C-FLEX

Compact | Flexible | Laser Combiner

HÜBNER Photonics

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1. Introduction

C-FLEX is a flexible and compact laser combiner that allows for integration of up to six different wavelengths on a single platform, modulation options for all wavelengths, and configuration with either free beam or fiber coupled beam delivery.

C-FLEX is intended for stand-alone use in laboratory environments or for integration as an OEM component in instruments for applications including fluorescence microscopy, flow cytometry, optogenetics, holography, raman spectroscopy and photochemistry.

This manual is intended to be used as a tool to give the user a detailed understanding of how to operate and align C-FLEX as well as the integrated lasers and auxillary equipment. The manual focuses on laser combiner functionalities and with practical inclusions for the operation of the Cobolt lasers and Cobolt Monitor™ control software and Acousto-optic modulators (AOMs). For more details on the functionality and performance of each laser product or the auxillary equipment, the specific product manuals can be a valuable resource.

C-FLEX is compatible with lasers from the Cobolt 04-01, 06-01, and 08-01 Series. The C-FLEX laser combiner is available in two different sizes, the C-FLEX C6 which can accommodate up to 6 lasers, and the C-FLEX C4 which can accommodate up to 4 lasers, from the Cobolt 06-01 or 08-01 Series. Below is a list of compatible Cobolt lasers and links to the Hübner Photonics website where the full list of available products can be found. Contact your sales representative to discuss an application specific solution.

Cobolt 04-01 Series

Powerful, single frequency CW diode pumped lasers:
457 nm – 1064 nm up to 400 mW

https://hubner-photonics.com/products/lasers/single-frequency-lasers/04-01-series/

Cobolt 06-01 Series

Plug & play modulatable lasers:
375 nm – 975 nm up to 400 mW

https://hubner-photonics.com/products/lasers/diode-lasers/06-01-series/

Cobolt 08-01 Series

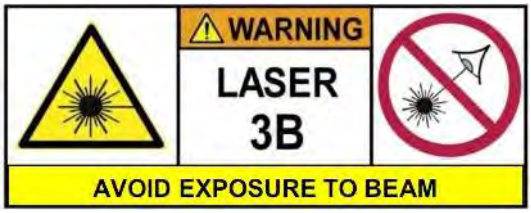
Compact narrow linewidth lasers:
405 nm – 164 nm up to 400 mW

https://hubner-photonics.com/products/lasers/narrow-linewidth-lasers/08-01-series/

2. Safety

2.1. General

The C-FLEX laser combiner's laser classification is dependent on the lasers integrated into the laser combiner system. The sum of the maximum emitted power of all lasers integrated into the laser combiner determines the laser classification. Residual emission of any wavelength not specified on the warning label does not exceed Laser Class 1. The sum of the maximum emitted power of all laser lines in the multi-line laser determines the laser classification. The residual emission at wavelengths outside the specified range do not exceed Laser Class 1. A laser combiner capable of emitting a maximum of less than 500 mW of laser radiation within the ultraviolet (UV) [< 400 nm] , visible [400-700 nm] and near infrared (NIR) spectrum [700-1400 nm] is Class IIIB (CDRH), Class 3B (IEC).



A Class IV (CDRH), Class 4 (IEC) laser combiner is capable of emitting more than 500 mW of laser radiation within the ultraviolet (UV) [< 400 nm] , visible [400-700 nm] and near infrared (NIR) spectrum [700-1400 nm] .

2.2. Symbols in the manual

WARNING – LASER RADIATION This symbol is used to call attention to important laser safety information

WARNING – STATIC MAGNETIC FIELD This symbol is used to call attention to important magnetic field safety information

CAUTION – GENERAL This symbol is used to call attention to important general operator and equipment safety information

NOTICE – GENERAL This symbol is used to call attention to best practices when using the equipment and does not indicate a hazard.

2.3. Beam Hazards

It is advised to perform a risk assessment for the facility and equipment prior to using the laser. In the case of integration into a larger system, laser safety compliance must be evaluated in the end product. The device must be handled by skilled personnel experienced with lasers, in a laboratory environment and with access to adequate laser safety equipment. The laser clearly displays a yellow warning label that shows the location of the laser beam aperture. This label must be visible unless the laser beam is totally enclosed.

WARNING Remove all watches, rings and other reflective jewelry before working with lasers. Always wear the appropriate eye protection from the wavelengths integrated into the system. As the system can be integrated with different laser lines after delivery, verify the accessible emission wavelength and power before operating. **Never look directly into a laser beam.**

The highest risk of exposure is when aligning the beam. Eye hazards are related to direct exposure, specular reflections and in the case of Class 4 lasers can even be related to diffuse reflections. Eye and skin exposure to direct or reflected laser light is hazardous and may be extremely harmful. Always wear eye protection appropriate to the beam wavelength(s) and intensity.

Laser radiation may ignite flammable materials and combustible gasses in the beam path and, in event of ignition, fumes may be generated. All equipment used in close proximity to the laser beam should be suitably fire resistant and the facility should be properly ventilated.

CAUTION Use of controls or adjustments or performance of any procedures other than those specified herein may result in exposure to hazardous radiation.

2.1. Non-Beam Hazards

Strong Internal Magnet

The laser combiner safety interlock, described in section 2.3, and laser heads with optical isolators (Cobolt model 08-11) contain strong permanent magnets. Proceed with caution when positioning or servicing the laser combiner near material which may be magnetized and when operating with tools which may be magnetized (e.g. screwdriver) around the laser head. Users with implanted medical devices should stay back at least 30cm (12 inches).

2.2. Accessible Emission and Eye Protection

The equations below describe how to use the nominal output power (mW) and beam area to calculate the irradiance (W/cm^2) and how to use the Warning label (Max) power (mW) and the Accessible Emission Limit (AEL) (mW) per laser safety standard IEC 60825-1:2014 to calculated the required optical density (OD) for eye protection per wavelength.

Using a laser combiner requires a combination of eye protection that is specifically tailored to the device configuration, be sure to consider all integrated wavelengths and power levels when selecting eye protection. Update eye safety protocols and eye protections specifications when adding or removing a laser line from the combiner.

$$\text{Irradiance}\left(\frac{\text{W}}{\text{cm2}}\right) = \frac{110\ \%\ \text{of Nominal Laser Power (mW)}}{\text{Beam area at bottom tolerance (cm}^2\text{)}}$$

$$\text{Require Attenuation of Laser Safety Glasses (OD)} = \log_{10}\left\{\frac{\text{Warning Label Power (mW)}}{\text{60825} - \text{1 Laser Class 1 AEL (mW)}}\right\}$$

See the individual laser manuals for information on the accessible emission and maximum emission parameters. The latest revision of all product manuals can be found via the Cobolt website https://hubner-photonics.com/ .

2.3. System Safety Features

The laser combiner is equipped with all safety features required by the laser safety standard IEC 60825-1.

Safety Interlock

The safety interlock is an automatic mechanism designed to prevent access to emission of integrated lasers when the access panel of the laser combiner is removed. When the access panel is removed the safety interlock circuit is open and all emission is interrupted and no radiation will be accessible. The safety interlock has two magnetic switches that must be actively closed to allow the laser combiner to function. When the lid of the combiner is in place, the magnets on the lid will close the circuit. When working inside the combiner, the 'Safety Interlock Overide Tool' must be used to override the circuit to allow the lasers inside the combiner to operate during alignment and maintenance.

WARNING – Laser Radiation accessible when safety interlock is defeated. Avoid skin and eye exposure to direct or scattered radiation.

WARNING – The magnetic switches use strong magnets which are attached to the underside of the access panel. Be aware of strong magnetic fields.

CAUTION – Alignment and maintenance of the lasers inside the C-FLEX should only be performed by trained personnel with appropriate laser safety equipment.

Remote Interlock Connector

The remote interlock connector allows the connection of external controls placed at a distance from the laser combiner. When the terminals of the connector are open-circuited, emission is interrupted and no radiation will be accessible. The remote interlock connector permits easy addition of an external interlock in laser combiner installation. After the remote interlock connector has been opened the laser will need to be reset by toggling the key switch or disconnecting from and then reconnecting to the power supply. The signal level is between 0V and +5V with a pull up resistor, and the current required to ground the remote interlock connector is 5 mA. The time delay in the hardware is < 1 ms, but after filtering by the firmware the reaction time is extended to < 20 ms.

Manual Shutter (Beam Stop)

The laser combiner is equipped with a manual shutter, which functions as the beam stop, capable of preventing human access to laser radiation. The aperture location and the open and close positions of the shutter are indicated on the top surface of the laser combiner access panel. C-FLEX is delivered with the shutter fixed in the 'closed' position using adhesive tape.

Key Control

The CE/CDRH compliant model comes with a key control switch which must be connected for the lasers to operate. When the key is in the OFF position, all integrated lasers are prevented from emitting. The key must be actively turned to the ON position each time the laser is powered on. When the key is removed from the system laser radiation is not accessible. The key is only removable in the OFF position.

Laser Radiation Emission Warning / Status LED

The emission warning LEDs are located on the back panel of the laser combiner or laser controller, there are at least two LEDs per laser line. The green "ON" LED is illuminated whenever the corresponding device is emitting or could emit light. In case of a break in the interlock circuit or any other error state the red "ERR" LED is illuminated. If a laser is off, no LED is illuminated.

2.4. Equipment Safety

Back Reflection Sensitivity

Laser light reflected directly back into the laser head can cause instabilities in laser performance, instantaneous damage to the laser diodes and a dramatic decrease in product lifetime. Cobolt 06-MLD lasers with a wavelength greater than 600 nm are particularly sensitive, exercise extreme caution. If additional filters are installed make sure that the corresponding anti-reflection coating is used to prevent back reflections into the laser head(s).

Electrostatic discharge

Always install the laser system to a properly grounded power outlet. Integrated lasers contain a laser diode which is sensitive to electrostatic discharge (ESD).

Fiber Care

It is important to always make sure the fiber end-facet is clean before turning any of the lasers on and before connecting the fiber connector in physical contact with another connector. Failure to do so may lead to irreparable damage of the fiber end-face. Do not clean the fiber when the laser is on. We recommend using appropriate equipment for fiber cleaning and inspection.

2.5. Warning and Identification Labels

The upper face of the laser combiner contains a yellow label with laser safety warning and classification information, the wavelength range and maximum power of each laser delivered originally with the C-FLEX. There are also labels that show the location of the laser beam aperture, indicates the open and closed positions of the manual shutter and the access panels. These labels must be visible unless the laser beam is totally enclosed. A label showing information about the system model, serial number, manufacturer date and location, and the power supply voltage and current, is located on the laser combiner. Laser combiners shipped to customers in the USA also contain a label of CDRH compliance.

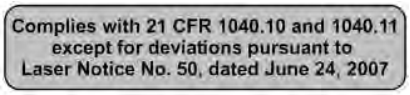
Manufacturer Identification Labels

Additional Aperture Warning Label

Access Panel Warning Labels

Aperture Laser Classification and Emission Warning Label

Magnetic field Strength Warning Label



Laser Notice No. 50 Label CDRH models shipped to USA

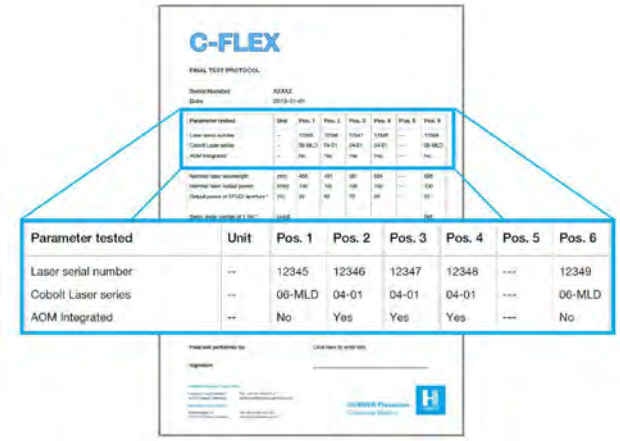
Label Placement

3. Laser Combiner Operation Instructions

Welcome to C-FLEX!

This section will cover the step-by-step process of getting a C-FLEX installed and ready for use. It is intended to be conceise and instructive. More elaborate information about system configuration, performance specifications, environmental requirements and alignment principles can be found in sections 7 through 10. It is important to get to know the specific C-FLEX configuration before attempting to install it.

To know which Cobolt lasers are built into the C-FLEX laser combiner refer to the test protocol delivered with the C-FLEX.


C-FLEX

Parameter tested	Unit	Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6
Laser serial number	--	12345	12346	12347	12348	---	12349
Cobolt Laser series	--	06-MLD	04-01	04-01	04-01	---	06-MLD
AOM Integrated	--	No	Yes	Yes	Yes	---	No

Determine if the C-FLEX should have been delivered with auxillary equipment which will need to be installed at the same time in order for the combiner to function.

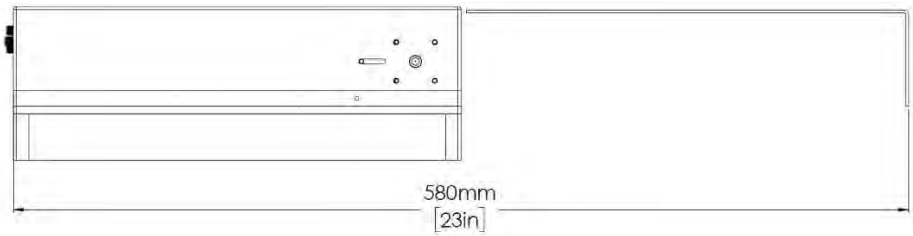
If the C-FLEX has Cobolt 04-01 lasers included the answer is **YES**! External controllers are required to run the Cobolt 04-01 series lasers integrated into the C-FLEX. The controllers and all necessary cables are delivered with the system.

If the C-FLEX has an integrated AOM, or possibly up to three, then the answer is also **YES**! The AOM Driver and all necessary cables are delivered with the system.

3.1. Preparing the installation space

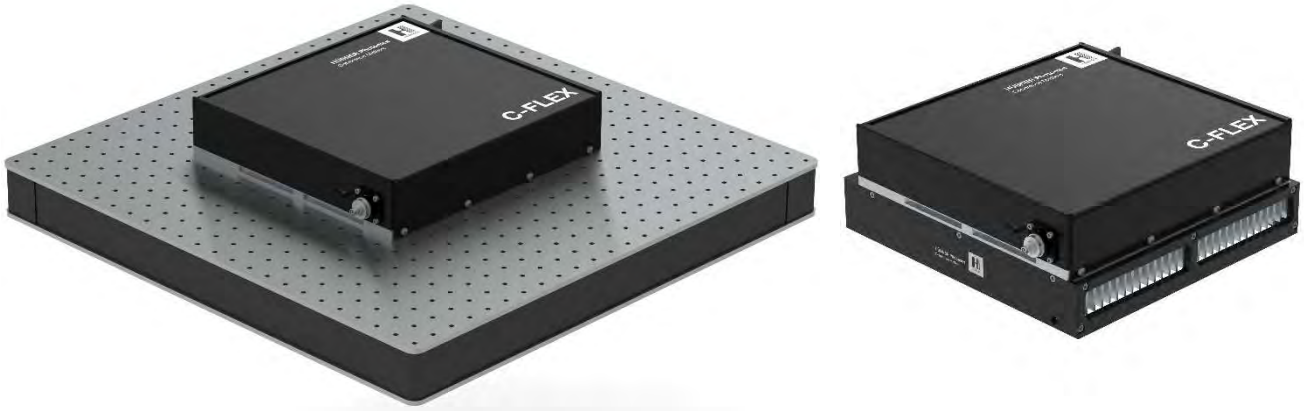
Read section 2 : Safety before continuing and be sure the appropriate laser safety precautions have been taken before installing and operating the C-FLEX laser combiner.

Decide if the C-FLEX is to be mounted directly on an optical table or on the custom heat sink. When installing, allow for the space required to remove the access panel whilst aligning the optics inside the system. It will be necessary to open the lid for both installation and alignment.



C-FLEX access panel space requirement

If using the heatsink mounted on an optical table, the heat sink must be fastened to the table before mounting the C-FLEX to the heatsink.



C-FLEX C6 Mounted on optical table (left) and mounted on a heat sink (right)

Use the test protocol delivered with the system to understand which lasers have been integrated into the C-FLEX to be installed. The Cobolt Laser series is listed just below the serial number.

3.2. Getting to know the parts

Check that all of the items listed in this section have been delivered and verify that the appropriate tools are available.

C-FLEX Laser Combiner System parts

- C-FLEX Laser combiner with integrated lasers and fiber coupler (in case of the fiber coupled option) are delivered assembled. The fiber is not mounted at delivery.

- Optional Optical Fiber (not mounted at delivery)

- C-FLEX System Power Supply 15VDC 7A

- C-FLEX System Data Cable USB-B/USB-A

- Keys

- Remote interlock plug (for short circuiting the remote interlock connector)

- Fixation bolts (3 pieces) – Both metric and imperial screws are delivered but only 3 will be used for mounting.

If the C-FLEX contains a Cobolt 04-01 series laser or an AOM it will be delivered with auxillary equipment.

Cobolt 04-01 Laser Controller and Cables

- Cobolt 04-01 Laser Controller(s) – one per Cobolt 04-01 Series laser head

- Cobolt 04-01 Controller cable (26-pin D-SUB) – one per Cobolt 04-01 Series laser head

- Control I/O Cable (8- pin to 6-pin Molex connector and 2-pin molex connector)

- Controller data cable (Mini USB to C-FLEX back panel)

- Laser power supply cable (Kycon 4 pin connector to C-FLEX back panel)

AOM Driver and Cables

- AOM Driver

- AOM Driver Cable – Sub-D 15 to 2x 5mm DC Socket

- AOM RF Input Cables

- AOM Power Supply 24 V

- AOM 5V DC Supply for use as digital modulation input signal

NOTICE The system is not delivered with a 1 V DC supply for the analog modulation input, this must be supplied by the customer before a system with integrated AOM can be operational.

Alignment tools

- Aperture mounted pinhole alignment tool (12749)

- Steering mirror mounted pinhole alignment tool (12748)

- Safety Interlock override tool for alignment

Installation tools – Included :

- Hexagon Screwdriver - 1.5 mm
- Hexagon Screwdriver - 2.5 mm
- Torx Screwdriver – T20
- Phillips Screwdriver – PH2
- Slotted Screwdriver – 6.5 mm

Verification and Alignment tools – Not included

- Fast power meter or photodiode
- Detector card
- Beam profile camera

Control Software

- Cobolt Monitor™ laser control software

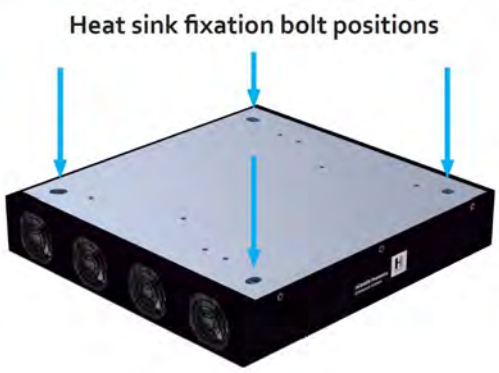
  Cobolt Monitor™ can be downloaded from the Cobolt website : https://hubner-photonics.com/downloads/ . The control software is a stand alone executable, it can be run directly without any installation. If using an older version of windows it may be necessary to install the Cobolt USB drive, which can also be downloaded from the Cobolt website. See section 4 : Cobolt Monitor™ Software for more information.

- Beam overlap calculation template : https://hubner-photonics.com/downloads/

3.3. Mounting the C-FLEX on a heatsink or optical table

WARNING – When the access panel is removed the safety interlock circuit will be open and prevent emission. At this point is not necessary to power the C-FLEX, for added safety it is recommended not to connect any cables to the C-FLEX while mounting.

1. If mounting the C-FLEX onto the heat sink, mount the heat sink to the optical bench before mounting the C-FLEX.

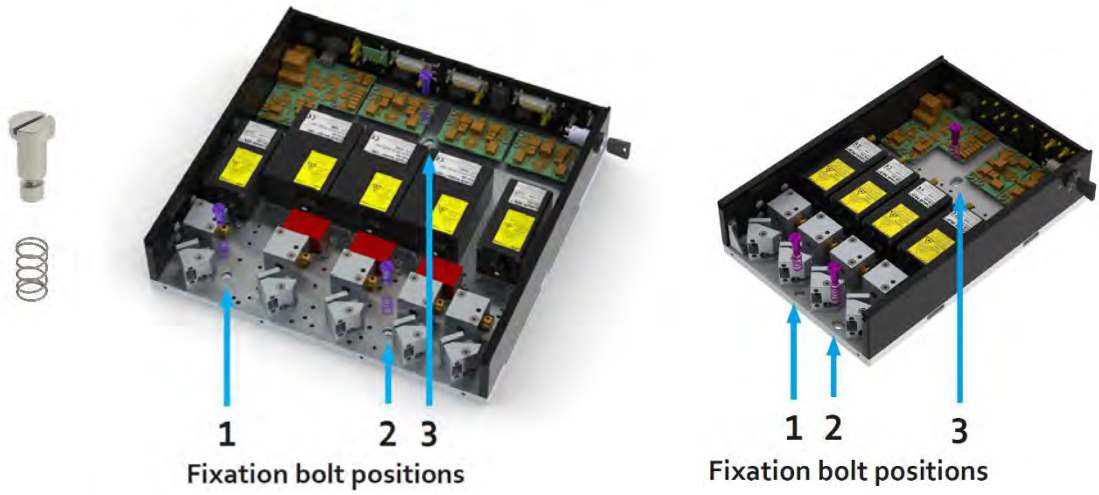


2. Remove the four screws from the access panel of the C-FLEX. Keep them in a safe place, they will be replaced after fixation and alignment.

NOTICE – The fixation bolts do not require the removal of any parts mounted within the C-FLEX! Take care not to bump the mirrors, it may affect the alignment accuracy.

NOTICE – Use ONLY the delivered spring loaded bolts, improper mounting of the C-FLEX may introduce mechanical stress that will have a negative impact on performance.

3. Use the provided fixation bolts and springs to fix the C-FLEX to the mounting surface, either directly on the optical bench or on the heat sink. The fixation bolts are designed to hold the laser combiner in place while allowing for thermal expansion during operation. Place the bolts in the order indicated on the illustration, C-FLEX C6 on the left and C-FLEX C4 on the right. Do not tighten completely until all three bolts are partially in place.



