Wavelength Combiner

User’s Manual

Version 2.5 July, 2020
INTRODUCTION

As the title hints, MatchBox products are ultra-compact, single-unit laser sources with overall dimensions comparable to a regular matchbox (30x50x18 mm$^3$), connector pins not included.

The ‘MatchBox®’ series include 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, passive Q-Switch short-pulse lasers, multi-wavelength lasers based on classical dichroic combining, 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, representing our commitment to perfect user experience and faster time to market for our customers.

Please take your time to read this instruction manual which provides essential information about the usage of the CW multi-wavelength lasers. We have also included various hints and tips that will help you to get the most out of a certain laser source.
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1. SAFETY INFORMATION

1.1: Labels

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

This icon is used to draw 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 about the presence of dangerous voltage, which might appear on certain conditions. Electric shocks caused by such voltage may constitute risks to the operator and the equipment used.

MATCHBOX® lasers belong to the class 3B or class 4.
1.2: Electrical safety

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

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

The laser body of MatchBox is connected to the ground, this means that all internal electronics share the same ground of the laser body.

It is recommended to make sure that the power supply used with MatchBox laser pin connection, is well grounded and that there are no grounding interruptions with other devices. Otherwise it can be dangerous for the operator and it can cause malfunction of the laser.
1.3: Optical Safety

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

MatchBox lasers are Class 3B laser products with rare exceptions of Class 4. Different models are arranged to emit up to 500 mW of visible or invisible (infrared) radiation.

The radiation is hazardous if the eye is exposed directly to the beam or to it’s specular reflection. The risk of permanent eye damage or even blindness increases due to longer exposure time.

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

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

Eye protection in the form of spectacles or goggles is preferred to be with appropriate wavelength filtering. For example, spectacles absorbing waves of spectral region from 180 to 532 nm are suitable to work with e.g. 405 nm, 457 nm, 473 nm, 488 nm, 491 nm, 515 nm and 532 nm MatchBox lasers, however you shouldn’t use these spectacles to filter 561 nm, 593 nm waves or radiation in the red and infrared regions.

Protective eyewear provides another significant advantage - when working in dark rooms, laser radiation could haze your eyes even if it is observed from diffuse reflections. Properly chosen eyewear will definitely reduce or even eliminate such haze and extend productive hours.
The beam emitted from Class 3B and Class 4 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 allowed fluency is necessary before using such devices with our lasers.

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

- Experimental setup must ALWAYS be horizontal and below eye level;
- To avoid accidental exposure, never bend over or look down. If something falls off of experimental setup, user must first turn off the laser or close the mechanical shutter and only then pick up the fallen parts;
- Use protective shields or filters to get rid of unnecessary reflections and scattering;
- User must never wear any kind of jewellery or watches while using the laser system to avoid any laser beam reflections from those surfaces;
- 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 precautions must be taken while using volatile substances in laser operational area;
- High level of ambient light in laser operating room should be maintained whenever it is 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 of it;
Use of laser must be limited to users, who are completely familiar with the rules above.

1.4: 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.

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 CDRH Accession Number for the MatchBox series lasers and wavelength combiners is: 1810832-000.

The MatchBox wavelength combiner alone has a simplified physical interface with 10 pins. These pins have power supply, communication bus (UART) and fan (predefined for different laser types) inputs/outputs. This interface is sufficient and convenient for OEM laser integration.

However, for quick laser installation into scientific setups a break-out-box comes handy to provide interlock, USB control, modulation and fan connector, complying the CDRH requirements.
2. DESCRIPTION AND SPECIFICATIONS

2.1: Part Numbers

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

- **Detector/Emitter Type:**
  - A - direct diode laser
  - B - DPSS laser
  - C - Si photodiode
  - H - Si avalanche photodiode
  - I - InGaAs photodiode
  - J - InGaAs avalanche PD

- **Output Type:**
  - 1 - free-space
  - 2 - SM fiber
  - 3 - MM fiber
  - 5 - PM fiber
  - 6 - SMA port
  - 7 - FPC SM fiber
  - 8 - FPG PM fiber
  - 9 - PCF

