

User's Manual

INTRODUCTION

The 'MatchBox 2' series is a major platform upgrade of market beloved 'MatchBox' series, which includes a range of continuous wave laser sources, featuring wide range of wavelength, output power, output type and line-width options.

The series is composed of solid state (DPSS) lasers as well as direct laser diode (LD) lasers. Despite the different technical implementation, physical and electrical properties, usability and connectivity are almost identical throughout the series. Therefore, Integrated Optics, UAB provides a single user manual for the entire series and emphasis on differences between models is provided wherever necessary.

As the title hints, MatchBox products are ultra-compact, single-unit laser sources with overall dimensions comparable to a regular matchbox ($30 \times 50 \times 16 \text{ mm}^3$, not taking into account the connector pins).

Please take your time to read this instruction manual which provides essential information on the usage of the laser. We have also included various hints and tips that will help you get most from a certain laser source.

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1. SAFETY INFORMATION

1.1: Electrical safety

Do not disassemble the enclosure. All units are designed to be operated as assembled. Warranty will be voided if the enclosure is disassembled.

Electric shocks from an unsuitable or poorly grounded power supply, can cause extreme pain, severe burns, cardiac arrest and can even be lethal, that is why the operator should always obey the safety measures below.

The laser body of MatchBox is connected to the ground - all internal electronics share the same ground of the laser body.



User must make sure that the power supply used with MatchBox laser has grounded pin connection (preferably a medical type power supply) and is well grounded and that there are no grounding interruptions with other devices, because it can be dangerous for the operator and cause malfunction of the laser.

1.2: Optical Safety

Light, emitted from a laser source features hazardous properties, as compared to conventional light sources, such as luminescent bulbs, light emitting diodes, etc. It is important for users, who use a laser system, or other persons approaching it, to know the dangers involved. Only users, who are familiar with laser safety should use the laser system to minimize the risks of laser radiation-related accidents.

MatchBox lasers are Class 3B or Class 4 laser products. Different models are arranged to emit up to 500 mW of visible or invisible (infrared) radiation. Several models emit CW or pulsed laser radiation up to 1 W of optical power.



The radiation is hazardous if the eye is exposed directly to the beam or to specular reflection thereof. The risk of permanent eye damage or even blindness increases with longer exposure times.

Diffuse reflections as those from paper or other matte surfaces are typically not harmful if viewed at a distance of 1 m (3 ft) or larger.

The use of eye protection when operating the MatchBox laser is necessary if at any circumstances the laser beam could be exposed to eye directly or through a specular reflection.

Eye protection in the form of spectacles or goggles with appropriate wavelength filtering is preferred. For example, eyewear absorbing in the spectral region 180 to 532 nm are suitable for working with e.g. 405 nm, 457 nm, 473 nm, 488 nm, 491 nm, 515 nm and 532 nm MatchBox lasers, but probably will not suit 561 nm, 593 nm or radiation of the red and infrared regions.

Use of protection eyewear provides another significant advantage - when working in dark rooms, laser radiation may haze your eyes even if observed from diffuse reflections. Properly chosen eyewear will reduce or even eliminate such haze and extend productive hours.



The beam emitted from Class 3B lasers can easily damage photosensitive surfaces like those found in photodiodes, CCD cameras or photomultipliers. It is important to make sure that an unattenuated beam does not strike any of aforementioned devices directly. Calculation of allowable fluency is necessary before using such devices with our lasers.

In addition to laser safety from the laser source alone, following safety precautions must be followed:

- Experimental setups must ALWAYS be horizontal and below eye level;

- To avoid accidental exposure, never bend over or sight down. If something falls down from experimental setup, user must first turn off the laser and just then pick up;
- Use protective shields or filters to get rid of unnecessary reflections and scattering;
- User should never wear jewels, watches while using the laser system to avoid the reflections from surfaces thereof;
- The laser system must be used in a closed room, because high power and collimated laser beam can damage biological tissues even at long distances;
- Extreme caution must be taken when using volatile substances in laser operational area;
- High level of ambient light in laser operating room should be maintained whenever possible, in order to keep the pupil of the eye as small as possible and to prevent the risk of eye damage;
- Warning signs must be posted near the entrance to the laser operation area and inside;
- Use of laser must be limited to users, who are completely familiar with the rules above.

1.3: Laser Safety and Classification

The European requirements for Electromagnetic Compatibility (EMC) are specified in the EMC Directive (published in 2004/108/EC).

Conformance (EMC) is achieved through compliance with the harmonized standards EN55011:2009 for emission and EN61000-6-1:2007 for immunity.

The laser meets the emission requirements for Class 3B or Class 4 as specified in EN55011:2009.

Compliance of lasers within the MatchBox series with the (EMC) requirements is certified by the CE mark.

The MatchBox lasers are OEM dedicated lasers and usually come without necessary safety means. OEM type products are designed for installation into Class 1 enclosures. However, by adding accessories like beam shutter and key-switch, CDRH compliance is reached.

The MatchBox laser alone has a simplified physical interface with just 5 pins. These pins have power supply, communication bus (UART) and modulation/fan (predefined for different laser types) inputs. This interface is sufficient and convenient for OEM laser integration.

However, for quick laser installation into scientific setups an additional box is needed to provide necessary interlock, USB control, modulation or fan connector, complying the CDRH requirements.

1.4: Labels

Along the text you will find icons designed to draw your attention to different bits of safety or otherwise important information:



This icon draws your attention to important information, related to the usage of a laser.



This symbol is a warning sign. It marks safety precautions related to optical laser radiation and alerts the operator to the danger of exposure to hazardous visible or invisible laser radiation.



This symbol is a warning sign. It marks safety precautions related to electrical safety and alerts the operator to the presence of dangerous voltage, which might appear on certain conditions. Electric shocks caused by such voltage may constitute risk both to the operator and equipment used.



Figure 1-1. Labels on a side of the laser indicates product safety information. MatchBox lasers belong to the class 3B or class 4.



Figure 1-2. Serial number is marked on the back of the laser body, right above the connecting pins.

2. DESCRIPTION AND SPECIFICATIONS

2.1: Part Numbers

The part number is composed as follows for the MatchBox series lasers:

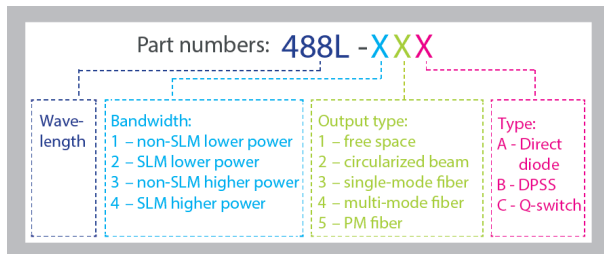


Figure 2-1. Understanding part numbers of the MatchBox series.

2.2: Description of Series

MatchBox laser system incorporates the finest laser technology with high quality direct diode and DPSS system manufacturing techniques.

The MatchBox laser system contains laser source with integrated power electronics, external +5 VDC power supply and interface cables. The system can be mounted to a heatsink accessory and a 'Breakout Box' can be used for convenience. The MatchBox laser system provides power, consistency and great performance in one of the smallest packages at one of the most attractive price levels available in the market.