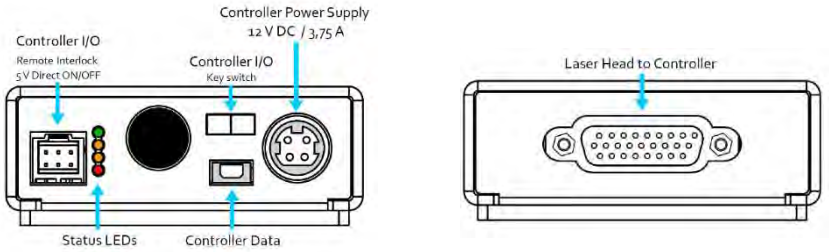
4. Replace the access panel before connecting the cables. Tighten all four screws to secure the access panel safely in place.

3.4. Connecting the cables from C-FLEX to auxillary equipment

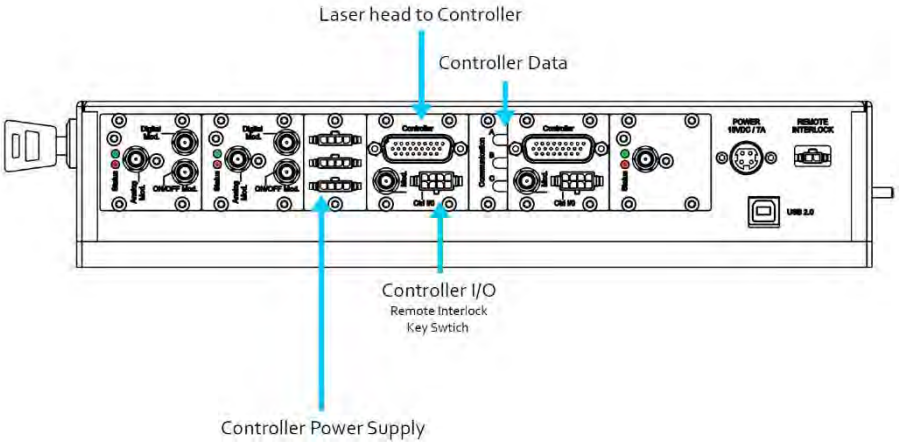
Connecting the controller cables of a Cobolt 04-01 laser

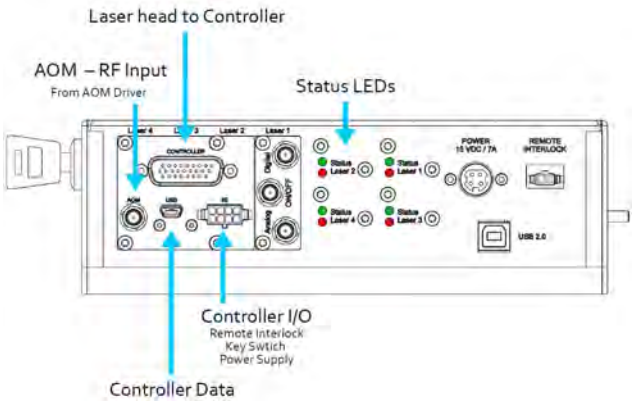
This section describes how to properly connect a controller delivered with a Cobolt 04-01 to the laser head interface on the C-FLEX. If no Cobolt 04-01 lasers are integrated, proceed to the next section.

NOTICE – Be sure to connect all cables to the laser controllers before supplying power to the system !



Cobolt 04-01 Controller





C-FLEX Back panel (top) C6 and (bottom) C4 with connections for Cobolt 04-01 Series lasers

1. For each Cobolt 04-01 laser integrated in the C-FLEX there is a specific controller and cable, they are labeled with the laser's serial number. Separate the controllers and cables by the laser they belong to and use only the corresponding equipment for each laser.

2. Connect the Controller I/O cable's 2-pin molex connector, with black and blue wires, to the laser controller's key switch socket. Pull gently to be sure the connector is locked in place.

3. Connect the Controller I/O cable's 6-pin molex connector, with the black and green wires, to the laser controller socket labeled 'Analog'.

4. Connect the Controller I/O cable's 8-pin molex connector to the 'Ctrl I/O' socket on the C-FLEX.

5. Connect the male end of the 26-pin D-SUB cable to the 'Laser' connectors on the controller and then connect the female end to the 'Controller' connector on the C-FLEX

6. Connect 12 V DC Laser Controller Power Supply cable's Kycon connector to the power socket on laser controller.

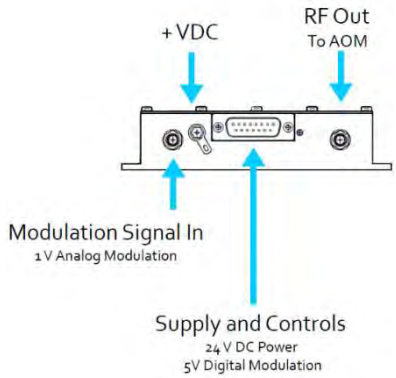
7. Connect 12 V DC Laser Controller Power Supply cable's 4 pin molex connector to the power socket on the C-FLEX.

8. Check that the key is present in the key switch of each controller. Turn the key(s) to the ON position.

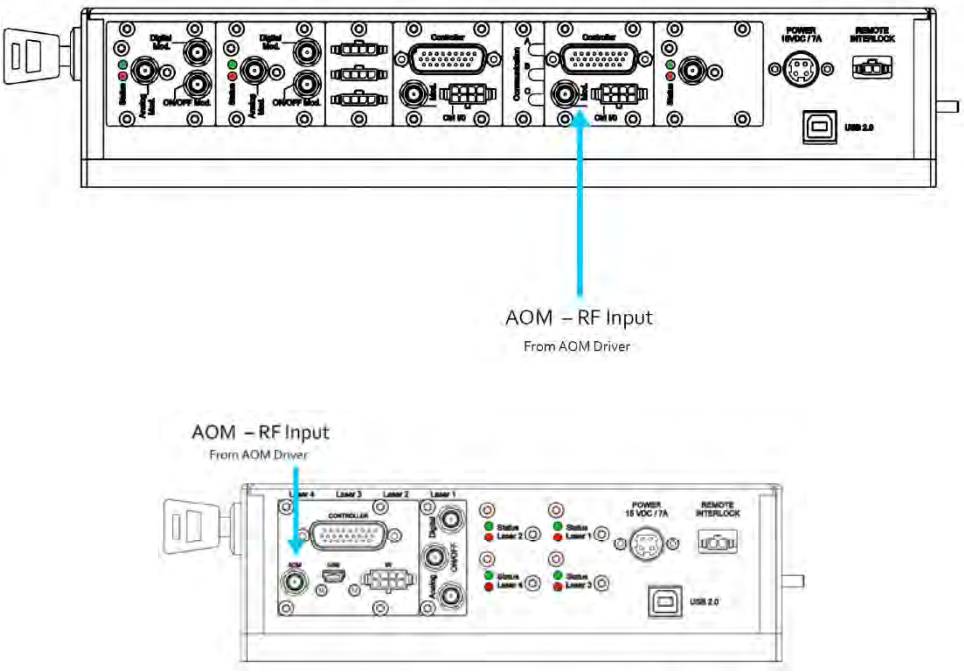
Connecting the AOM driver cables

This section describes how to properly connect the driver, delivered with an integrated AOM, to the laser head interface on the C-FLEX, as well as the input signals to the AOM Driver from the delivered DC power supplies. Details on how to connect modulation signals will be covered in section 6 : Controlling Emission with Modulation Mode Operation. For each AOM integrated in the C-FLEX there is an AOM driver. If no AOMs are integrated, proceed to the next section.

NOTICE – A 5V DC supply voltage must be connected to the digital modulation input and 1 V DC supply voltage must be connected to the analog modulation of the AOM driver or there will be no transmission through the AOM and no laser emission at the C-FLEX aperture.



AOM Driver



C-FLEX Back panel (top) C6 and (bottom) C4 with connector for AOM RF Input

1. For each AOM integrated in the C-FLEX there is a specific driver, they are labeled with the laser serial number. Separate the drivers and cables by the laser they belong to and use only the corresponding equipment for each laser.

2. Connect the 'AOM Driver Cable's Sub-D 15 connector to the Supply and Control connector on the AOM driver.

NOTICE – Always connect the RF Input cable between the laser head and the AOM driver before providing power to the AOM.

3. Connect the AOM RF-Input cable to the RF-Out connector on the AOM Driver.

4. Connect the other end of the RF-Input connector to the AOM Input connector labeled 'Mod.' on the C-FLEX.

5. Connect a 1 V DC signal (not delivered) to the SMA connector labeled MOD IN on the AOM Driver.

6. Connect the 5 V DC signal to the DC Socket labeled '5V' on the AOM Driver Cable. C-FLEX systems with Integrated AOM's are delivered with a 5 V / 3A DC power supply but any 5V DC signal may be used.

7. Connect the 24 V DC Power Supply to the DC Socket labeled '24 V' on the AOM Driver Cable.

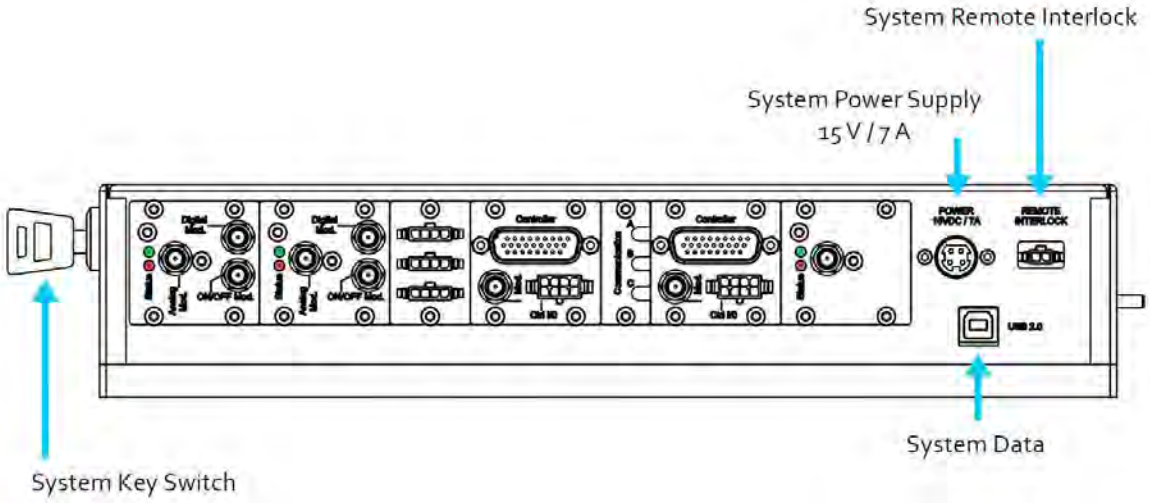
3.5. Connecting the System Cables and starting emission

In this section the initial start up of the C-FLEX will be explained, how to connect the system cables and start emission of the lasers.

1. Verify that the shutter is closed

DANGER – Laser Radiation is accessible when the safety interlock is defeated. Avoid skin and eye exposure to direct or scattered radiation. **Close the shutter before powering up the system.**

WARNING - Alignment and maintenance of the lasers inside the C-FLEX should only be performed by trained personnel with appropriate laser safety equipment.



2. Place the remote interlock jumper, a 2 pin molex jumper with a green wire, into the remote interlock socket or, if applicable, connect the external interlock.

3. Connect the System Data cable's USB-B connector to the socket labeled 'USB 2.0'.

4. Connect the System Data cable's USB-A connector to the PC being used to control the C-FLEX.

5. Connect the 15 V / 7 A power supply to the Kycon power socket on the C-FLEX.

6. To start the lasers, turn the key to the ON position. If it is already in the ON position, turn it to OFF and then ON again.

Once the key is turned to the ON position the lasers will automatically start up, Wait at least 3 minutes for the lasers to stabilize. See section 5 for detailed discussion of the emission control options in continuous wave operation.

Key Swtich ON and OFF

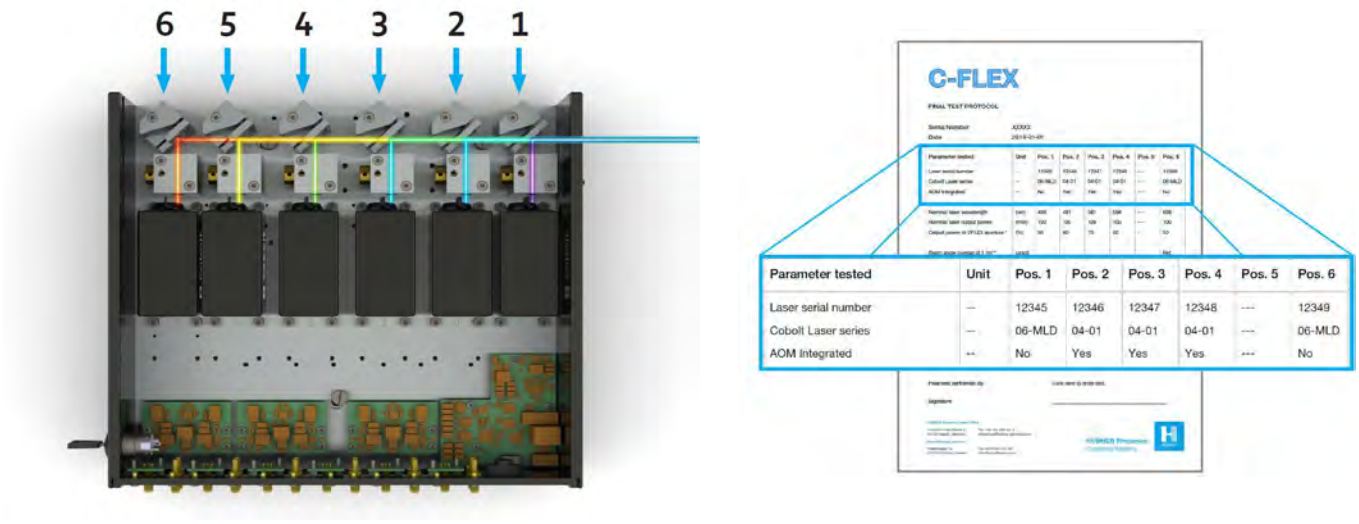
Each Cobolt laser will go through the auto start sequence:

Waiting for Temp	Laser emission is not enabled until all temperatures have reached their set point and the TECs are stabilized.
Waiting for Key	Toggle the key to proceed, if the key is already in the ON position, turn OFF and ON again.
Warm up	A low current is provided to warm the laser before setting full power
Completed	The device is emitting or armed for emission.

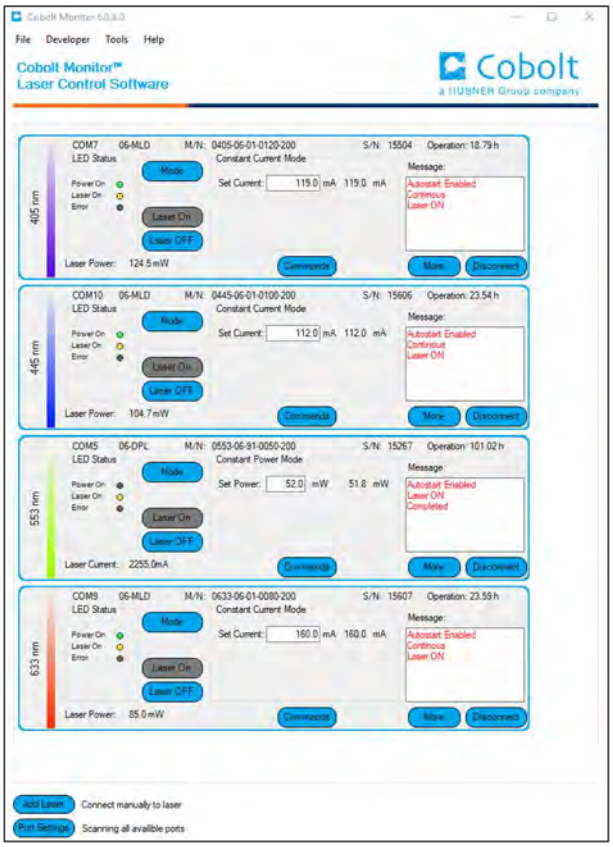
7. Verify that all Status LEDs are green, including those on the Laser Controllers.

8. Open Cobolt Monitor control software. If not already done, the application can be downloaded from the Cobolt website : https://hubner-photonics.com/downloads/ .

9. Identify each laser displayed in the software and note the position in the C-FLEX. The position of each laser is noted on the delivered test protocol.



Laser position numbers, typically the lasers are located from red to blue with the shortest wavelength laser closest to the aperture.



Example of four lasers displayed in the Cobolt Monitor™ Software. Note that the COM port assignments are not sequential or correlated to the laser position

3.6. Verifying the Laser performance and System Alignment

In this section the user will verify that the C-FLEX and integrated lasers are performing as expected and to determine if re-alignment is necessary. Choose the appropriate subsection for the beam delivery depending on if the C-FLEX is fiber coupled or free beam. For detailed instructions on how to control the emission of each laser individually see section 5. The steps described in this section can be used to confirm alignment at any time. Regular verification and maintenance is recommended for applications that require high precision in beam overlap. An excel template 'Alignment Verification Calculation Tool' is available for download from https://hubner-photonics.com to facilitate the verification described in this section.

DANGER – Never look directly at the laser beam! Avoid exposure to scattered and reflected light. Always wear the appropriate eye protection for the specific wavelengths (nm) and powers (mW) integrated into the system.

NOTICE – Using the Laser ON and Laser OFF buttons in the software will require toggling of the system key switch to resume emission, all laser line will be turned OFF when the key is toggled.

1. Turn all lasers ON with the key switch.

2. Wait at least 3 minutes for the lasers to complete warm up.

Measure the output power of a free beam C-Flex

3. Place a power meter in front of the C-FLEX aperture.

4. Open the Cobolt Monitor software to control the emission of each laser line individually.

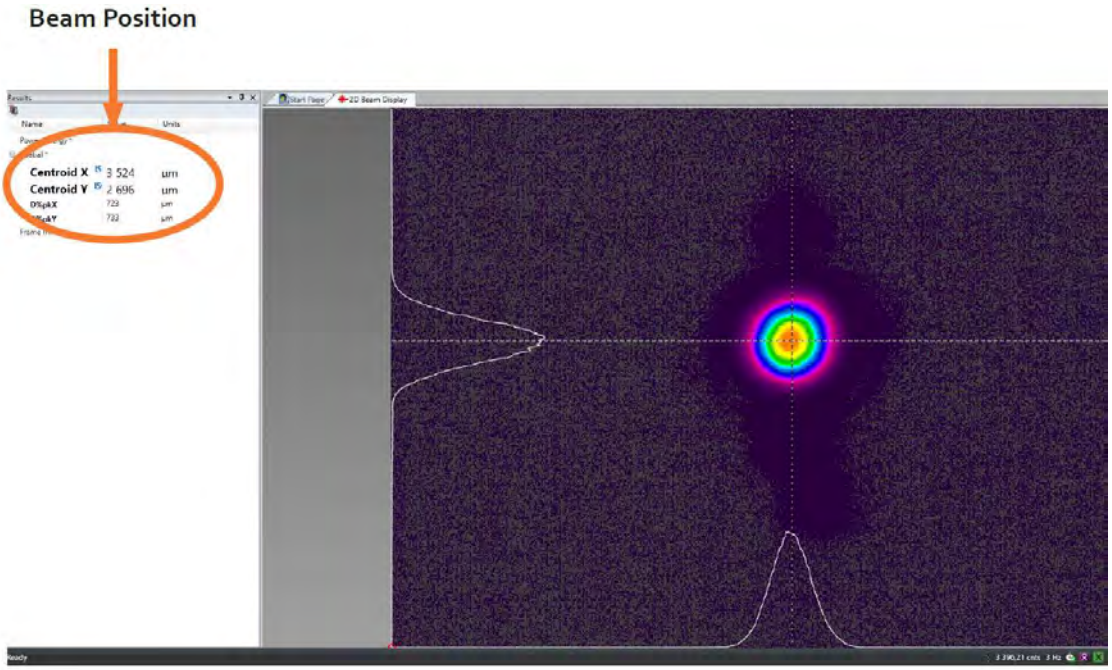
5. Measure the output power for each beam individually, be sure to adjust the wavelength setting on the power meter. Verify that the measured power agrees with the test protocol.

6. Make a note of the output power for your records, the Beam overlap calculation template can be used for this.

Measure the alignment of a Free Beam C-Flex (for fiber coupled see next section)

7. Place a beam profile camera at the C-FLEX aperture. Measure the centroid position of each laser, one laser at a time. Record the centroid position in X and Y of each laser.

NOTICE – Wait for the laser power to stabilize at the nominal set point power before verifying alignment. Operation at different power or current settings could result in changes in the beam overlap.



$$\text{Beam position overlap } (\mu\text{m}) = \sqrt{(\oplus_{Xtest}(\mu\text{m}) - \oplus_{Xref}(\mu\text{m}))^2 + (\oplus_{Ytest}(\mu\text{m}) - \oplus_{Yref}(\mu\text{m}))^2}$$

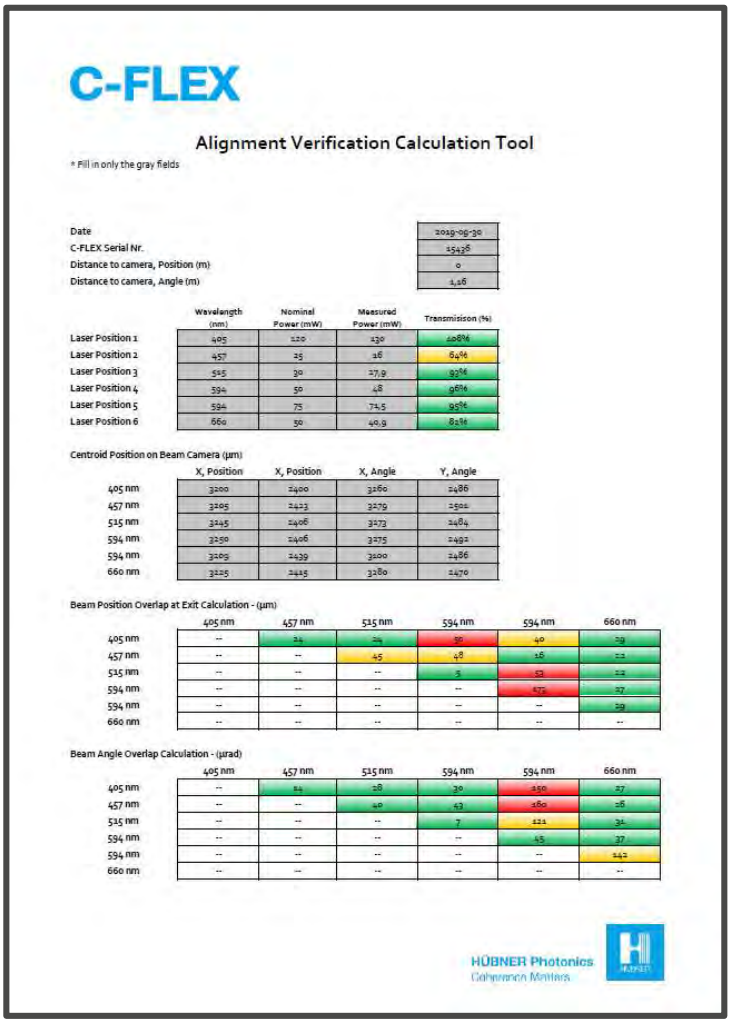
8. Place a beam profile camer at 1 meter distance from the C-FLEX aperture. . If no camera is available it is possible to use a 1 mm diameter pin hole and a fast power meter, but there will be no quantitative beam angle overlap result.

