is tightened so that the power signal is a little beyond the maximum. The procedures is repeated for each screw until two are three complete cycles of adjustment are completed. The last screw in the last adjustment round is tightened in a way, so that the detector shows maximum power at the fiber end. Please note, that the maximum torque for these screws must not exceed 50 Ncm.

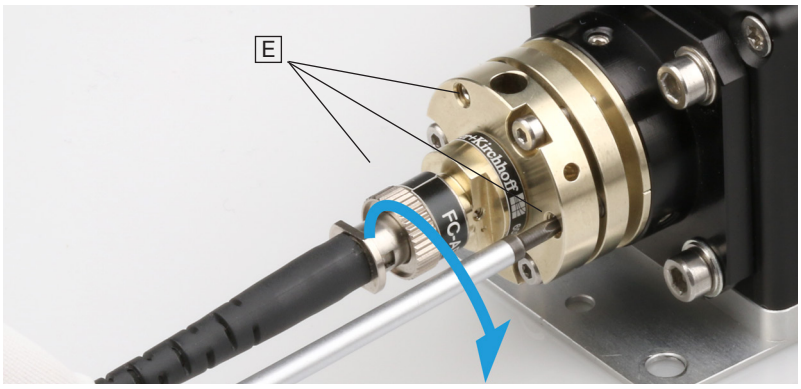

Figure 23:

Fine-adjustment and locking of the laser beam coupler with the three grub screws E.

9. Checking the Alignment, ‚Thumb Test‘

As a useful check of the optimal alignment, the fiber connector can gently be pressed by hand in different directions (Figure 24). The coupling efficiency, i.e. the maximum power seen on the detector will change. However, the induced slight displacement is reversible. Once you stop pressing onto the fiber connector, the coupling efficiency will be as high as before. When optimally aligned, this slight displacement of the fiber

should always reduce the coupling efficiency. If the coupling efficiency increases by pressing in one direction, the locking screw shifting the fiber position into the desired direction has to be tightened further, see Figure 24.

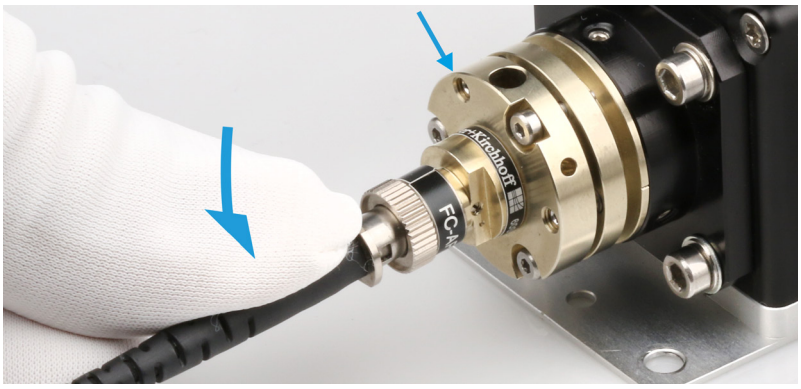

Figure 24:

Thumb test: Pressing of the fiber connector in the shown direction has the same effect such as fastening the marked locking screw F.

10. Focussing the Laser Beam Coupler

Focus adjustment (adjustment of the coupling lens in z-direction) is a demanding task and should preferably be performed using a collimating telescope.

Notice: The laser beam coupler is shipped pre-adjusted for the given wavelength and, often, it is not necessary for the customer to readjust the coupling lens position. This is why you can skip this step in most cases.