The heatsink accessory might be needed for cooling to a maximum ambient temperature of 40 °C. Also, it can be used as an adapter for

mounting the MatchBox laser system to the optical table. None the less, heat sink provides a perfect foundation for the laser source, maintaining the specified system pointing stability and capability to mount accessories. Also, some heatsinks include a controllable speed fan cooler. It is recommended for high power diode and most DPSS lasers in the MatchBox series.

For quick laser installation into scientific setups an additional box is needed to provide necessary interlock, USB control, modulation or fan connector. We call it 'Breakout Box'. It can be attached directly to the pins as shown below.



Figure 2-2. The 'Breakout Box' attached to the MatchBox laser.

2.3: The 'Breakout Box'

The so called 'Breakout Box' is depicted in Figure 2-2. The 'DATA' port is suitable both for power and control of the laser while the second USB port is dedicated for additional power supply. Lasers requiring more than 2.4 amps of current should be connected using both USB ports or a desired power socket can be arranged on flying leads.

The 'Breakout Box' also has interlock pinheads, which are originally provided with a jumper. The jumper can be easily replaced with appropriate Dupont type wires leading to electromechanical part of an interlock. The fan socket receives a PWM signal from the laser, based on the temperature of the laser body. If the body is in its optimal temperature range, the fan stays still, thus eliminating any possible noise or vibration. But if the laser body gets hot, the fan starts to rotate aiming to keep the body temperature as close to the optimum as possible.

The fastening bolt serves for a reliable fastening of the Box and protects it from the detachment in case the cables are pulled.



Pay attention that not all USB cables are suitable for powering up our lasers. We recommend cables rated 2.4 Amps of current. Such cable is included with every laser.

2.4: Thermal Management

The MatchBox series includes DPSS and direct diode lasers, whereas the higher power DPSS lasers tend to generate more excessive heat than the diode lasers.

Depending on model, one or two thermo-electric coolers (TEC) are equipped inside the enclosure for thermal management of a pump laser diode and associated optics. Thermal stabilization of all critical components is very important for low-noise and efficient operation of the complete laser.

Depending on laser configuration, cooling of 5 to 25 W (5 W for most diode lasers and 10 to 25 W to DPSS) may be required in a form of conduction-cooled or water-cooled heatsink, attachable to the bottom side of the laser.

Also, depending on model, a suitable heatsink must have low thermal resistance. For DPSS lasers thermal resistance of $<0.5 \text{ }^{\circ}\text{C/W}$ is

recommended, while for diode lasers $<1\text{ }^{\circ}\text{C/W}$ is sufficient. $<0.5\text{ }^{\circ}\text{C/W}$ requirement is usually met by a larger passive copper heat sink or an actively cooled aluminium heat sink.

As an accessory, Integrated Optics, UAB offers few heatsinking solutions, including self-sufficient forced air cooler, water-cooled adapter plate and breadboard adapter plate. Both adapter plates are used to fasten the laser to a standard 25 mm M6 thread pattern of a standard optical table or breadboard. Additionally, Integrated Optics, UAB offers adapter plates, which help to accommodate the MatchBox laser in place of previously installed laser of other brands.



For efficient cooling, make sure that there are no other heat radiating devices, such as heat exchangers, heaters or computers in the proximity of the laser.



For efficient cooling, make sure that the laser is not covered with or obstructed by any obstacles, which could prevent air circulation around the laser.



All MatchBox lasers are equipped with internal thermal protection feature. If the internal temperature reaches $45\text{ }^{\circ}\text{C}$, the laser shuts down or starts to blink. If this happens, turn off the laser and ensure better heat dissipation by decreasing the heat-sink temperature and increasing the heat-dissipation capabilities thereof.

2.5: Power Supply

The MatchBox series includes a variety of lasers featuring different power ratings, thus requiring different power supply parameters. Power supply requirements are provided below.

Table 2-1. Power supply requirements regarding laser type.

Type	Part No.	MAX Current at 45 °C	Typical Current at 25 °C
DPSS	L-XXB	4 A	1-2 A
LP Diode	L-1XA and L-2XA	0.6 A	0.2-0.4 A
HP Diode	L-3XA and L-4XA	1 A	0.4-0.5 A

Voltage of 5 V is needed for these types of MatchBox series lasers.

Lasers of the same model could require different current. For instance low-power laser 405L-21A needs maximum current of 0.6 Amps and typical of 0.3 Amps, whereas it is estimated that low-power laser 785L-21A needs maximum current of 0.3 Amps and typical of 0.2 Amps.

To understand the specifics of power supply requirements for your MatchBox laser more in depth, power supply requirements regarding laser type during start-up are depicted below.

Table 2-2. Power supply requirements regarding laser type during start-up.

Type	Part No.	MAX Current at 45 °C	Typical Current at 25 °C
DPSS	L-XXB	3.5 A	2-3 A
LP Diode	L-1XA and L-2XA	1.8 A	1-1.2 A
HP Diode	L-3XA and L-4XA	2.2 A	0.8-1.2 A



Current values are not absolute for all lasers and can vary from laser to laser.

2.6: Cables

As seen in section “Power Supply” on page 14, different types of lasers require different power supplies, hence different cabling for MatchBox laser system is required in some cases.

The MatchBox laser system includes a standard USB cable (A type to micro) as an interface cable. The interface cable is connected through control USB port to a computer.

The MatchBox laser system supports two types of power supplying: via ‘DATA’ port and via ‘POWER’ port. Both ports are ‘micro’ USB type, only ‘DATA’ port is connected to a computer and is used for both power

supplying and communication, whereas 'POWER' port has to be connected to a regular power source, say a regular electrical network.



Free space lasers starts instantaneously when power is applied.



Fiber coupled lasers must be turned on via MatchBox laser control software.

As MatchBox series lasers are OEM dedicated lasers, there are many cabling solutions, but most common for diode lasers are:

1. laser-computer connection via 'DATA' port;
2. laser-power source connection via 'POWER' port;
3. laser-computer-power source connection via both 'DATA' and 'POWER' ports.

As for DPSS lasers:

1. flying leads with female ID 2.1 x OD 5.5 connector, provided by Integrated Optics, UAB;
2. laser-computer-power source connection via both 'DATA' and 'POWER' ports.



Most suitable cabling solution is offered by MatchBox distributors or Integrated Optics, UAB.

2.7: Power and Signal Connections

The MatchBox laser alone has a simplified physical interface with just 5 pins (Figure 2-3). These pins have power supply, communication bus

(UART) and modulation/fan (predefined for different laser types) inputs. This interface is sufficient and convenient for OEM laser integration.

All MatchBox lasers, are powered from a +5 V DC power supply. Depending on wavelength, output power and temperature of a mounting surface the laser might require up to 5 Amps (25 W) power supply.

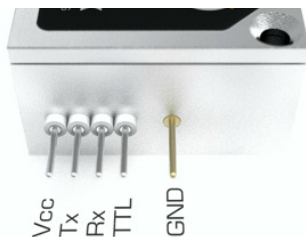


Figure 2-3. Connecting pins with 2.54 mm spacing on the back side of the laser; pinout left to right.

Viewing left-to-right, the pins are dedicated for: first pin is for +Vcc, next two are UART bus interface pins Tx and Rx, then follows a multifunctional pin (TTL modulation or fan speed control).

An empty slot is used as a key, ensuring that the female pinhead connector will not be inserted in a wrong orientation or position.

The fifth pin works as a ground. The ground pin is soldered into the enclosure of the laser, thus complete laser body is grounded.