9. Turn on only the laser in the position farthest from the aperture, the laser with the longest wavelength. Use this laser as the reference laser to set the position of the camera. Be sure to secure the camera in place during the measurement.

10. Use the small angle approximation as seen in the equation below, where ⊕ represents the beam position on the camera, to calculate the angular overlap between each beam and the reference laser. Be sure to express all position and distance units in meters to get a beam angle overlap result in radians.

$$\text{Beam angle overlap (rad)} = \frac{\sqrt{(\oplus_{Xtest}(\text{m}) - \oplus_{Xref}(\text{m}))^2 + (\oplus_{Ytest}(\text{m}) - \oplus_{Yref}(\text{m}))^2}}{\text{Distance to camera (m)}}$$

11. While comparing the reference laser will give a good indication of the beam overlap, to be complete each laser position must be compared to all of the others. To download the beam 'Alignment Verification Calculation Tool' go to https://hubner-photonics.com/downloads/ .



C-FLEX

Alignment Verification Calculation Tool

* Fill in only the gray fields

Date	2019-08-30
C-FLEX Serial Nr.	15436
Distance to camera, Position (m)	0
Distance to camera, Angle (m)	1,16

	Wavelength (nm)	Nominal Power (mW)	Measured Power (mW)	Transmission (%)
Laser Position 1	405	120	130	108%
Laser Position 2	457	25	16	64%
Laser Position 3	515	30	27,9	93%
Laser Position 4	594	50	48	96%
Laser Position 5	594	75	71,5	95%
Laser Position 6	660	50	40,9	81%

Centroid Position on Beam Camera (µm)

	X, Position	X, Position	X, Angle	Y, Angle
405 nm	3200	2400	3260	2486
457 nm	3205	2423	3279	2502
515 nm	3245	2406	3273	2484
594 nm	3250	2406	3275	2492
594 nm	3209	2439	3200	2486
660 nm	3225	2415	3280	2470

Beam Position Overlap at Exit Calculation - (µm)

	405 nm	457 nm	515 nm	594 nm	594 nm	660 nm
405 nm	--	24	24	50	40	29
457 nm	--	--	45	48	16	22
515 nm	--	--	--	5	53	22
594 nm	--	--	--	--	67	27
594 nm	--	--	--	--	--	29
660 nm	--	--	--	--	--	--

Beam Angle Overlap Calculation - (µrad)

	405 nm	457 nm	515 nm	594 nm	594 nm	660 nm
405 nm	--	24	28	30	150	27
457 nm	--	--	40	43	180	26
515 nm	--	--	--	7	121	34
594 nm	--	--	--	--	45	37
594 nm	--	--	--	--	--	142
660 nm	--	--	--	--	--	--

HÜBNER Photonics

Coherence Matters

12. Close the C-FLEX shutter

If each beam angle overlap is within specification (< 100 µrad) **DO NOT** re-align the system.

Measure the alignment of a fiber coupled beam C-Flex

1. Close the shutter of the C-FLEX behind the fiber coupler.

2. Mount the fiber into the fiber coupler. Press down on the lens tube locking plunger and place the fiber lens tube into the coupler. Be sure the locking pin is completely docked to ensure the best coupling efficiency. See the image in section 3.7 : Aligning the Fiber Coupler for more information about the fiber coupler.

3. Place an appropriate optical power meter at the fiber exit. Be sure the fiber and power meter are secured in place with the fiber end close enough to the power meter to measure accurately. Be sure to set the measurement wavelength when changing from laser to laser.

NOTICE – Always remove the fiber end cover and clean the fiber end before opening the shutter, emission onto a closed or dirty fiber end can cause damage to the fiber ferrule

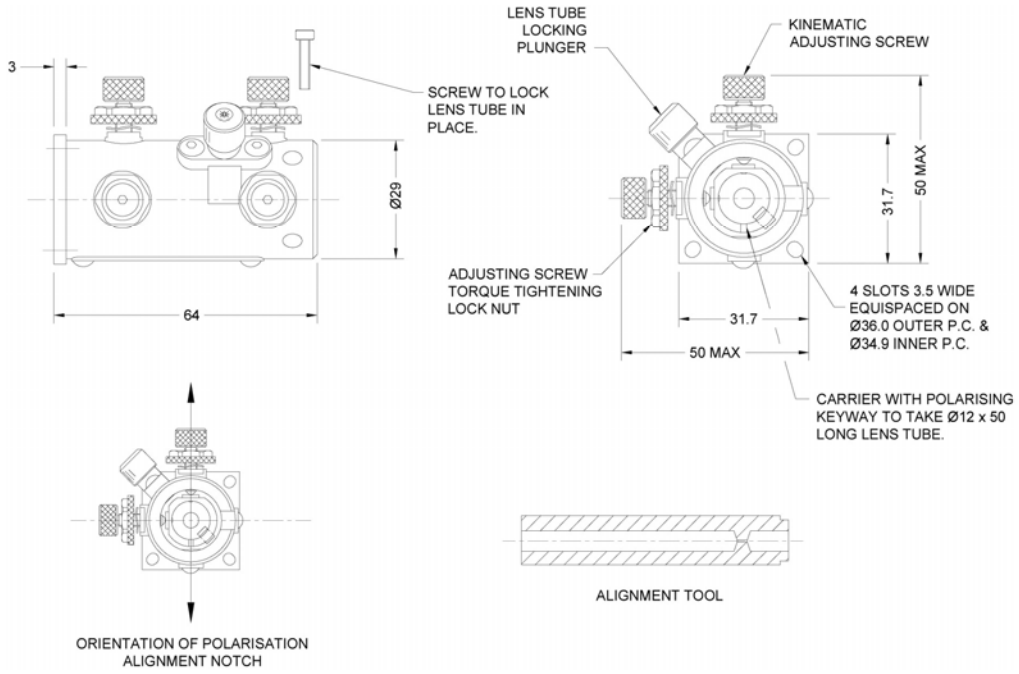
4. Measure the power through the fiber of each laser, one at a time. Compare to the test protocol delivered with the C-FLEX.

5. If the coupling efficiency is not sufficient, use the kinematic adjusment screws to fine align the lens tube in the fiber coupler.

STOP If the output power of all integrated lasers is within specification **DO NOT** re-align the system.

3.7. Aligning the Fiber Coupler

This section outlines the basic steps of Kineflex™ fiber coupler alignment. For more detailed discussion of optical alignment techniques see Section 10 : Principle of laser beam alignment. In the case of free beam C-FLEX laser combiners proceed directly to section 3.8 : Aligning the Combiner Optical Path. If using another type of fiber coupler, similar principles may apply, but the adjustment instructions may differ. See the manufacturer's instructions.



WARNING – Keep the C-FLEX shutter closed when placing or removing components or equipment from the beam path.

1. Remove the fiber from the fiber coupler lens tube to allow the beam to exit the C-FLEX unobstructed.

2. Place an appropriate optical power meter at the exit of the fiber coupler to measure the free beam power of each laser out of the C-FLEX.

3. Measure the free beam laser power for each laser line, one at a time. Be sure to set the measurement wavelength when changing from laser to laser. Make a note of this power level for reference. The power into the fiber is required to calculate the coupling efficiency out of the fiber.

4. Place the alignment tool (see image above) into the fiber coupler with the pin hole closest to the aperture.

5. Begin with the laser in position 1, closest to the aperture. Stop emission on all other lasers.

6. Adjust the position of the pin hole alignment tool using the kinematic adjustment screws, closest to the C-FLEX aperture, on the fiber coupler until the power through the pin hole is maximized.

7. Turn the pin hole alignment tool in the fiber coupler so that the pin hole is away from the aperture.

8. Adjust the angle of the the pin hole alignment tool using the kinematic adjusment screws, away from the aperture, on the fiber coupler until the power through the pin hole is maximized.

9. Remove the pin hole alignment tool and mount the fiber into the fiber coupler. Be sure the lens tube on the fiber is securely in place and that the polarization key is in the slot. If the lens tube is not all the way in the coupler the alignment will not be sucessfull.

10. Measure the power of the laser in position 1 through the fiber. Compare to the test protocol delivered with the C-FLEX. If the coupling efficiency is not sufficient, use the kinematic adjusment screws to fine align the lens tube in the fiber coupler.

11. Turn on each of the laser individually, and verify the power though the fiber. Make a note of the coupling efficiency as a percentage of the power measured before fiber alignment and compare to the test protocol delivered with the C-FLEX. If the fiber coupling is not sufficient the combiner optics may need to be aligned, this procedure is described in section 3.8 : Aligning the Combiner Optical Path.

NOTICE – If the adjustment screws have reached the end of their travel before a maximum is found the mounting of the fiber coupler on the C-FLEX may need to be adjusted. If so, turn the adjustment screws to the middle of their range, loosen the 4 x mounting bolts (where the coupler is fixed to the C-FLEX) and adjust the position manually until a maximum is achieved.

If the output power of all integrated lasers is within specification **DO NOT** re-align the combiner optical path.

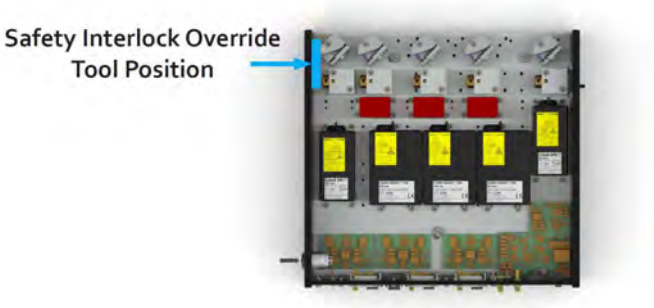
3.8. Aligning the Combiner Optical Path

This section outlines the basic steps of laser combiner alignment. For more detailed discussion of optical alignment techniques see Section 10 : Principle of laser beam alignment.

WARNING – Keep the C-FLEX shutter closed when placing or removing components or equipment from the beam path.

NOTICE – The alignment accuracy can be improved by using a CCD or beam profiler at 1 meter from the aperture.

1. Turn all lasers OFF with the key switch.
2. Remove lid by unscrewing the four screws on the side.
3. If present, remove the fiber coupler from the C-FLEX aperture.
4. Use the safety interlock override tool to close the interlock circuit with magnetic switches. The override tool has been designed in such a way that the access panel may not be put back onto the C-FLEX with the override in place. The interlock override tool should be placed 1 cm from the edge of the side wall.



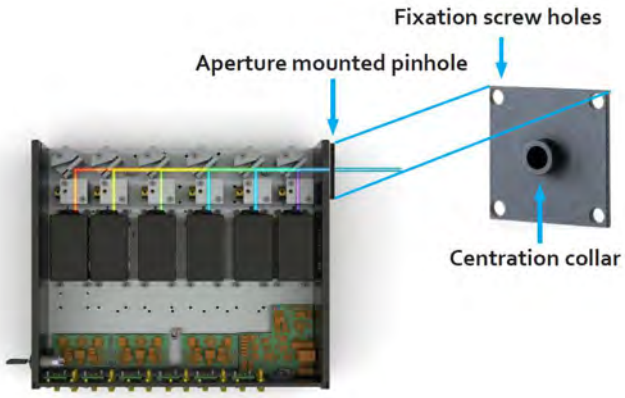
WARNING – When the access panel is removed the safety interlock circuit will be open and prevent emission. Contact a laser safety officer about handling, safety measures and safe service procedures before using the interlock override.

5. Turn all lasers ON with the key switch. Wait at least 3 minutes for the lasers to complete warm up.
6. Open the Cobolt Monitor software to control the emission of each laser line individually.

NOTICE – Using the Laser ON and Laser OFF buttons in the software will require toggling of the system key switch to resume emission, all laser lines will be turned OFF when the key is toggled. See section 5 for instructions on how to stop and start emission.

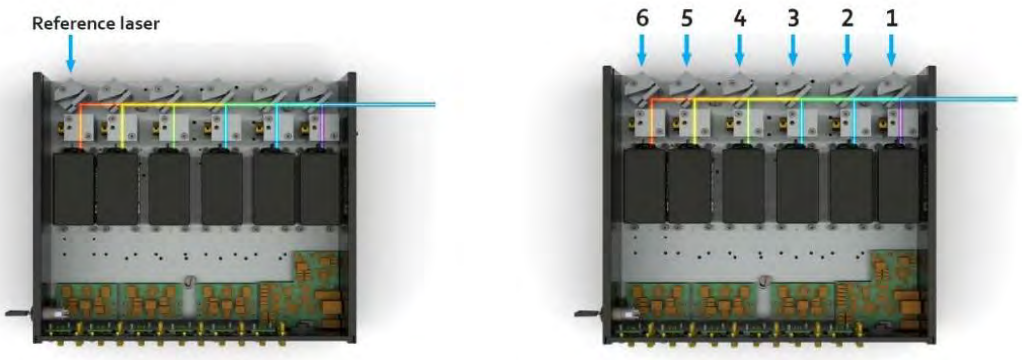
7. Stop the emission on all laser lines. Be sure the shutters on each laser are open, as well as the system shutter.

8. Place the aperture pin hole in the C-FLEX aperture. The collar is intended to be used for positioning the pinhole in the center of the aperture. The pin hole alignment tool can be used in place of the aperture mounted pin hole. It is not necessary to fix the pin hole with screws but it is advised to orient the article number markings in the same direction for all measurements.



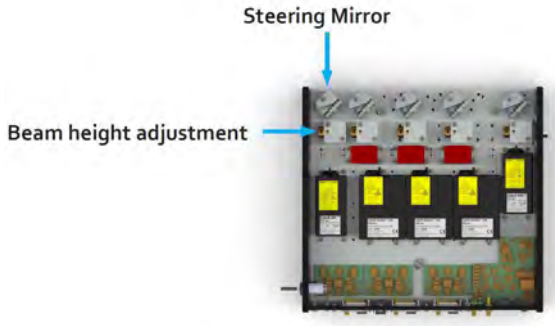
9. Place a fast optical power meter 10 cm from the aperture mounted pin hole and secure it in place. Moving the detector can affect the measurement.

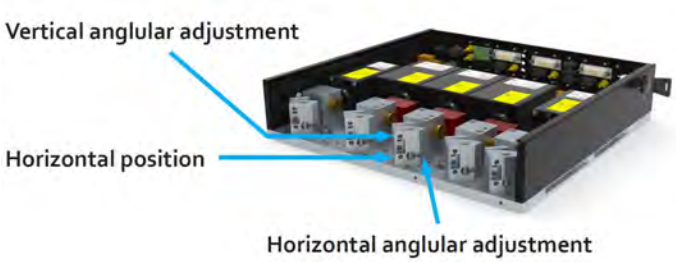
10. Resume the emission of the laser line in the position farthest from the aperture. For example, the red laser line shown below in position 6. This is considered the 'reference laser'.



11. Measure the power through the aperture mounted pin hole.

12. Use the horizontal angular adjustment set screw of the steering mirror to adjust the position of the beam on the pin hole horizontally and maximize the power through the pin hole.



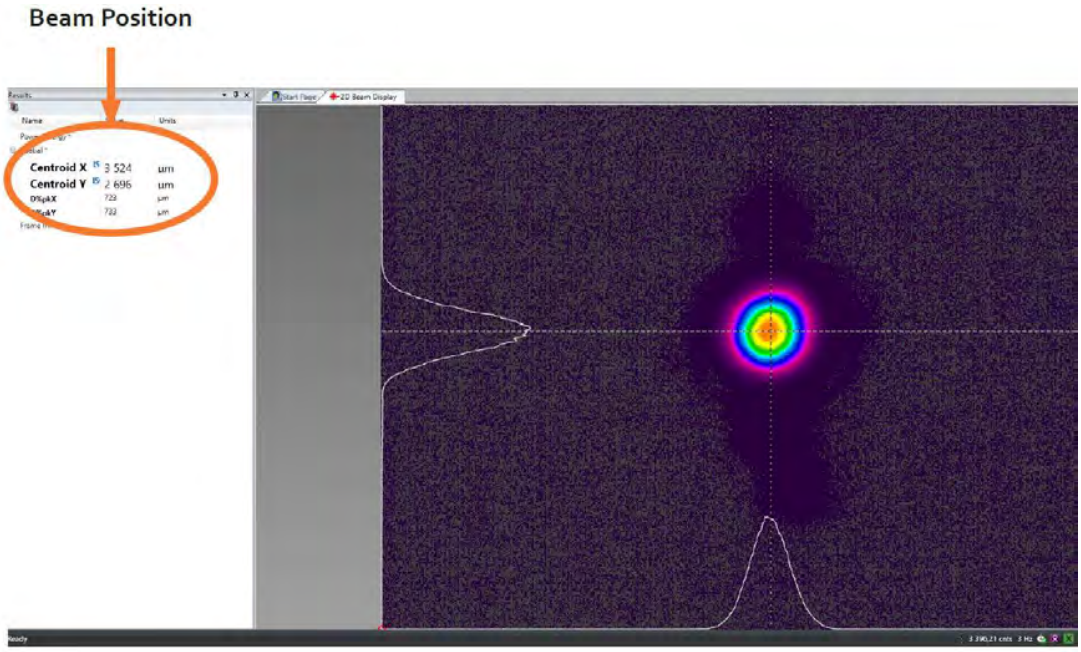


13. Use the vertical angular alignment set screw of the steering mirror to adjust the position of the beam on the pin hole vertically and maximize the power through the pin hole.

14. Remove the aperture pin hole and power meter from the beam path.

15. Place a beam camera with position measurement capabilites one meter from the aperture. If no camera is available it is possible to use a 1 mm diameter pin hole and a fast power meter, but there will be no quantitative beam angle overlap result.

16. Adjust the position of the camera or pin hole to the reference laser. Record the reference beam's exact centroid position and do not move the camera until alignment process is complete for all lasers.



Beam profile camera control software displaying the centroid position of the measured beam.

17. Make note of the centroid position of the reference beam. While comparing the reference laser will give a good indication of the beam overlap, to be complete each laser position must be compared to all of the others. To download the beam 'Alignment Verification Calculation Tool' go to https://hubner-photonics.com/downloads/ .

NOTICE – Be sure to secure the pin hole or camera in place on the optical table before aligning the remaining lasers. If the pin hole or camera moves the alignment will not be successful.

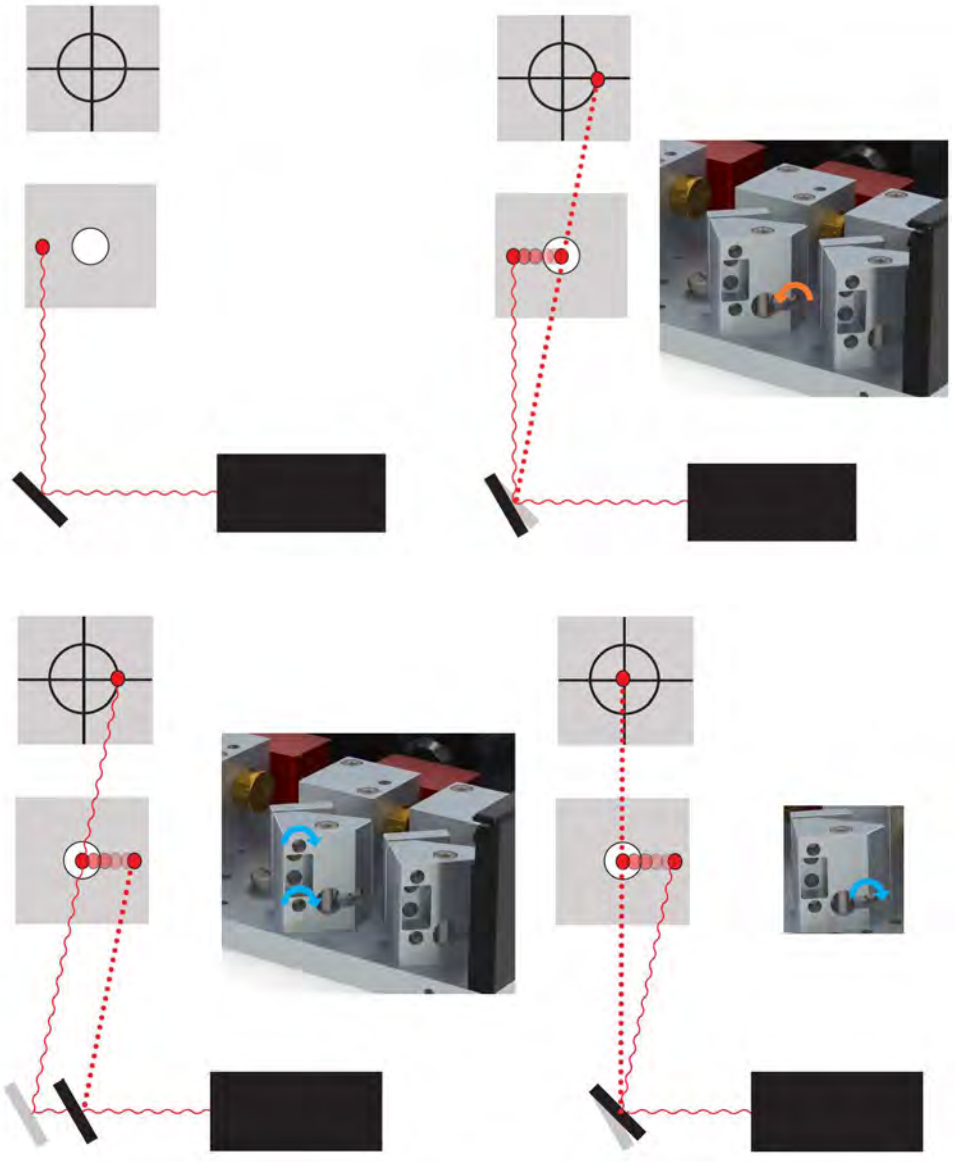
18. Stop emission of the reference laser.

