integrated optics ®

MatchBox series

Wavelength Combiner

User's Manual

Version 2.5 October 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 continuous wave 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.

CONTENTS

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.

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 pin connection.

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.

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 an 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, these spectacles shouldn't be used 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 user's eyes even if it is observed from diffuse reflections. Properly chosen eyewear 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 of 10 pins. These pins are dedicated for power supply, communication bus (UART), programmable pin and TTL modulation. 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 power supply 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:

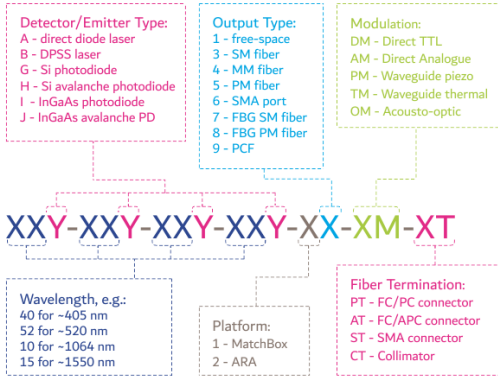

Figure 2-1. Understanding part numbers of the MatchBox wavelength combiners.

The part number of MatchBox wavelength combiners is composed of seven sections:

- The first four sections describe wavelengths and detector/emitter types;
- The fifth section describes platform and output type;
- The sixth section describes modulation type;
- The last, seventh section is for fiber termination.

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 MatchBox accessories.

The MatchBox laser combiner includes up to 4 laser diode drivers and digital control electronics, which allows 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 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 diodes are operated simultaneously.

The MatchBox series wavelength combiners have a single thermo - electric cooler (TEC) equipped inside enclosure for thermal management of up to 4 laser diodes 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 multiwavelength lasers <0.8 °C/W is sufficient. This requirement is usually met by a larger passive copper heatsink or an actively cooled aluminium heat sink. 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 these lasers might not provide sufficient thermal stability. For these applications Integrated Optics, UAB released a number of TEC based coolers and adapter (AM-H10/AM-H11), which provide the extra stability needed. Furthermore, these heatsinks provide higher thermal handling capacity and/or extend operational temperature range.

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, 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 include 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 9-12 V at 1.5-3 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 Integrated Optics, UAB offers is the 18 W USB type C PD (Power Delivery) power supply (AM-P7), suitable with wavelength combiner dedicated Break-out-Box (AM-C9).

Free space lasers are pre-set to start instantaneously when power is applied.Once the power is applied, all laser combiner wavelengths start emmiting the laser beam. Fiber coupled lasers must be turned on via MatchBox laser control software.

2.5: Cables

The MatchBox wavelength combiner 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 laser.

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 wavelength combiner.

Figure 2-2. Wavelength combiner pinout on the back side of the laser.

Wavelength combiner pin-out explanation:

- L1: on/off diode TTL modulation, up to 10 MHz, 3.3-5 V tolerant;
- L2: on/off diode TTL modulation, up to 10 MHz, 3.3-5 V tolerant;
- GND: ground, connected to the laser body;
- L3: on/off diode TTL modulation, up to 10 MHz, 3.3-5 V tolerant;
- L4: on/off diode TTL modulation, up to 10 MHz, 3.3-5 V tolerant;

- GND: ground, connected to the laser body;
- Prog.pin: pre-programmed to supply heatsinks' fan with up to 5 V PWM signal, depending on laser body temperature;
- Rx: UART communication, 3.3-5 V tolerant;
- Tx: UART communication, 3.3-5 V tolerant;
- Vcc:+9 or +12 VDC at 1.5-3 A.

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

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 wavelength combiners are 30 x 50 x 18 mm^3 (Width x Depth x Height), not taking into account the pins, which are used

for connecting the laser to a power source and control interface. 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.

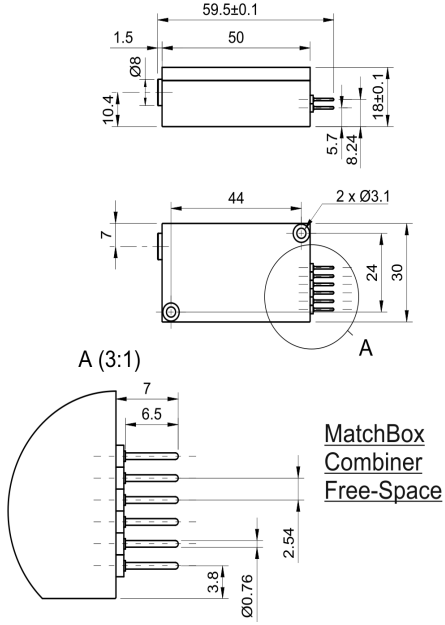

Figure 2-3. Top and side view drawing of wavelength combiner free-space laser.