2.8: Specifications

The MatchBox series includes a variety of lasers featuring different wavelength and power ratings. The complete specifications of the laser radiation are provided together with a certain laser, which is sold to the customer. Further some general specifications will be provided.

BEAM PROPERTIES:

- Transversal mode: TEM00, except 500 mW versions of 532 nm and 785 nm
- Beam diameter at aperture ($1/e^2$): <2 mm for diode and ~1 mm for DPSS
- Beam divergence (full angle): <2 mrad for diode and <1.5 mrad for DPSS, except 500 mW versions of 532 nm and 785 nm
- Beam pointing stability: <1 mrad/°C
- Bore sight error: +/-2 mrad (vertical), +/-3 mrad (horizontal)
- Beam quality, M2: <1.3, except multimode 500 mW versions of 532 nm and 785 nm
- Polarization ratio: better than 500:1

POWER STABILITY:

- Power stability of free-space lasers is <1 % RMS over 8 hours
- Power stability of fiber-coupled lasers is <2 % RMS over 8 hours
- Non-SLM DPSS lasers have significant noise peaks at above 200 kHz

MODULATION:

- Broad spectrum diode lasers can be modulated up to more than 10 MHz via TTL pin (this feature is not a standard one and is implemented on request)
- For SLM diode and all DPSS lasers, the TTL pin is configured for fan speed control
- DPSS lasers can be modulated at low frequencies (up to few kHz) but modulation is implemented upon request

FIBER SPECS:

- SLM fiber coupled lasers are made with FC/APC connectors
- Non-SLM lasers are made with FC/PC connectors
- Standard length of a fiber is 1 m to 1.1 m
- Polarization extinction ratio (PM fiber): better than 20 dB
- Polarization rotation (PM fiber): less than 5 degrees

PHYSICAL PROPERTIES:

- Control interface type: UART serial bus, convertible to USB with standard accessories
- External power supply requirement: +5 VDC, 5 A for DPSS, 1.5 A for diode up to 200 mW
- Dimensions (WxDxH): 30 x 50 x 16 mm (excluding pins and output window)
- Beam height from the base: 10.4 mm (+/- 0.3 mm)
- Heatsink requirement: diode <1 °C/W, DPSS <0.5 °C/W

- Optimum heatsink temperature (non-condensing): +15...+30 °C
- Max. heatsink temperature 40 °C
- Internal temperature stabilization: TEC
- Overheat protection: Yes
- Storage temperature (non-condensing): -10 to +50 °C
- Warranty: 12 months
- Hours limitation of 5000 hours applies for 405, 445, 488, 515, 633, 635, 660 nm diode lasers. Operational time calculation is based on an internal EPROM counter

COMPATIBILITY:

- ROHS
- General Product Safety Directive (GPSD) 2001/95/EC
- Electromagnetic Compatibility (EMC) Directive 2004/108/EC
- IEC60825-1:2014 (compliant only using additional accessories)

2.9: Mechanical Design

The laser sources within the MatchBox series employ a single-box design, which means that all optics, power electronics and thermal management components are located within a single enclosure.

The overall dimensions of the laser are 30 x 50 x 16 mm³ (WxDxH), not taking into account the connecting pins, which are used for connecting the laser to a power source and control interface. The pins extend approx. 10 mm from the back of the laser. Different output options, such as free-

space output with or without a mechanical shutter, permanently fixed fibers, have different arrangements on the front facet of the laser.

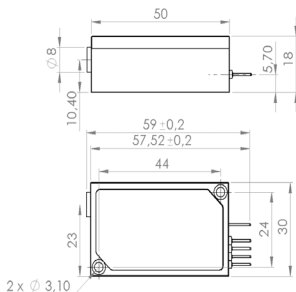


Figure 2-4. Top and side view drawing of the MatchBox laser, free-space output option.

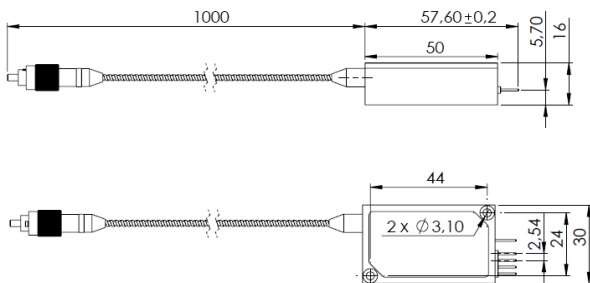


Figure 2-5. Top and side view drawing of the MatchBox laser, fiber coupled output option.

2.10: Laser Output Options

MatchBox laser sources are offered in two main configurations with respect to the type of output.

Free-space output is commonly used in compact (portable) laser setups, where working area (an object to be irradiated) is relatively close to the laser source and the beam could be delivered directly or using just few mirrors.

Furthermore, the free-space output versions are provided with a PTFE safety cap (not shown in pictures), which might be necessary for a scientific open-frame setup. The cap must be attached to the output window, whenever the laser is not in operation or it could be shut for a short period of time, in case minor adjustments need to be made without stopping the laser, thus stable operation is not lost.

In all other cases, it is advisable to trigger the interlock function found on all attachable control interfaces of the MatchBox laser.

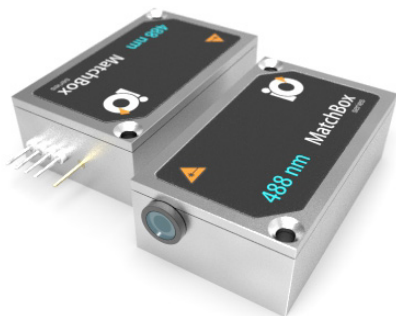


Figure 2-6. Free-space output version of the MatchBox laser.

Permanent fiber pigtailed output has few modifications, though it looks essentially similar. The difference is in the fiber type, which is represented by the indicating colour. Multi-mode (orange), single-mode (yellow) or single-mode polarization maintaining (blue) fiber could be arranged with this output type.

It is readily used in microscopy and diagnostic setups, where few laser sources are placed in a distance from the analytical device, e.g. a microscope, and radiation of several wavelengths is delivered to the microscope via optical fibers.

Lasers with non-detachable fibers feature lower output power, and 2-3 times worse output power stability, as compared to free-space versions.



Figure 2-7. Fiber pigtailed output version of the MatchBox laser; blue fiber jacket represents a polarization maintaining fiber type.

2.11: Line-width Options

Most of MatchBox lasers are offered in two line-width options - broad and narrow, in other words, featuring respectively multiple longitudinal modes or single-longitudinal mode (SLM). In all cases, the broad line-width option means, that no additional measures were taken to narrow the emission spectrum - it is as radiated by a laser diode (in direct diode lasers) or a gain medium (in DPSS lasers). The narrow line-width option means that special measures were taken in order to force (or filter) radiation of just single longitudinal mode (SLM in DPSS lasers) or just stabilized wavelength and one or just few longitudinal modes (in direct diode lasers).

2.12: Operating Environment

MatchBox lasers are designed to be operated in non-condensing environment, in temperature range between 15 and 30 °C. Whether the customer needs to operate the laser at higher temperature, such option has to be provided by Integrated Optics, UAB during assembly of the laser. The temperature range can also be extended by attaching the laser to a cold plate, which has surface temperature in the aforementioned range and good thermal conductivity parameters.

Dusty environment might cause collection of debris on an output window of the laser. Therefore special maintenance, such as cleaning of the exterior of the output window must be performed from time to time in order to keep the laser power within the desired power range and extend the lifetime of the laser.