19. Replace the aperture mounted pin hole and power meter.

20. Start emission of the next laser to be aligned. It is advised to start with the laser nearest to the aperture (position 1) and progressing away from the aperture when optimizing all lasers, including the reference laser if necessary.

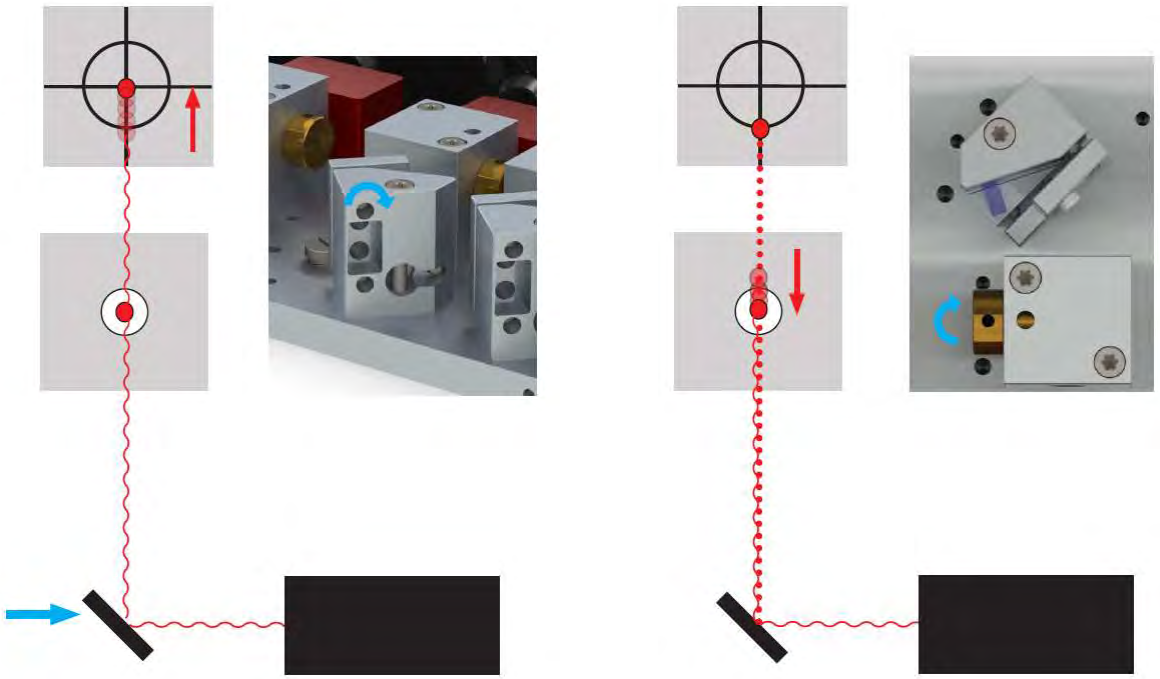
21. Use the horizontal angle adjustment screw to sweep the beam across the pin hole. Measure the change in power as the beam is swept and determine the direction of horizontal translation required to maximize the power through the pin hole.

22. Adjust the horizontal position set screw of the steering mirror in the opposite direction of the horizontal angular adjustment screw that resulted in increased power through the aperture pin hole. Use the angular adjustment screws (both horizontal and vertical if necessary) to reoptimize power through the pin hole.

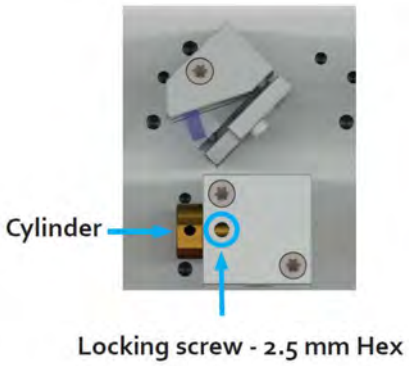


In the example above the steering mirror is tilted forward by turning the horizontal angular adjustment screw to the left, then the mirror is translated forward by turning both the horizontal position and vertical angular adjustment screws to the right. Then the beam angle and power through the pin hole is restored by turning the horizontal angular alignment screw to the right as well.

23. Apply the same procedure to vertical alignment. Sweep the beam across the pin hole. Measure the change in power as the beam is swept with the vertical anglular adjustment screw and determine the direction of vertical translation required to maximize the power through the pin hole.



24. Loosen the locking screw on the beam height adjustment block. Use the beam height adjustment cylinder to translate the beam vertically. A small (2,0 mm) screw driver can be placed in the hole in the golden knob and used as a lever for fine alignment.



25. Remove the aperture mounted pin hole and power meter from the beam path.

26. Measure the beam position on the camera and compare the measured position to the reference laser position.

27. If necessary, use the angular adjustment screws (both horizontal and vertical if necessary) to align the position of the beam on the camera to the reference laser position.

28. Iterate through the alignment process for each laser until the power through the pin hole is maximized and the beam angle as measured with the camera is within specification, while the steering mirror is fixed in the same position.

29. Evaluate the beam angle overlap at 1 meter, see section 3.6 : Verifying the Laser performance and System Alignment for details on beam overlap calculations.

30. After aligning with the aperture mounted pin hole and beam profile camera at 1 meter, further precision in beam position at the exit may be required, place the camera at the exit and measure the centroid position of each beam.

31. Repeat the steps 19 through 28 for each laser until the beam position and angular overlap are within specification or sufficient for the application requirements.

32. While comparing the reference laser will give a good indication of the beam overlap, to be complete each laser position must be compared to all of the others. To download the beam 'Alignment Verification Calculation Tool' go to https://hubner-photonics.com/downloads/ .

33. Compare the alignment achieved with the alignment at shipment found on the C-FLEX test protocol.

34. Interate through the position and angular alignment procedure as described above until the beam overlap at exit and angular beam overlap are simultaneously within specification. See section 8 : C-FLEX System Specifications.

3.9. Preparing for Operation

WARNING – Verify that the safety interlock is working properly after any service or alignment procedures to ensure safe operation.

1. Remove the safety interlock override tool and verify that all lasers stop emitting and indicate an error.
2. Replace the access panel of the C-FLEX and fasten with the 4 access panel screws removed at the beginning of the alignment procedure.
3. Toggle the key switch OFF and ON to clear the interlock fault and resume emission.

3.10. Closedown operation

1. Close the C-FLEX shutter.
2. Turn the key switch to OFF first (CDRH models only).
3. Disconnect PSU from mains outlet.
4. Wait for the LED indicator on the PSU to stop shining.
5. Disconnect C-FLEX from PSU.
6. Disconnect the USB Cable from the C-FLEX.

4. Cobolt Monitor™ Software

The Cobolt Monitor™ software provides a graphical way to monitor the laser performance and to change the output power, operation mode and other settings. Cobolt Monitor™ has been tested with operating systems Windows XP, Windows Vista, Windows 7, Windows 8 and Windows 10. Microsoft .NET 4.0 is required to run the Cobolt Monitor™ software. Most computers with operating systems Windows XP, Windows Vista, Windows 7 and Windows 8 have this included as standard. When using versions of Windows older than Windows 10, a USB driver may be required, see section 7.5.

4.1. Installation

Download the latest version of the Cobolt Monitor™ software from https://hubner-photonics.com/downloads/ . The Cobolt Monitor™ software is a stand-alone executable, the executable file is packaged with other files needed to run the program in a .zip file. Save the .zip file to any storage device, and extract all files. The folder created after extracting the files can be placed on any storage device and Cobolt Monitor™ can be run from there. All files and folders contained in the .zip file must be present for the program to function properly.

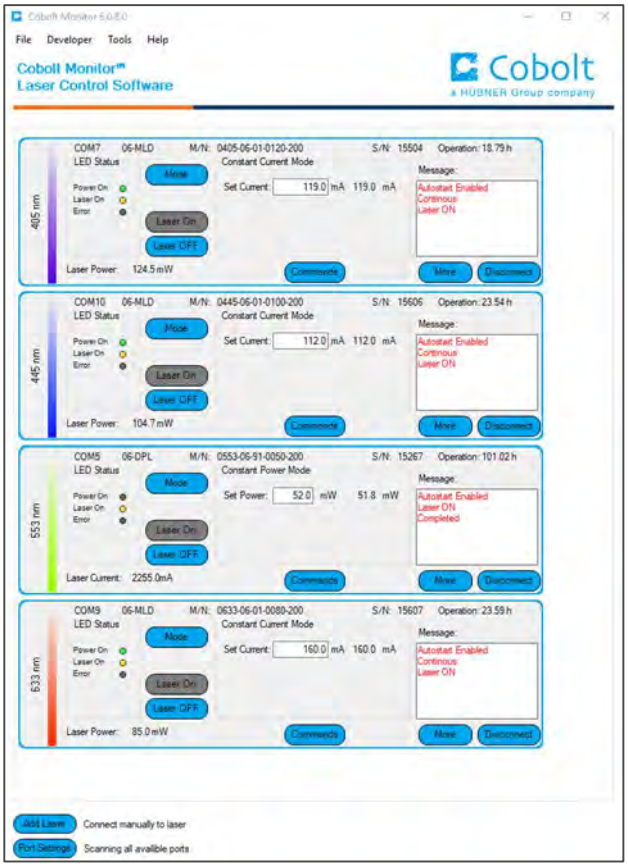
4.2. Software instructions

The software automatically searches for Cobolt devices every 5 seconds and automatically connects the laser if detected. The software can identify USB connected lasers as well as RS232 connected lasers.

The first Cobolt Monitor™ window that appears in the software.

NOTICE The communication cable should not be removed when the software is in connected state. The communication within the laser may then malfunction and this might require a power restart of the driver. To disconnect the laser click "Disconnect" or close Cobolt Monitor™ completely. It is also possible to disconnect by powering the laser OFF. In this case Cobolt Monitor™ will automatically close the window for that laser.

Once the lasers are connected they can be controlled from the box dedicated for the laser. Only the most critical information is displayed on this level, including the status the laser is in and the possibility to switch each line ON or OFF (not for modulation). Here follows a short description of how to use the Cobolt Monitor™ software on this level.



Lasers successfully connected.

M/N Displays the laser model number.

S/N Displays the laser serial number.

Laser ON Turns the laser ON. If the laser is in autostart mode this is equivalent to "restart".

Laser OFF Turns the laser OFF.

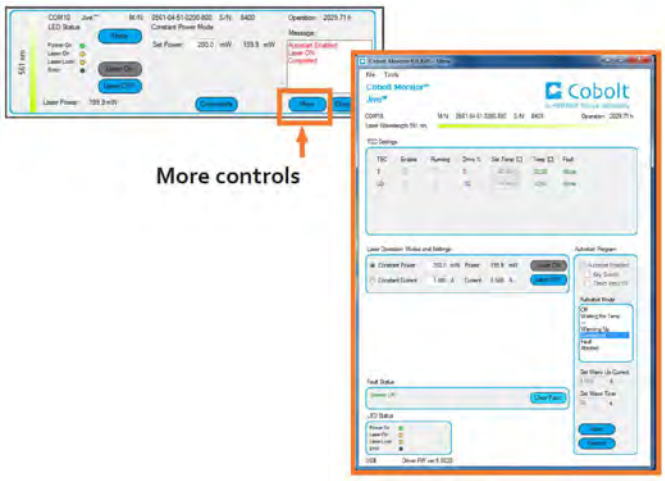
Mode Gives a choice of operational modes possible to choose for the laser model.
For example, Cobolt 06-01 Series laser models offer Constant Power, Constant Current or Modulation mode operation. Only relevant choices for the mode of operation are presented.

Commands Opens a command communications window to send commands directly to the laser.

Message Highlights important information of the laser status to the user.

Disconnect Allows the user to disconnect from the Cobolt Monitor™ software in a controlled way.

More An additional Cobolt Monitor™ window will open containing more detailed information of that laser's status.



TEC Settings Shows the running status and the fault status for the laser's internal thermoelectric coolers (TEC).

Laser Operation Mode and Settings

Displays the set laser power. The user can switch between constant power mode, constant current mode and modulation mode. Likewise, there are boxes to set the constant power level and constant current level. In constant power mode the current will be set by Cobolt Monitor to reach the power level set in the this field. When in modulation mode it is recommended to use an external power meter. See section 5 and 6 for more details on continuous wave and modulation modes.

Autostart Program

Displays whether the laser is in CDRH (key switch enabled) or OEM (key switch disabled) mode and displays the current laser operational status. There are also buttons to "abort" the autostart sequence or to "restart" the laser after a fault.

Fault Status Displays ERROR messages. In the event of an ERROR, the laser action is stopped. When the reason for the ERROR event is understood and the problem is addressed the fault status can be cleared with "Clear Fault". If the Autostart Program is enabled, click restart to restart the laser.

Clear Fault Is displayed in the event of a fault. The user can resolve the cause of the fault and then press "Clear Fault" and then restart the laser by clicking "Laser ON". Example: if the remote interlock loop is open the user must make sure the loop is closed again before issuing a "Clear Fault" followed by "Laser On".

LED Status Displays the LEDs that are currently illuminated.These are displayed even if the laser is in OEM mode.

POWER	Green	Power is supplied.
ON	Orange	Laser emission is on. This light is on in modulation mode if laser emission is possible.
ERROR	Red	An error has occurred.

5. Controlling emission in Continuous Wave operation

In this section the different ways to control the emission of each laser in continuous wave (CW) operation will be discussed in detail. It is not recommended to use the continuous wave emission or power level controls to turn the laser ON and OFF with high speed. See section 6 : Controlling Emission with Modulation Mode Operation for instructions on high speed emission control.

5.1. RESTART and ABORT Button

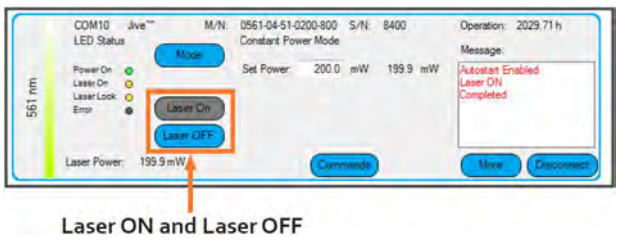
The 'Restart' button will start the complete autostart sequence including temperature stabilization and warm up. The 'Abort' button cancels the autostart sequence and places the entire device in an OFF state. The key switch is required to restart the device when in CDRH mode. The restart button corresponds to the command 'restart', the abort button corresponds to the system command 'abort'.

5.2. Laser ON and Laser OFF Button

The Laser ON and Laser OFF buttons can be used to stop and start emission regardless of the operation mode (constant power, constant current or modulation mode). Access to the Laser ON and Laser OFF buttons is available in the summary level of the user interface as well as the 'More' window.

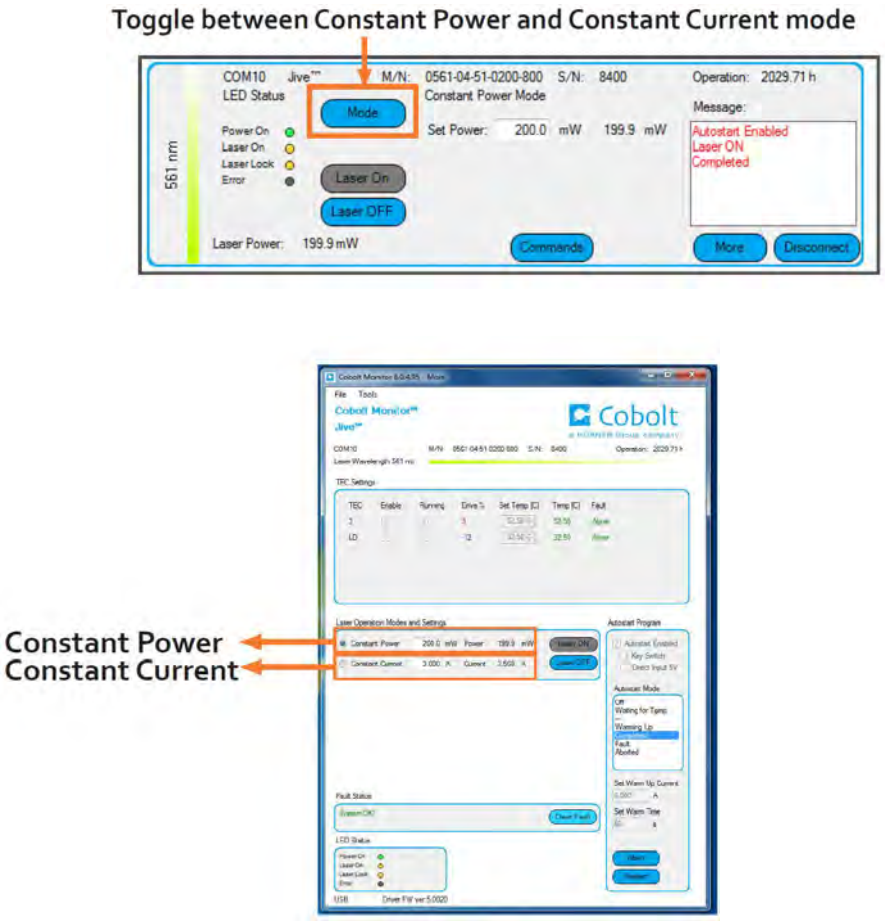
NOTICE Turning the lasers ON and OFF with these buttons will require toggling of the key switch. When the system key switch is toggled it will stop and start all lasers.

The ON and OFF button corresponds to the command '@cob1' for Laser ON and 'l0' for Laser OFF.



5.3. Optical output power level controls

Cobolt lasers have two continuous-wave operating modes: **constant power** and **constant current**. In constant current mode the laser runs at a set current level. The constant power setting is used to regulate the output power level. All lasers are delivered in the most appropriate operating mode for optimized stability. To restore original power level settings refer to the test protocol delivered with the C-FLEX.



Location of emission controls in Cobolt Monitor™ Software

NOTICE Though the output power setting and drive current can be changed the other laser performance parameters are only guaranteed at 100% of nominal output power.

Constant power controls

In constant power mode each laser has a field where the output power can be set. The power set point for each laser controls the emission from the individual laser heads and not through the C-FLEX aperture. The expected power out of the C-FLEX aperture can be found on the test protocol.

Cobolt 04-01, Cobolt 06-DPL and Cobolt 08-DPL laser power controls are connected to a calibrated internal photodiode that delivers a real time power measurement and controls the drive current via a feedback loop.

Cobolt 06-MLD lasers display the power corresponding to a particular diode current from a calibrated look up table.

Cobolt 08-NLDs and Cobolt 06-MLD's are shipped in constant current mode to achieve optimum performance, it is not recommended to run these products in constant power mode.

To read the power setting without the Cobolt Monitor software, use the command 'p?' . The output power of a specific laser line can be set with the command 'p X.X' where X.X is the power in **Watts (W)**. For example, to set an 08-DPL power to 25 mW the command is 'p 0.025'. The maximum allowed power is set at the factory.

Constant current controls

The laser output power can also be controlled with the current setting in constant current mode. Cobolt 08-NLDs and Cobolt 06-MLD's are shipped in constant current mode to achieve optimum performance, it is not recommended to run these products in constant power mode.

To read the current setting without the Cobolt Monitor software, use the laser specific command 'i?' . The drive current, and therefore output power, of a specific laser line can be controlled by setting the current with the command 'slc XXXX' where XXXX is the current in **milliamperes (mA)**. For example, to set the current to 2500 mA the command is 'slc 2500'.

The emission from a specific laser line can be stopped by sending the command to set the current to zero. For example, to set the current to 0 mA the command is 'slc 0'.

The current control can be used to toggle the laser between different current settings with commands, such as between the threshold current (low or no current) and the current setting that corresponds to the nominal output power. This can be especially useful during alignment of the optical path. There are safety controls in place to prevent the user from exceeding the safe maximum current for any given laser line.

Combining Constant Power operation and Constant Current operation during alignment

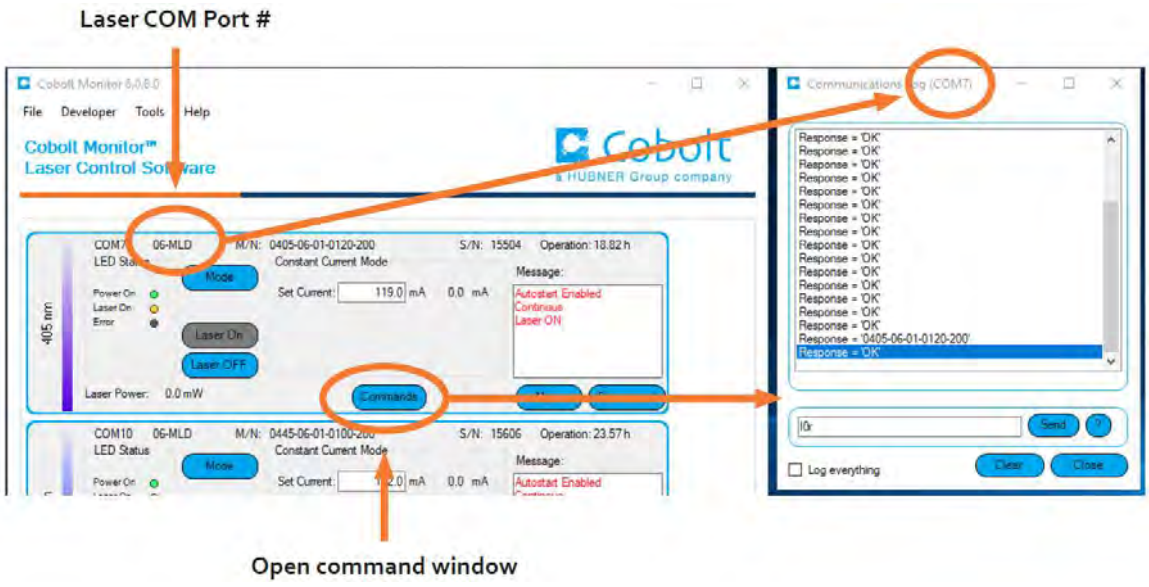
When aligning the C-FLEX, one way to stop and start the emission is to set the constant current level to zero and set the constant power level to the nominal output power and then use the mode button in the Cobolt Monitor software to toggle between Constant Power operation and Constant Current operation. This will allow the user to maintain the laser in an armed state with all temperature controls running while stopping emission when aligning other laser lines.