- **Modulation:**
  - DM - Direct TTL
  - AM - Direct Analog
  - PM - Waveguide piezo
  - TM - Waveguide thermal
  - OM - Acousto-optic

- **Fiber Termination:**
  - PT - FC/PC connector
  - AT - FC/APC connector
  - ST - SMA connector
  - CT - Collimator

- **Platform:**
  - 1 - MatchBox
  - 2 - ARA

- **Wavelength, e.g.:**
  - 40 for 4005 nm
  - 52 for 520 nm
  - 50 for 5064 nm
  - 15 for 1550 nm

Figure 2-1. Understanding part numbers of the MatchBox wavelength combiners.

2.2: Description of Series

The MatchBox wavelength combiner is configurable turnkey emitter/detector system for life sciences, sorting and particle analysis.
applications. It has a MatchBox footprint and is compatible with most of MatchBox accessories.

The MatchBox laser combiner includes up to 4 laser diode drivers and digital control electronics, which allow smart control and a TEC controller diagnostics of the complete module. To operate this module an external PD (Power Delivery - in the latest generation of Break-out-Boxes) power supply and interface cables are needed as well. The system can be mounted on a heatsink accessory and a 'Break-out-Box' can be used for converting UART communication to USB. 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.

2.3: Thermal Management

Multi-wavelength diode lasers tend to generate more excessive heat than the single-wave diode lasers, especially if the diodes are operated simultaneously.

The MatchBox series wavelength combiners have a single thermo-electric cooler (TEC) equipped inside enclosure for thermal management of the 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, heat dissipation of 5 W to 15 W may be required in a form of conduction-cooled (AM-H8/AM-H3) or water-cooled heatsink (AM-H4), attachable to the bottom side of the laser.

Also, depending on a laser model, a suitable heatsink must have low thermal resistance. For multwavelength lasers <0.8 °C/W is sufficient. This requirement is usually met by a larger passive copper heatsink or an actively cooled aluminium heatsink. The most popular and suitable
cooling option for wavelength combiners is forced air heatsink (AM-H8/ AM-H3).

In case of specific applications, where better power and central wavelength stability is required, the internal TEC of the laser might not provide sufficient thermal stability. For these applications Integrated Optics, UAB released a number of TEC based coolers and adapters (AM-H10), which provide the extra stability needed. Furthermore, these heat-sinks provide higher thermal handling capacity and/or extend operational temperature range.

As an accessory, Integrated Optics, UAB offer a few heatsinking solutions, including self-sufficient TEC based heatsink, 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. However, adapter plates need to be attached to heatsinks made of aluminium or copper, having sufficiently low thermal resistance.

- Attaching a multiwavelength laser to a stainless steel breadboard through M6 optical breadboard adapter will not provide sufficient heat dissipation and the laser will most likely overheat. Steel is a very poor heat conductor.
- 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. Also, 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 °C, the laser shuts down or starts to blink, turn off the laser and ensure better heat dissipation by decreasing...
the heatsink temperature and increasing the heat dissipation capabilities thereof.

2.4: 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. The wavelength combiner can be operated with power supplies of 12 V at 1.5-2 A. At lower voltages, the 405 nm, 450 nm, 488 nm, 520 nm Wavelength combiner might not turn on or operate properly. For wavelength combiners the optimal power supply that we offer is the 18 W USB type C PD (Power Delivery) power supply (AM-P7).

Free space lasers are pre-set to start instantaneously when power is applied. Once the power is applied, all laser combiner wavelengths start emitting laser beams.

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

2.5: Cables

The MatchBox laser features an OEM design, where integrators implement their own physical interface to connect directly to the pins of the laser. This is the reason why it is sold without any cables in its standard configuration. However, standard cables are handy for end-user setups, and therefore MatchBox accessories come with compatible cables - power supplies are shipped with USB-C to USB-C type cables for power delivery and Break-out-Boxes are shipped with USB-A to USB-micro cable for data communication.
Please contact Integrated Optics, UAB for a customized physical interface for data and power.