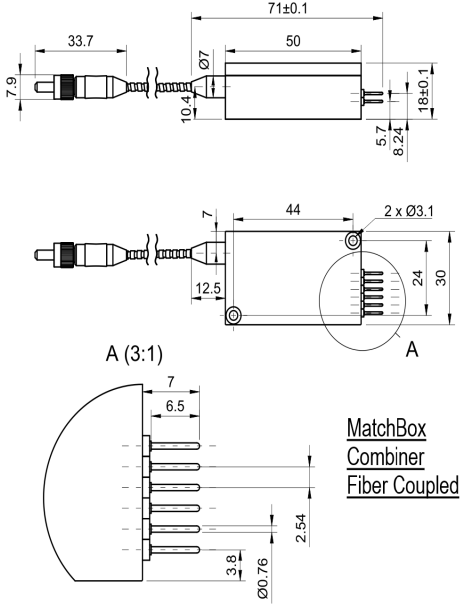

Figure 2-4. Top and side view drawing of the fiber coupled MatchBox wavelength combiner fiber laser.

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 wavelength combiner. If triggered, it disconnects the power supply of the laser.

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

Permanent fiber pigtailed output has a 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.

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

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 metal cap is removed from fiber tip before operating the laser. If the cap is not removed, the metal cap might heat up and damage the fiber tip. This would not be a warranty case.

Figure 2-6. SM fiber, fiber-coupled MatchBox wavelength combiner.

Lastly, Integrated Optics, UAB offers MatchBox laser sources with **SMA port**. Such lasers are supplied with metal safety cap. The cap must be attached to the SMA port, 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.

This output is designed for custom multi-mode fiber installations. Fiber can be supplied optionally upon clients request.

2.10: Operating Environment

MatchBox lasers are designed to be operated in non-condensing environment, in temperature range between 20 and 25 °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 or TEC based heatsink which has surface temperature in the aforementioned range and good thermal conductivity parameters.

Dusty environment might cause collection of debris on an output 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.

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 wavelength combiner.

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.

Item	Quantity
Laser Source	1 unit
Thermal Paste (1 gram)	1 unit
Countersunk Screws of M2.5x25 mm	2 units

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 heatsinks, Break-out-Boxes, key-switches, 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 heatsink, providing a required thermal resistance. To find out more about thermal requirements for wavelength combiners, see “Thermal Management” on page 12.

Integrated Optics, UAB recommends to use a thermal paste between a MatchBox wavelength combiner and a heatsink to provide proper thermal contact.

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

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

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 heatsink. Optimal enclosure's temperature for most effective and stable laser operation is 25 - 28 °C.

In case laser installation does not meet heatsinking requirements, internal thermal protection stops the laser operation whenever the internal (laser diode) temperature reaches around 45°C.

To find out more about Integrated Optics, UAB heatsinks and heatsinking requirements, see "Thermal Management" on page 12.

In order to mount a laser on a heatsink appropriately, please follow these steps:

1. Secure a heatsink to a desired location. Ensure that proper air flow is granted and room temperature is not over 25 °C.

2. Apply a thin layer of thermal paste to the interface between a laser and a heatsink. Spread the paste evenly and remove the surplus.

3. Mount a MatchBox laser head to a heatsink with M2.5 screws (provided in package).

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

3.4: Starting the laser

Starting a MatchBox Wavelength combiner is quite simple:

1. The laser has to be mounted and secured on a heatsink;

2. A Break-out-Box or any other UART has to be connected to a laser pins. However, if no communication is needed, UART is not necessary and a laser can be operated by supplying power to its' Vcc and GND pins;

3. 9-12 V at 1.5-3 A has to be provided directly to laser pins. If laser is being used with a Break-out-Box, 18 W (12 V at 1.5 A) USB type C PD power supply has to be used.

