Cobolt

a HÜBNER Group company

Cobolt Modulated DPSS Lasers

**High performance DPSS lasers
with integrated AOM**

457 nm	515 nm	594 nm
473 nm	532 nm	660 nm
491 nm	561 nm	

HÜBNER

CONTENTS

1. Introduction

The Cobolt Modulated DPSS option incorporates both the diode pumped laser (DPL) from the Cobolt 04-01 series and an Acousto Optic Modulator (AOM) in one single compact package, slightly longer than the standard 04-01 Series laser head.

This allows fast and effective integration of a modulated DPSSL without the need for time consuming external alignment. AOMs are commonly used in combination with DPSSLs to achieve high speed modulation while maintained good stability and low noise.

Utilising Cobolt's extensive experience in optical alignment along with our proprietary manufacturing method HTCure™ for ultra robustness, the Modulated DPSSL option offers a modulated DPSSL with the ease of integration of a direct diode lasers and the specifications associated with high performance diode pumped lasers, such as single frequency operation, excellent spectral purity and a perfect beam.

2. Safety

2.1. General

Cobolt Modulated DPSS Lasers are Class IIIB (CDRH), Class 3B (IEC) laser products emit less than 500 mW of laser radiation within the visible spectrum. Residual emissions from the pump diode are contained within the laser head housing via filtering optics. The residual emission does not exceed Laser Class 1.

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 and intensity. Class 3B lasers may pose a risk of igniting flammable materials and in event of ignition gasses and 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. 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 on 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 head 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.

The table below describes the irradiance in W/cm^2 and appropriate level of eye protection in terms of optical density (OD) for each product line.

Product	Nominal Output Power (mW)	Irradiance (W/cm²)*	Eye protection Requirement**
Twist™ 457nm	40	13	> OD 4
Blues™ 473nm	40	13	> OD 4
Calypso™ 491nm	80	27	> OD 4
Fandango™ 514.4nm	120	40	> OD 4
Samba™ 532nm	320	106	> OD 4
Jive™ 561nm	160	53	> OD 4
Mambo™ 594nm	80	27	> OD 4
Flamenco™ 660nm	80	27	> OD 4

* Irradiance (W/cm2) = 110% of Nominal Power (W) ÷ Beam Area at bottom tolerance (cm2)
** Eye protection (OD) = Log_{10}(Max Power (W) ÷ 60825-1 Emission Limit : Class 1 (W)), rounded up to the next integer.

⚠CAUTION

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

2.2. Safety features

The laser is equipped with all required safety features as described in the laser safety standard 60825-1. Disabling any safety features negate the CE/CDRH compliance of this product.

Remote Interlock Connector

The remote interlock connector is a connector which permits the connection of external controls placed apart from other components of the laser product. 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 installation. See section 4.3 for a detailed description of the remote interlock circuit and operation.

Manual Shutter (Beam Stop)

The laser head 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 head.

Key Control

The CDRH compliant model comes with a key-switch on the Controller which must be connected for the laser to operate. When the key is in the OFF position, the laser is 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.

Laser Radiation Emission Warning

The Controller incorporates information LEDs which display whether power is connected, the laser is on, or a fault has occurred. The "ON" LED is illuminated whenever the device is emitting or could emit light. See section 3.4 for details on the controller. The emission warning indicators are also visible in the Cobolt Monitor™ software, see section 8 for details on the control software

2.3. Equipment Safety

Always install all power supplies used in the laser system to properly grounded power outlets. The laser head, laser controller and AOM driver must be mounted on a common ground plane, such as an optical table. Cobolt lasers contain a laser diode which is sensitive to electrostatic discharge (ESD).
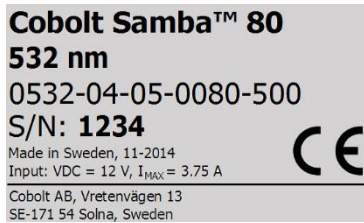
2.4. Warning and Identification Labels

The upper face of the laser head contains a yellow label with laser safety warning and classification information, the wavelength and maximum power of the unit. It also shows the location of the laser beam from the aperture and indicates the open and close positions of the manual shutter. This label must be visible unless the laser beam is totally enclosed. A silver label showing information about the laser model, manufacturer date and location, and the power supply voltage and current, is located on the laser head. Lasers shipped to customers in the USA also contain a label of CDRH compliance.
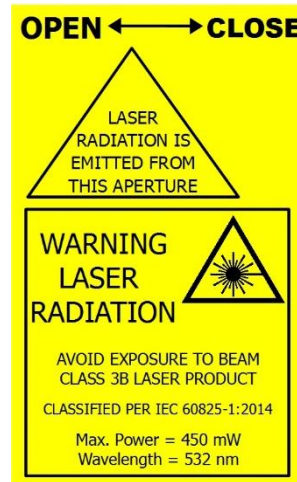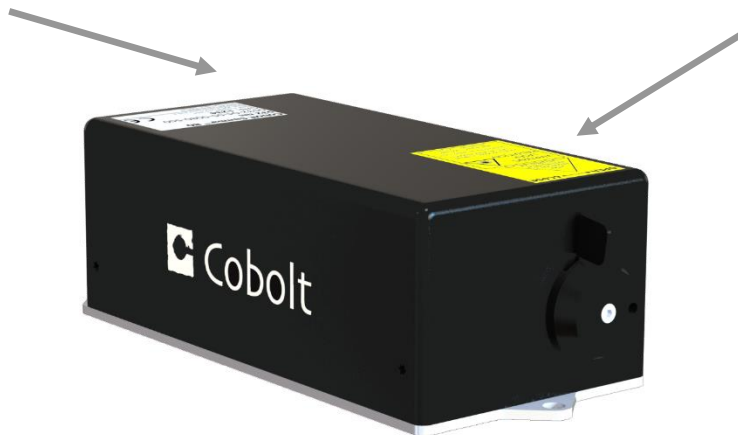
Manufacturer Identification Labels

Cobolt Samba™ 80
532 nm
0532-04-05-0080-600
S/N: **1234**   **OEM LASER**
                                 DEVICE
Made in Sweden, 11-2014
Input: VDC = 12 V, I_{MAX} = 3.75 A
Cobolt AB, Vretenvägen 13
SE-171 54 Solna, Sweden

OEM Label

Cobolt Samba™ 80
532 nm
0532-04-05-0080-500
S/N: **1234**   CE
Made in Sweden, 11-2014
Input: VDC = 12 V, I_{MAX} = 3.75 A
Cobolt AB, Vretenvägen 13
SE-171 54 Solna, Sweden

CE marking for CDRH models only

OPEN ←→ CLOSE

LASER RADIATION IS EMITTED FROM THIS APERTURE

WARNING LASER RADIATION

AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

CLASSIFIED PER IEC 60825-1:2014

Max. Power = 450 mW
Wavelength = 532 nm

Aperture Warning Labels

Complies with 21 CFR 1040.10 and 1040.11
except for deviations pursuant to
Laser Notice No. 50, dated June 24, 2007