2.6: Power and Signal Connections

Different from the CW (continuous-wave) and pulsed lasers, the MatchBox wavelength combiner has a physical interface of 10 pins. The pins are 0.7 mm diameter with 2.54 mm spacing, which provide full access to complete functionality of the combiner.

The pinout of MatchBox Combiner is an expanded version of standard MatchBox pinout. The lower row of pins is the same as for single-wavelength lasers, while the second (upper) row is added for individual TTL modulation of each laser diode installed in the combiner.

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

Wavelength combiner pin-out explanation:

- L1: on/off diode TTL, 5V tolerant;
• L2: on/off diode TTL, 5V tolerant;
• GND: ground connected to the laser body;
• L3: on/off diode TTL, 5V tolerant;
• L4: on/off diode TTL, 5V tolerant;
• GND: ground connected to the laser body;
• Progr. pin: pre-programmed to control fan of a heatsink, based on laser temperature;
• Rx: UART communication, 5V tolerant;
• Tx: UART communication, 5V tolerant;
• VCC:12 VDC.

Empty slots are used as a key, ensuring that the female pinhead connector will not be polarizing in a wrong orientation or position.

2.7: Specifications

The MatchBox series includes a variety of lasers featuring different wavelength and power ratings. The actual specifications of a laser are provided in a test report accompanying a laser, which is sold to the customer. General specifications for all laser models can be found at www.integratedoptics.com, you can scan the QR code below for a quick access to our website:
2.8: 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 arranged inside a single enclosure.

The overall dimensions of the laser are 30 x 50 x 18 mm³ (Width x Depth x Height), 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 2-3. Top and side view drawing of the MatchBox wavelength combiner laser, free-space output option.
Figure 2-4. Top and side view drawing of the MatchBox wavelength combiner laser, fiber coupled output option.

2.9: Laser Output Options

MatchBox wavelength combiners are offered in two main configurations regarding to the type of the 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 a 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 operating or when 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. The cap helps to keep the output window clean during maintenance of the setup.

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

Figure 2-5. Free-space output version of the MatchBox wavelength combiner.

The MatchBox wavelength combiners have all fiber-coupling options - SM, PM, and MM.

Fiber with metal protection bend radius is 30 mm and fiber without metal protection bend radius is 20 mm.

Wavelength combiner 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, 2-3 times worse output.
power stability, but significantly improved beam shape and homogeneity, as compared to free-space versions.

As standard, fiber pigtailed lasers do not have auto-start enabled. If one enables the auto-start function, please make sure the plastic cap is removed from fiber tip before operating the laser. If the cap is not removed, the plastic might melt and damage the fiber tip. This would not be a warranty case.

Figure 2-6. Fiber coupled output version of the MatchBox wavelength combiner laser. Yellow fiber jacket represents a single mode maintaining fiber type.

2.10: 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 or the fiber tip 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.
Integrated Optics
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 box.

![Figure 3-1. The package of a MatchBox laser.](image)

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 laser package boxes for potential later shipments.

Table 3-1. Contents of a typical package.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Source</td>
<td>1 unit</td>
</tr>
<tr>
<td>Thermal Paste (1 gram)</td>
<td>1 unit</td>
</tr>
<tr>
<td>Countersunk Screws of M2.5x25 mm</td>
<td>2 units</td>
</tr>
</tbody>
</table>

Note: if there is an extra screw, it is used for mounting the Break-out-Box to the heatsink or adapter.

Power supplies and bigger accessories, such as heat-sinks, ‘Break-out-Box’, key-switch, accessory bundles or external control interfaces may be included in the same box or packed separately.

3.2: Heatsink Requirements

To ensure satisfying operation and for the warranty to be valid, the MatchBox Wavelength combiner must be attached to a heat sink providing a required thermal resistance. Various types of MatchBox
lasers have different thermal resistance requirements, to find out more, see “Thermal Management” on page 12.

Integrated Optics, UAB recommends to use a thermal paste between the MatchBox Wavelength combiner 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 Chapter “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.