4. Once the laser is powered up, it is ready to be operated.

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

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

To control a multi-wavelength laser through Integrated Optics, UAB software, firstly it has to be installed.

Follow these steps to install Integrated Optics, UAB software:

1. Download the MatchBox control software at the 'Downloads' section on our website (more in depth explanations are shown on our Youtube page).

2. When the download is finished, extract .zip file to a desired directory.

3. After the .zip file is extracted, the CP210xUSB to UART Bridge Driver has to be installed. Depending on the operational system of a computer, click on either CP210xVCPInstaller_x64 or CP210xVCPInstaller_x86.

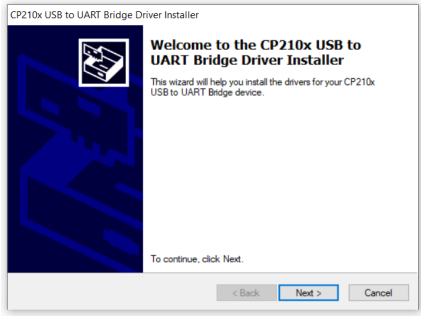

Figure 3-2. Initial installation window.

4. While installing the driver a user will be asked to read and accept the license agreement to proceed.

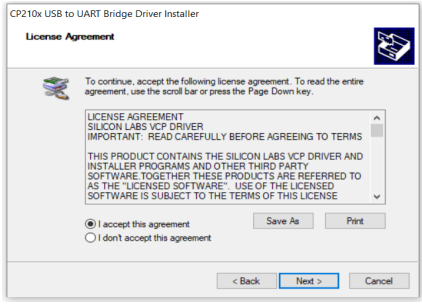

Figure 3-3. License agreement window.

5. After the agreement is accepted, the driver will automatically install and a user is informed about the successful installation.

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

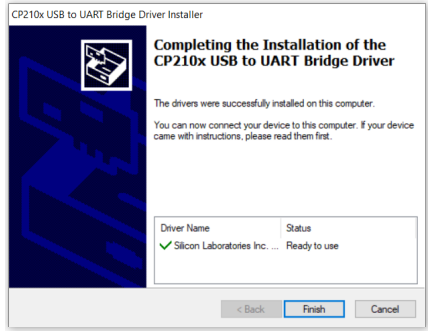

Figure 3-4. Installation complete window.

See section “Laser Control Software” on page 31 to learn about the use of the control software.

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 20mm.

Figure 4-1. Fiber-Coupled MatchBox Laser with MM Fiber.

The fiber cap has to be removed before turning the laser on. Starting the laser with an attached safety cap 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 wavelength combiner.

Full CDRH compliance is reached only with additional accessories. Please contact your sales support for recommendations.

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. Free-space Output of MatchBox Wavelength combiner.

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 wavelength combiner with necessary power input of 12 V at 1.5 Amperes using PD type power supplies.

With this UART, called, wavelength combiner Break-out-Box, the user is able to send TTL signals to all wavelength channels, supply an air forced heatsink with PWM signal of 0-5V at 0.1-0.4 A and send commands through serial port using Tx/Rx 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 install the MatchBox software see chapter “Starting the laser” on page 26.

To connect a MatchBox 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, power up the laser and plug the communication cable to UART and a computer. Once this cable is connected to both devices, it is advised to check in ‘Device manager’ (in Windows operating system) 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.

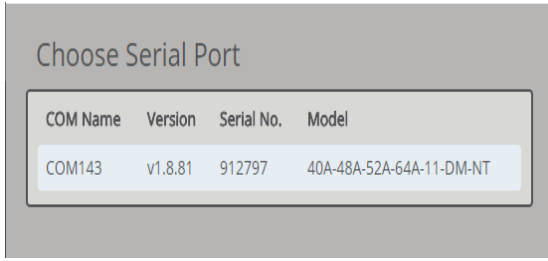

Figure 4-3. Laser connection window

When wavelength combiner is connected to the software, all information that is saved inside a laser and all control options will be read and displayed by MatchBox software.

Information about laser firmware version, serial number, model, operating duration and times the laser was started is provided on the top right side of the application window in the section ‘more...’.