Laser Notice No. 50 Label

CDRH models shipped to USA

3. Overview

In order to modulate the laser, at least one additional modulation source is required, for instance a function generator. The Controller Cable should always be used to connect the Laser Head with the Controller before supplying power to the system.
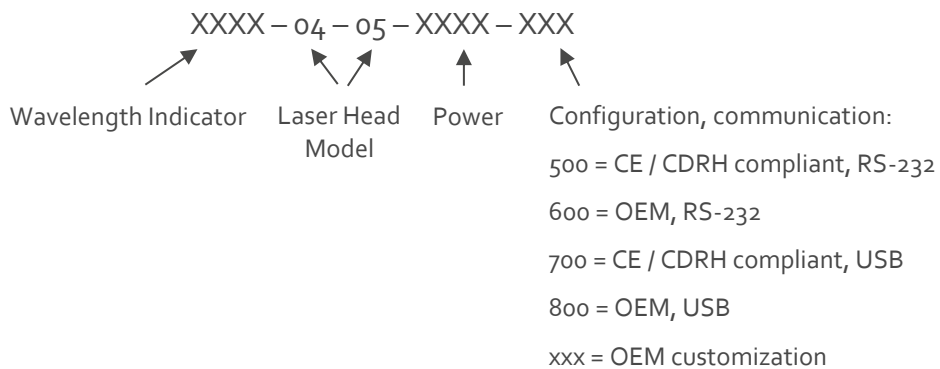
Always install the laser system to a properly grounded power outlet. Cobolt lasers contain a laser diode which is sensitive to electrostatic discharge (ESD). The device must be handled in an ESD protected workstation.
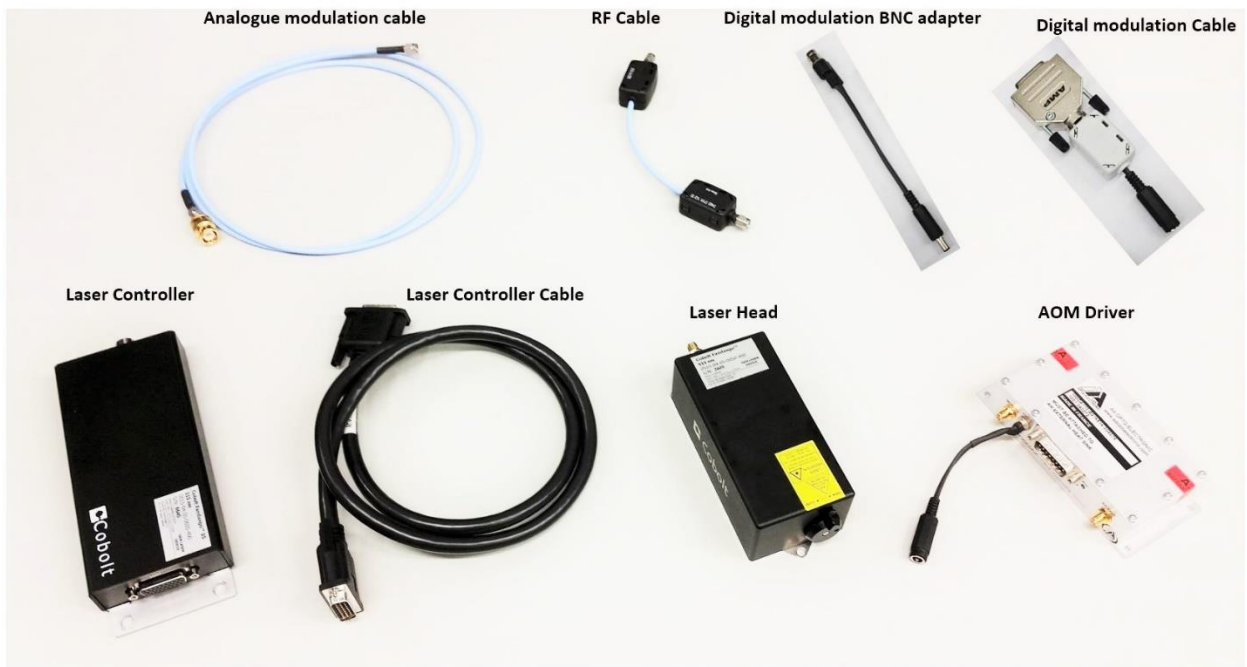
Actual length and appearance of cables may differ.

3.1. Model number

Cobolt Modulated DPSS Lasers (04-05) models are sold in two configurations: CDRH and OEM, described in section 0. The model numbers are composed as described below.

XXXX – 04 – 05 – XXXX – XXX

Wavelength Indicator   Laser Head Model   Power   Configuration, communication:

500 = CE / CDRH compliant, RS-232

600 = OEM, RS-232

700 = CE / CDRH compliant, USB

800 = OEM, USB

xxx = OEM customization

3.2. Configuration

3.2.1. CDRH Compliant

The CDRH compliant system is supplied with a key switch on the Controller, which must be connected, along with a remote interlock connector. Once power is supplied, laser radiation starts when the key is turned from the OFF position to the ON position. The laser radiation will not be emitted from the aperture until the AOM receives the appropriate signals, see section 5.1 for start-up instructions. The status of operation can be monitored via LEDs on the Controller. Setting the key to its OFF position puts the laser in stand-by mode. **The CDRH model is CE compliant.**

The standard CDRH model consists of:
- Laser head with Integrated AOM
- Laser Controller with key switch
- Keys
- 1(m) Laser Controller Cable
- 12V/3.75A power supply unit for Laser Controller
- Remote interlock jumper (for short circuiting the remote interlock connector)
- Data communication cable
- AOM driver
- 24V/1.25A power supply for the AOM driver
- RF cable
- Digital modulation cable + Digital modulation BNC adapter
- Analogue modulation cable
- 5V power supply (can be used to provide a constant digital "on")

3.2.2. OEM

The OEM system is supplied **without** a key switch on the controller. Connecting the power supply to the controller initiates an automatic start-up sequence. If the remote interlock is connected, laser radiation will start automatically as soon as power is supplied and internal temperatures are stabilized. The laser radiation will not be emitted from the aperture until the AOM receives the appropriate signals, see section 5.1 for start-up instructions.

The OEM model consists of:
- Laser head
- Laser Controller
- Laser Controller Cable
- 12V power supply unit
- Remote interlock jumper (for short circuiting the remote interlock connector)
- Data communication cable
- AOM driver
- 24V/1.25A power supply for the AOM driver
- RF cable
- Digital modulation cable + Digital modulation BNC adapter
- Analogue modulation cable
- 5V power supply (can be used to provide a constant digital "on")

3.3.   Laser Head

The Laser Head contains a pump diode, laser cavity, beam shaping optics and thermoelectric coolers (TEC) routing optics and an integrated AOM. The laser head contains an optical feed-back loop which measures the output power. The Laser Head gets electrical power and control signals from the Controller via a 26-pin HD Sub-D cable. The AOM does not require electrical power. There is an SMA connector on the laser head for the input modulation signals.

3.4.   Laser Controller

The Controller supplies driving current and control signals to the Laser Head. All Laser Heads are delivered with a controller. The operation set points are specific to each Laser Head and have been fixed during manufacturing. The operation set points are stored in the laser head so the controller can be interchanged or replaced.

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

POW	(green light)	Power is supplied.
ON	(orange light)	Laser light is on in constant current mode.
LOCK	(orange light)	Laser light is on and the output power has been locked to set point. The las operating according to specifications.
ERR	(red light)	An error has occurred. No laser light.

When power is supplied to the Controller, regardless of on/off state, the temperature control elements are operating to reach set point values. The Controller includes a remote interlock connector, pin 1-2 according to Section 4.3. The operation of the laser can be controlled and monitored via the data port that supports either USB or RS-232 commands. See Section 7 for further details. RS-232 controllers may also be delivered with a RS-232 to USB adaptor.

3.5. Cables

In the CDRH compliance configurations delivered the standard cables listed below, using any other cable type or length may violate CE compliance.

3.5.1. Laser Controller Cable

The laser controller cable is a 1m SubD26-SubD26 cable that connects the Laser Head to the Laser Controller. The cable has a minimum bending radius 8 cm. When connected care should be taken not to bend or break any of the 26 pins.

3.5.2. RF Cable

The RF cable is a SMA-SMA cable that connects the AOM to the AOM driver.

#### 3.5.3. Digital Modulation Cable + Digital Modulation BNC adapter

The Digital modulation cable is a DC-plug to subD cable connects the AOM driver to the digital modulation source. The Digital Modulation BNC adapter can be added for connecting to a source with BNC connectors. The digital modulation source can be any source capable of delivering a TTL digital signal. For convenience a 5V power supply is provided which can be used as a digital modulation source delivering a constant digital "on". This can be useful if only analogue modulation is of interest. See the set-up instruction below for more information.

3.5.4. Analogue Modulation Cable

The Analogue modulation cable is a BNC-SMA cable that connects the AOM driver to the analogue modulation source.