The optimal heatsink temperature for MatchBox wavelength combiners is 15 - 30 °C while the thermal resistance of such a heatsink should be <1 °C/W. Integrated Optics supplies an optimal heatsink for wavelength combiners - forced air or TEC based standalone heatsink (AM-H8/AM-H3/AM-H10).

3.3: Heatsink Installation

All MatchBox Wavelength combiners are equipped with an internal TEC (Peltier) thermal management, which, when operated, generates even more heat to stabilize the optical components 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 laser installation does not meet heatsinking requirements, internal thermal protection stops the laser operation whenever the internal (laser diode) temperature reaches around 40-45°C.
As an accessory, Integrated Optics, UAB offers few heatsinking solutions, including a variety of TEC based coolers, self-sufficient forced air cooler, water-cooled adapter plate and breadboard adapter plate. Most heatsinks 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 a desired location. Ensure that proper air flow is granted.
2. Apply thin layer of thermal paste to the interface between the laser and the heatsink. Spread the paste evenly and remove the surplus.
3. Mount the MatchBox laser head to the heatsink with the M2.5 screws.
4. Attach to the laser pins and mount the Break-out-box or a break-out PCB.
5. Connect laser with a required power supply.
6. Operate and control the laser. If needed, proceed to section "Starting the laser" on page 26.

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

Starting the MatchBox Wavelength combiner is quite simple:

1. The laser has to be mounted and secured on a heatsink;
2. Control interface or UART has to be connected to the laser pins;
3. 12 V at 1.5 A or 2 A have to be applied to the power pins;
4. To control the laser, the control software has to be installed.

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 at the factory.

To install the software, please follow these steps:

1. Make sure that the MatchBox wavelength combiner laser head and the heatsink are secured in place according to the instructions in section “Heatsink Installation” on page 25.
2. Download MatchBox control software that is suitable for your device at the ‘Downloads’ section on our website.
3. When the download is finished, a .zip file has to be extracted to the desired directory in your device.
4. At the extracted file click on ‘CP210x_Windows_Drivers’ folder and choose which driver installer is suitable for your device. For example, if a computer has x86 operational system, choose ‘CP210xVCP_x86’ driver installer; if it has x64 operational system, choose ‘CP210xVCP_x64’ driver installer.

Some newer versions of Silabs’CP210x USB to UART bridge VCP’ drivers are not compatible with Integrated Optics, UAB laser control software. Please install only the drivers that are included in the .zip file.
5. Once the correct drivers are chosen, the driver installation begins by asking a user to click ‘Next’ to continue.
6. While installing the driver you will be asked to read and accept the license agreement to proceed. After accepting the agreement, drivers will automatically install and you will be informed about the successful installation.

![Installation complete window.](image)

Figure 3-4. Installation complete window.

7. When drivers are installed successfully, you can run the MatchBox-Controller file. It is a portable application and it does not need to be installed.

See section “Laser Control Software” on page 34 to learn about the use of the control software.

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

4.1: Operating Fiber Coupled Laser

Fiber coupled wavelength combiner 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.

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

Fiber with metal protection bend radius is 30 mm and fiber without metal protection bend radius is 20 mm.

Figure 4-1. Exemplary Fiber Coupled Laser. SLM Laser with MM Fiber.
The fiber cap has to be removed before turning the laser on. Starting the laser with a safety-cap attached might damage the laser and render the warranty void.

Fiber coupled wavelength combiners must be turned on via MatchBox laser control software. The autostart function shall be only enabled after careful consideration of laser safety and potential contamination of the fiber tip.

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 or a mechanical shutter assembly can be purchased from Integrated Optics, UAB. Using these options a 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 start instantaneously when power is applied, i.e. the auto-start function is enabled by default at the factory.
Figure 4-2. Exemplary Free-space Output of Wavelength combiner.

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 by using USB control interface AM-C9 which not only allows UART to USB conversion, but also supplies a laser with necessary power input of 12 V at 1.5-2 Amperes. With this UART called wavelength combiner Break-out-Box, the user is able to send TTL signals to all wavelength channels, supply the air-forced heatsinks with 5 V and send commands through serial port using TX/RX (Transmit/Receive) serial communication.
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.