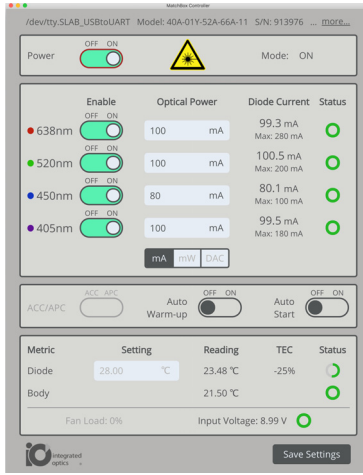

Figure 4-4. The main software window for wavelength combiners.

The software window 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 a port number, an item name, a serial number and a hardware version can be seen. **The first segment** is used to turn on the power of the laser. Once power is enabled, laser will start warming up. A warning sign can be seen in this segment too. It indicates weather the laser power is on or off. Next parameter seen in this column is operating mode of the laser. There are two types of operating modes:

- if laser beam is turned off, the laser is in warming mode - Wrm;

- if laser is in ACC mode, it means that laser is in automatic current control mode. It keeps the laser diode current stable and output power can only be changed by changing current for each laser diode individually.

The second section of the software window is used for each laser diode output power control. You can enable or disable up to 4 laser diodes, and change the diode current settings in mA, to control output power of every wavelength individually. This column also shows the current of the laser diode - its maximum value and the actual supplied 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 wavelength combiner operation modes - ACC/APC, Auto Warm-up, auto-start. However, changing ACC operation mode to APC for wavelength combiners is not available and enabling Auto Warm-up is not recommended (the laser would have to be turned on and off to switch to ACC operation).

The last section is for observing laser diodes' and body temperatures, TEC and fan load, and laser input voltage.

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

Gray -like parameter settings are unavailable to the user.

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 device is shown.

Whether some parameters are changed, they are not saved automatically. This is done intentionally for several reasons. If 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.

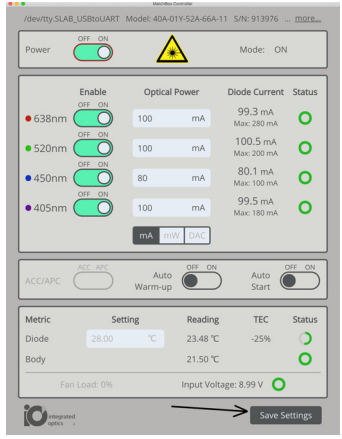

Figure 4-5. In order to save newly set parameters, press 'Save settings'.

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 top right corner of the main software window.

Figure 4-6. 'more...' section view

'more...' section provides detailed information about a laser combiner: 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, like: 'Send Command', 'Access level', 'Programmable Pin', 'Fan Temperature', 'Generate report', 'Graph', 'New Window', 'Keep on top', 'Disconnect and Feedback'.

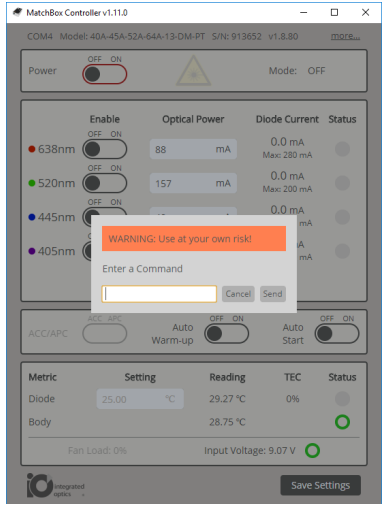

Figure 4-7. 'Send Command' section view

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 45

Entering commands with higher access levels might cause undesirable laser function.

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

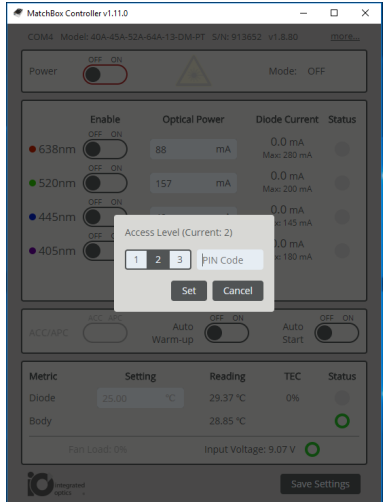

Figure 4-8. 'Access level' section view.

By default, access level for all lasers used without control software, is 0. However, if laser is connected to the control software, the access level automatically changes to level 1.

If laser is operated without control software, access level can be changed to Level 1 with a command 'c u 1 1234'.