3.6.   Thermal Management

To ensure operation within given specifications and for the warranty to be valid, the Laser Head must be attached to a heat sink providing adequate thermal resistance. The required thermal resistance for low power models is <0.6 K/W and <0.4 K/W for high power models (i.e. Calypso 80 mW, Samba 240 mW, Samba 320 mW, Jive 160 mW, Mambo 80mW, and Flamenco 80 mW). This value is the difference between the maximum allowed Laser Head base plate temperature (50°C) and the maximum specified ambient temperature at the air-heatsink interface (40°C), divided by the maximum power dissipated from the (15W or 25W depending on laser model, see specification below). The mounting surface should be flat within ±0.05 mm over mounting surface. It is recommended to use a thermal heat compound between the Laser Head and the heat sink to provide good thermal contact. The Cobolt 'HS-03 Laser Head Heatsink' meets these requirements, see www.cobolt.se for more information on heat sinks. For assistance in thermal management and system integration, please contact Cobolt technical support.
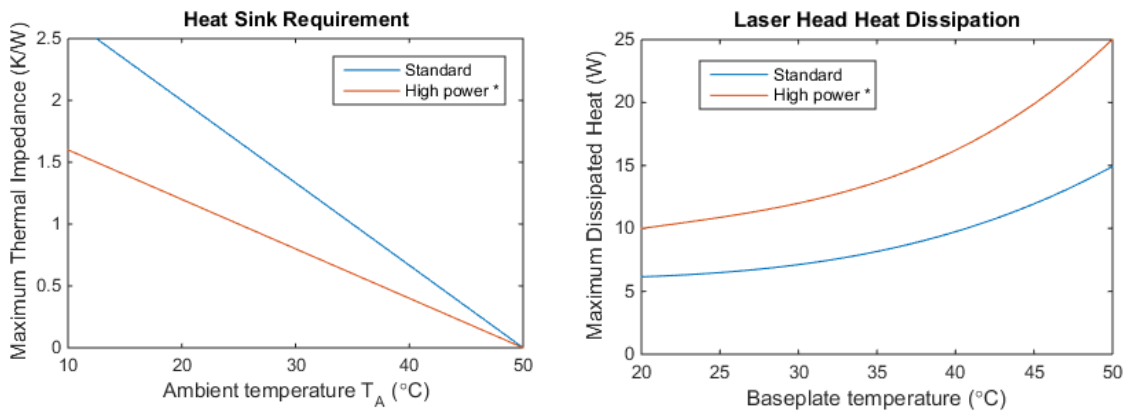
*Heat Sink Requirements and typical maximum heat dissipation for Cobolt 04 Series. *High power applies to the following models only: Calypso 80 mW, Samba 340 mW, Samba 320 mW, Jive 160 mW, Mambo 80mW, and Flamenco 80 mW.*

3.6.1. AOM Driver Heat Sink

The AOM driver requires a heat sink <1.2K/W.

3.7.   Power Supply Requirements

An appropriate Power Supply Unit (PSU) is supplied by Cobolt with the laser and must be plugged into a properly grounded standard power outlet. The output from this PSU is 12 VDC/3.75 A. The power supply accepts 100 – 240 V AC and 50-60 Hz. Ripple and noise 1% peak-peak max, 20 MHz bandwidth. The accepted voltage range is 11 V - 28 VDC.

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.

4. System Description

The information presented here is believed to be accurate and is subject to change without notice. The specifications contained herein cannot be guaranteed outside of normal operational conditions. The output power can be adjusted using control commands, see Section 7.4. Specifications are guaranteed at 100% of nominal power.

4.1. Specification

4.1.1. Optical Specifications

	Centre wavelength (nm)[1]	Output power (mW)
Twist™	457.0 ± 0.3	25, 40
Blues™	473.0 ± 0.3	25, 40
Calypso™	491.5 ± 0.3	25, 50, 80
Fandango™	514.4 ± 0.3	25, 50, 100, 120
Samba™	532.1 ± 0.3	25, 50, 100, 150, 240, 320
Jive™	561.2 ± 0.3	25, 50, 100, 120, 160
Mambo™	593.6 ± 0.3	25, 50, 80
Flamenco™	659.6 ± 0.3	80

Product Wavelength	457	473	491	514	532	561	594	660
Rise/Fall time	< 200ns							
Modulation Frequency (analogue and digital)	DC-3MHz							
Extinction Ratio (free space) [3]	> 30 dB (DC)							
Beam diameter at Aperture (1/e²)	700 ± 50 μm							
Beam divergence (mrad, full angle, 1/e²)	< 1.2						< 1.3	< 1.5
Noise 20 Hz – 20 MHz (pk-pk)	< 2 %		< 3 %	< 2 %			< 3%	< 1 %
Noise 20 Hz – 20 MHz (rms)	< 0.25 %		< 0.3 %	< 0.25 %			< 0.3%	< 0.1%
Long-term power stability (8 hours)	< 2 %		< 3 %	< 2 %			< 3 %	< 2 %
Spatial mode	TEM$_{00}$, M² <1.1							
Spectral linewidth	< 1 MHz							
Wavelength stability (after warm-up)	2 pm over ± 2 ºC and 8 hrs							
Beam symmetry at aperture	> 0.95 : 1							
Beam pointing stability (after warm-up)	< 20 μrad/°C (over 10-40°C)							
Coherence length	> 100 m							
Beam waist location (from exit window)[2]	± 20 cm							
Beam angle accuracy	< 5 mrad							
Beam position accuracy	< 0.25 mm							
Polarization ratio (linear, vertical)	> 100:1							
Residual IR emission	< Class 1							

1. The wavelength is fixed with this accuracy, while drift is defined as Wavelength stability. The wavelength is specified in air.
2. The exit window is located optically ~20cm before the laser head shutter.
3. Predominantly due stray light, fiber coupling will further improve the extinction ratio.

4.1.2. Operation and Environmental Specifications – Laser Head

Power supply	12 VDC, 3.75 A, 11-28 VDC accepted
Power consumption, total system (Laser Head + Controller)	<25 W (typical ~15 W) < 35 W (typical ~25 W) *
Maximum heat dissipation of Laser Head	<15 W (typical ~10 W) < 25 W (typical ~15 W) *
Maximum Laser Head baseplate temperature	50°C
Ambient temperature, operation	10-40°C
Ambient temperature, storage	0-60°C
Warm-up time, from OFF	< 3 min
Humidity	0-90% RH non-condensing
Ambient Air pressure	950-1050 mbar
Heat sink thermal resistance, Laser Head	<0.6 K/W <0.4 K/W *

* Applies to high power models: Calypso 80 mW, Samba 240 mW, Samba 320mW, Jive 160 mW, Mambo 80mW, Flamenco 80 mW

4.1.3. Operation and Environmental Specifications – AOM Driver

Power supply	24VDC, 1.25A
Power consumption	< 12 W
Ambient temperature, operation*	10–40°C (max T_{case} 55°C)
Ambient temperature, storage	-40°C - +50°C, non-condensing
Heat sink thermal resistance, AOM driver	<1.2 K/W
Warm-up time	10 min

4.1.4. Electrical Interfaces - Controller

Interfaces	Connector	Function
Input power	Kycon KPJX-45, 4-pin	Power supply to Controller
Laser Head to Controller	HD-sub 26-pin, male	Connection to Laser Head
Controller to Laser Head	HD-sub 26-pin, female	Connection to Controller
Data port	USB-type mini B	Control and monitoring via control commands
Remote interlock & Analog signals	Molex 90130-3206	Analog input 5 – 12 V => Laser ON Analog input <2.7 V => Laser OFF
Warm-up time		2 min

4.1.1. Electrical Interfaces – AOM Driver

Interfaces	Connector	Function
Control input connector – AOM Driver	DB 15, male	Digital (TTL) modulation input , Optional Power supply to AOM driver, Optional Analogue modulation input
RF output connector ("RF out")	SMA female	Modulation signal to laser head
RF modulation input ("Mod in")*	SMA female	Analogue modulation input
Input power ("+VDC")*		Power supply to AOM driver