To connect a Wavelength combiner to the software, the user must connect the UART or a Break-out-box (AM-C9) to the laser, connect the power supply and plug the USB type A to USB type micro cable to an UART and a computer. Once this cable is connected to both devices, it is advised to check in ‘Device manager’ (if Windows operating system is used) if a COM port is created. Once the COM port is created open Integrated Optics, UAB laser control software and choose a required serial port. If no serial ports appear, refresh the software window by clicking the ‘Refresh’ button at the bottom of the page. Once the serial port appears, the laser is ready to connect to the software.

![Figure 4-3. Laser connection window](image-url)
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 duration and times the laser was started will be provided on the right side of the application window in the section ‘more…’.

The software window, when a laser is connected is shown in Figure 4-4. The window is divided in four segments. Each segment represents different control fields of the MatchBox wavelength combiner. Right above the first segment you can see a port number, an item name, a serial number and a hardware version.

Figure 4-4. The main software window for wavelength combiners.
The first segment is used for turning on the power of the laser (but laser isn’t emitting light). A warning sign can be seen in this segment too. It indicates whether the laser power is on or off. Next parameter seen in this column is operational mode of the laser. There are three types of operating modes:

- if laser beam is turned off, but the power is enabled, the laser is in warming mode - Wrm. In this state the TEC inside the laser provides the laser diode with proper (factory set temperature) and prepares the laser for stable operation
- if laser is in ACC mode, it means that laser is in automatic current control mode. In this mode if TTL modulation is enabled, the modulation speed can reach up to 10MHz. Also, if the laser switches to ACC mode automatically, it could be an early sign of laser diode failure or poor laser body heat dissipation;
- if laser is in APC mode, it means that laser is operating in automatic power control mode. If TTL modulation is enabled, the modulation speed can reach up to 1kHz. This operation mode is default for all lasers.

There are two versions of the software – User edition (limited functionality) and Integrator edition (less limited functionality). In user edition grey-like parameter settings are unavailable to the user.

The second section of the software window is used for laser power control. In this section it is available to enable or disable laser radiation, change the units of optical power setting. This column also shows the current of the laser diode - its maximum value and the actual current. In the status bar if the circle is green, the laser is emitting light, if it is grey, laser radiation is turned off.

The third section is for controlling operation modes of the laser - ACC/ APC, auto-Warm-up, auto-start.
The last section is for observing temperature of the laser body and the laser diode, cooler status, fan load and laser input voltage.

Any warning signs seen in the main window display explanations if clicked on them.

Figure 4-5. Laser control software window when a Wavelength combiner is connected and radiating.
If laser is connected to the computer, but no devices are shown, please check if USB port is connected correctly. After checking the connection press refresh button, until the device is shown.

Figure 4-6. In order to save newly set parameters in the laser memory, user must press ‘Save settings’.

Whether some parameters are changed, they are not saved automatically. This is done intentionally for several reasons. If newly set 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 ‘Save settings’ at the bottom of the main software window.

Next, we will briefly describe particular lines of the software window. These lines are accessed through ‘more...’ section in the right top corner of the main software window.

![Figure 4-7. ‘more...’ section view](image)
‘more...’ section provides detailed information about a laser: item code, serial number, firmware version, operational time (laser working time), started time (how many times turned on), and virtual port. Also this section provides other laser control options.

‘Access level’ function is used as a protection that allows different type of users to operate the laser safely without a risk to misconfigure it.

Access level can be changed to Level 1 with a command ‘cu 1 1234’.

Figure 4-8. ‘Access level’ section view.
If access level is not sufficient to execute a command, the laser will return <ERR 1>.

For access level 2 and level 3 code please contact your distributor.

Figure 4-9. ‘Send Command’ section view

Send command section is used for sending commands directly to the laser. See which commands can be sent in paragraph “Communication Command Table” on page 46.

Entering commands with higher access levels might cause laser to malfunction.
‘Programmable pin’ section is used for lasers’ TTL pin configuration programming. To program this pin access level 2 or 3 is needed.