3. INSTALLATION

3.1: Preliminary Checks

Every MatchBox unit is packed in an antistatic foam package, which is arranged to protect electronics inside the laser from charge accumulation and is absorbing mechanical shocks well during transportation. Further the foam is packed into a carton.



Figure 3-1. The package of a MatchBox laser.

Make sure that shipping boxes do not have any signs of damage. In case of inspected damage, do not accept the package. Such case scenario should be immediately reported to the shipping carrier, to Integrated Optics, UAB administration or to an authorized MatchBox distributor.

During unpacking, keep the box in a horizontal position. In order to see the laser, carefully remove the upper part of the foam inlay, which contains accessories and cables.



After unpacking, save the shipping boxes for potential later shipments.

Table 3-1. Contents of a typical package.

Item	Quantity
Laser Source	1 unit
Breakout Box	1 unit
Standard USB Cable	1 unit
Thermal Grease	1 unit
Countersunk Screws of M2.5x20 mm	2 units
Button-head screw of M2.5x12 mm	1 unit
Hex key: 1.5 mm; BN:1169; DIN:911	1 unit

Note: one of the screws comes in slightly different shape and colour. It is used for mounting the breakout box to the adapter.

Power supplies and bigger accessories, such as heat-sinks, other options of 'Breakout Box' (RS232, key-switch) or external control interfaces, if provided, are packed separately.

3.2: Heatsink Requirements

To ensure satisfying operation and for the warranty to be valid, the MatchBox laser must be attached to a heat sink providing a required thermal resistance. Various types of MatchBox lasers have different thermal resistance requirements, depicted in Table 2.

Integrated Optics, UAB recommends to use a thermal grease between the MatchBox laser and the heatsink to provide proper thermal contact.



The mounting surface of the heat sink should be flat within <0.05 mm over the mounting surface.

See section “ACCESSORIES” on page 53 for more details about types of heatsinks offered by Integrated Optics, UAB.

For assistance in thermal management and system integration, please contact Integrated Optics, UAB technical support.

Table 3-2. Power supply requirements regarding laser type.

Type	Part No.	Optimum Heatsink Temp	Thermal Resistance
DPSS	L-XXB	15-30 °C	0.5 °C/W
LP Diode	L-1XA and L-2XA	15-30 °C	1 °C/W
HP Diode	L-3XA and L-4XA	15-30 °C	0.5 °C/W

3.3: Heatsink Installation

The MatchBox series includes DPSS and direct diode lasers, whereas the higher power DPSS lasers tend to generate more excessive heat than the diode lasers.

Furthermore, all MatchBox lasers are equipped with a TEC (Peltier) thermal management, which, when operated, generates even more heat to stabilize optical cavity and electronics inside the laser, thus it is required to attach the laser enclosure to an external heat-sink, such as an aluminium breadboard or a water cooled plate. Optimal enclosure's temperature is 26-28 °C for most effective operation.



In case a laser installation does not meet heatsinking requirements, internal thermal protection stops the laser operation whenever the internal (laser diode) temperature reaches around 40 °C.

As an accessory, Integrated Optics, UAB offers few heatsinking solutions, including self-sufficient forced air cooler, water-cooled adapter plate and breadboard adapter plate. Both adapter plates are used to fasten the laser to a standard 25 mm M6 thread pattern of a standard optical table or breadboard. Please contact us for purchase.

In order to operate the heatsink appropriately, please follow these steps:

1. Secure the heatsink with M6 bolts to desired location. Ensure that proper air flow is granted.
2. Apply thin layer of thermal grease to the interface between the laser and the heatsink.
3. Connect the breakout box female cavities to the MatchBox laser head male pin connectors.

4. Mount the MatchBox laser head to the heatsink with the M2.5 screws.
5. Connect laser with required power supply. See section "Power Supply" on page 14.
6. If needed, proceed to section "Starting the laser" on page 31.



For the best performance, screws for fixing the laser to a mounting plate should be screwed with tightening torque of 0.25 - 0.35 N·m.

3.4: Starting the laser



No user adjustments are possible inside the laser. Never open the laser module. Any attempt to open the laser module will damage it and render the warranty void.



Maintenance of the product is done exclusively by Integrated Optics, UAB personnel.

1. Make sure that the MatchBox laser head, breakout box and the heatsink are secured in place according to the instructions in section 3.3: Heatsink Installation.
2. Download a MatchBox control software from the web directory of Integrated Optics, UAB. For this download please contact us at sales@integratedoptics.com.
3. In order to install the software, extract installation files from a RAR compressed folders and run the file 'Setup'.

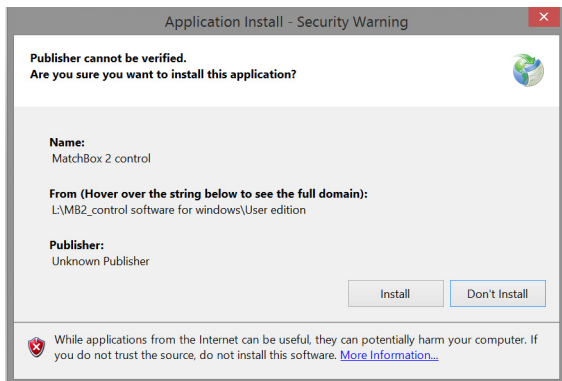


Figure 3-2. Initial installation window.

4. After the installation procedure, run the control program. It can be launched by finding 'MatchBox Control' among installed programs or by searching this in a search field of Windows.
5. Connect 'micro' type USB cable to the 'DATA' port of the breakout box and the USB connector to a computer.
6. If your MatchBox laser source requires more than 2.4 A current (see section "Power Supply" on page 14), connect additional USB cable to the 'POWER' port of the breakout box and the power supply.
7. Press 'Search Device->Find device'.

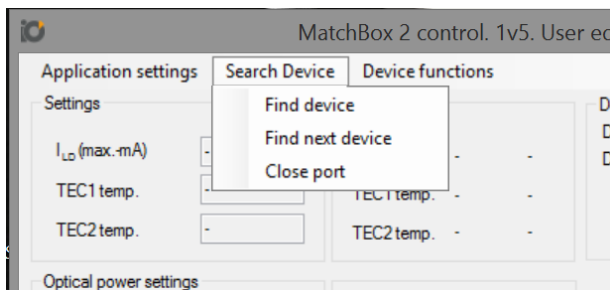


Figure 3-3. In order to detect the laser and start communication, press 'Search Device ->Find device'.

8. Laser is now ready to operate.

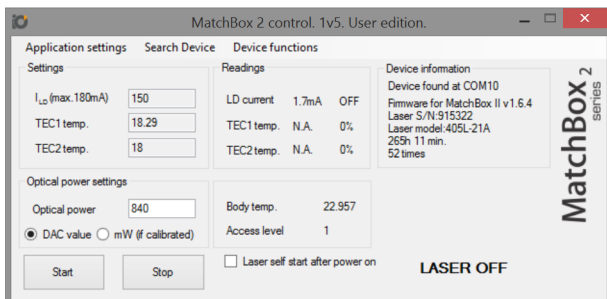


Figure 3-4. Once the laser is identified, the fields are filled with information.

See section "Laser Control Software" on page 37 to learn about the use of the control software.

For assistance in thermal management and system integration, please contact Integrated Optics, UAB technical support.