4.1.2. Electrical Characteristics – 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	-0.5V - +1.1V
Digital modulation	
Impedance	1k Ω
vHigh level	≥3V – 5V (=RF on)
Low level	0 - <0.8V (=RF off)
RF ON/OFF ratio	70 dB
Absolute maximum ratings	-0.5V - +5.5V

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

www.aaoptoelectronic.com

4.1.3. Mechanical Interfaces

|	

Dimensions:
    Laser Head
    Controller
     12V PSU
     AOM Driver
     24V Power Supply
	137x60x45 mm (4.1x2.4x1.6 inches)
	190x72x28 mm (7.5x2.8x1.1 inches)
	130x55x30 mm (5.2x2.2x1.2 inches)
	129x61x30 mm (5.1x2.4x1.2 inches)
	121x50x30.8 mm (4.76x1.97x1.21 inches)

Fixation holes, Laser Head	$\varnothing$ = 4x 4.5mm (M4); 115mm x 55mm
Fixation holes, Controller	$\varnothing$ = 4x 6.4mm (M6); 178mm x 51mm
Fixation holes, AOM Driver	$\varnothing$ = 4x 4.5mm (M3); 120mm x 51mm
Laser Head weight	<0.5 kg

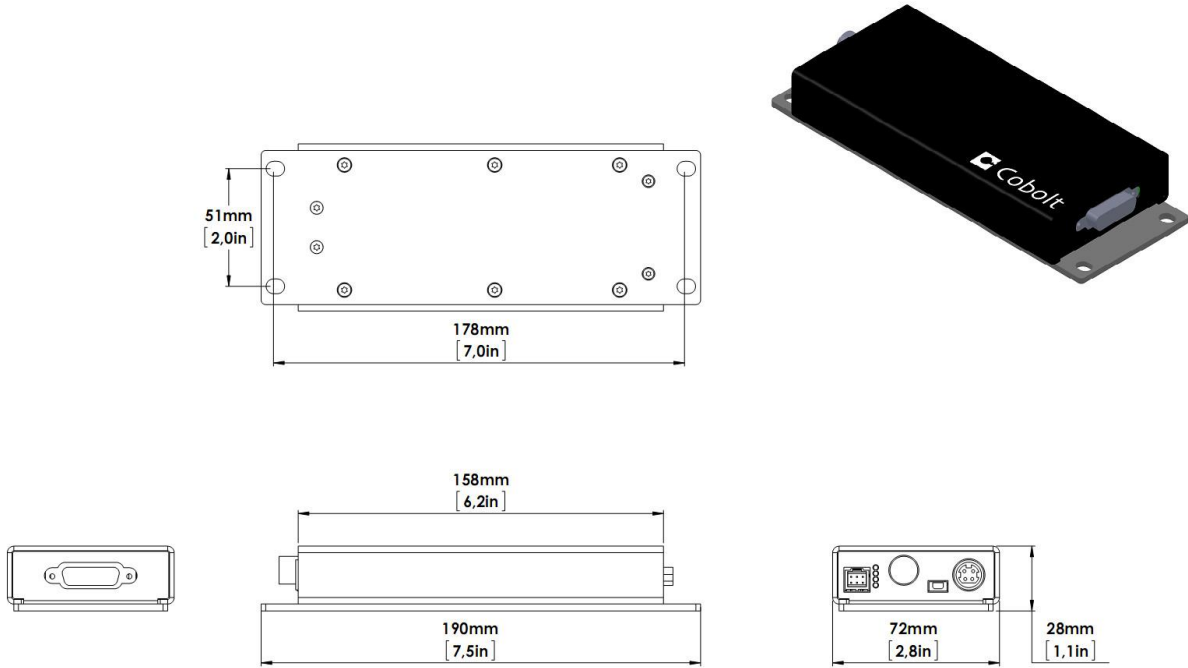## 4.2. Mechanical Drawings

4.2.1. Laser Head
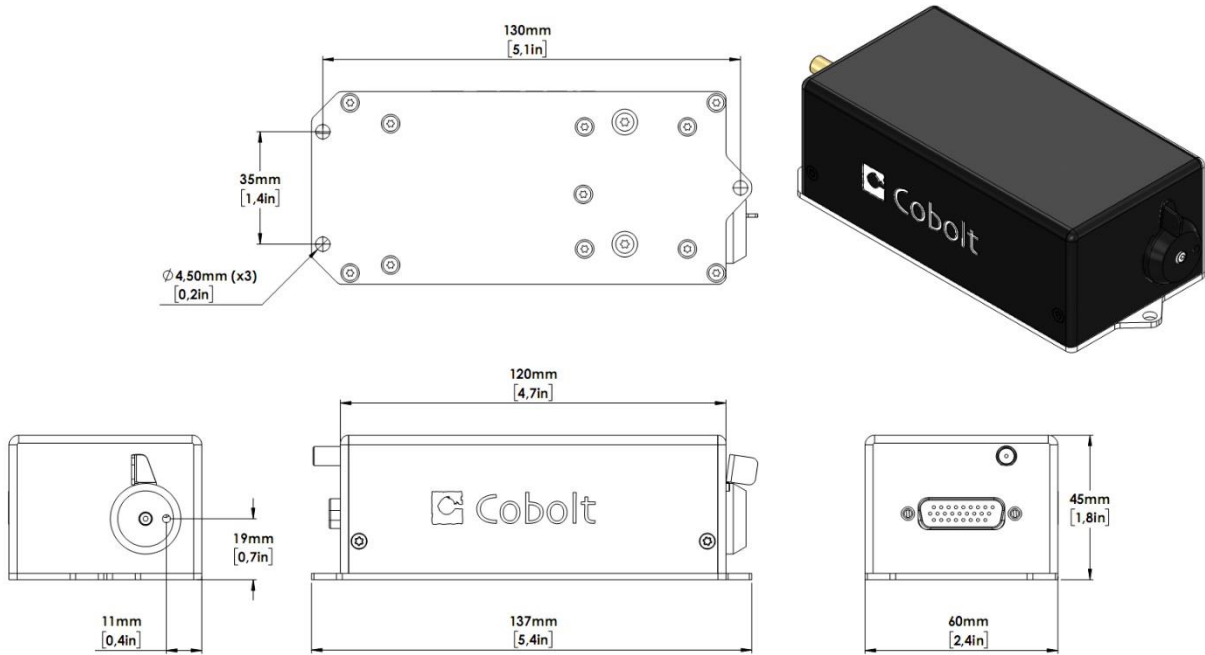
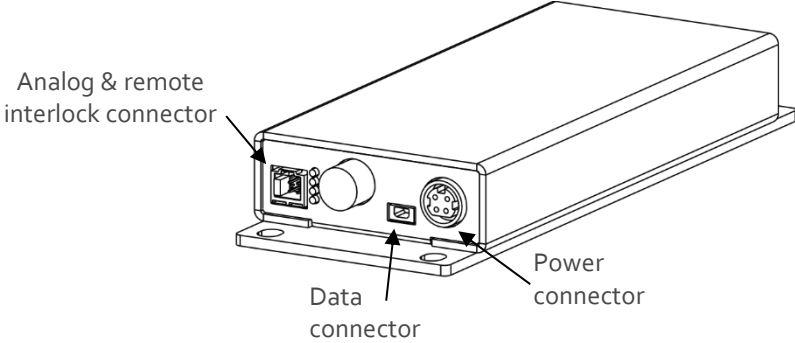*Laser head mechanical outline. Dimensions in mm [inches].*

4.2.2. AOM Driver
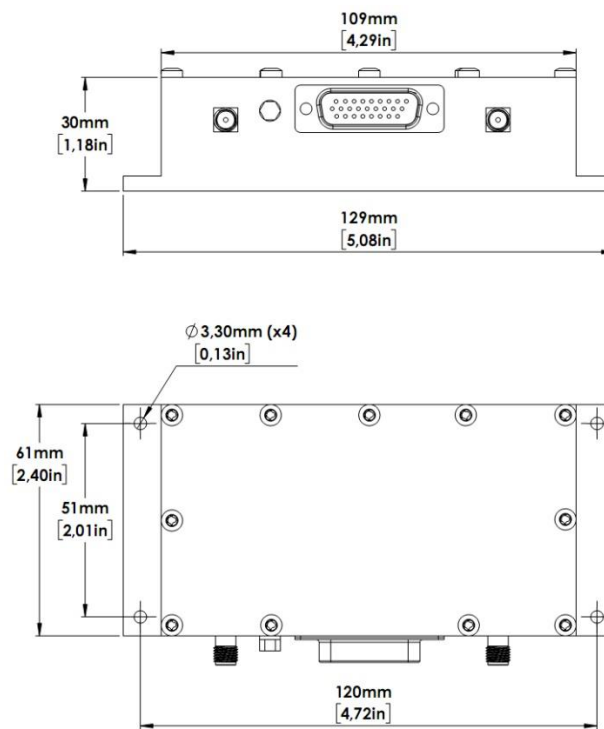
AOM Driver mechanical outline. Dimensions in mm.

4.2.3. Laser Controller

Controller mechanical outline. Dimensions in mm [inches].