⚠️ For wavelength combiners programmable pin can only be set to fan control - ‘P1’ setting.
'Fan temperature control' section is used to control fan rotation speed. Fan speed can be set to maintain the laser body temperature in the range from 15 deg.C to max 35 degrees. Controlling fan speed helps to stabilize laser body temperature and prevents it from heating up.

If the temperature in the environment is too hot, e.g. 30 deg. Celsius or higher, or the surface area of the heatsink is too small to radiate enough heat, the fan speed control might not be enough and at some point the temperature of the laser body will keep rising until the laser shuts down at the pre-programmed temperature level.
Figure 4-12. ‘Generate Report’ section view.

‘Generate report’ section provides user the ability to generate a report about the laser. This report provides information of what settings were set, what is the type of laser (model name, serial number) and other parameters.

⚠️ Laser will start emitting light as soon as the ‘Enable’ button is pressed. Please make sure that there is no risk of getting the laser to radiate to an
Before starting the laser, make sure that the cap is taken off of the output window or a fiber connector.

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, but these lasers must be connected to different COM ports. Once connected, lasers are detected automatically. If a newly connected laser is not found, try to check if laser USB port is connected properly and press the ‘Refresh’ button.

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 heat dissipation and it heats too much. In such case, the laser will turn off automatically if internal laser diode and laser body temperature reaches 40 deg. Celsius.

Default laser parameters will be displayed, once the laser is connected to the computer and power is supplied. In order to save customized parameters, click ‘Save Settings’ at the bottom of the main window.

4.5: Changing Output Power

In order to change the optical power of a laser, DAC (digital-analogue converter) value should be entered. The DAC value is related to the internal optical feedback loop and represents a value of optical signal, which must be detected by the internal photodiode and the values are
from 0 to 8191, however each laser has a pre-set power limit and in most cases maximum optical power value will be lower than 8191 DAC value. Other options of changing the laser power are setting the power of the laser in mW (in APC operation mode) or in mA (in ACC operation mode).

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. a microscope setup.

4.6: Communication Command Table

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

**TABLE 4-1. COMMUNICATION COMMANDS OF MATCHBOX WAVELENGTH COMBINERS.**

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
<th>Argument Example</th>
<th>Returned Value</th>
<th>Access Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lcn</td>
<td>Set current in mA for laser diode 'n'; int n = 1..4</td>
<td>200 for 200 mA</td>
<td>&lt;ACK&gt; or &lt;ERR&gt;</td>
<td>2</td>
</tr>
</tbody>
</table>
### TABLE 4-1. COMMUNICATION COMMANDS OF MATCHBOX WAVELENGTH COMBINERS.

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
<th>Argument Example</th>
<th>Returned Value</th>
<th>Access Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lc?</td>
<td>Return current settings for each wavelength in mA</td>
<td>-</td>
<td><code>&lt;200  100  100  100 mA&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>Lr</td>
<td>Return measured current in mA for each wavelength</td>
<td>-</td>
<td><code>&lt;220 219 155 100&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>Le</td>
<td>Return diodes that are enabled</td>
<td>-</td>
<td><code>&lt;1 1 1 1&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>LnE</td>
<td>Enable ‘n’ pin diode; int n = 1..4</td>
<td>-</td>
<td><code>&lt;ACK&gt;</code> or <code>&lt;ERR&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>LnD</td>
<td>Disable ‘n’ pin diode; int n = 1..4</td>
<td>-</td>
<td><code>&lt;ACK&gt;</code> or <code>&lt;ERR&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>Ln?</td>
<td>Returns laser combiner wavelengths</td>
<td>-</td>
<td><code>&lt;405,488,520,638&gt;</code></td>
<td>0</td>
</tr>
<tr>
<td>LPD</td>
<td>Laser combiner is not emitting light if no external devices are connected</td>
<td>-</td>
<td><code>&lt;ACK&gt;</code> or <code>&lt;ERR&gt;</code></td>
<td>3</td>
</tr>
<tr>
<td>LPU</td>
<td>Laser combiner is emitting light if no external devices are connected</td>
<td>-</td>
<td><code>&lt;ACK&gt;</code> or <code>&lt;ERR&gt;</code></td>
<td>3</td>
</tr>
</tbody>
</table>
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 4-13.