If access level is changed to level 2 or 3, after the software re-load or laser turn off, access level automatically restores back to level 1 or 0 (depending on whether laser is used with control software or without).

For access level 2 and 3 code, please contact your distributor or Integrated Optics, UAB technical support.

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

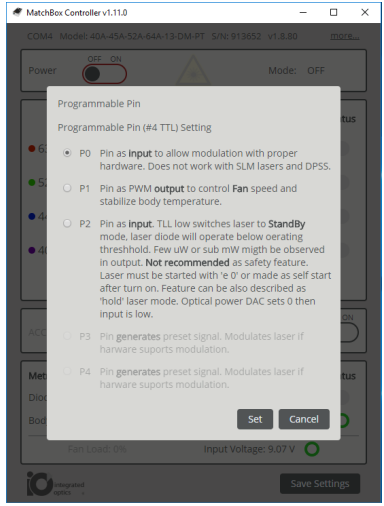

Figure 4-9. 'Programmable pin' section view

'Programmable pin' section is used for defining programmable pin configuration. To program this pin access level 2 or 3 is needed.

'P0' setting is for direct diode TTL modulation (electronics version 1.8v);

'P1', 'P2', 'P3' and 'P4' are reserved for future development, so their explanations provided in software can be disregarded.

If 'P1' setting is set, TTL modulation for each laser diode is disabled.

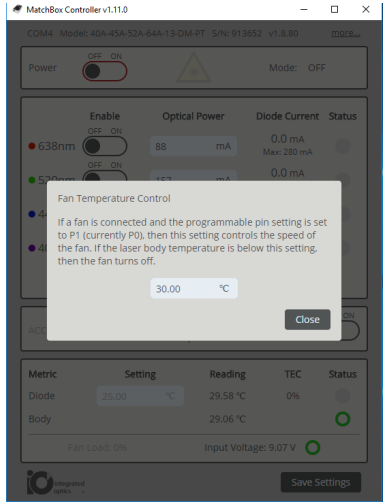

Figure 4-10. 'Fan Temperature' section view

'Fan temperature control' section is used for controlling 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.

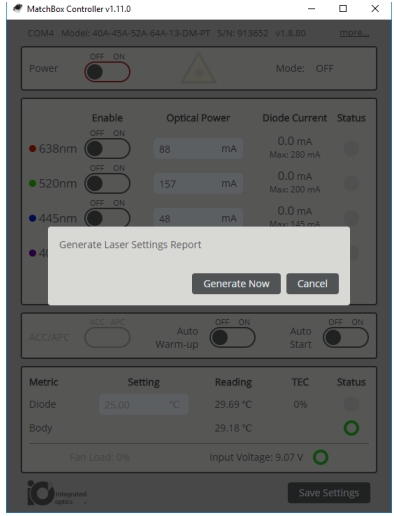

Figure 4-11. 'Generate Report' section view.

'Generate report' section provides user the ability to generate a report about the laser. This report provides information of what settings were set, what are laser readings, like: laser body and diode temperature, every diode current and other parameters. This is a very helpful tool,

which, if any issues occur, should be provided to Integrated Optics, UAB technical support.

Laser will start emitting light as soon as the ‘Enable’ button is ON. Please make sure that there is no risk of getting the laser to 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 safety cap is taken off of the output window or a fiber connector.

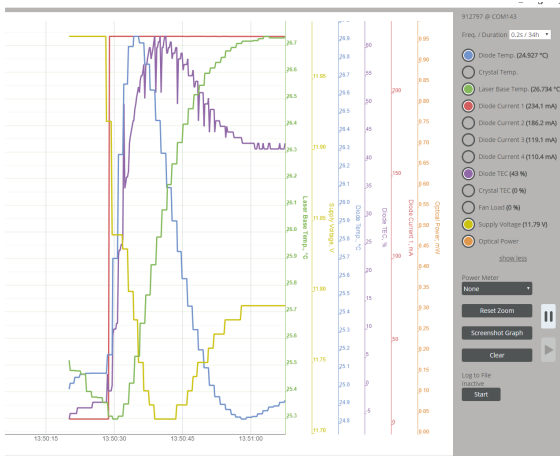

Figure 4-12. ‘Graph’ section view.

‘Graph’ section is a very handy tool to check how laser behaves in longer periods of time.

It can be used to identify many issues regarding laser operation instabilities.