Analog & remote interlock connector

Data connector

Power connector

Connector location Controller

4.3. Remote Interlock Connector

The remote interlock connector is located at pin 1 and 2 of the Molex connector on the Controller. The connector can be short-circuited with an interlock jumper (included at delivery) for operation of the laser. To use the remote interlock connector with an external switch, connect a pin 1 and 2 on a Molex plug. After the remote interlock connector has been opened the laser will need to be reset by disconnecting from and then reconnecting to the power supply in order to start again. Alternatively, it can be re-started using a special sequence of commands, see Section 7.4 for further details. 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 <1ms, but after filtering by the firmware the reaction time is extended to < 20ms.

4.4. Direct ON/OFF control

The Direct On/Off Control feature enables turning the laser ON/OFF using a 5-12 VDC signal. After having configured the Controller for Direct Control operation (factory set or by executing @cobasdr 1), the laser can only start-up when 5-12V VDC (max 12.5 VDC) is applied to pin 3 on the analog connector with 0 VDC on pin 2 as reference. Shifting the signal to 0 VDC on pin 3 will turn the laser off and put the laser in stand-by mode (status LED:s is POW and not flashing).

This function is not available for CDRH compliant models.

! **Note:** This input only controls the on/off state of the laser and cannot be used to modulate the power output.

4.5. Pin assignment

4.5.1. Analog connector & Remote interlock connector

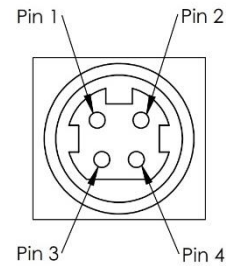Manufacturer Molex 90130-3206, mates with 90143-0006.

Pin	Function
1	Remote Interlock (connect to pin 2 for enable)
2	0 V - GND
3	Remote On/Off (+5V Input)
4	TST (Internal Cobolt use only)
5	LED "Laser on" (5V)
6	LED "Error" (5V)
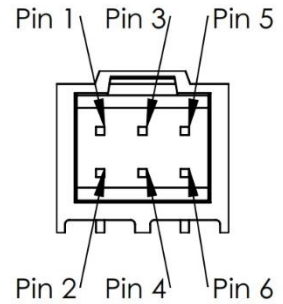
4.5.2. Power connector

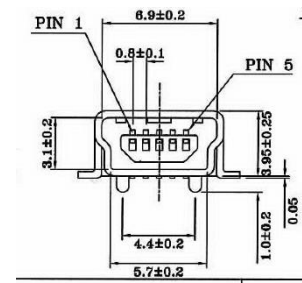Kycon KPJX-4S, mates with Kycon KPPX-4P. Grounded shield.

Pin	Function
1	0 V
2	+11-28 VDC
3	0 V
4	+11-28 VDC

4.5.3. Data connector

Connector USB-type, manufacturer Hsuan Mao C8320-05BFDSB0, mates with connector mini-B.

Pin	Function
1	+5 V
2	D-
3	D+
4	Not connected
5	0 V (GND)

5. Operating Instructions

As standard, all lasers are delivered with the Controller set in Auto-start mode. As soon as power is supplied to the Controller the temperature control elements are operating to reach set-point values and the laser emission will start, unless the key-switch is enabled (CDRH model).

5.1. Installation start-up operation

1. Mount the Laser Head on a suitable heat sink (see Section3.6).
2. Ensure that the remote interlock jumper is connected.
3. Connect the Laser Head to the Controller with the Cable and fasten screws at both ends.
4. Connect the 12 VDC power supply to the mains outlet and then to the Controller.
5. The laser now goes through the following auto-start sequence:
   - Temperature stabilization (1-2 min). Status LEDs: POW flashing, then POW goes on.
   - Turn key switch to start the laser. Status LEDs: ON goes on (CDRH model only)
   - The laser starts (light is emitted) in a constant warm-up current constant for 60 sec.   Status LEDs: ON goes on.
   - The laser locks to pre-set output power (<2 min) and operates according to specifications. Status LEDs: LOCK goes on.

! **Note:** If the power does not match the power as stated on the test sheet see Section 11: Service for more information.

6. The laser itself is now radiating, but the AOM must be operational for laser radiation to be emitted from the laser head aperture. Continue to the section 6.1 to set up the modulation controls.

5.2. Shutdown procedure operation

1. Turn the key switch to OFF first (CDRH models only).
2. Disconnect PSU from mains outlet.
3. Disconnect Controller from PSU.
4. Disconnect AOM driver PSU from mains outlet.

6. Operating Modes

There are two operating modes: constant power and constant current. The default mode for Cobolt 04 series lasers when shipped is constant power. In constant power mode the power is monitored on an internal photodiode, and this is used to regulate the current to maintain a constant power level. In constant current mode the laser runs at a set current level.

6.1. Modulation

6.1.1. Set-up

Without an input signal from the AOM driver to the laser head, there is no laser beam emitted from the laser head. Both analogue *and* digital modulation signals has to be applied to the AOM Driver. A typical source for digital and analogue modulation would be any type of function generator fulfilling the signal levels specified in the table above. Note that two separate sources are required since the signal levels are different for analogue and digital modulation. For recommendation on suitable function generators, please contact Cobolt's technical support. The AOM driver is set up as follows:

1. Mount the AOM driver on a suitable heat sink. Make sure that the heat sink can provide adequate heat dissipation (see specification in section 4.1).
2. Connect the AOM driver to the Laser Head using the RF cable.
3. Connect the AOM driver to the source for digital modulation using the digital modulation cable. If you do not want to modulate digitally, the provided 5V power supply can be used to deliver the necessary digital "on".
4. Connect the AOM driver to the source for analogue modulation using the analogue modulation cable.
5. Connect the DC plug of the 24V power supply to the AOM driver.
6. Connect the 24V power supply to the mains outlet.
7. Allow at least 10 minutes warm-up time for the AOM driver for optimum stability.

6.1.2. Modulation Options

The modulation can be digital, analogue 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 when the AOM is in its off-state.

Analogue modulation

In pure analogue modulation, the digital modulation must be in on-state, i.e. a voltage of 3-5V must be applied 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.
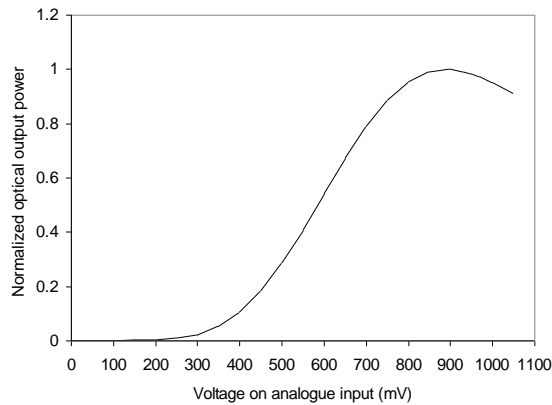
Plot of typical optical output power as function of the applied analogue voltage. There is a device specific maximum.