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 4-14, where the 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.

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

Figure 4-13. Suggested communication diagram for multiple lasers in a single bus.
Figure 4-14. ID request sent from the system UART to a bus with multiple lasers.

Controlling multiple lasers with Integrated Optics, UAB software isn’t possible. It is only an example for integrators.
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 an instrument 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 and the warranty will be void.
- 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 mounting.

As our company strives for perfection and diversity, our engineers and researchers work hard everyday to make improvements of our products, especial in new products newly created equipment. Henceforth, accessories in MatchBox user manual are only mentioned in general, without going into specifications of each product.

For additional detailed information please visit our website at www.integratedoptics.com.
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: For wavelength combiners, the input voltage should be 12 V at 1.5-2 A current. 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 more current at the moment of turn on, compared to specified.

Q: Power has dropped drastically. What happened?
A: There might be several reasons: the laser overheating, the power supply is not sufficient, the laser diode or pump diode has failed. Please check if heat dissipation is sufficient. Launch the laser control software, check whether the TEC is operating at 100% capacity. What is the voltage between Vcc and GND pins? It should not be less than 9.0 V and not exceed 12 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 Wavelength combiner?
A: Diode laser typically requires 7.5 W heat dissipation so basically such laser could be cooled when attached to any optical table or cooling device.

Q: How to be sure that laser gets enough cooling?
A: During production, our lasers are tested on a large aluminium breadboard. Aluminium breadboards could be used to dissipate low
amount of heat, but that would not be enough for stable laser operation. Thermal paste should always be used 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 7.5W heat dissipation. All broad spectrum diode lasers in the MatchBox series could work properly attached to our forced-air cooler.

Q: What accessories are needed in order to use MatchBox Wavelength combiner?
A: The MatchBox series is designed for OEM applications. Integrators can install the laser without any other accessories, just by providing 12 V at 1.5-2 A power and UART control signals to corresponding pins on the back of the laser. However for quick setup, a Break-out-Box and a power supply are necessary. Power supply and the Break-out-Box should be ordered separately as they are not included in the package.

Q: What is the Breakout-Box?
A: Breakout-box includes a small printed circuit board attachable directly to the laser pins. This electronics board features a USB-C power socket, pins for TTL and fan control. Furthermore it incorporates a UART-to-USB converter chip (SiLabs) and a micro USB socket for data communication.

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 ‘Save settings’ at the bottom of the main software window 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: The GND pin of the laser should be connected to the GND of a power supply.

Q: Can I modulate the laser with PWM square wave?
A: In general, yes. However, the bandwidth of PWM depends on the laser type and pinout configuration. Direct diode lasers are typically configured for fast (up to 10MHz in ACC mode) modulation instead of fan control, thus PWM with a bandwidth of 10MHz is possible.

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 “WARRANTY” on page 65.

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 the 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 (exceptions may apply).

Q: Laser emits no light at all. Power is 0mW.
A: Firstly, internal cold plate of the laser could be more than 45 °C temperature. It could be that the internal laser diode has died. If the laser is fiber-coupled, another option is that the fiber damaged inside the jacket. 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 paste
and the screws that were provided with the laser. Please make sure that thermal paste is put evenly and covers whole bottom of the laser. If laser is fiber coupled, the fiber should be carefully straightened up first.

Q: Is there a recommended way to improve the diode laser's longevity?
A: Cold start is one of the factors reducing the lifetime of laser diodes. ‘Warm laser’ is the best mode for stand-by operation to improve the longevity of the laser diode or the pump diode.

Q: How to send laser to a warm-up state?
A: There are two ways to send laser to warm-up state, or in general to control laser: using our software. There is simply a button, that says ‘Auto Warm-up’ or sending commands via terminal. The command is: ‘e 2’.