5.4. Pause Emission with Commands

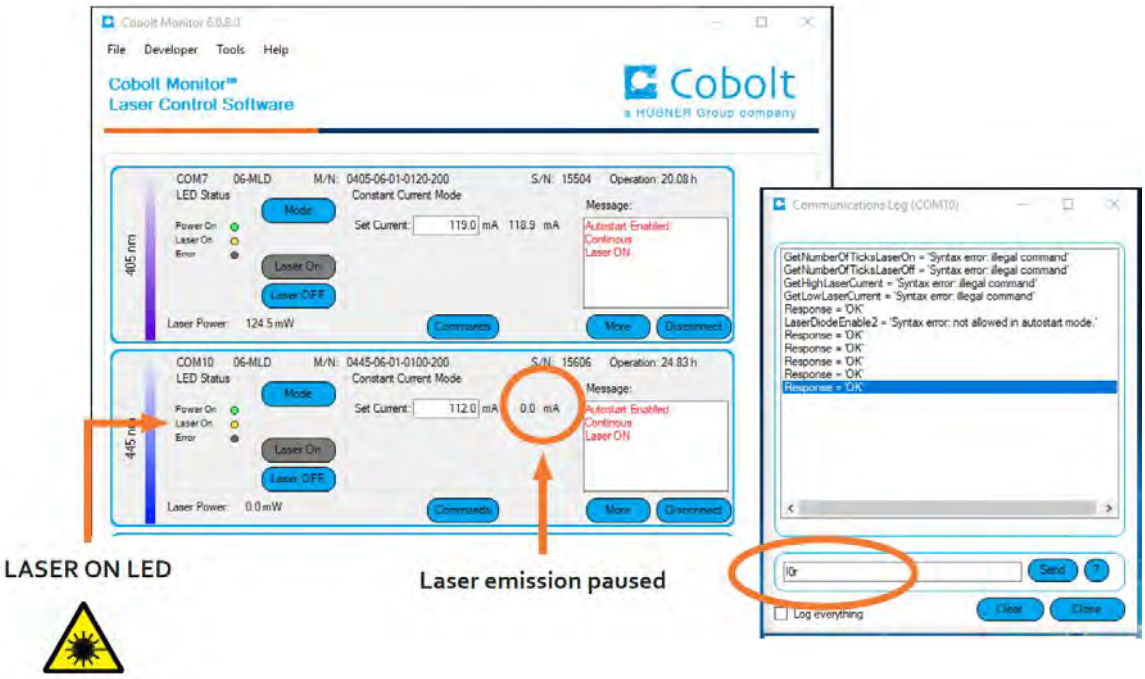
DANGER – Pausing the laser radiation does not make it inaccessible and will not prevent emission in a fail safe way. Laser ON warning indicators will be illuminated as the lasers are considered armed for operation. Treat the system accordingly and observe all safety precautions.

There is a command to temporarily stop emission without changing the current or power set points saved in the laser memory. To stop emission use the command 'l0r' and to resume emission use the command 'l1r'. Below is a step by step instruction on how to control emission with these commands via Cobolt Monitor. It is not recommended to use the Pause Emission commands to turn the laser ON and OFF rapidly. See section 6 : Controlling Emission with Modulation Mode Operation for instructions on high speed emission control.

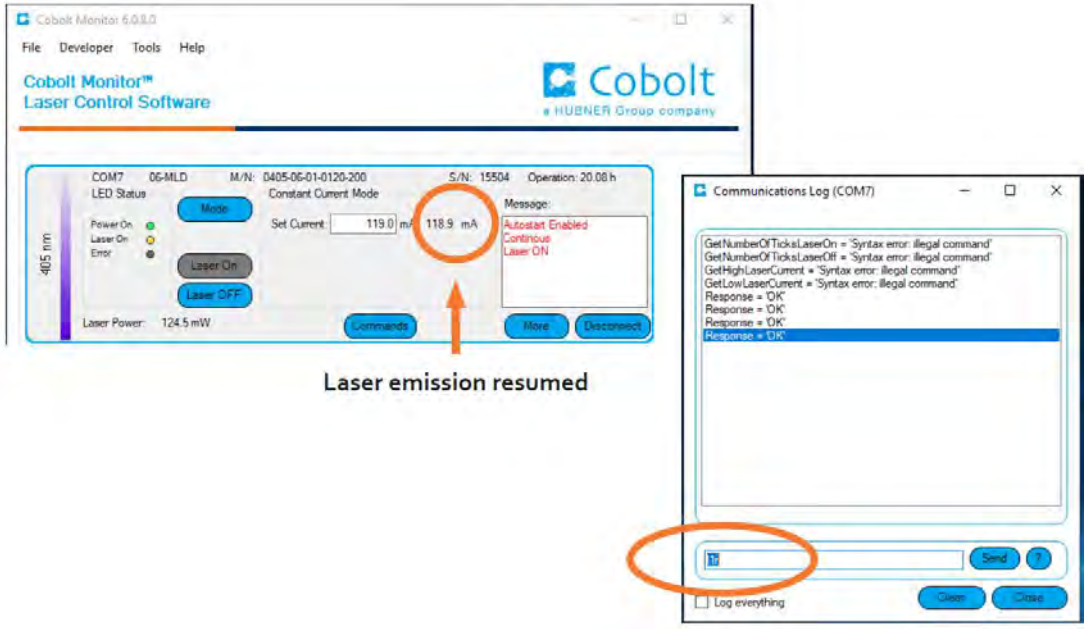
1. Open a command window for each laser. The laser COM port will be displayed in both the laser control sections of the Cobolt Monitor main window and in each command window. Use this information to keep track of which command window corresponds to a certain laser.



2. To control the emission of individual lasers during testing and alignment it can be usefull to pause the emission. Send the command 'l0r' to temporarily stop emission on all lasers not being tested. The LASER ON emission indicator will remain illuminated.



3. Use the command 'l1r' to resume emission in the same operation mode the laser was in before it was paused.

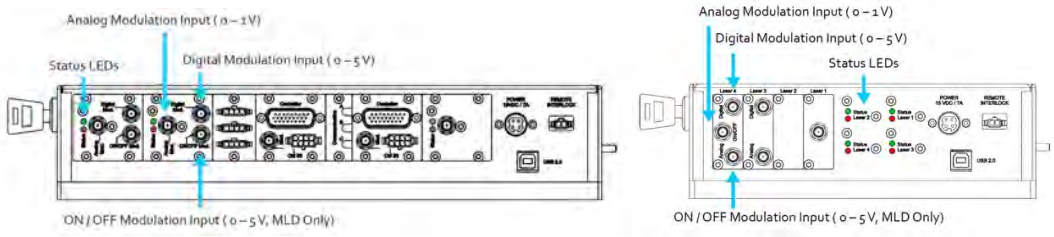


6. Controlling Emission with Modulation Mode Operation

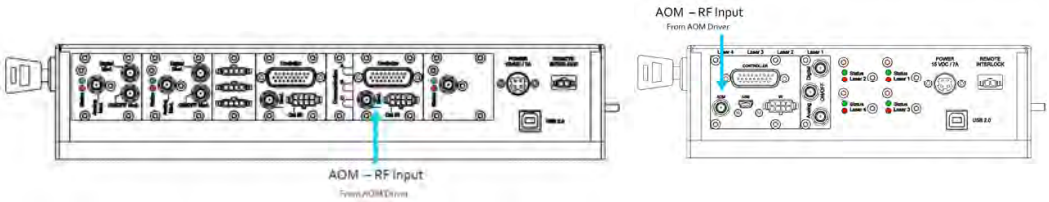
When C-FLEX is delivered with modulatable lasers or AOMs the modulation signal input connectors can be found on the back panel of the laser combiner. The modulation of the Cobolt lasers requires an external signal source, such as a function generator, to drive the modulation. Each of the laser lines with modulation capabilities can be modulated individually using both analog and/or digital modulation, and in the case of 06-MLDs, additionally with ON/OFF modulation. Modulation is not available for Cobolt 04-01 or 08-01 Series lasers without an integrated AOM.

6.1. Connecting the modulation cables

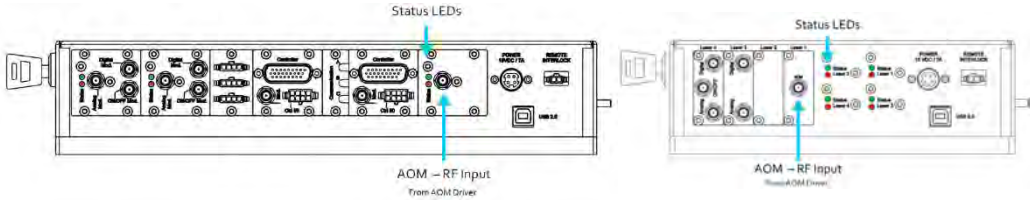
This section describes how to properly connect modulation inputs for Cobolt 06-MLD , Cobolt 06-DPL lasers with integrated modulation controls and Cobolt 04-01 or 08-01 laser which can be modulated using an AOM. The modulation input signal generator and cables are not delivered with the C-FLEX.



Cobolt 06-MLD and 06-DPL modulation interface on C-FLEX C6 (left) and C-FLEX C4 (right)



Cobolt 04-01 laser with AOM RF Input interface on C-FLEX C6 (left) and C-FLEX C4 (right)

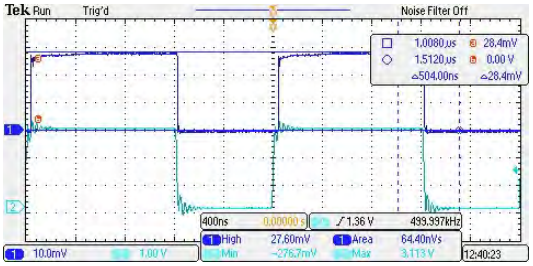


Cobolt 08-01 laser with AOM RF Input interface on C-FLEX C6 (left) and C-FLEX C4 (right)

6.2. Cobolt 06-MLD Modulation inputs

Digital modulation input signal

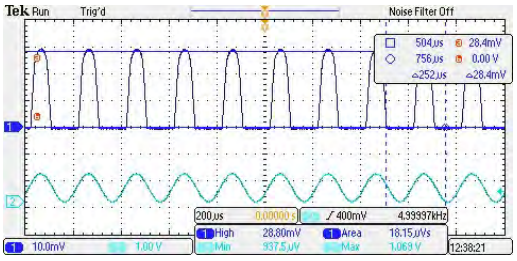
- Input signal : 0 – 5 V TTL signal, square wave
  - 0.0 – 1.5 V: OFF
  - 3.5 – 5.0 V : ON
- Modulation Frequency : DC – 150 MHz
- Impedance : 50 Ω



Sample of 06-MLD digital modulation at 50 MHz

Analog modulation input signal

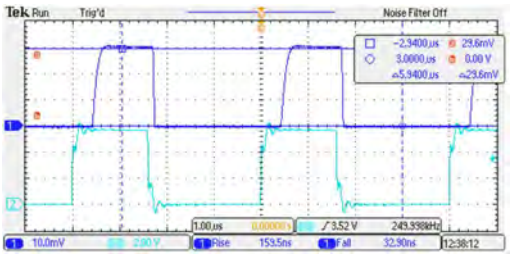
- Input signal : 0 – 1.0 ± 0.3 V , arbitrary waveform
- Modulation Frequency : DC – 2 MHz
- Impedance : 1 kΩ or 50 Ω



Sample of 06-MLD analog modulation at 5 kHz

ON OFF modulation input signal

- Input signal : 0 – 5 V, TTL
- Modulation Frequency : DC – 500 kHz
- Impedance : High

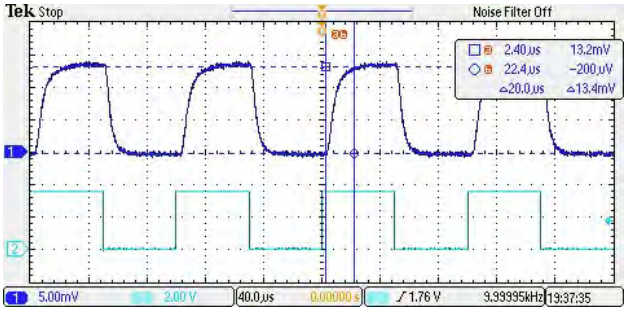


Sample of 06-MLD ON OFF modulation at 250 kHz

6.3. Cobolt 06-DPL Modulation Inputs

Digital modulation input signal

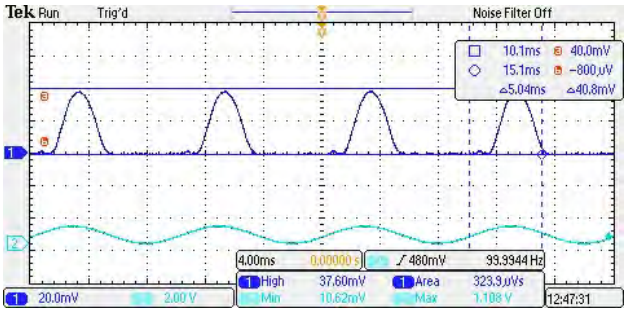
- Input signal : 0 – 5 V TTL signal, square wave
  - 0.0 – 1.5 V: OFF
  - 3.5 – 5.0 V : ON
- Modulation Frequency : DC – 5 kHz, 10 kHz or 50 kHz (depending on wavelength)
- Impedance : 10 kΩ



Sample of 06-DPL digital modulation at 10 kHz

Analog modulation input signal

- Input signal : 0 – 1.0 ± 0.3 V , arbitrary waveform
- Modulation Frequency : DC – 5 kHz
- Impedance : 1 kΩ



Sample of 06-DPL analog modulation at 1 kHz

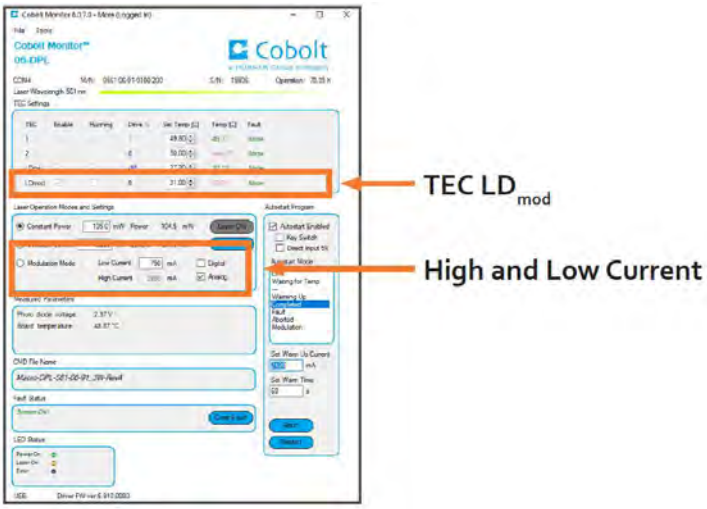
Cobolt 06-DPL modulation mode settings

The modulation settings of Cobolt 06-DPLs are optimized at the factory with a default modulation frequency of 1 kHz. The settings can be adjusted to optimize performance for the modulation scenario being used. The modulation mode temperature, high and low current settings can have strong influence on the pulse shape and can be optimized for a particular modulation frequency. The modulation mode settings can be adjusted to optimize the laser's modulation performance in application.

Low Current The low current defines the drive current the laser diode is set to in the **OFF** state while in modulation mode. The default factory setting is the current just below the lasing threshold.

High Current The high current defines the drive current the laser diode will modulate up to while in modulation mode. The default factory setting is the current needed to reach nominal output power in the **ON** state.

TEC LD_{mod} The TEC LD_{mod} temperature can be adjusted to optimize the laser's modulation performance in application.



6.4. AOM Modulation controls and input signals

Both analogue and digital modulation signals need to be applied to the Acousto-Optic Modulater (AOM) Driver. Two separate sources are required because the signal levels are different for analogue and digital modulation. Without an input signal from the AOM driver to the laser head, there is no laser beam emitted from the laser head. A typical source for digital and analogue modulation would be any type of function generator fulfilling the signal levels specified in thelist below.

NOTICE Without both analog and digital input signals to the Acousto-Optic Modulater (AOM) driver and the RF signal from the AOM driver to the C-FLEX, there is no laser beam emitted through the combiner.

Digital modulation input signal

- Input signal : 0 – 5 V TTL signal, square wave
  - 0.0 – 0.8 V: OFF
  - 3.0 – 5.0 V : ON
- Modulation Frequency : DC – 3 MHz
- Input impedance : 1 kΩ

Analog modulation input signal

- Input signal :
  - Range : 0.5 – 1.0 ± 0.1 V , arbitrary waveform
  - 1.0 ± 0.1 V DC : ON
  - < 0.5 ± 0.1 V : OFF
- Modulation Frequency : DC – 3 MHz
- Input impedance : 1 kΩ

AOM Operation

The modulation can be controlled with the digital modulation signal, analogue modulation signal or a combination of the two. If no signal is applied on either the digital or the analogue input, the AOM is in its off-state. The DPSS laser inside the device is however on and it is normal that some stray light in the µW range can be seen by the human eye even when the AOM is in its off-state, this can also be experienced as an 'ugly beam'. If the power is < 20 % of nominal in a non-gaussian beam, check the modulation input signals. Always start with 1 V DC on the analog modulation input and 5V DC on the digital modulation input.

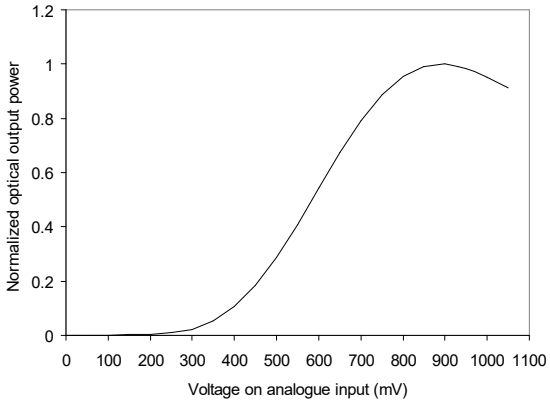
The analog input signal of the AOM can also be used to attenuate the power from the laser when working in constant power or CW operation. It is always recommended to use the CW diode pumped lasers at their nominal power level to guarantee optimal performance. Use the analog inupt with a DC signal of < 1 V. As shown in the analog modulation section, the output power will not scale linearly with the input voltage so it recommended to make a look up table for

the system. Use a 5 V DC signal on the digital modulation input, or use the digital modulation to toggle the laser ON and OFF and the power level set by the analog modulation signal.

Analogue modulation

In pure analogue modulation, the digital modulation must be in on-state, i.e. a voltage of 3-5 V must be applied continuously on the digital input.

The output power of the laser head has an optimum for a specific voltage of the analogue input. This voltage is device specific and is stated on the test protocol, but can be easily found by measuring the output power as function of applied DC voltage on the analogue input. Make sure not to exceed the absolute minimum and maximum voltages for the analogue input as stated above. The output power as function of the applied analogue voltage is slightly nonlinear as can be seen in the plot below.



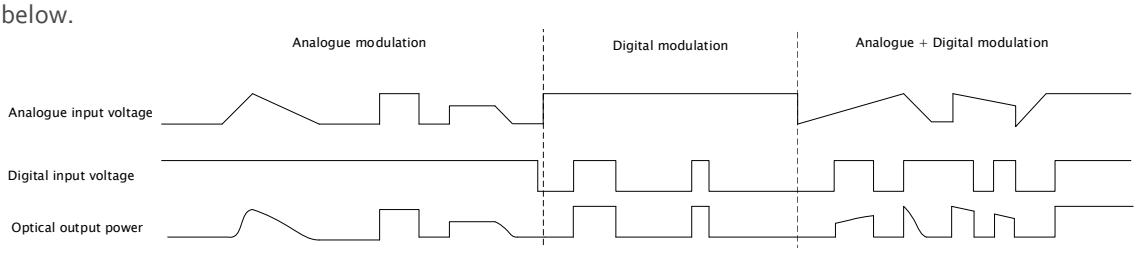
Plot of typical optical output power as function of the applied analogue voltage. There is a device specific maximum.

Digital modulation

In pure digital modulation, the applied analogue voltage determines the on-state optical output power in accordance with the plot above. E.g. if the amplitude of the digital modulation should be maximized, the analogue voltage corresponding to the maximum output power should be applied. In this way, the on-state optical power in digital modulation can be controlled.

Analogue + digital modulation

The analogue and digital modulation described above can be combined where the digital modulation can be seen as a control signal that can switch the analogue modulation on and off. The principle is schematically illustrated in the figure below.



Schematic illustration of the three different modulation modes.

7. System Overview

7.1. CDRH Configuration

The CE/CDRH compliant system is supplied with a key control function, which must be in place, along with a remote interlock connector prior to operation. Once power is supplied, laser emission starts when the key is turned from the OFF position to the ON position. The status of operation can be monitored via LEDs. Setting the key to its OFF position puts the laser in stand-by mode.

The standard CDRH model consists of:

- C-FLEX Laser combiner with lasers and modulation accessories (configuration will vary)
- Power supply 15VDC, 7A
- Remote interlock jumper (for closing the remote interlock)
- Safety Interlock override tool
- Aperture alignment pin-hole
- Steering mirror mount pin-hole
- Key(s)
- USB-B to USB-A data cable
- Tool kit

7.2. OEM Configuration

The laser combiner may be customized for integration in a larger system and supplied **without** the key control. Connecting the DC power supply to the laser combiner initiates an automatic start-up sequence. If the remote interlock is connected, laser emission will start automatically as soon as power is supplied and internal temperatures are stabilized.

The OEM model consists of:

- C-FLEX Laser combiner with lasers and modulation accessories (configuration will vary)
- Power supply 15VDC, 7A
- Remote interlock jumper (for closing the remote interlock)
- Safety Interlock override tool
- Aperture alignment pin-hole
- Steering mirror mount pin-hole
- USB-B to USB-A data cable
- Tool kit

Fiber coupled option also includes:

- Fiber coupling adapter (mounted to the C-FLEX)
- Optical fiber
- Alignment tool(s) for the fiber coupling adapter

7.3. C-FLEX Model identification and serial number

The model description of the laser combiner in all cases is 'C-FLEX'. The the serial number XXXXX is clearly visible on the manufacturers identification label. The serial number is used for tracing the as-delivered configuration of any C-FLEX, and the individual lasers that have been integrated at the factory.

7.4. Laser model numbers

All Cobolt lasers have a model number designation which describes that type of laser they are and which user interfaces they are delivered with.

WWWW-SS-SS-PPPP-XXX-C ← Delivered to C-FLEX

Wavelength | Power Level | Configuration :

Series designation:

04-XX	Cobolt 04-01 series
06-01	Cobolt 06-MLD
06-91	Cobolt 06-DPL
08-XY	Cobolt 08-01 Series

Configuration :

100 = USB, CE / CDRH Compliant
200 = USB, OEM
300 = RS-232, CE / CDRH Compliant
400 = RS-232, OEM
500 = Gen5b, RS-232, CE / CDRH Compliant
600 = Gen5b, RS-232, OM
700 = Gen5b, USB, CE / CDRH Compliant
800 = Gen5b, USB, OEM
xxx = OEM customization

7.5. Operation via data port

To connect a C-FLEX laser combiner to a data port use USB-B connection. The appropriate cable is provided with all lasers.