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.
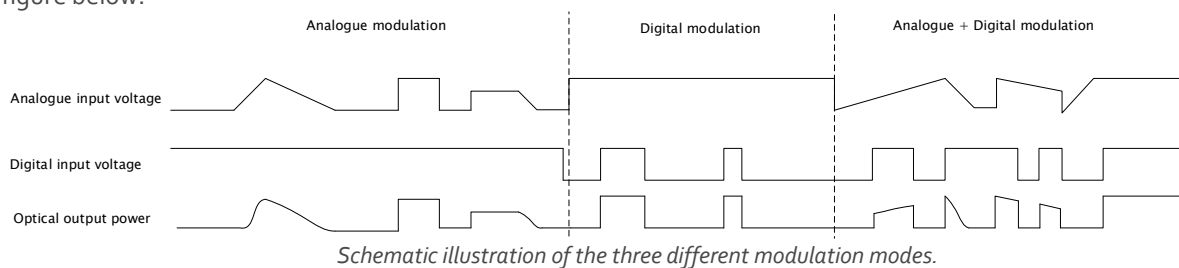
7. Operation via data port

7.1. Handshaking

Under no circumstances does the Controller initiate communication; it only transmits characters in response to a message. Every message to the Controller generates a response, either a numerical value or the acknowledgment string "OK". In the event that the Controller receives a message that it cannot interpret, it responds: "Syntax error:" followed by the complete command string (minus the termination character) that caused the error.

Every Controller response is terminated by a carriage return (ASCII 13) and a full stop is used with floating numbers.

7.2. RS232 configured controllers

To communicate with the laser, a communication cable is supplied. Each Controller is shipped from the factory with a fixed baud rate (115200). The other serial port parameters are: 8 data bits, 1 stop bit and no parity. Hardware flow control is not supported. Each command to the Controller must be terminated by a carriage return. All commands are case-sensitive. Leading and trailing white space is ignored, but command arguments must be delimited by a single space character (ASCII 32).

7.3. USB configured controllers

The USB configured controllers requires a driver for communication with a computer. The USB driver must be installed and can be downloaded from the Cobolt website (www.cobolt.se). When installed, a virtual COM port will be created to communicate with the Controller.

To install the USB driver in Windows 7 follow these instructions:
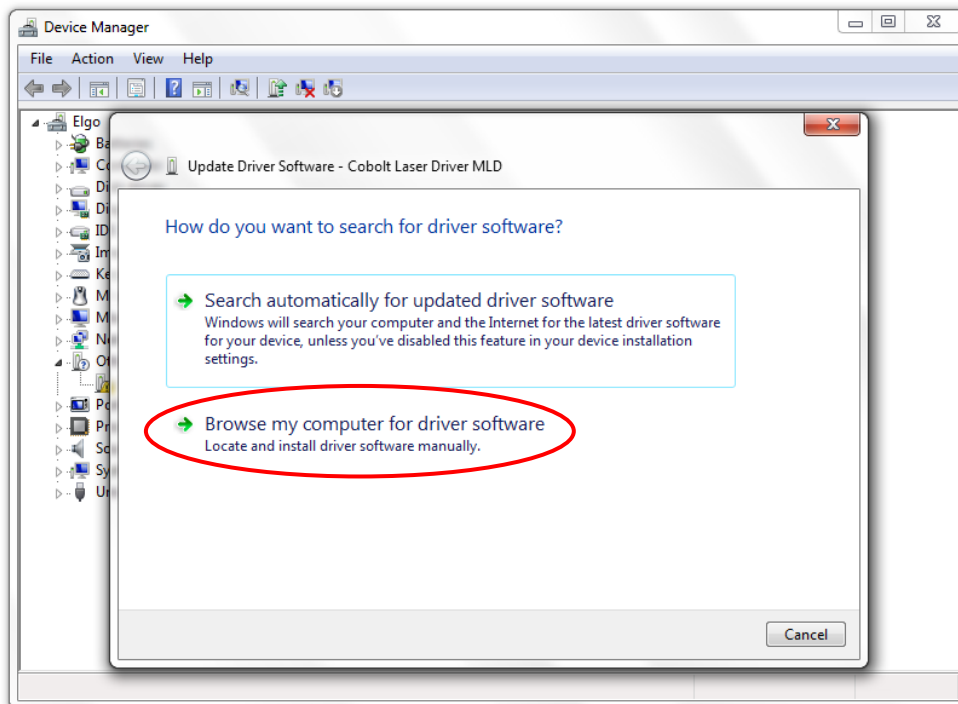
1. Go to the **Control Panel** and choose **Hardware and Sound**.
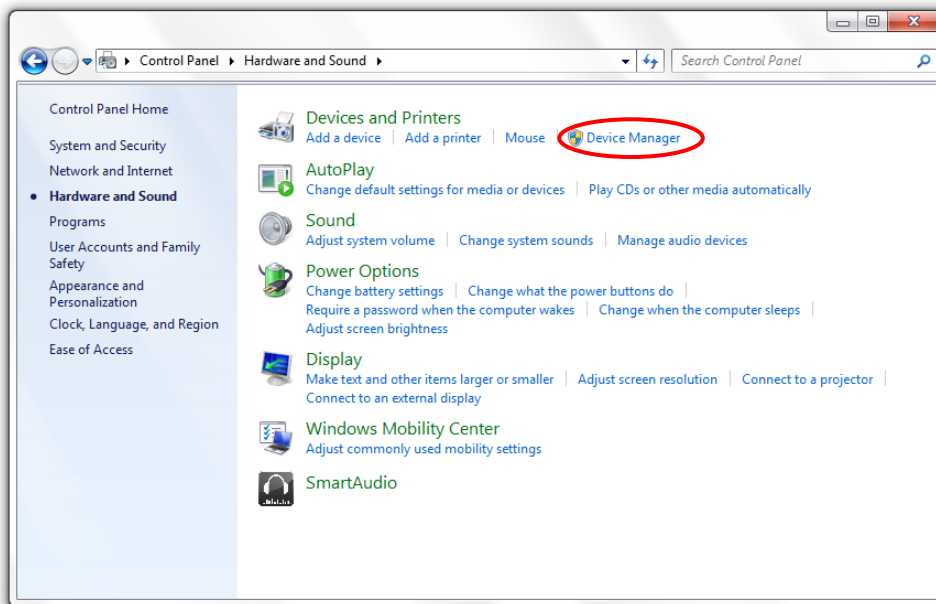
2. Under the **Devices and Printers** section, choose **Device Manager**.