This section can track:

1) diode temperature;

2) laser base temperature;

3) diode current;

4) diode TEC load;

5) fan load;

6) supply voltage;

7) optical power, if Thorlabs, Inc. PM100, PM100USB or PM100D power meter is connected.

It is recommended to generate this graph for 30 minutes before contacting Integrated Optics, UAB technical support about any laser issues.

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.

A 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 45 deg. Celsius.

'New window', enables controlling a few MatchBox lasers using the same computer. However, each laser has to be connected to different COM ports. Controlling multiple lasers with only one software window is unavailable.

'Keep on top', keeps the MatchBox control software on top of other programs windows.

'Disconnect', disconnects the laser from control software. The software window changes to initial connection window, displaying MatchBox lasers that are connected to computers' COM ports.

'Feedback', directs user to a short survey, regarding lasers operation and user experience. The survey is sent directly to Integrated Optics, UAB.

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

Output power for wavelength combiners is not calibrated, thus changing it is only available by changing the supplied current for each laser diode and measuring the output power with power meter.

Each laser diode inside the combiner has a set current limit, meaning that output power can only be changed from 0 mA to a set limit.

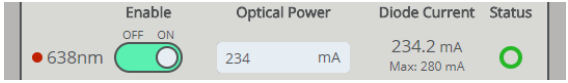

Figure 4-13. Diode current setting view in software.

Continuously operating laser diodes at maximal current will decrease their lifetime.

4.6: Communication Command Table

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

Table 4-1. Communication commands of Wavelength Combiners.

Command	Function	Argument Example	Returned Value	Access Level[a]
Lcn	Set current in mA for laser diode 'n', int =1..4	200 for 200 mA	<ACK> or <ERR>	2
Lc?	Return current settings for each wavelength in mA	-	<200 100 100 100 mA>	0
Lr	Return measured current in mA for each wavelength	-	<220 219 155 100>	0
Le	Return diodes that are enabled	-	<1 1 1 1 1>	0
LnE	Enable 'n' pin diode; int n= 1..4	-	<ACK> or <ERR>	0
LnD	Disable 'n' pin diode; int n= 1..4	-	<ACK> or <ERR>	0
Ln?	Returns laser combiners wavelengths	-	<405,488,520,638>	0

Table 4-1. Communication commands of Wavelength Combiners.

Command	Function	Argument Example	Returned Value	Access Level[a]
LPD	laser is not emitting light if no external devices are connected	-	<ACK> or <ERR>	3
LPU	laser is emitting light if no external devices are connected	-	<ACK> or <ERR>	3

a. To execute the commands, access level must be equal to the values given in the table or higher.

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 4-14.

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.

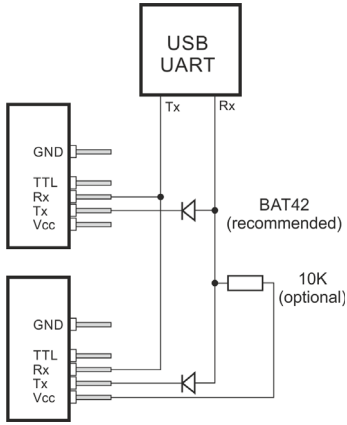

Figure 4-14. Suggested communication diagram for multiple lasers in a single bus.

One example of such communication is shown in Figure 4-15, 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.

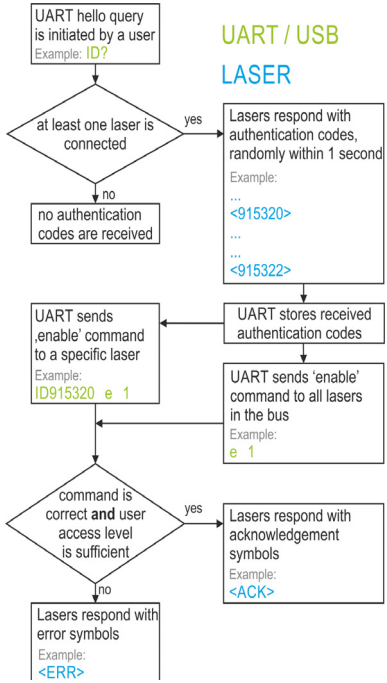

Figure 4-15. ID request sent from the system UART to a bus with multiple lasers.

Controlling multiple lasers with Integrated Optics, UAB software isn't possible. It is only an example for integrators.