Data port connections

To connect a C-FLEX to a data port use the USB-A/USB-B cable from the laser combiner to the PC/workstation. Since there are two ways to connect a laser internally there are two kinds of drivers that may need to be installed depending on the laser configuration: Cobolt USB driver or a FTDI-Chip driver for the serial connection (if not automatically installed by the operating system). For installing the Cobolt laser USB driver, please refer to the USB driver section below. If the drivers for the serial connection are not installed automatically, please follow the instructions in the below section FTDI Chip driver. It may be necessary to install the drivers for each laser individually due to the fact that they are recognized by the system as individual laser units.

FTDI Driver for Serial Connection

Download the latest and most appropirate driver from http://www.ftdichip.com/Drivers/VCP.htm consider the operating system of the computer being used for controlling the C-FLEX. Unzip the files into a known location and install the drivers using the windows routine. If the driver installation was canceled when C-FLEX was first connected, use device manager to update the driver using the previously downloaded drivers.

Handshaking

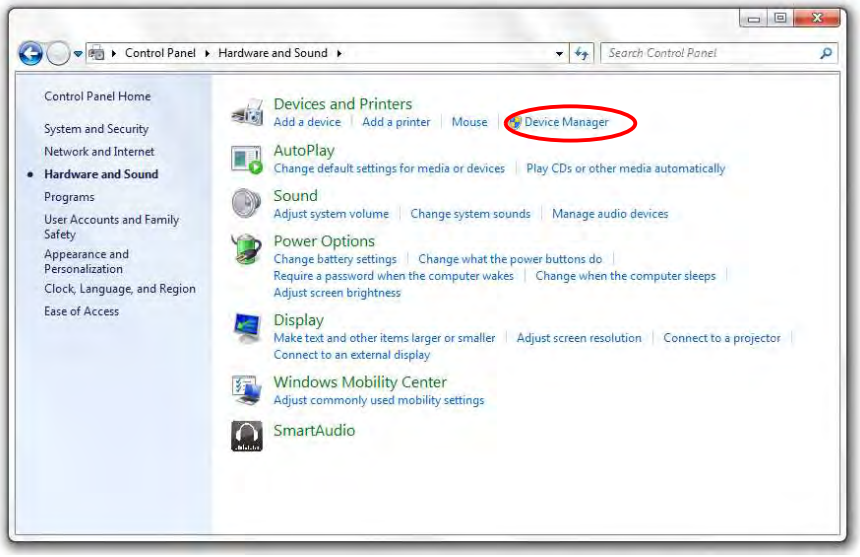
Under no circumstances does a laser initiate communication; it only transmits characters in response to a message. Every message generates a response, either a numerical value or the acknowledgment string "OK". In the event that the system receives a message that it cannot interpret, it responds: "Syntax error: illegal command". Every system response is terminated by a carriage return (ASCII 13) and a full stop is used with floating numbers.

USB driver

When using Cobolt Monitor™ with Windows 10, the USB device is automatically detected. When using Windows 8 or earlier (e.g Windows 7, Vista, XP) it is necessary to install the Cobolt signed USB driver. To be able to connect to a Cobolt laser integrated into a C-FLEX via USB, a USB driver may need to be installed on the computer. The USB driver can be downloaded from the Hübner Photonics website (https://hubner-photonics.com/). When installed, a virtual COM port will be created to communicate with the laser.

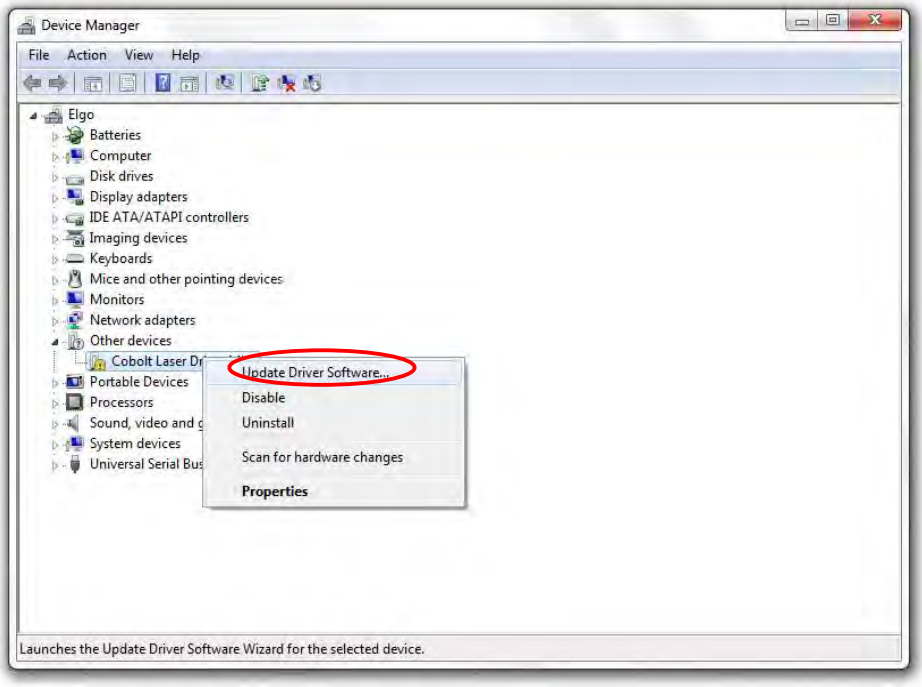
To install the USB driver in Windows 7 follow the instructions below.

1. Go to the **Control Panel** and choose **Hardware and Sound**.

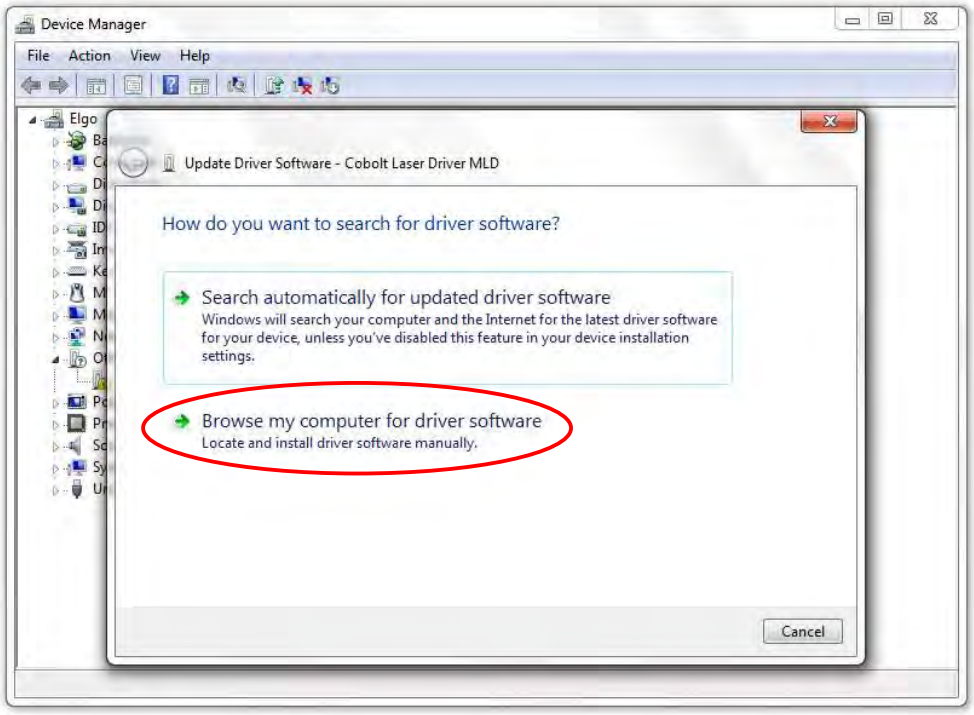


2. Under the **Devices and Printers** section, choose **Device Manager**.

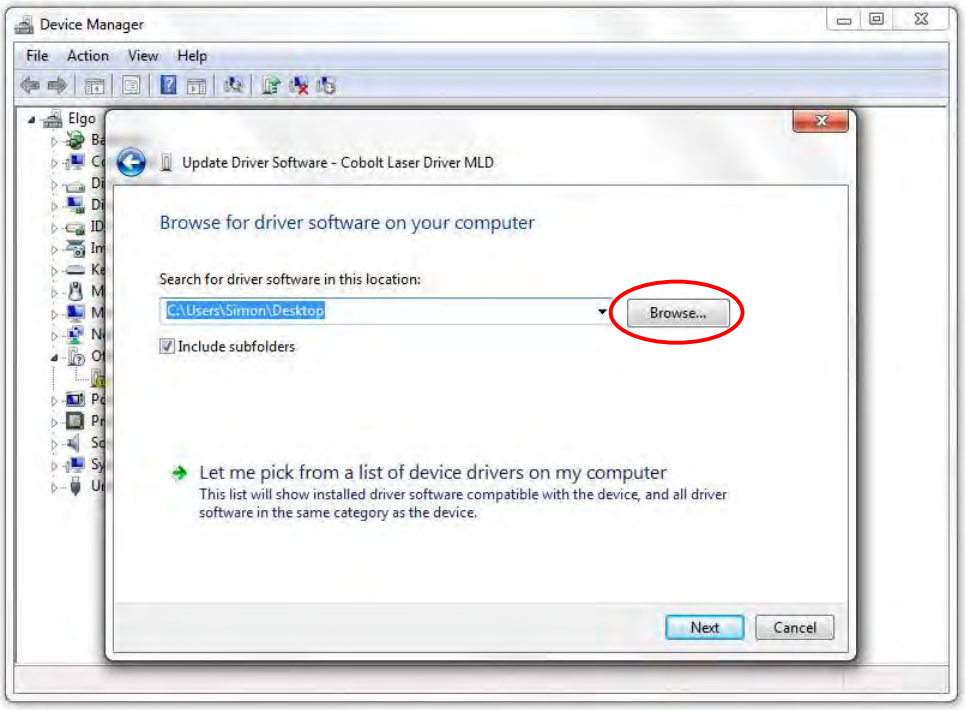
3. Under **Other devices**, find the device called **Cobolt Laser Driver**. Right-click it and chose **Update Driver Software**.



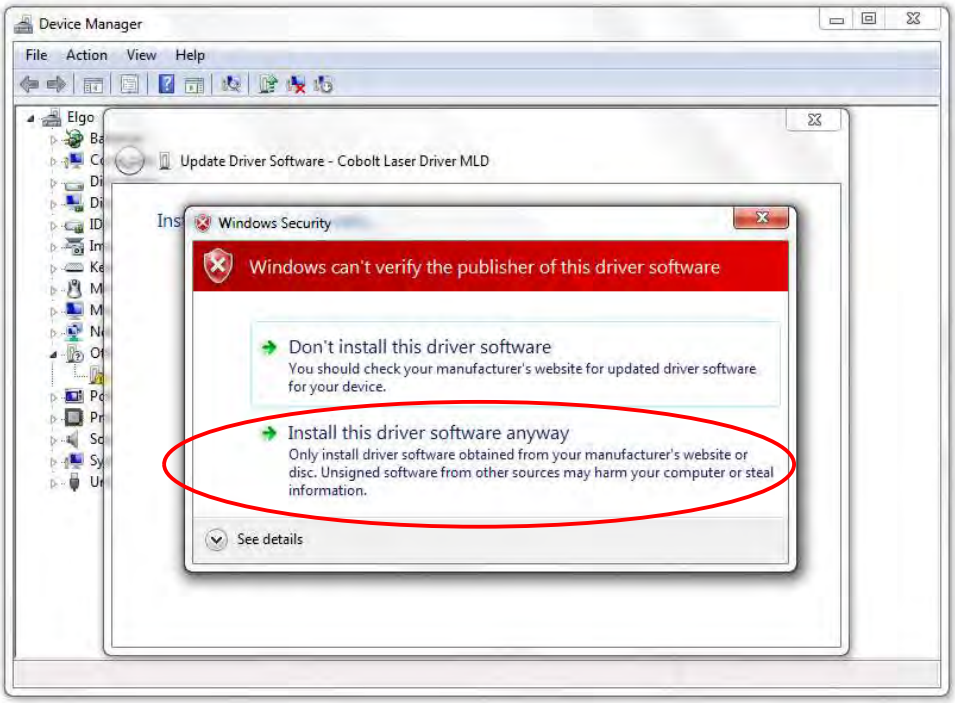
4. On the next screen chose the **Browse my computer for driver software** option.



5. Click **browse,** and find the folder on your computer where the USB driver is stored.



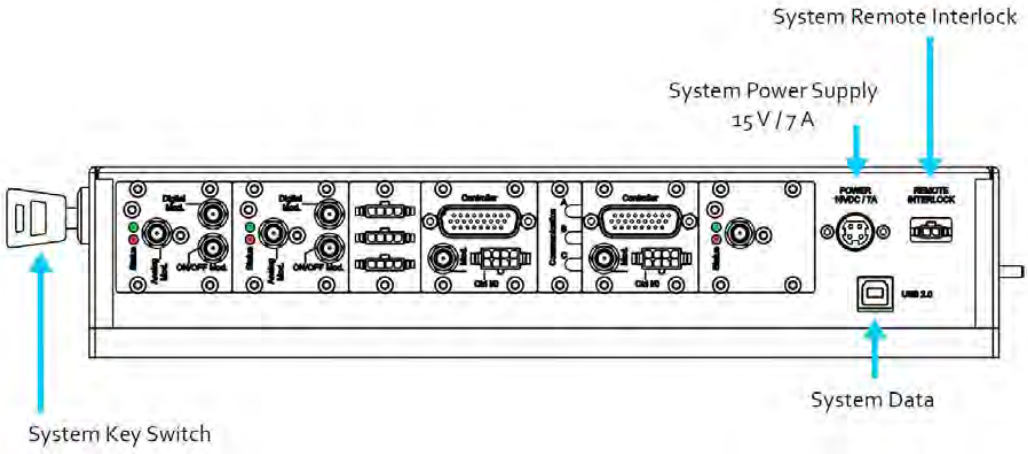
6. Windows security may warn you that the publisher of the driver is unverified. Choose **Install this driver software anyway**.



7. The installation should now be complete.

7.1. System Interfaces

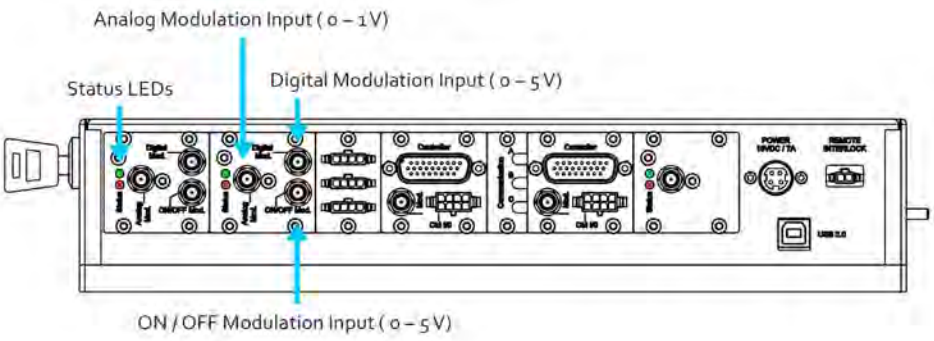
The laser combiner has several system interfaces, through which the operator can control all integrated lasers simultaneously. The key switch can be used to toggle the lasers ON and OFF as described in section 2.3. The remote interlock, when removed will result in all lasers being disabled. The 15 V power supply delivers power to all integrated lasers via internal power distribution and conversion circuitry.



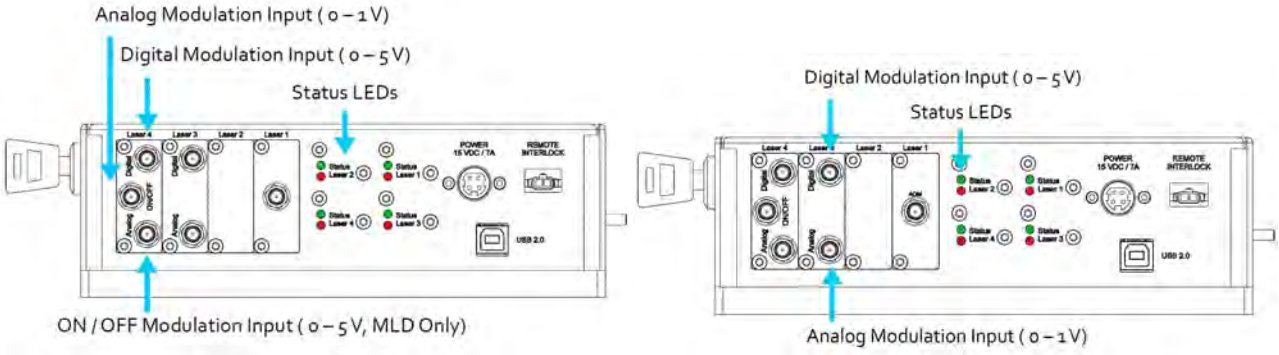
7.2. Laser Interfaces

Cobolt 06-01 Series

Cobolt 06-01 Series lasers integrated into the combiner have an interface for status LEDs as well as modulation inputs. There are two SMA connectors on each interface panel, one for digital and one for analog modulation inputs to the Cobolt 06-MLDs and 06-DPLs.



Cobolt 06-01 laser interface on C-FLEX C6



Cobolt 06-MLD (left) and 06-DPL (right) interface on C-FLEX C4

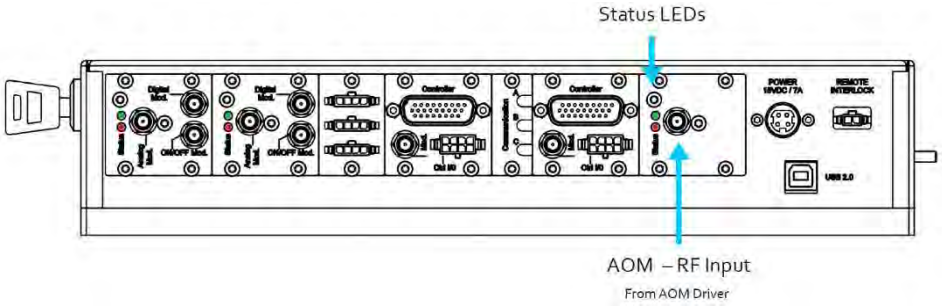
The C-FLEX back panel has LEDs to indicate each laser's status. When power is supplied to the laser head, regardless of key-switch state, the temperature control elements will be active to reach set point values.

The status of the laser operation is given via LED indicators:

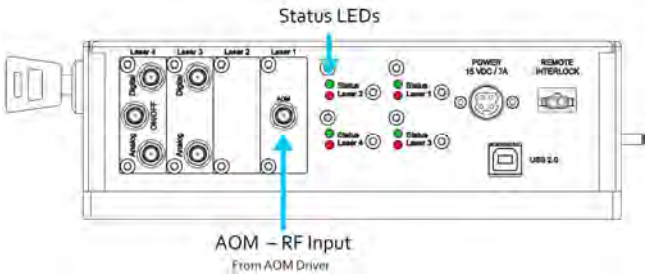
ON	Green	The system is emitting or armed for emission.
ERROR	Red	An error has occurred.

Cobolt 08-01 Series

Cobolt 08-01 Series lasers integrated into the combiner have an interface for status LEDs as well as an RF input for access to an integrated AOM where applicable.



Cobolt 08-01 laser with AOM RF Input interface on C-FLEX C6



Cobolt 08-01 laser with AOM RF Input interface on C-FLEX C4

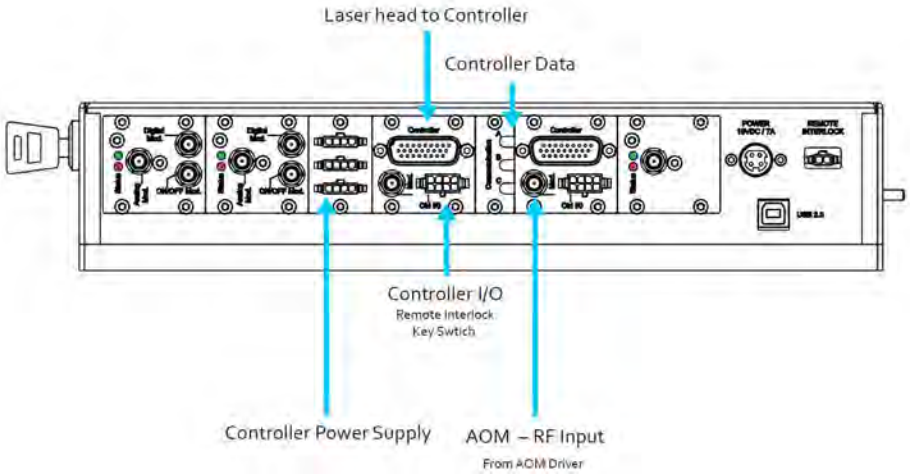
The C-FLEX back panel has LEDs to indicate each laser's status. When power is supplied to the laser head, regardless of key-switch state, the temperature control elements will be active to reach set point values.

The status of the laser operation is given via LED indicators:

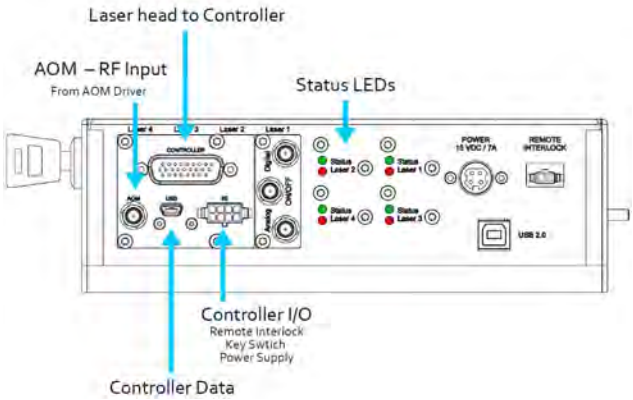
ON	Green	The system is emitting or armed for emission.
ERROR	Red	An error has occurred.

Cobolt 04-01 Series

Cobolt 04-01 Series lasers integrated into the combiner have an interface on the C-FLEX back panel for the controller cable, power, data, key switch and remote interlock. There is also an SMA connector for each integrated AOM. The status LEDs are located on the laser controller.