4. OPERATION

4.1: Operating Fiber Coupled Laser

Fiber coupled laser diode is a compact and robust unit for alignment-free operation throughout the lifetime of the laser.

Proprietary fiber coupling technology ensures good power stability and excellent fiber-coupling efficiency. A fusion spliced end-cap is provided against degradation of the fiber tip inside the module, thus up to 100 mW of power can be coupled into the fiber.

FC/PC connector is provided as a standard for all non-SLM lasers, whereas SLM fibered lasers come with FC/APC, in order to minimize impact from back-reflections. In any case, the pigtail length is approx. 1 m. Other connectors and fiber lengths are available on request.



Figure 4-1. Exemplary Fiber Coupled Laser. SLM Laser; MM Fiber.



The fiber cap has to be removed before turning the laser on. Starting the laser with safety-cap put on will damage the laser and render the warranty void.



Fiber coupled lasers must be turned on via MatchBox laser control software.

4.2: Operating Free-space Output Laser

Free-space output MatchBox lasers series deliver superior performance regarding power stability, signal to noise ratio, beam properties, polarization contrast and many more. Plug and play operation allows the customer to use the laser as soon as possible, saving hours of precious time.

Scientific open-frame setups might require full CDRH compliance. The PTFE cap (provided with each free-space laser) can be used as a shutter, i.e. attached to the output window, whenever the laser is not in operation or it could be shut for a short period of time, in case minor adjustments need to be made without stopping the laser, thus stable operation is not lost.

In all other cases, it is advisable to trigger the interlock function found on all attachable control interfaces of the MatchBox laser.

Full CDRH compliance is reached only with additional accessories. Please contact your sales person for a proposal.



Free-space lasers starts instantaneously when power is applied.

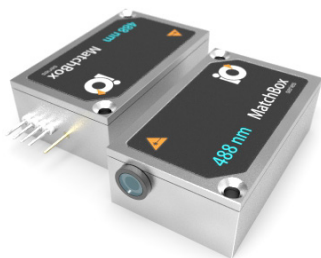


Figure 4-2. Exemplary Free-space Output Diode Laser.



The safety-cap has to be removed before turning the laser on. Starting the laser with end-cap put on will damage the laser and render the warranty void.



Fiber coupled lasers must be turned on via MatchBox laser control software.

4.3: UART bus

UART (Universal Asynchronous Receiver/Transmitter) is a commonly used communication device in computer based systems. UART communication can be converted to USB and RS232 by use of attachable break-out boxes.

4.4: Laser Control Software

The control software incorporates many useful parameter settings and readings. It also displays operational hours and times the laser has been started.

The software window is shown in Figure 4-3. The window comprises 3 columns, which display the most important information about a particular laser. The first column shows information about laser settings, the second column shows information about actual readings of laser parameters and the third column indicates laser properties, like model, serial number, operating time, etc. The third column also shows a radiation sign whenever the laser radiation is turned on.

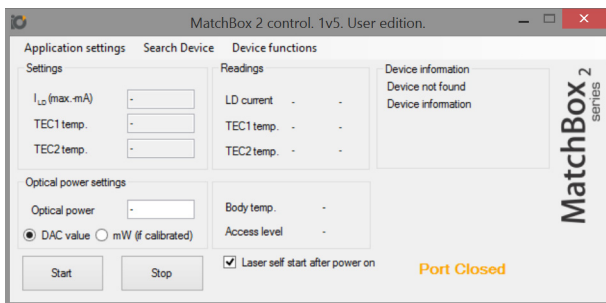


Figure 4-3. Main software window.

There are two versions of the software – User edition (strongly limited functionality) and Integrator edition (less limited functionality). User edition allows changing only the optical power. Other parameters are locked. This way the laser is working in its optimum mode, at factory settings.

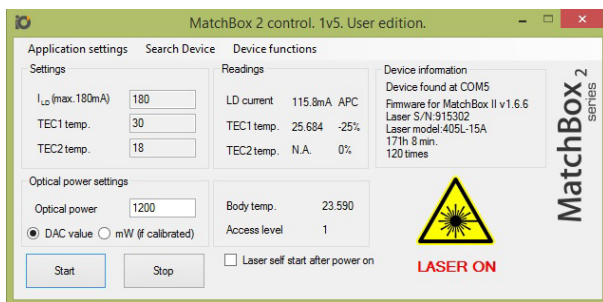


Figure 4-4. Laser control software window when a laser is connected and radiating.

After launching the software, connect the laser to the computer. Press 'Search Device->Find device'.

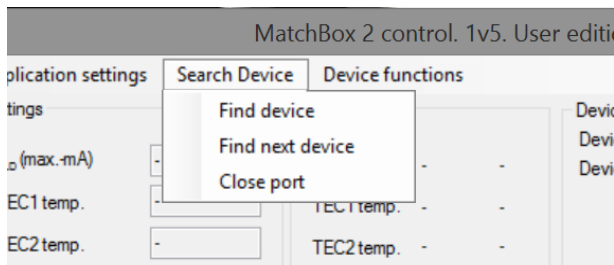


Figure 4-5. In order to detect the laser and start communication, press 'Search Device ->Find device'.

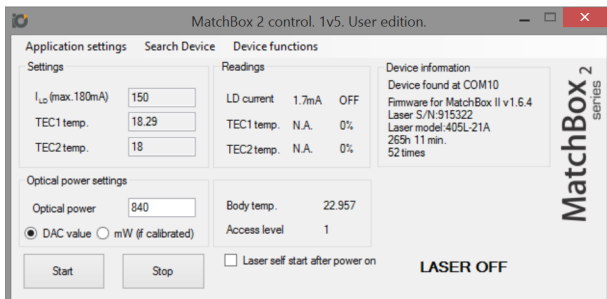


Figure 4-6. Once the laser is identified, the fields are filled with information.

Whether some parameters are changed, they are not saved automatically. This is done intentionally for several reasons. Whether the new laser parameters make the laser operate undesirably, the user can always simply disconnect the laser from USB and power supply and connect it again - the old settings will be restored and displayed on the screen.

Another reason not to write new parameters in the memory is limited write cycles of the EPROM. Especially if integrators are making their own control software, having for example a slider for power setting, one stroke of such slider might result in hundreds of values saved in the EPROM, reducing its cycle capacity.

In order to save newly set parameters in the laser memory, user must press 'Device functions->Save settings'.

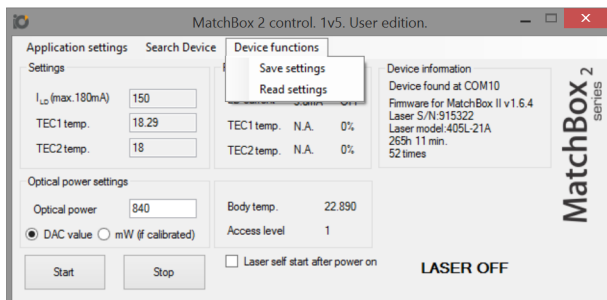


Figure 4-7. In order to save newly set parameters in the laser memory, user must press 'Device functions->Save settings'.

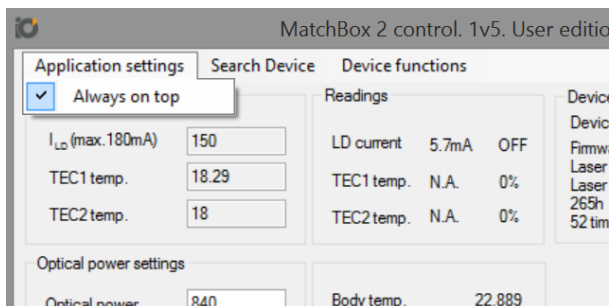


Figure 4-8. 'Always on top' setting can be found under 'Application settings'.