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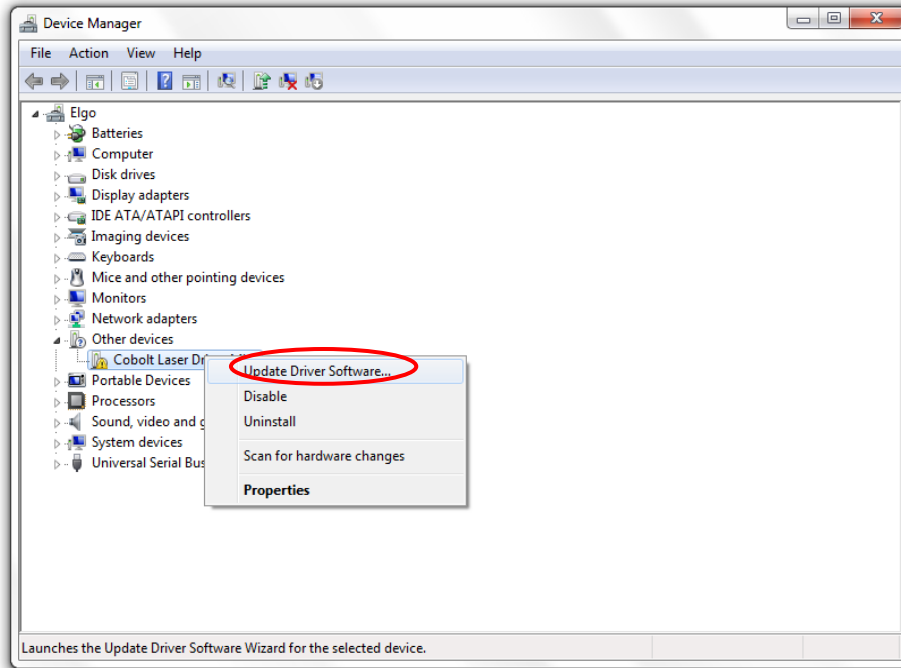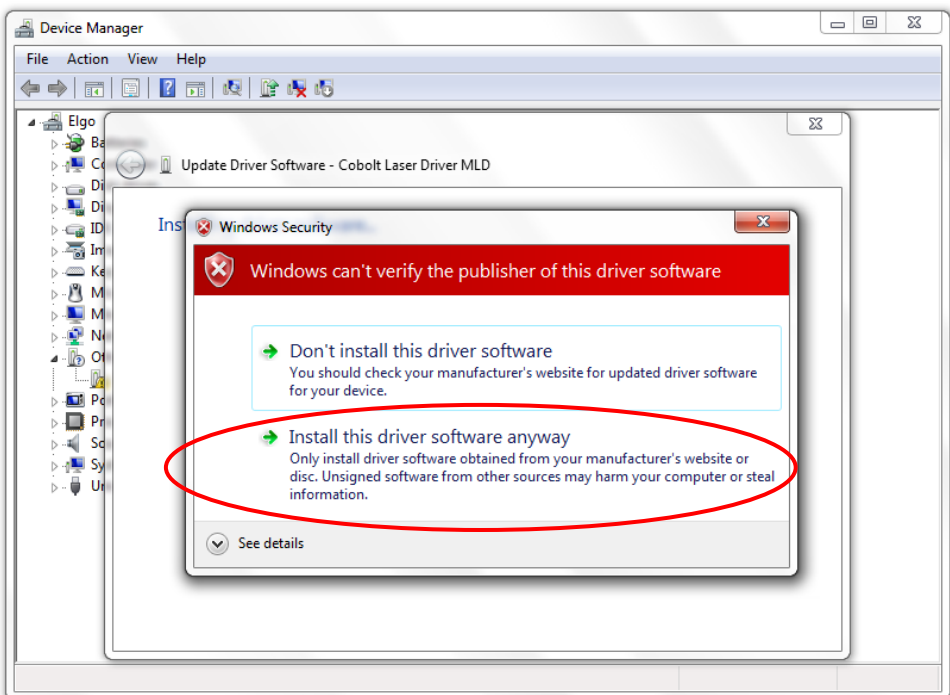

4. On the next screen chose the **Browse my computer for driver software** option.

5. Click **browse,** and find folder on your computer where the USB driver is stored.
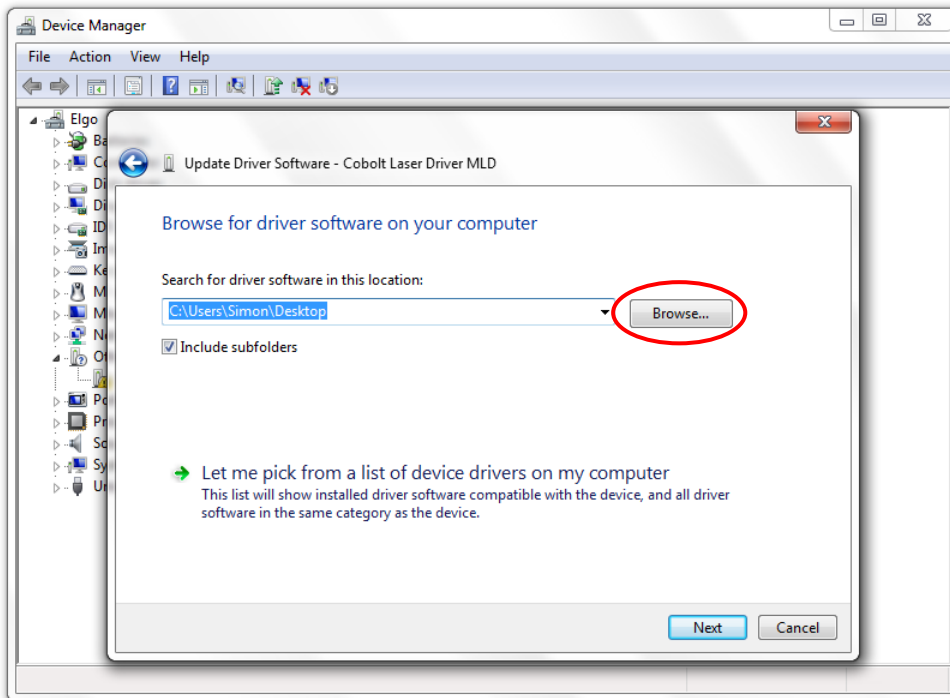
6. Windows security may warn you that the publisher of the driver is unverified. Choose **Install this driver software anyway**.

7. The installation should now be complete.

7.4. Communication commands

The laser is delivered with the Controller set in Auto-start mode (see section 5.1 for Auto-start sequence description). For system integration the Auto-start sequence can be disabled and the following commands can be used to control the laser (NOTE some commands require Auto-start to be disabled but others will work when Auto-start is active). As long as power is supplied to the Controller the temperature control elements are always operating to reach set-point values and the laser will be idle waiting for the next command. All arguments are in lower case and separated by a space (ASCII 32).

Command	Function	Argument	Returned value
ilk?	Get interlock state		0 = OK, 1 = remote interlock open
@cob1	Laser ON after interlock Forces the laser into Autostart without checking if autostart is enabled (OEM models).		
@cobas	Enable/disable autostart See sect 5.1 for description (to be used on OEM models only, disabling autostart means the laser no longer goes through its warm up routine).	0 = disable, 1 = enable	
@cobas?	Get autostart enable state		0 = disabled, 1 = enabled
l?	Get laser ON/OFF state		0 = OFF, 1 = ON
l1	Laser ON Requires autostart disabled. Use this command for manual ON (OEM models).		
lo	Laser OFF Use this command for manual OFF (OEM models).		
p?	Get set output power		Float (W)
p	Set output power	Float (W) (e.g. p 0.050 for 50 mW)	
pa?	Read output power		Float (W)
i?	Get drive current		Float (A)
slc	Set drive current	Float (A)	
leds?	Status of 4 LEDs		Int [0:15] Bit 0 = "POWER ON" Bit 1 = "LASER ON" Bit 2 = "LASER LOCK" Bit 3 = "ERROR" 1 = LED on 0 = LED off
f?	Get operating fault		0 = no fault 1 = temperature error 3 = open interlock

			4 = constant power fault
cf	Clear fault		
@cobasdr	Enable/disable direct control See section 4.4 for description (OEM models).	0 = disable, 1 = enable	
@cobasdr?	Get direct control enable state		0 = disabled 1 = enabled
sn?	Get serial number		32-bit unsigned integer
hrs?	Get system operating hours		Float

For re-starting the laser with commands after having opened the remote interlock switch, execute "cf" for clear fault followed by "@cob1" to restart the laser. This command forces the laser into Auto-start enabled so Auto-start must be disabled if this is the required set up. On CDRH models the key switch is the only way to re-start.
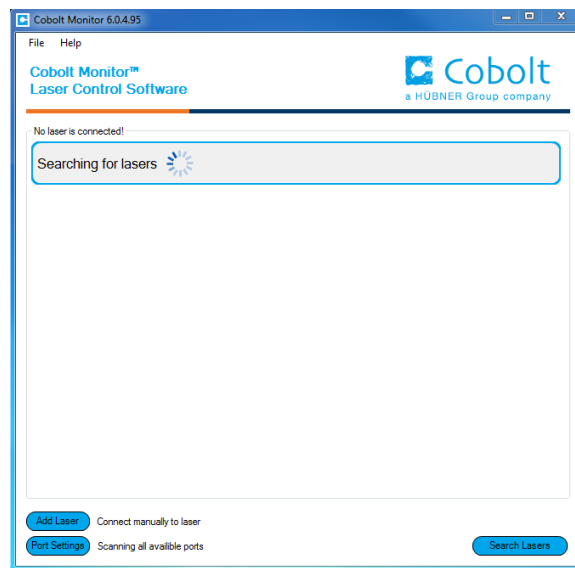
8. Cobolt Monitor™ Software

The Cobolt Monitor™ software provides a graphical way to monitor the laser performance and to change power, operation mode and other settings. The software can connect to the laser either via RS-232 port or via USB, depending on the type of controller. The USB driver must be installed manually and can be downloaded from the Cobolt website (www.cobolt.se), see section 7.3. Cobolt Monitor™ has been tested with operative systems Windows XP, Windows Vista, Windows 7 and Windows 8. Microsoft .NET 2.0 is required to run the Cobolt Monitor™ software. Most computers with operative systems Windows XP, Windows Vista, Windows 7 and Windows 8 have this included as standard.