Cobolt 04-01 laser with AOM RF Input interface on C-FLEX C6

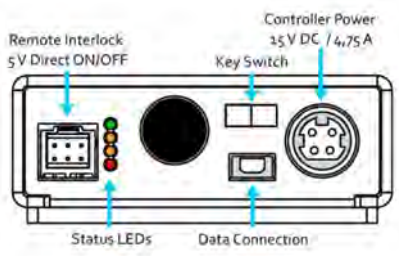


Cobolt 04-01 laser with AOM RF Input interface on C-FLEX C4

On the laser controller there are interfaces for the Controller I/O cable, which is split to connect with the key switch on one branch and the Remote Interlock and 5V Direct ON/OFF on the other branch.

The status of the laser operation is given via LED indicators:

POW	Green	Power is supplied to the controller.
ON	Orange	The system is emitting or armed for emission.
LOCK	Orange	The system has reached the set point for operation.
ERROR	Red	An error has occurred.

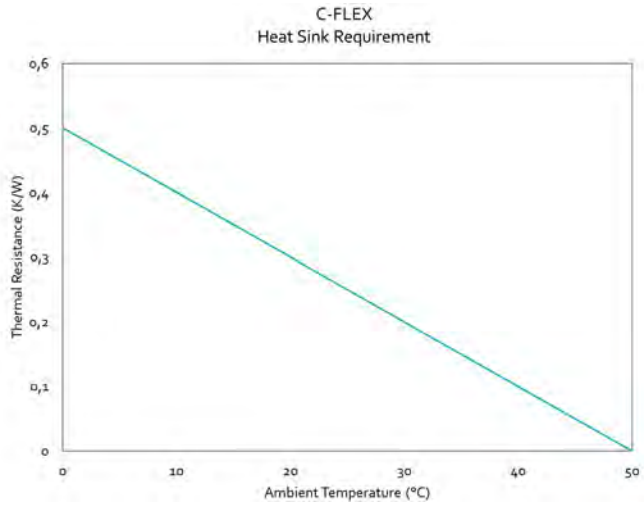


7.3. Access panels

The C-FLEX access panel can be removed to access the lasers and mounting screw holes inside. When removed, the access panel will open two magnetic switches and trigger the safety interlock, disabling all lasers and preventing emission. The access panel slides off to the side. When mounting or integrating C-FLEX leave space for removing the access panel during service or alignment.

7.4. Thermal Management

To ensure operation within given specifications and for the warranty to be valid, the laser combiner must be mounted on a suitable heat sink or an optical table in a temperature controlled environment. The requirement on thermal resistance of the heat sink can be calculated by taking the difference between the maximum allowed laser head base plate temperature (50 °C) and the ambient temperature at the air-heat sink interface (e.g. 40 °C), divided by the maximum power dissipated from the system, 100 W. The C-FLEX laser combiner must be attached to a heat sink providing a thermal resistance of < 0.2 K/W at 30 °C ambient temperature. The mounting surface should be flat within 0.05 mm over the mounting surface. Under normal circumstances thermal heat compound is not required, however if the laser is operated in an area with a high ambient temperature it is recommended to use active temperature control.



Heat Sink Requirements for C-FLEX

7.5. AOM Driver Heat Sink

The AOM driver requires a heat sink providing a thermal resistance of < 1.2 K/W.

7.6. Power Supply Requirements

An appropriate System Power Supply Unit (PSU) is supplied with the C-FLEX laser combiner and can be plugged into a standard power outlet. The power supply accepts 100-260 VAC and 47-63 Hz. Ripple and noise 1% peak-peak max, 20 MHz bandwidth. Accepted voltage for C-FLEX is 15 VDC, 7 A. Specification values are given at 15 VDC.

AOM Power supply requirements

A 24V power supply for the AOM driver is also supplied and should be connected to the input marked +VDC on the AOM driver. A 5V power supply is supplied with the system to allow for generation of a simple constant TTL digital 'ON' state.

8. C-FLEX System Specifications

8.1. Combiner Optical Specifications

Output power losses per beam diverter package	< 10 %
Fiber coupled power stability (8 hrs, ± 3 °C)	± 10 %
Achievable fiber coupling efficiency	> 50 %
Temperature dependant pointing stability per laser (10-40 °C)	< 20 µrad / °C
Static beam pointing stability per laser (8 hrs, ± 3 °C)	< 50 µrad
Achievable beam position overlap at exit	< 50 µm
Achievable beam-to-beam angle deviation (at 1 m)	< 150 µrad

8.2. Configuration Specifications

C-FLEX Model	C4	C6
Maximum number of lasers in combiner – total	4	6
Maximum number of Cobolt 06/08 lasers in combiner	4	6
Maximum number of Cobolt 04-01 lasers in combiner	1	3
Maximum number of AOMs lasers in combiner	1	3
Minimum wavelength separation	15 nm	

8.3. Fiber coupling options

Wavelength Range	405 - 660 nm
Fiber Types	SM / PM Multimode
FIber Outputs	Collimated FC / APC FC/PC
Number of fiber outputs	Single Custom

8.4. Operation and Environmental Specifications

Power supply requirements	15 VDC, 7 A
Communication protocol	USB
Maximum baseplate temperature	50 °C
Warm-up time to system thermal stability	< 15 min
Intended use environment	Laboratory
Storage temperature	10 °C to 40 °C
Humidity (non-condensing)	0 – 90 % RH
Ambient air pressure	950 – 1050 mbar
Heat sink thermal impedance at 30 °C ambient	< 0.2 K/W
Maximum heat dissipation of Laser Head	< 100 W

8.5. Modulation Interfaces – Cobolt 06-01 Series

		06-MLD	**06-DPL**		
		(all)	532 nm	561 nm	553 nm
Digital modulation	Bandwidth	DC – 150 MHz	DC – 50 kHz	DC – 10 kHz	DC – 5 kHz
	Rise/Fall time	< 2.5 ns	< 6 µs	< 30 µs	< 60 µs
	Extinction ratio (@10MHz)	> 70 dB	---		
	Input signal	0 – 5 V, TTL			
	Impedance	50 Ω	10 kΩ		
Analog modulation	Bandwidth	DC-2 MHz	DC – 50 kHz	DC – 10 kHz	DC – 5 kHz
	Rise/Fall time	< 300 ns	< 6 µs		
	Extinction ratio (@250kHz)	> 70 dB	---		
	Input signal	0 – 1 V, Arbitrary			
	Impedance	1k Ω			
ON/OFF modulation	Bandwidth	DC-500 kHz	---		
	Extinction ratio	inf:1	---		
	Rise/Fall time	< 300 ns	---		
	Input signal	0 – 5 V, TTL	---		
	Impedance	High	---		

8.6. Modulation Interfaces – AOM Driver

Supply voltage	+24VDC
Output impedance – RF output connector	50 Ω (nom.)
Analogue modulation	
Impedance	1k Ω
Voltage range	0 – 1 V
RF ON/OFF ratio	60 dB
Absolute maximum ratings	-0.5 V – +1.1 V
Digital modulation	
Impedance	1k Ω
High level	≥ 3V – 5V (=RF on)
Low level	0 – < 0.8 V (=RF off)
RF ON/OFF ratio	70 dB
Absolute maximum ratings	-0.5 V – +5.5 V

For more details on the specification of the AOM driver, see the website of AA Opto-Electronics, www.aaoptoelectronic.com

8.7. Electrical Interfaces – AOM Driver

Interfaces	Connector	Function
Control input – AOM Driver	DB 15, male	5V TTL Digital modulation input , 24 V Power supply to AOM driver,
RF output connector ("RF out")	SMA female	Modulation signal to laser head
RF modulation input ("Mod in")	SMA female	Analogue modulation input

8.8. Electrical Interfaces – C-FLEX

Interface	Location	Connector
System Input power	C-FLEX	Kycon KPJX-45, 4-pin
System Remote interlock connector	C-FLEX	Molex pin 1 & 2
System Data port	C-FLEX	USB-B
Digital modulation	C-FLEX	SMA female (where available, per laser line)
Analog modulation	C-FLEX	SMA female (where available, per laser line)
ON/OFF modulation	C-FLEX	SMA female (where available, per laser line)
AOM Driver	C-FLEX	SMA female (where available, per laser line)
Cobolt Laser Controller	C-FLEX	26 pin D-SUB Male
Cobolt Laser Controller Power	C-FLEX	4-Pin Molex
Cobolt Laser Controller I/O	C-FLEX	8-Pin Molex
Cobolt Laser Controller Data	C-FLEX	USB-type mini B plug (cable)

8.9. Electrical Interfaces – Laser Controller

Interface	Location	Connector
Cobolt Laser	Laser Controller	26 pin D-SUB
Cobolt Laser Controller Power	Laser Controller	Kycon KPJX-45, 4-pin
Cobolt Laser Controller I/O	Laser Controller	USB-type mini B
Cobolt Laser Data (RS-232)	Laser Controller	USB-type mini B
Cobolt Laser Controller I/O – Key Switch	Laser Controller	2 pin Molex
Cobolt Laser Controller I/O – Remote Interlock / 5V Direct	Laser Controller	4-pin Molex

8.10. Mechanical Interfaces

C-FLEX Model	C4	C6
Laser combiner (mm)	196 x 292 x 64.5	309 x 292 x 64.5
Weight, combiner without lasers	< 3 kg	< 5 kg

8.11. Compatible Laser Products

Cobolt 04-01 Series

Powerful, single frequency CW diode pumped lasers:

457 nm – 1064 nm up to 400 mW

https://hubner-photonics.com/products/lasers/single-frequency-lasers/04-01-series/

Cobolt 06-01 Series

Plug & play modulatable lasers:

375 nm – 975 nm up to 400 mW

https://hubner-photonics.com/products/lasers/diode-lasers/06-01-series/

Cobolt 08-01 Series

Compact narrow linewidth lasers:

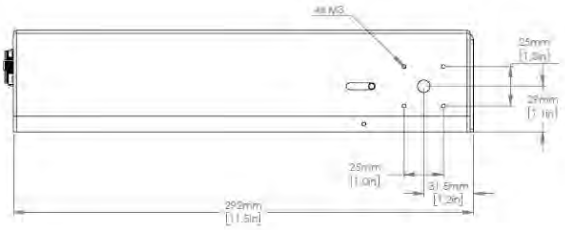
405 nm – 1064 nm up to 400 mW

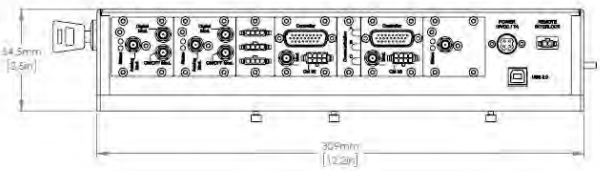
https://hubner-photonics.com/products/lasers/narrow-linewidth-lasers/08-01-series/

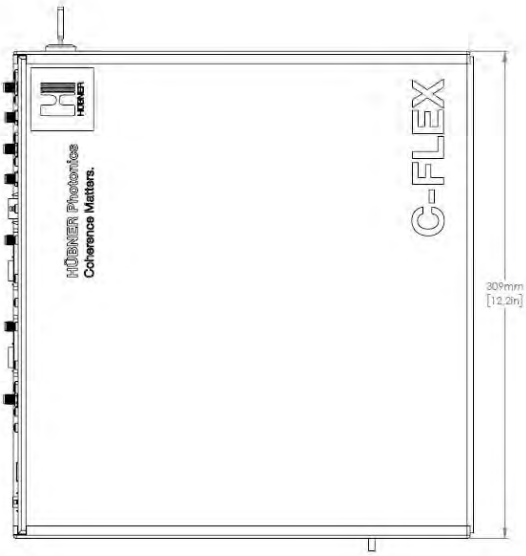
9. Mechanical Drawings

In this section we will describe the the outer dimensions of the C-FLEX and auxillary equipment.

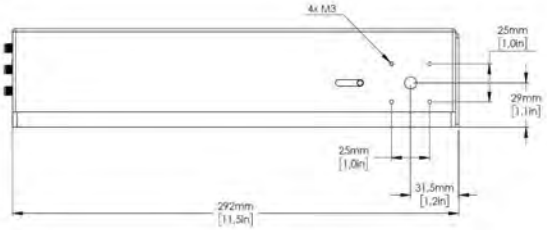
9.1. C-FLEX – C6

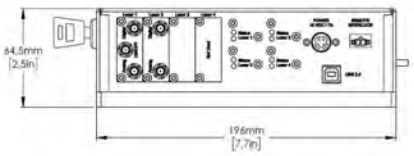


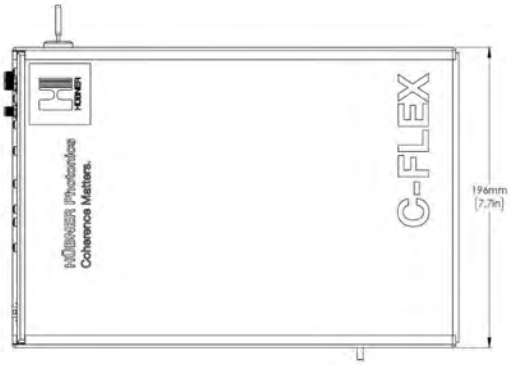




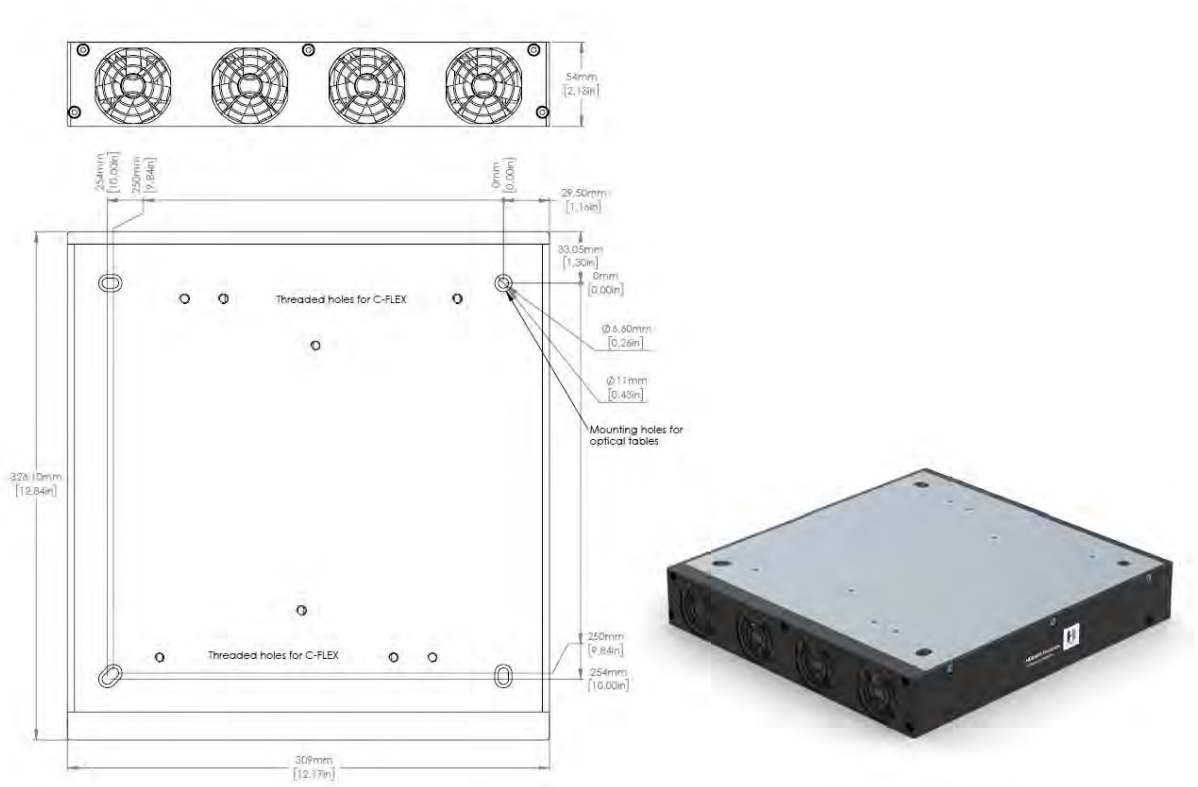
9.2. C-FLEX – C4



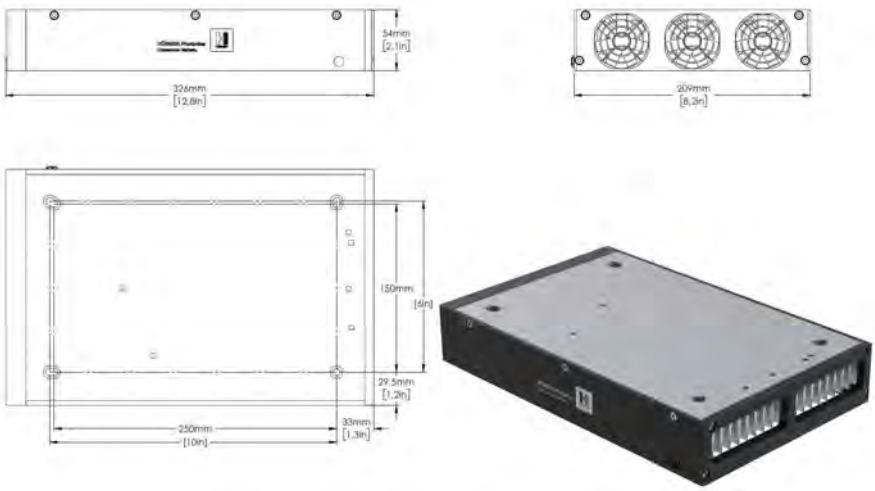




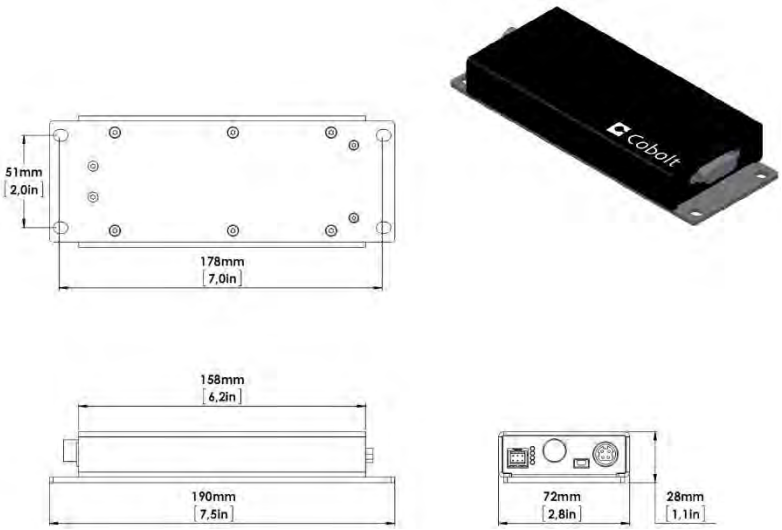
9.3. Heat sink – C6



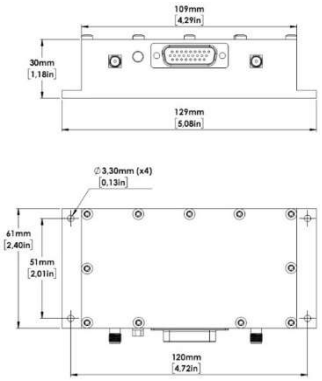
9.4. Heat sink – C4



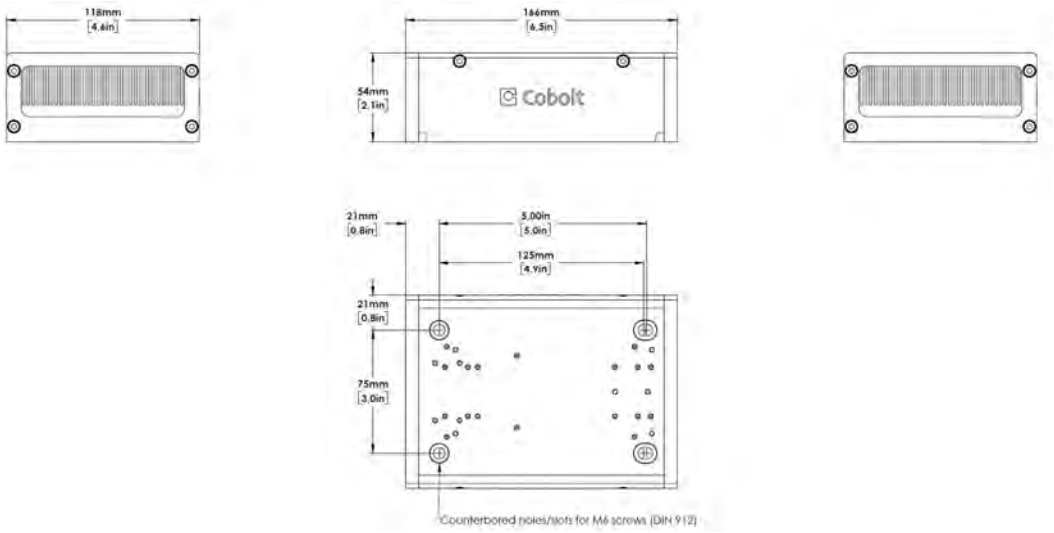
9.5. Laser Controller



AOM Driver



9.6. AOM Driver Heat Sink

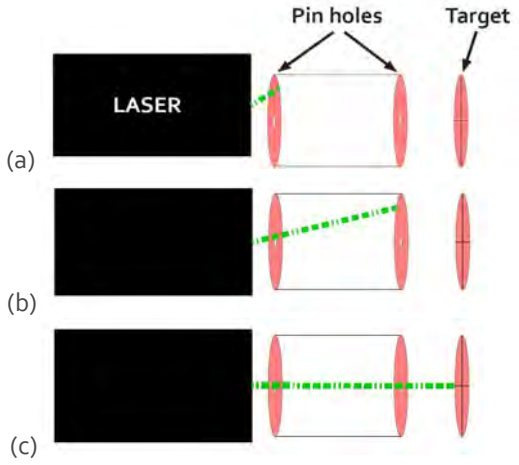


10. Principle of laser beam alignment

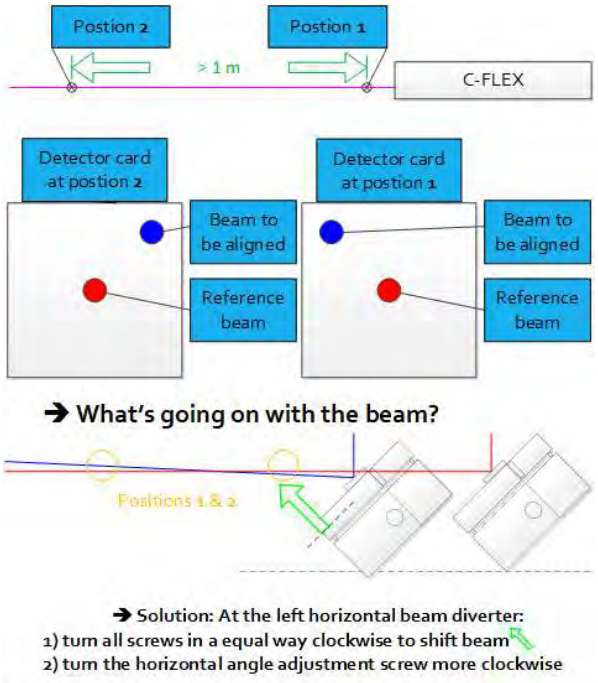
C-FLEX beam combiner alignment can be complicated and requires some experience with laser beam alignment. In this section the principles of beam alignment are discussed in detail.