Q: Our laser has a Firmware version of 1.76483. Is there a later version of the firmware and can it be upgraded?
A: Updating firmware is highly not recommended, because if in any case power source would disconnect or get damaged while updating, laser would be instantly damaged and would have to be sent to Integrated Optics, UAB for repair. So laser firmware can only be updated in particular situations after consulting with the support team at Integrated Optics, UAB.

Q: After a while, laser power dropped by a few mW, why is that?
A: There could be a few reasons why the laser power might drop by few mW:

1. The laser is getting some back-reflections and these are having impact on the internal photodiode response. The photodiode ‘sees’ more light and triggers the driving electronics to reduce LD current.

2. Environmental temperature changed significantly and the internal photodiode isn’t perfectly thermally stabilized and it’s temperature has changed as did the quantum efficiency of the laser.
3. The wavelength of the laser diode drifted. If it is on the slope of efficiency of the photodiode, then wavelength change of hundreds of pico-meters can change the response of the photodiode. Please, adjust the DAC value to restore the power level. If the power of the laser was calibrated, you might want to recalibrate it.

4. The power sensor of the power measurement degraded.

5. The power sensor got saturated. Please, check the parameters of the power sensor.

In cases 1 to 3 it should be visible in the software window that the LD current decreased upon decrease of the laser power.

Q: Is there a way to change the polarization direction of MatchBox lasers?

A: You can change the polarization direction by turning the laser body by a desired angle or using optical devices like: quartz polarization rotator, waveplate/2. We should note that different types of MatchBox lasers have different polarization direction, but two of the same type lasers of MatchBox’es must have the same polarization!
### 7. GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>µm</td>
<td>Micrometer = 10⁻⁶ m</td>
</tr>
<tr>
<td>A/Amps</td>
<td>Amperes</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ACC</td>
<td>Automatic Current Control</td>
</tr>
<tr>
<td>APC</td>
<td>Automatic power control</td>
</tr>
<tr>
<td>bps</td>
<td>Bytes Per Second</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge-coupled device</td>
</tr>
<tr>
<td>CDRH</td>
<td>Centre for Devices and Radiological Health</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital-to-Analog Converter</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DPSS</td>
<td>Diode-Pumped Solid-State</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>EPROM</td>
<td>Erasable Programmable Read-Only Memory</td>
</tr>
<tr>
<td>Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>kHz</td>
<td>Kilohertz  $= 10^3$ Hz</td>
</tr>
<tr>
<td>LD</td>
<td>Laser Diode</td>
</tr>
<tr>
<td>MHz</td>
<td>Megahertz  $= 10^6$ Hz</td>
</tr>
<tr>
<td>MM</td>
<td>Multi-Mode</td>
</tr>
<tr>
<td>mrad</td>
<td>Milli-radian $= 10^{-3}$ radians</td>
</tr>
<tr>
<td>mW</td>
<td>Milliwatt $= 10^{-3}$ Watts</td>
</tr>
<tr>
<td>nm</td>
<td>Nanometre $= 10^{-9}$ meter</td>
</tr>
<tr>
<td>N·m</td>
<td>Newton metre</td>
</tr>
<tr>
<td>NTC</td>
<td>Negative Temperature Coefficient</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PM</td>
<td>Polarization maintaining</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse Width Modulation</td>
</tr>
<tr>
<td>RMS</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>RoHS</td>
<td>Restriction of Hazardous Substances</td>
</tr>
</tbody>
</table>
### RS232
Standard for serial communication transmission of data

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx</td>
<td>Receive</td>
</tr>
<tr>
<td>SLM</td>
<td>Single-Longitudinal-Mode</td>
</tr>
<tr>
<td>TEC</td>
<td>Thermo-Electric Cooler</td>
</tr>
<tr>
<td>TTL</td>
<td>Transistor-Transistor Logic</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmit</td>
</tr>
<tr>
<td>UART</td>
<td>Universal Asynchronous Receiver/Transmitter</td>
</tr>
<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>Vcc</td>
<td>Voltage at the Common Collector</td>
</tr>
<tr>
<td>VBG</td>
<td>Volume Bragg Grating</td>
</tr>
</tbody>
</table>
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:

- 14 months or 10000 hrs, whichever occurs first;
- 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.