8.1. Installation

Download the latest version of software Cobolt Monitor™ from the www.cobolt.se. 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 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.

8.2. 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 Cobolt Monitor software.

Once the laser is connected it can be controlled from the box dedicated for the laser. The interface, found in the following figure, is intended for typical user cases. Only the relevant information is presented on this level, displaying only the status the laser is in and relevant choices to make. Here follows a short description of how to use the Cobolt Monitor™ software on this level.
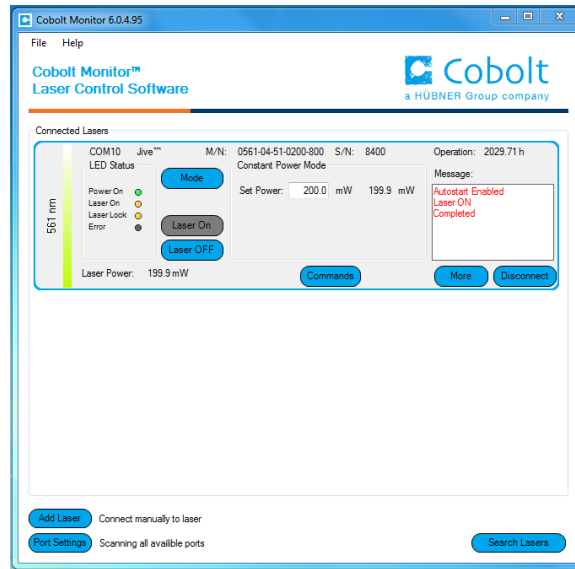
Laser successfully connected.

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 04 series lases Constant Power or Constant Current operation can be chosen. Only relevant choices are presented to the mode of operation chosen.

Commands – opens a command communications window to send commands directly to the laser controller.

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.

! Note: The communication cable should not be removed when the software is in connect state. The communication within the controller 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.

Clear Fault - is displayed in the event of a fault. The user can deal with 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".

More –an additional Cobolt Monitor™ window will open containing more detailed information of that laser's status.
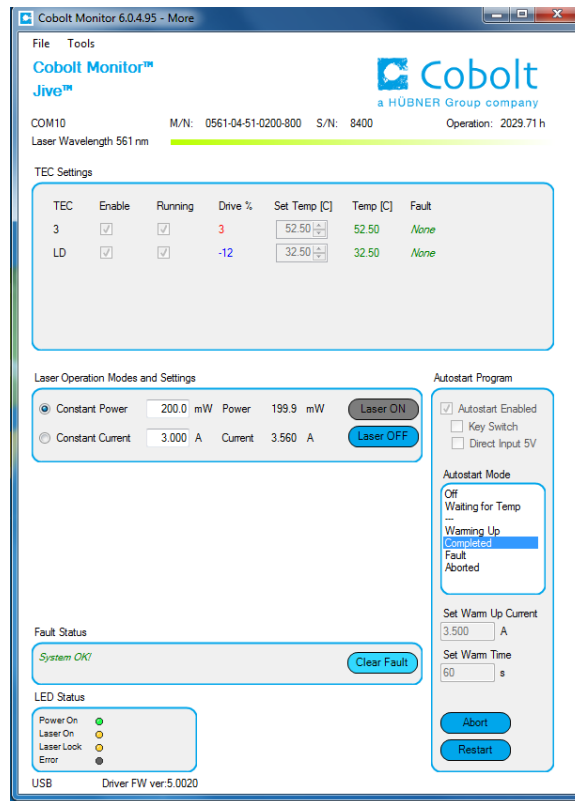
Cobolt Monitor™ software expanded to for more detailed monitoring.

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 and constant current mode. Likewise, there are boxes to set the constant power level and constant current level. The output power (as monitored measured on an internal photodiode) and the current through the laser pump diode are both displayed.

Autostart Program - displays whether the laser is in CDRH or OEM mode and displays the current laser operational status. 5V direct input is set here, see section 4.4. There are also buttons to "abort" the autostart sequence or to "restart" the laser after a fault.
! **Note** Specifications are only guaranteed in constant power mode, at 100% of nominal power.

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.

LED Status - displays the LEDs that are currently illuminated on the Controller, see section 3.4. These are displayed even if the laser is in OEM mode.

9. Troubleshooting

In the unlikely case of a problem occurring, use the table below to help identify the error. Some faults can be fixed remotely. Back reflections into the cavity can cause instability of operation. Isolators are available as an option. In case of a sudden voltage drop the laser will turn itself off and restart. If it is in CDRH configuration it will require that the key is turned on again. Contact Cobolt support or your local representative to identify corrective action.

LEDs	Status		Explanation	Action
	off	flashing		
POW	x		Mains power off	Check connections
POW		x	Temperatures not stabilized	Check if heatsink is sufficient
LOCK		x	Laser cannot lock in constant power, current limit has been reached	Check for back reflections. Contact the factory.
ERROR		on	Error in laser parameters	If lights at start-up check cable connections, if lights >5s after start-up contact the factory.

10. Warranty and Maintenance

Cobolt provides a warranty of 12 months on faulty workmanship and 24 months on the laser itself, with unlimited number of operation hours. The laser systems are designed for modular repair or replacement in the event that the Laser Head or Controller malfunctions. Warranty is invalid if the laser system is operated outside of the specific limits and conditions as outlined in this document.

The Cobolt lasers are contained in sealed enclosures and should not be opened for any reason. Disassembly of any part of the system (including the cable) means the system no longer complies with the EMC standards will void the warranty. All laser parameters are set at the factory, and there are no adjustments required. Maintenance is limited to wiping dirt off the enclosures and cleaning the aperture.

11. Service

Due to accuracy tolerances, calibration differences and allowed power drift there may be discrepancies between the Cobolt measurement of the optical output power and the customer measurement equipment. If the output power deviates from the reported value please contact your local Cobolt representative for an online re-calibration. If the laser does not function, do not attempt to open any of the units, or the warranty will be voided. Contact your local Cobolt representative for consultancy and to request an RMA number (see back cover for contact information). If an RMA number us issued and the laser needs to be shipped back to Cobolt 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 Cobolt.

12. Compliance (CDRH models only)

The CDRH model lasers (-5/700) 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, controller, key, 1m controller cable, AOM driver, 0.2m RF cable, 0.2m digital modulation cable, 1m analogue modulations cable and Cobolt-supplied power supplies. All equipment must be mounted on a common ground plane, such as an optical table. The equipment might not conform to the EC directives if any part of the supplied equipment is replaced with a part not supplied by Cobolt or if the equipment is not properly grounded. Disabling any of the safety features nullifies the CE marking and the laser safety standard.

CE

The following harmonized standards are in use:

Electrical Safety: EN 61010-1, IEC-61010-1, UL 61010-1

Laser Safety/Class: IEC-60825-1 , CDRH 21 CFR 1040.10 and 1040.11

EMC: IEC 61326-1
                          EN55011 class A
                          EN61000-4-X, where X=2,3,4,5,6 and 11
                          FCC Part 15, subpart B, class A

All Cobolt products are RoHS compliant as defined by the EU Directive 2011/65/EU.

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

13. Disclaimer

Cobolt will assume no responsibility for damage incurred by faulty customer equipment, such as measurement equipment, cables etc, used in conjunction with Cobolt lasers. Cobolt makes no warranty of any kind with regard to the information contained in this guide, included but not limited to, implied warranties of merchantability and suitability for a particular purpose. Cobolt 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 Cobolt.

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