10.1. Two pin-hole technique

Alignment of the C-FLEX can be done by using two pin holes or targets to adjust the beam position and the beam angle. The pin hole closest to the light source is used for beam position adjustments and the second pin hole is used for angular adjustments.

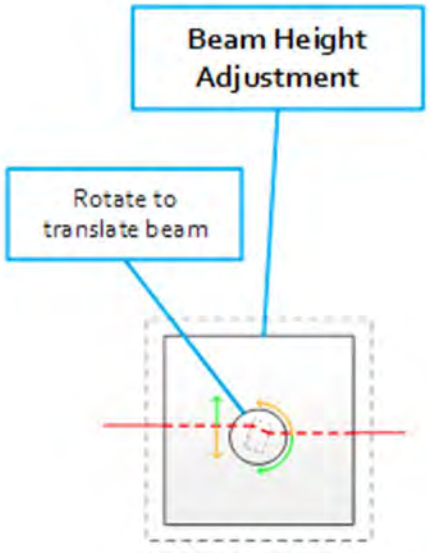


Above is a simplified schematic of two pinhole alignment (a) beam misaligned in position and angle. (b) beam aligned in position but not angle (c) beam properly aligned and reaching the target



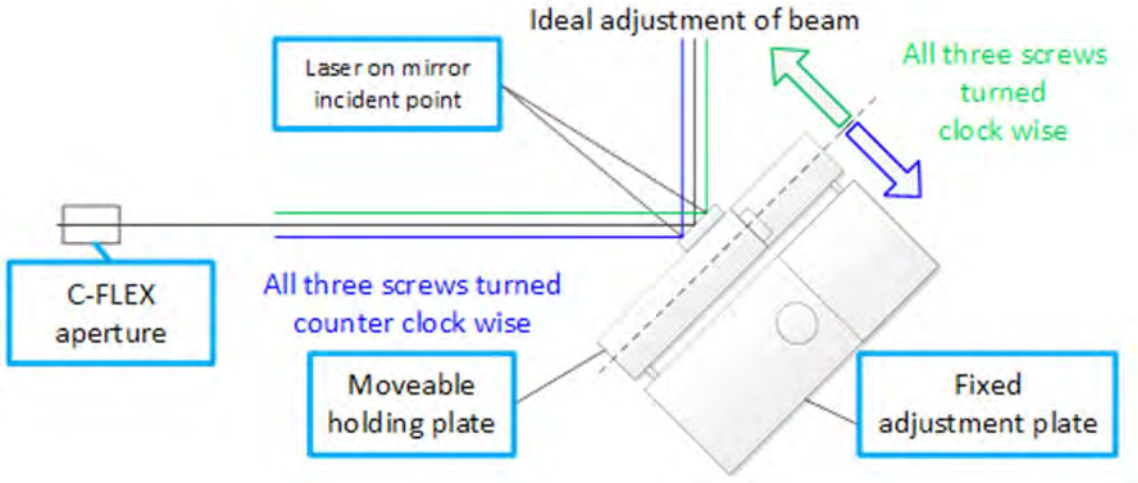
10.2. Vertical alignment

In the case of C-FLEX the beam height can be adjusted independently from the horizontal position and beam angle. After loosening the **set screw,** adjust the beam height by turning the beam height adjustment wheel until the beam is aligned in the middle of the steering mirror. The beam height adjustment translates the beam up and down parallel to the base plate.



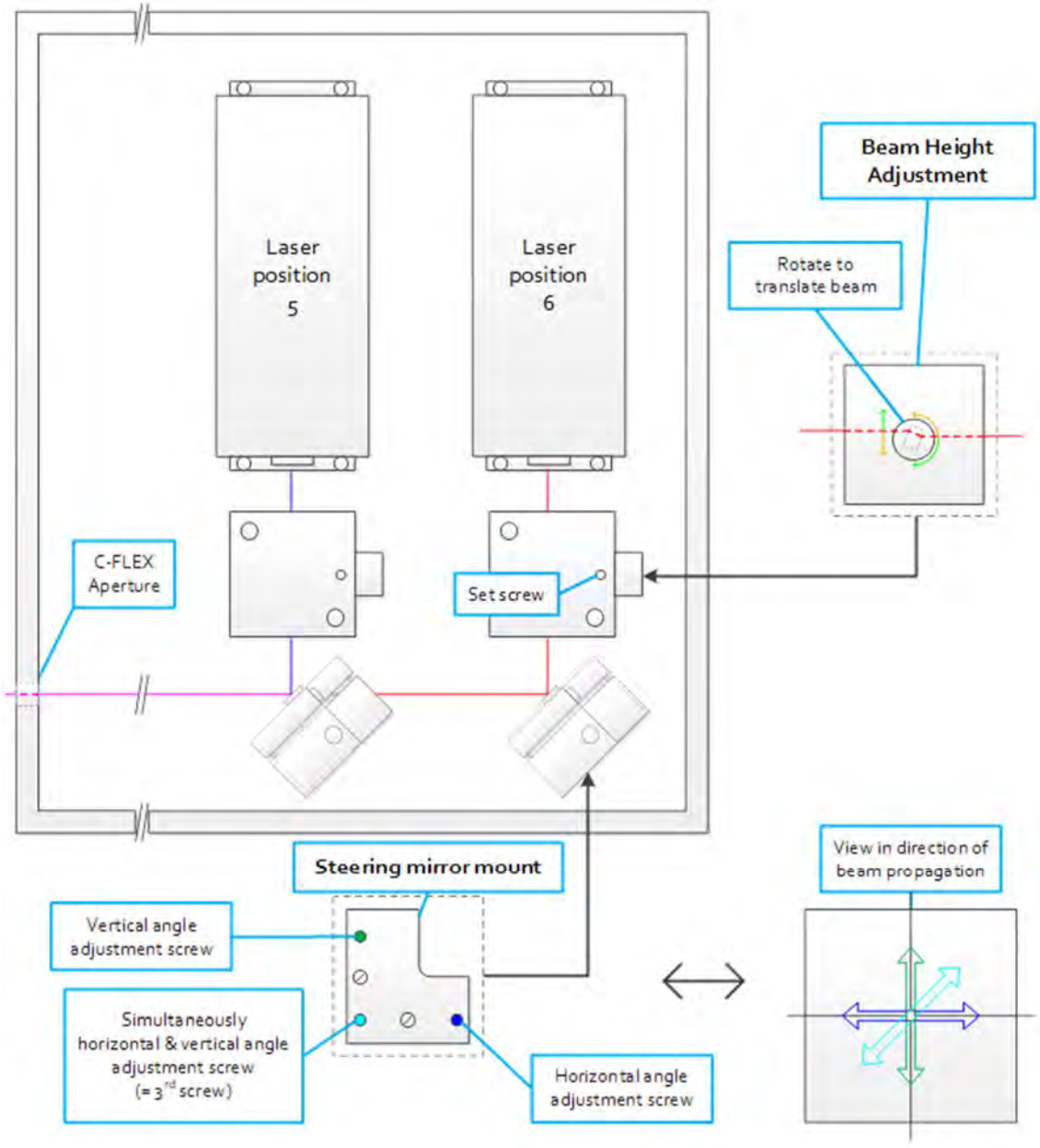
10.3. Horizontal alignment

The steering mirror mount is used for both horizontal translation and angular compensation. To translate the beam horizontally adjust all three screws equally, this will push or pull the steering mirror into the appropriate position for the ideal adjustment of the beam.



10.4. Angular alignment

Once the beam is aligned horizontally and vertically the same three screws can be used for tip/tilt adjustments, controlling the beam angle.

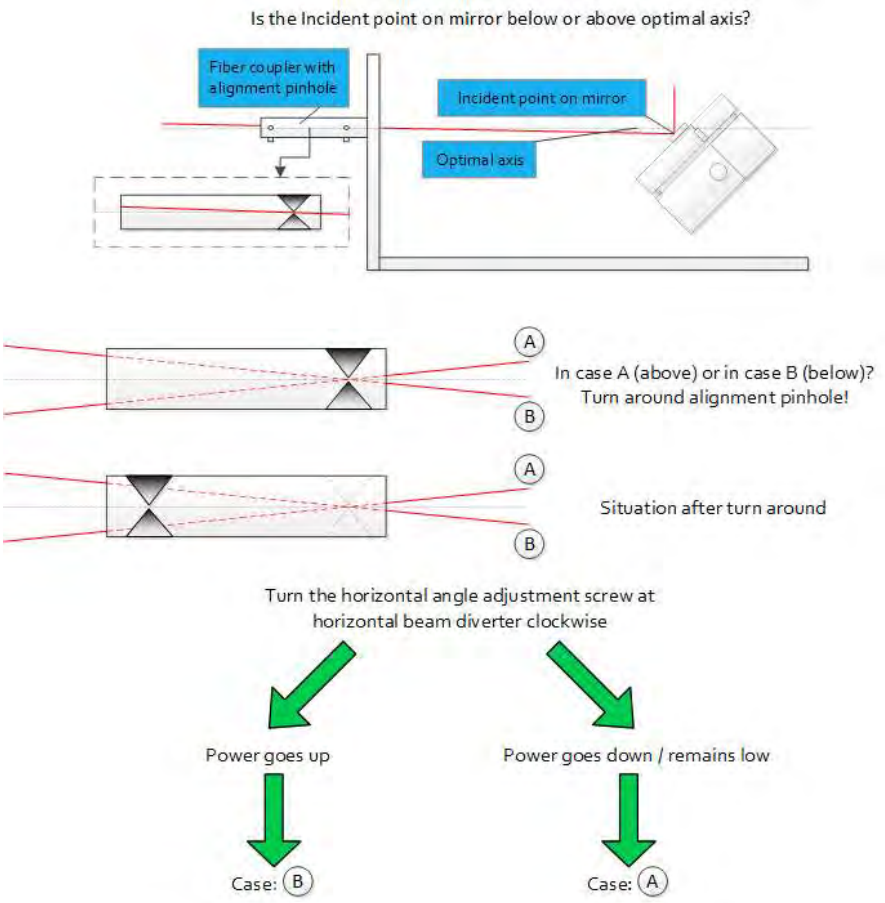


When adjusting the beam angle, do not use all three screws. As described above, the dark blue and green screws are used for angular alignment, turning all three will translate the steering mirror and change the incident location on the mirror. It may be necessary to iterate between translational and angular adjustment to complete alignment. The horizontal angle screw can be used to sweep across the aperture to determine the required horizontal translation direction, then the 3rd screw screw is turned in the opposite direction to push the mirror into positon.

10.5. Fiber alignment

After the beam is aligned to the aperture the fiber must be aligned within the coupler. The fiber coupler provided with the C-FLEX is supplied with a black tube with a pin-hole in one end. Use this tube to align the system by placing the pin-hole tube in the coupler, maximizing the output power through the pinhole using the corresponding set of adjustment screws on the coupler. Flip the pin-hole tube and re-optimize the output power with the second set of adjustment screws on the coupler.

It is also possible to align the C-FLEX to the coupler. Follow the same principles as above in sections 10.1 - 10.4.



10.6. Beam Path Alignment – Reference Laser Re-Alignment

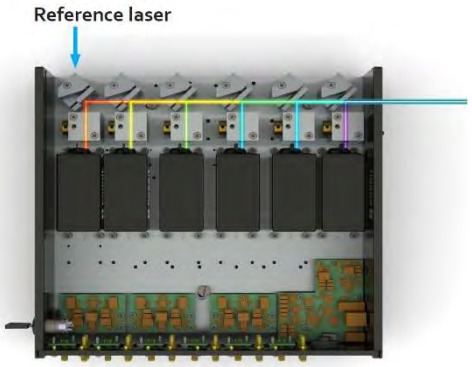
This section describes the realignment the reference laser. This should only be necessary when replacing a laser or if the beam path has for some other reason become drastically misaligned.

NOTICE – This is a drastic re-alignment and should only be performed if absolutely necessary **– OR –** when integrating a new laser head.

DANGER – Laser Radiation is accessible when the safety interlock is defeated. Avoid skin and eye exposure to direct or scattered radiation. **Close the shutter before powering up the system.**

WARNING - Alignment and maintenance of the lasers inside the C-FLEX should only be performed by trained personnel with appropriate laser safety equipment.

1. Begin with laser farthest from the aperture, the position number may vary depending on configuration. This will be considered the 'reference laser'.



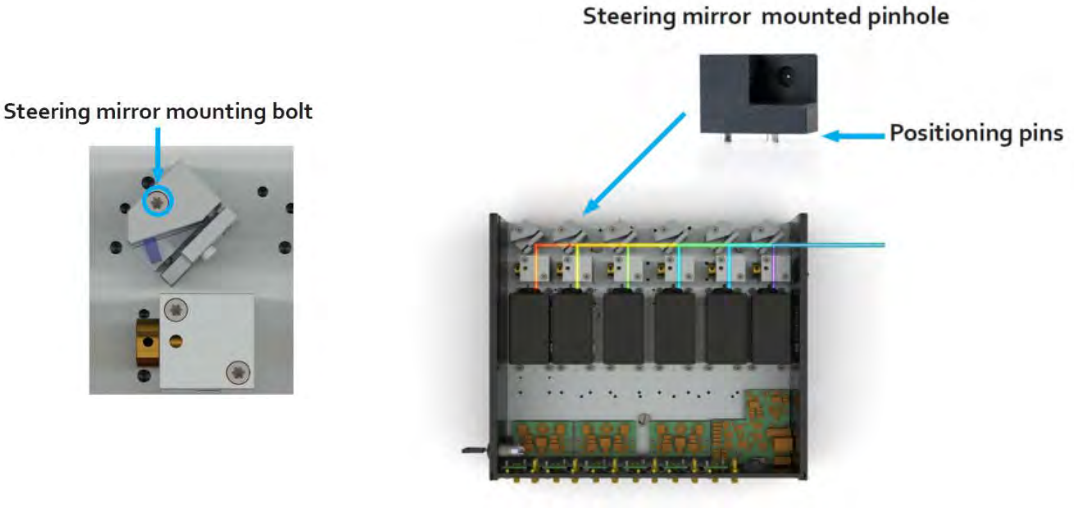
2. Place a fast optical power meter 10 cm from the aperture mounted pin hole and secure it in place. Moving the detector can affect the measurement.

3. Resume the emission of the laser line in the position farthest from the aperture (the red laser line shown above, in position 6). This is considered the 'reference laser'.

4. Check that the beam is hitting the **steering mirror** in the center horizontally, if the beam is far from the center of the mirror loosen the laser head mounting screws and push or twist the laser head gently until the beam hits the center of the steering mirror.

WARNING – The system is powered up and voltages are present in the power distribution circuits. Take care not to make touch any electronics with screws or screw drivers. Always use screw drivers with isolated handles when working in an opened, powered up system.

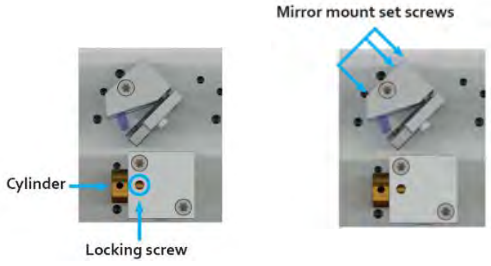
5. Remove the steering mirror mount from the position towards the aperture from the laser being aligned by loosening the mounting bolt and pulling the mirror mount up. The positioning pins can be a tight fit, some force may be required.



6. Place the mirror mount pin hole in the open position.

7. Use the **steering mirror** to center the beam on the pin hole horizontally. Maximize the power through the pin hole. Use the three set screws on the back of the mirror mount to translate the beam horizontally and make angular adjustments. See Section 10.4 : Angular alignment for a more elaborate discussion on the steering mirror controls.

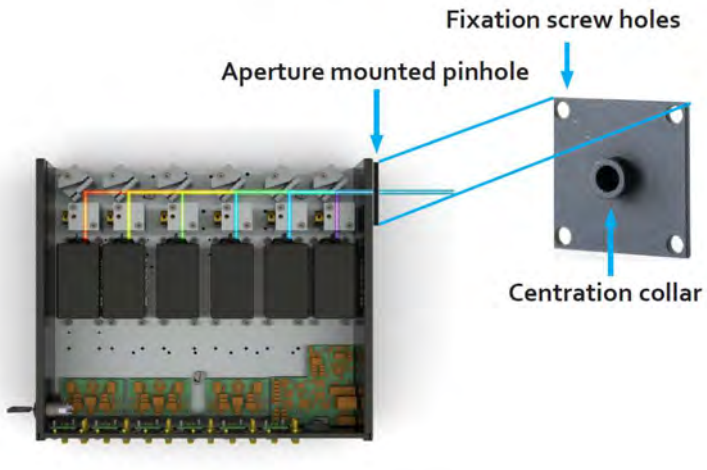
8. Use the **beam height adjustment** to center the beam on the pin hole vertically. Maximize the power through the pin hole. Loosen the locking screw and rotate the cylinder. Tighten the screw when the beam height is correct. See Section 10.2 : Vertical alignment for a more elaborate discussion on the beam height adjustment.



9. Remove the mirror mount pin hole.

10. Replace the steering mirror mount that was removed during alignment and tighten the steering mirror mounting bolt.

11. Place the aperture mounted pin hole.



12. Use the steering mirror mount angular adjustment set screws to adjust the beam angle and maximize the power through the aperture pin hole. Do not translate the beam horizontally.

13. Use the vertical tilt of the steering mirror to align the beam vertically on the aperature pin hole. Do not adjust the beam height.

14. Remove the aperture mounted pin hole.

15. Place beam camera with position measurement capabilites one meter from the aperture. If no camera is available it is possible to use a 1 mm diameter pin hole and a fast power meter, but there will be no quantitative beam angle overlap result.

16. Adjust the position of the camera or pin hole to the reference laser. Record the reference beam's exact centroid position and do not move the camera until alignment is complete. It can be usefull to define the position of the reference lasers as the (0,0) position.

17. Stop emission of the reference laser.

18. Go to section 3.8 : Aligning the Combiner Optical Path and continue with the alignment procedure.

11. Warranty and Maintenance

Hübner Photonics issues 12 months of limited warranty on workmanship and mechanics. The lasers integrated are provided with the manufacturers warranty, see laser specifications for details.

12. Service

Due to accuracy tolerances, calibration differences and allowed power drift there may be discrepancies between the manufacturer measurement of the optical output power and the customer measurement equipment. If the output power of a laser deviates from the reported value please contact your local representative for an online re-calibration. The delivered values of achieved alignment from the factory verify that it is possible for the laser combiner to delivery the beam overlap as specified but the actual performance will depend on the alignment after integration.

If one of the integrated lasers does not function, do not attempt to open any of the units, or the warranty will be voided. Call or e-mail your local Hübner Photonics representative for consultancy and to request an RMA number (see back cover for contact information). If an RMA number is issued and the laser needs to be shipped back to Hübner Photonics or your local representative, please pack the complete system for shipment using the original package or equivalent. Ensure the unit is free from thermal paste before packing. The warranty covers repair or replacing the unit at the option of Hübner Photonics.

13. Disclaimer

Hübner Photonics will assume no responsibility for damage incurred by faulty customer equipment, such as measurement equipment, cables etc, used in conjunction with Hübner Photonics laser products. Realignment of the laser combiner beam path may be required at regular intervals. Hübner Photonics makes no warranty of any kind with regard to the information contained in this manual, included but not limited to, implied warranties of merchantability and suitability for a particular purpose. Hübner Photonics shall not be liable for errors contained herein nor for incidental or consequential damages from the furnishing of this information. No part in this manual may be copied, reproduced, recorded, transmitted, or translated without the express written permission by Hübner Photonics..

14. Compliance (CDRH models only)

The CDRH model lasers are designed and manufactured to comply with the EC Low Voltage Directive and the EC EMC Directive in the CDRH-compliant configuration of laser head, key control, key and Hübner Photonics supplied power supply. All equipment must be mounted on a common ground plane, such as an optical table. If any part of the delivered equipment is replaced with a part not supplied by Hübner Photonics or if the equipment is not properly grounded, the system may not conform to CE / CDRH compliance standards listed in this section. Disabling any of the safety features nullifies the CE marking and violates the laser safety standard. Replacing mounted lasers or mounting new lasers may negate the compliance of the delivered laser combiner. The user must evaluate compliance and compatibility whenever making changes to the system.

CE

The following harmonized and limits standards have been applied:

Electrical Safety:	EN 61010-1, IEC-61010-1, UL 61010-1 (Limited Energy System)	
Laser Safety/Class	IEC-60825-1 , CDRH 21 CFR 1040.10 and 1040.11	
EMC	IEC 61326-1	
	EN 55011	Electromagnetic Emission , Class B FCC Part 15, subpart B, class B
	Electromagnetic Immunity – Table 2 Requirements	
	EN 61000-4-2	Electrostatic Discharge ±4 kV contact discharge and ±2 kV, ±4 kV, ±8 kV air discharge
	EN 61000-4-3	Radiated electromagnetic fields 80 – 1000 MHz 10 V/m with 80 % AM @ 1 kHz 1.4 – 2.7 GHz 10 V/m with 80 % AM @ 1 kHz
	EN 61000-4-4	Fast transient / Burst AC Power input port ±2,0 kV
	EN 61000-4-5	Surge AC Power input port ±0,5 kV, ±1,0 kV, ±2,0 kV Com. Mode AC Power input port, ±0,5 kV, ±1,0 kV Diff. Mode
	EN 61000-4-6	Conducted Immunity 10 V with 80 % AM @ 1 kHz
	EN 61000-4-11	Dips and Interruptions 50 Hz and 60 Hz. Test voltages: 100 V and 230 V
RoHS	EU Directive 2011/65/EU	

Contact your sales representative for a copy of the full Declaration of Conformity.

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