Further we will briefly describe particular lines of the software window. 'Access level' function is used as a protection that allows different type of users to operate laser safely without a risk to misconfigure laser.

Access level can be changed to Level 1 with command 'c u 1 1234'.

If access level is not sufficient to execute command laser will return <ERR 1>.

For access level 2 code please contact your distributor.

Table 4-1. Explanations of software fields.

Field	Meaning	User Editable
ILD max.	Maximum current for the laser diode.	No
TEC1 temp.	Target temperature of the first Peltier cooler	Access level 3
TEC2 temp.	Target temperature of the second Peltier cooler	Access level 3
Optical Power	Target optical power of the laser. Can be set in DAC values or mW, if the power calibration was done	Access level 1 ^a
LD current	actual LD current	No
TEC1 temp. (readings)	Actual temperature of the first Peltier cooler	No

Table 4-1. Explanations of software fields.

Field	Meaning	User Editable
TEC2 temp. (readings)	Actual temperature of the second Peltier cooler	No
Body temp.	Temperature of the laser enclosure	No
Access level	User access level; 1 - basic configuration, 2 - wider configuration	Yes, with password
Laser self start after power on	If checked, the laser will start whenever DC power is applied.	Saves to EPROM immediately.

a. Power change is not recommended for SLM lasers - this might influence spectral properties of the laser.

Laser control software will not work if a laser is not connected to a power supply. In the first instance, the laser should be connected to PC via USB cable. Only then the laser should be connected to the power supply using a breakout cable or a breakout PCB.



Laser will start emitting light as soon as Start button is pressed. Please make sure that there is no risk of getting the laser radiate to an eye or skin of a person, as outlined in the chapter "SAFETY INFORMATION" on page 5.

Before starting the laser, make sure that the cap is taken off of the output window or a fiber connector.

After connecting the laser to a PC via USB port, all information that is saved inside the laser will be read and displayed in the computer screen. Information about laser firmware version, serial number, model, operating time and times laser was started will be provided on the right side of the application window.

More than one laser can be connected to a computer simultaneously. All connected lasers can be controlled with multiple program windows – one for each laser. Once connected, lasers are detected automatically. If a newly connected laser is not found, use a function 'Search Device' in the top bar.

The lasers in MatchBox series can have either one or two TEC (thermo-electric cooler) elements arranged inside the laser body. One TEC is used for thermal control of a laser diode and another TEC can be used either for VBG (in direct diode lasers) or non-linear crystal (in DPSS lasers with second harmonic generation). Both temperature values will be displayed in the program window. The user can also observe a percentage of TEC capacity, which is being used. If TEC value is near 100% for more than 10 seconds, it means that the laser does not get enough cooling and it heats too much. In such case, the laser will turn off automatically if body temperature reaches 38 deg. Celsius.

Next to LD current reading, there is an indicator having two values: ACC (Automatic Current Control) and APC (Automatic Power Control). Normally, the laser should be working in ACC mode while it is warming-up and in APC mode after reaching target temperatures on TECs.

There is a check box named 'Laser self start after power on'. It can be changed any time laser is connected to a PC. Once checked, the setting is saved to EPROM immediately.



Default laser parameters will be displayed, once the laser is connected to the computer. In order to save customized parameters, click 'Device Functions -> Save Settings'.

In case some parameters have been changed but not saved, default settings can be restored by going to 'Device Functions – Read Settings'.

4.5: Changing Output Power

In order to change the optical power of a laser, DAC value should be entered. Possible DAC values are from 0 to 8191, however each laser has a pre-set power limit and sometimes maximum optical power value will be lower than 8191 DAC value.

If the laser power is calibrated, calibration values are saved in the internal micro-controller. In such case, the optical power can be entered in mW. Calibration process can be either done in the factory or user can request instructions from the manufacturer, describing how to do the calibration in a specific setup. For calibration instructions, please contact our tech support team writing an email to support@integratedoptics.com.



Calibration is also possible for fiber coupled lasers, as well as for a complete turnkey system, e.g. microscope setup.

4.6: Communication Command Table

The following commands are used with MatchBox series lasers at serial communication rate of 115200 bps.

Table 4-2. Communication commands of MatchBox lasers.

Comm and	Function	Argument Example	Returned Value	Access Level ^a
e_	start/stop laser	1 or 0	<ACK> or <ERR>	0
c_1_	set 25.5 °C temperature	2550	<ACK> or <ERR>	3
c_2_	set 25.5 °C temperature	2550	<ACK> or <ERR>	3
c_3_	set LD current to 180 mA	180	<ACK> or <ERR>	3
c_4_	set 100 mW optical power using	100	<ACK> or <ERR>	1
c_5_	set 32 °C FAN temperature	3200	<ACK> or <ERR>	1
c_6_	set optical power DAC in 12bit full range	1100	<ACK> or <ERR>	1
c_a_	enable/disable autostart after power on	1 or 0	<ACK> or <ERR>	1
c_u_	Change user access level to 1 “c u 1 1234”	0..3_ code ^b	<ACK> or <ERR>	0

Table 4-2. Communication commands of MatchBox lasers.

Comm and	Function	Argument Example	Returned Value	Access Level ^a
r_s	receive settings. Returned values are: Set T1 [integer] deg, Set T2 [integer] deg, set LD current [integer] mA, set Optical power [integer] 12bit range, Optical power [float] mW, Max allowed LD current [integer] mA, Autostart enable [boolean], access level [integer]	-	1800 1829 150 840 nan 180 Autostart: OFF 0	0
r_r	receive readings. Returned values are various parameters of the laser: NTC1, NTC2, NTC3 (body temp), LD current, TEC1 load%, TEC2 load%, Laser status	-	27.386 27.086 24.978 0.0mA 0% 0% OFF	0
r_i	show laser information. Returned values are: firmware version, serial number, product code, operating time, LD turn-on times.	-	Firmware for MatchBox v1.6.5 Laser S/N: 915322 Laser model: 405L- 21A 266h 15 min. 58 times	0

Table 4-2. Communication commands of MatchBox lasers.

Comm and	Function	Argument Example	Returned Value	Access Level ^a
ID?	return product ID. 6 digit value is returned with random delay up to 1000msv	-	<123456>	0
NM?	Returns laser name - the product code.	-	<405L-21A>	0
r_t	receive operating hours. Returns information about operating hours and how many times the laser diode has been switched on.	-	266h 15 min. 58 times	0
r_m	receive operating mode (APC/ACC)	-		0
r_l	receive access level	-	Access level: 0	0
f_s	save changes	-	<ACK> or <ERR>	1

- To execute the commands access level must be equal or higher.*
- To change access level, command argument code can be provided by sales person on separate request.*

The list below explains error codes for MatchBox lasers:

- 0 - error name not assigned yet
- 1 - command forbidden for current access level

- 2 - laser already on or making ramp-up
- 3 - laser busy, task is not complete please wait for 1 s and try again
- 4 - arguments out of range
- 5 - unknown command
- 6 - laser must be enabled to execute this command

4.7: Communication with Multiple Lasers in a Bus

There are several ways, how integrators can connect and control multiple lasers in a single communication bus. Our engineers have tested and recommend connecting diagram as depicted in Figure 4-9.