A fine-adjustment of the focus setting of a laser beam coupler - if necessary - is performed in the following steps:

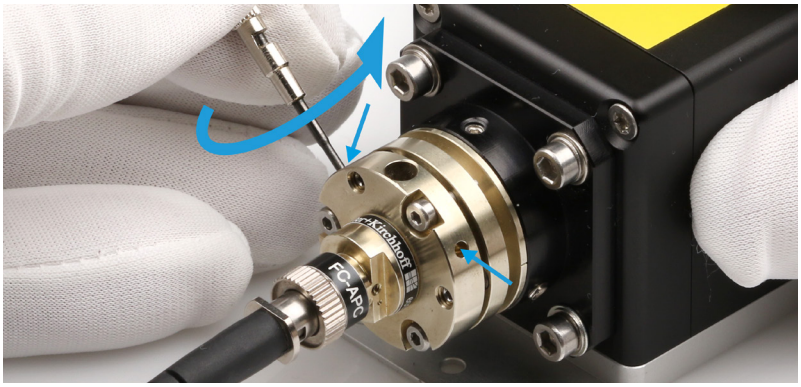

Figure 25:

Slightly loosen the lens by the loosening the two grub screws. Use the screwdriver type 9D-12.

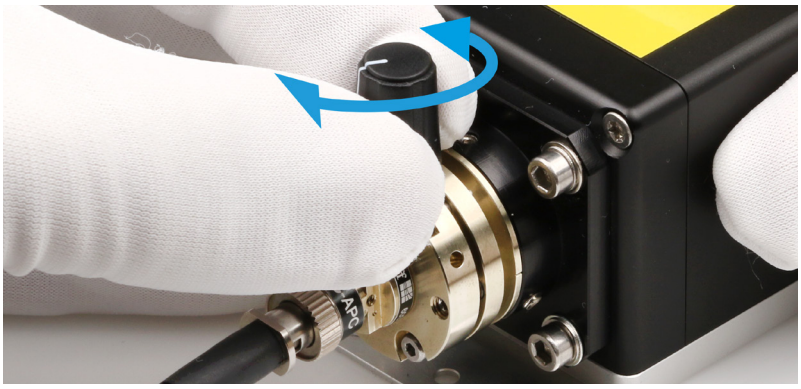

Figure 26:

Use the eccentric key type 60EX-4 or 60EX-5 for fine-adjusting the focus setting.

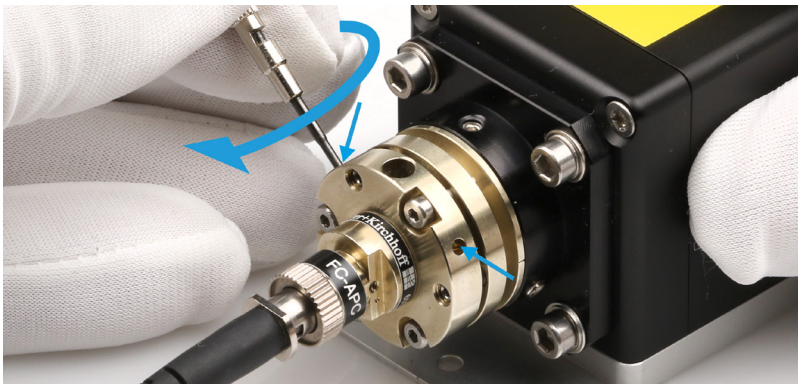

Figure 27:

Finally, lock the focus setting by fixing the two grub screws using the screwdriver type 9D-12.

11. Alignment of the Fiber Polarization Axis

When coupling a laser beam into a polarization-maintaining single-mode fiber, the polarization axis of the fiber must be aligned with respect of the polarization axis of the source in order to obtain a high polarization extinction ratio. The polarization axis of the fiber is adjusted by rotating the laser beam coupler. Since both laser beam coupler and fiber are connected, this means that the fiber polarization axis is rotated with respect to the polarization axis, as well.

Notice: The following steps have to be performed only if the laser beam coupler is used with a polarization-maintaining fiber cable.