4.8: TTL modulation

TTL modulation stands for transistor-transistor-logic. In the context of laser modules, TTL modulation means a convenient and standardized method for lasers modulation.

MatchBox wavelength combiners can only be modulated by sending digital signals.

The voltage tolerance for TTL inputs of all wavelength combiners is +5 VDC (+ 3.3 VDC compatible).

For each laser diode, TTL modulation speed is up to 10 MHz.

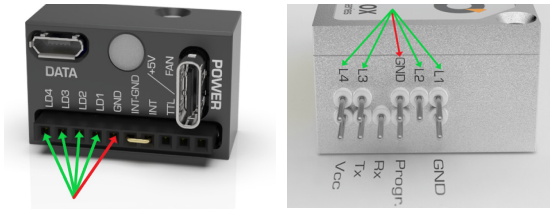

Figure 4-16. Pins for TTL modulation in Break-out-Box (left) and the laser module.

To use TTL modulation, modulation inputs should be connected to 'GND' and L1..L4 (in wavelength combiner) or LD1..LD4 (in Break-out-Box), as shown in Figure 4-16.

Green arrow marked inputs show each laser diodes' positive TTL input, red arrow marked inputs are for TTL ground input.

To find out how wavelength combiner operation is affected by different TTL modulation pin states, check the table below.

Table 4-2. Laser control via TTL input truth table

TTL input	Laser output
Open	Y
Low (0 V)	N
High (+ 3.3 VDC and above)	Y

Note: In all cases laser is either ON, using GUI or is autostart enabled.

Laser control via TTL input truth table explanations:

- when TTL input is **open** and laser beam is enabled through software, laser is emitting light;

- when TTL input is **low**, the laser is not emitting light even if the laser beam is enabled through software, instead laser is put to warm-up.

- when TTL input is **high** and laser beam is enabled through software, laser is emitting light.

If laser is turned off by TTL modulation, but modulation signal is somehow disconnected, the laser will start to emit light at the set output power, causing potential harm to a user or burning facets that the beam is pointed to.

4.9: 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 described 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 9-12 V at 1.5-3 A current.

If laser is being powered through a Break-out-Box, we recommend using 18 W PD type power supply. We highly recommend using the same power supply as we offer on our website. Otherwise we can not 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:

a) the laser overheating,

b) the power supply is not sufficient,

c) the laser diode or pump diode has failed.

Please check if heat dissipation is sufficient. Launch the laser control software, check whether the internal TEC is operating at 100% capacity. What is the voltage between Vcc and GND pins? It should not be less than 8.0 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: Low power, broad spectrum diode lasers typically require 7.5 W heat

dissipation, so such laser could be cooled using air-forced (AM-H8/AM-H3) or TEC based (AM-H11) heatsink.

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

A: During production, our lasers are tested on water-cooled adapter plates, that can keep laser base at 25 °C temperature. Aluminium breadboards could be used to dissipate low amount of heat, but that would not be enough for stable laser operation.

User's should always use thermal paste when mounting the laser.

Body temperature of the laser should not exceed about 40 °C, and the TEC load should not exceed 80%, with rare exceptions.

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, by providing 9-12 V at 1.5-3 A 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.

Also, for stable laser operation it is always advised to use heatsinks. Contact our sales support for suitable heatsinking recommendations.

Q: What is a Breakout-Box?

A: Break-out-box includes a small printed circuit board attachable directly to a laser pins. This electronics board features a USB-C power socket, pins for interlock, TTL and fan control. Furthermore, it incorporates a UART-to-USB converter chip (SiLabs) and a micro USB socket for data communication. Also, it converts PD type (Power Delivery) power supply input to a suitable and stable voltage and current output for a laser.

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 our technical support.

Q: When do I have to use FC/PC and FC/APC fiber connector?
A: By default, fiber-coupled wavelength combiners are manufactured with FC/PC connector, but 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 10 MHz in ACC mode) modulation instead of fan control, thus PWM with a bandwidth of 10 MHz 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 also 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.
Also, 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: 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

°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	Kilohertz = 10^3 Hz
LD	Laser Diode
MHz	Megahertz = 10^6 Hz
MM	Multi-Mode
mrad	Milli-radian = 10^{-3} radians
mW	Milliwatt = 10^{-3} Watts
nm	Nanometre = 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:

- 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.

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