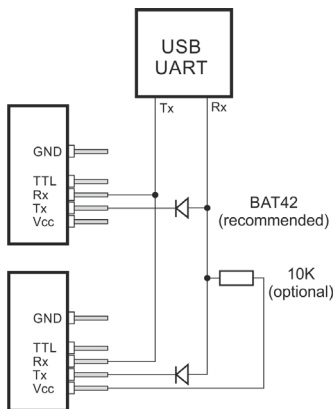


Figure 4-9. Suggested communication diagram for multiple lasers in a single bus.

This communication diagram is based on simultaneous communication from the system UART controller to all connected lasers and individual response from a particular laser. Random response timing is used only for laser initialization with 'ID?' command.

One example of such communication is shown in Figure 4-10, where system UART enquires all lasers in the bus to send their IDs. All lasers respond randomly.

All communication from the laser side features commands with '<' '>' beginning and end symbols.

New laser can be connected while others are operating. ID request is repeated in order to collect IDs once again.

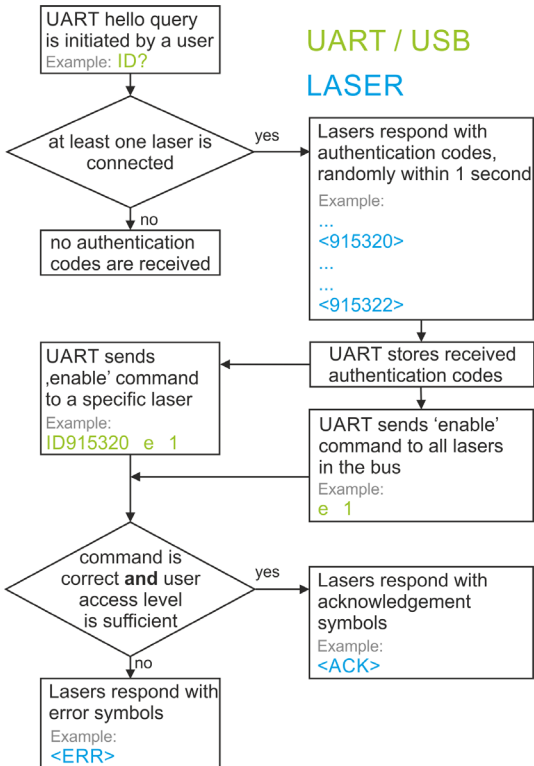


Figure 4-10. ID request sent from system UART to a bus with multiple lasers.

4.8: Attaching Control Interfaces

The pins of the laser can be attached to control interfaces, which are designed as accessories of the MatchBox series. On the other hand, in OEM arrangements, the pins can be connected to a custom electronics within a laser workstation or portable laser equipment, which is arranged to work as a control interface for the laser.

Orientation of the pinhead has to be taken into account, when connecting a control interface to the laser.



All pins of the laser must connect to corresponding pins in the control interface. Wrong connection of the pinhead might lead to permanent damage of the laser electronics.



Do not solder or bend the pins of the laser. These actions might make service impossible and thus void the warranty.

5. ACCESSORIES

Integrated Optics, UAB offers a variety of accessories for heat management, power supplying and fixation.

As our company strives for perfection and diversity, our lab team work hard everyday to make slight improvements of our products, not to forget newly created equipment. Henceforth, accessories in MatchBox user manual are described in general, without going into specifications of the product.

For additional detailed information please visit our website at www.integratedoptics.com.

5.1: Breakout PCB

For quick laser installation into scientific setups an additional PCB board is needed to provide necessary interlock, USB control, modulation or fan connector. We call it 'Breakout Box'. It can be attached directly to the pins as shown in Figure 5-1.



Figure 5-1. The 'Breakout Box' attached to the MatchBox laser.

Additional accessory provides RS232 control interface for the MatchBox series of lasers.

On-board connections:

- RS232 control
- USB 'POWER' port
- Interlock
- TTL signal connector
- Fan control

RS232



Figure 5-2. The RS232 type 'Breakout Box' attached to the MatchBox laser.

The fastening bolt serves for a reliable fastening of the Box and protects it from the detachment in case the cables are pulled.

5.2: Power Supply

The MatchBox series includes a variety of lasers featuring different power ratings, thus requiring different power supply parameters. Most suitable cabling solution is offered by MatchBox distributors or Integrated Optics, UAB. For more detailed information please visit our website at www.integratedoptics.com.



Figure 5-3. Various types of power supplies.

5.3: Heatsinks

Heatsinks are used in MatchBox laser systems to:

- Ensure superior heat dissipation
- Provide quick fastening of the laser
- Elevate the laser output

Integrated Optics, UAB offers few heatsinking solutions, including self-sufficient forced air cooler, water-cooled adapter plate and breadboard adapter plate. Both adapter plates are used to fasten the laser to a standard 25 mm M6 thread pattern of a standard optical table or breadboard. Please contact us for purchase.

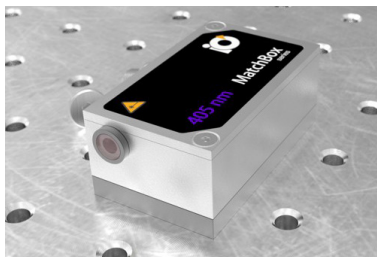


Figure 5-4. A laser mounted onto the AM-H7 adapter.



Figure 5-5. Several lasers mounted on adapters to M6; such arrangement is space saving.

The adapter set comprises two standard M6 bolts and a small syringe of thermal grease.



The adapter to M6 does not dissipate the excessive heat from a laser itself, it just transfers the heat to a larger surface or to into water for heat dissipation.



Always apply a thermal grease to both surfaces of the adapter. The layer of thermal grease shall be as thin as possible, but it should cover the interfaces between a laser and the adapter and between the adapter and an optical breadboard homogeneously.

5.4: Additional Accessories

MatchBox laser series are OEM dedicated lasers, but Integrated Optics, UAB offer additional accessories, modifying the MatchBox into CDRH-compliant laser system. More specifically, safety key-switch, interlock and beam shutter can be provided as an additional accessories.



In order to start operating CDRH-compliant laser system, insert the key into the breakout box and open the beam shutter.

6. TROUBLESHOOTING Q&A

Whether there are any technical issues concerning our products or any general questions, we are always willing to answer it as fast as possible via email or phone. In order to save both our and our clients time, we have provided a list of frequently asked questions.

6.1: Frequently Asked Questions

Q: What type of power supply should I use?

A: It should be 5 V output power and 4 A current for DPSS lasers and 1 A for diode lasers. We highly recommend to use the same power supply as we offer on our website. Otherwise we cannot ensure that the laser would work the same as it was tested during production. Note: Some lasers can draw a little more current at the moment of turn on, compared to specified.

Q: Power has dropped drastically. What happened?

A: Please check if heat dissipation is sufficient. Launch the laser control software, check whether the TEC is not operating at 100% capacity. What is the voltage between +5 Vcc and GND pins? It should be not less than 4.9 V and not exceed 5.5 V. In case the voltage is different, wires might be too long or too thin or other components are involved that might cause voltage drop/increase.

Q: How should I cool the MatchBox series laser?

A: Diode laser typically requires 5 W heat dissipation so basically such laser could be cooled when attached to any optical table or cooling device.