In order to adjust for the polarization axis, perform the following steps:

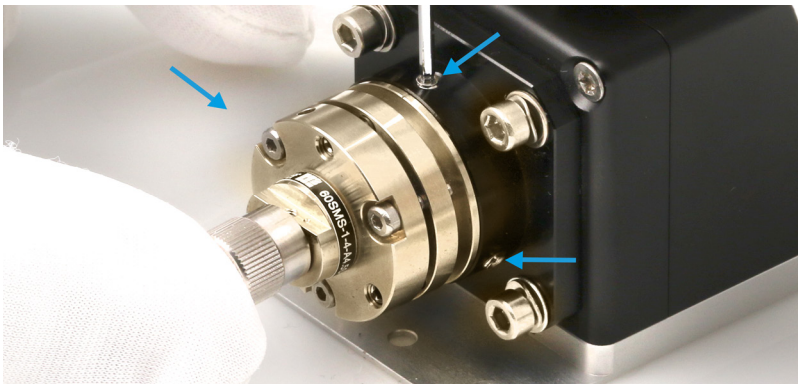

Figure 28:

Slightly loosen the three radially arranged pin screws at the adapter.

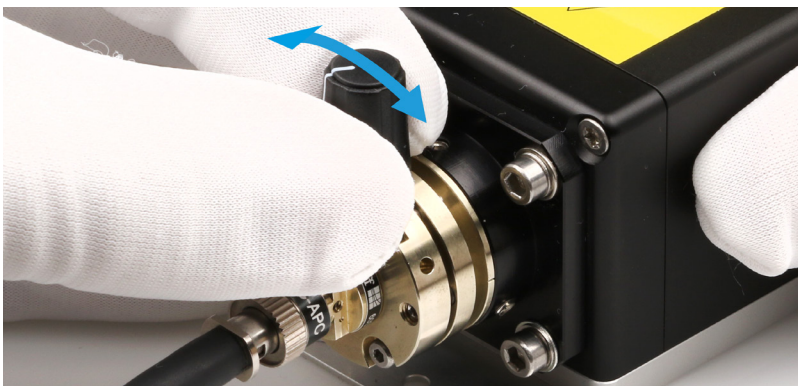

Figure 29:

Now, gently rotate the laser beam coupler. You can use the eccentric key type 60EX-4 or 60EX-5 just as as a lever.

The polarization extinction of the laser radiation transmitted by the fiber cable is measured using a polarization

analyzer, such as the SK010PA Polarization Analyzer from Schäfter+Kirchhoff.

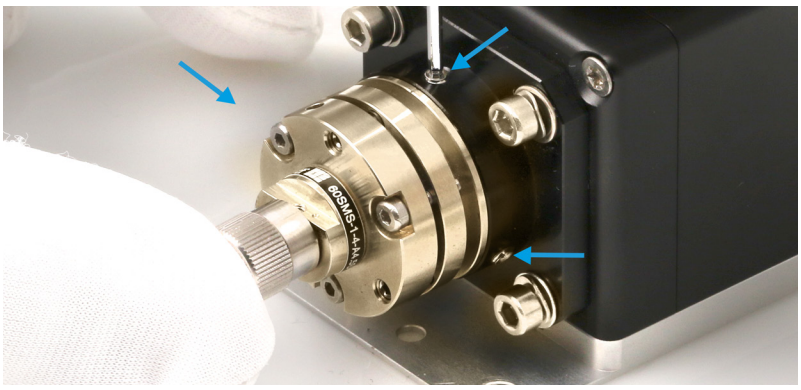

Figure 30:

Finally, fix the three radially arranged pin screws at the adapter. Please consider a comparable torque for the three screws and the gap of the steel ring such as described in Chapter 5.

13. Accessories

Figure 31:

Adapter type 60A19-5-F.
Other adapter types are available.

14. Adjustment Tools

For assembling and adjusting the laser beam couplers series 60SMS you need the following tools:

Figure 32:

Screw driver type 9D-12, hex key 50HD-15, and eccentric key type 60EX-4 or type 60EX-5.

Figure 33:

Aperture 13H and as an alternative the adjustable iris diaphragm 13BL1-13.

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