DPSS laser typically requires 15 W heat dissipation so such laser should be cooled using our air-cooled heatsink (AM-H3) or Adapter to M6 with water cooling option (AM-H4).

Q: How to be sure that laser gets enough cooling?

A: During production, our lasers are tested on a large aluminium breadboard - this is one example how to dissipate heat. Keep in mind that steel has very poor thermal conductivity, therefore conventional optical tables and breadboards are not suitable for heatsinking of DPSS lasers. Customer should always use thermal grease when mounting the laser. Body temperature of the laser should not exceed about 35 °C, and the TEC load should not exceed 80%, with rare exceptions. Diode laser needs no more than 7.5 W heat dissipation. DPSS lasers usually require more – about 15 W heat dissipation. All diode lasers and majority of DPSS lasers in the MatchBox series could work properly attached to our forced air cooler.

Q: What accessories are needed in order to use MatchBox laser?

A: The MatchBox series is designed for OEM applications. Integrators can install the laser without any other accessories, just by providing 5 V power and UART control signals to corresponding pins on the back of the laser. However for quick setup, a breakout PCB or a breakout cable is a good help to start the laser and connect it to a PC via USB. Breakout PCB and a standard USB cable is always included in the laser package free of charge. Also power supply and AC power cable are necessary. You should have in mind that power supply should be ordered separately and that power cable is not included in the package with the power supply.

Q: What is the Breakout-Box?

A: Breakout-box includes a small printed circuit board attachable directly to the pins of the laser. This electronics board features a USB power socket (optionally, a soldered DC power cable), an RF connector for TTL signal, a fan control socket. Furthermore it incorporates a UART-to-USB converter chip (SiLabs) and a micro USB socket for remote control.

Q: I changed the laser power in the control software, but after restart of the system the new power setting was not saved?

A: New parameters are not saved in the micro-controller of the laser

unless 'Device functions → Save settings' is activated. This is done to save EPROM write resource.

Q: What fiber core diameter do you use?

A: We use fibers from many different vendors. Whether you need to know the actual fiber details, please contact us in order to get detailed information, such as core diameter or NA of the fiber.

Q: When do I have to use FC/PC and FC/APC fiber connector?

A: We recommend to use FC/APC for SLM lasers - this is to avoid back-reflections from a polished fiber tip to the laser cavity. In all other cases both FC/PC or FC/APC connectors can be used, depending on users preference.

Q: Should I ensure grounding for the laser?

A: We recommend that the laser would be mounted to a breadboard which is properly grounded. Electrical socket where power supply is connected must be grounded too. We sell power supplies having grounded pin only.

Q: Can I modulate the laser with PWM square wave?

A: Yes. It could be modulated using computer control, by sending commands over the UART interface.

Q: Do I get a replacement if the laser is broken?

A: Lasers within warranty period are repaired or replaced free-of-charge. Warranty becomes obsolete in cases indicated in the chapter 'Warranty'.

Q: I have ordered a SLM laser, but can observe more than one longitudinal mode. How can I solve this problem?

A: It is possible that laser is working at non-optimal temperature point. First step is to make sure if the laser gets enough heat dissipation. Second step is to adjust laser diode (or cavity) temperature using the laser control software. For this access level 2 is needed. Please contact Integrated Optics, UAB for further instructions.

Q: How hard should I tighten the screws of the laser?

A: Recommended Tightening torque is 0.25 - 0.35 N·m.

Q: Laser is working, but it's body is very hot.

A: First of all it means that laser diode should be fine, but it could be that heat dissipation is not sufficient. You should check how much Amperes does the laser consume. It should be no more than 1.5 A for diode lasers and typically no more than 4 A for DPSS lasers (exceptions may apply).

Q: Laser emits no light at all. Power is 0mW.

A: Firstly, internal coldplate of the laser could be more than 45 °C temperature. Second option is that laser fiber could be not fully straightened up or even damaged. You should check for any damages on the fiber itself or its connector. Recommendations: Before turning the laser on, proper cooling of the laser should be ensured. Laser should be mounted using thermal grease and the screws that were provided with the laser. Please make sure that thermal grease is put very evenly and covers whole bottom of the laser. If laser is fiber coupled, the fiber should be carefully straightened up first.

Recommendations:

Before turning the laser on, proper cooling of the laser should be ensured. Laser should be mounted using thermal grease and the screws that were provided with the laser. Please make sure that thermal grease is put very evenly and covers whole bottom of the laser. If laser is fiber coupled, the fiber should be carefully straightened up first.

7. GLOSSARY

°C	Degrees Celsius
μm	Micrometer = 10^{-6} m
A/Amps	Amperes
AC	Alternating Current
ACC	Automatic Current Control
APC	Automatic power control
bps	Bytes Per Second
CCD	Charge-coupled device
CDRH	Centre for Devices and Radiological Health
cm	Centimetre
DAC	Digital-to-Analog Converter
DC	Direct Current
DPSS	Diode-Pumped Solid-State
EMC	Electromagnetic Compatibility
EPROM	Erasable Programmable Read-Only Memory

kHz	Kiloherz = 10^3 Hz
LD	Laser Diode
MHz	Megahertz = 10^6 Hz
MM	Multi-Mode
mrاد	Milliradian = 10^{-3} radians
mW	Milliwatt = 10^{-3} Watts
nm	Nanometer = 10^{-9} meter
N·m	Newton metre
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PCB	Printed Circuit Board
PM	Polarization maintaining
PVC	Polyvinyl Chloride
PWM	Pulse Width Modulation
RMS	Root Mean Square
RoHS	Restriction of Hazardous Substances

RS232	Standard for serial communication transmission of data
Rx	Receive
SLM	Single-Longitudinal-Mode
TEC	Thermo-Electric Cooler
TTL	Transistor-Transistor Logic
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
Vcc	Voltage at the Common Collector
VBG	Volume Bragg Grating

8. WARRANTY

Integrated Optics, UAB warrants the MatchBox laser to the original purchaser (the Buyer) only, that the laser system, that is the subject of this sale, (a) conforms to specifications provided before a certain laser has been shipped to the buyer and (b) is free from defects in materials and workmanship.

The MatchBox lasers are warranted to conform to Integrated Optics, UAB published specifications and to be free from defects in materials and workmanship for a period of:

- 12 months;
- Hours limitation of 5000 hours applies for 405, 445, 488, 515, 633-638, 660 nm diode lasers. Operational time calculation is based on an internal EPROM counter.

The Buyer is responsible for providing the appropriate utilities and an operating environment as outlined in the product literature. Damage to the laser system caused by failure of the buyer's utilities or failure to maintain an appropriate operating environment, is solely the responsibility of the buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Integrated Optics, UAB of any claims made under warranty. In no event will Integrated Optics, UAB be responsible for warranty claims made later than seven (7) days after the expiration of warranty.

8.1: Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

- Components and accessories manufactured by companies, other than Integrated Optics, UAB, which have separate warranties,
- Improper or inadequate maintenance by the buyer,
- Buyer-supplied interfacing,
- Operation outside the environmental specifications of the product,
- Unauthorized modification or misuse,
- Improper site preparation and maintenance, or
- Opening the laser housing.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED, AND DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. Integrated Optics, UAB SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

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Integrated Optics, UAB

Kalvariju str. 125B
08221 Vilnius, Lithuania
Tel: +370 5 2196393
info@integratedoptics.com

www.integratedoptics.com

