moglabs

Fibre Amplifier
MFE

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Preface

The MOGLabs MFE Fibre Amplifier is a modular system based on Er and Yb doped active fibres. Internal modules can include seed and up to three stages of amplification, from 500 mW to 20 W. Wavelengths extend from 1000 to 1100 nm and 1530 to 1610 nm. It can be operated via front–panel controls, or using a computer communications interface (TCP/IP or USB) with simple text–based commands.

We hope that the MFE meets and exceeds your expectations. Please let us know if you have any suggestions for improvement in the MFE or in this document, and check our website from time to time for updated information.

MOGLabs www.moglabs.com

Safety Precautions

Safe and effective use of this product is very important. Please read the following safety information before attempting to operate your laser. Also please note several specific and unusual cautionary notes before using the MOGLabs MFE, in addition to the safety precautions that are standard for any electronic equipment or for laser-related instrumentation.

CAUTION – USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE

Laser output can be dangerous. Please ensure that you implement the appropriate hazard minimisations for your environment, such as laser safety goggles, beam blocks, and door interlocks. MOGLabs takes no responsibility for safe configuration and use of your laser. Please:

- Avoid direct exposure to the beam.

- Avoid looking directly into the beam.

- Note the safety labels and heed their warnings.

- When the laser is switched on, there will be a short delay of two seconds before the emission of laser radiation, mandated by European laser safety regulations (IEC 60825-1).

- The STANDBY/RUN keyswitch must be turned to RUN before the laser can be switched on. The laser will not operate if the keyswitch is in the STANDBY position. The key cannot be

removed from the controller when it is in the clockwise (RUN) position.

- To completely shut off power to the unit, turn the keyswitch anti–clockwise (STANDBY position), switch the mains power switch at rear of unit to OFF, and unplug the unit.

- When the STANDBY/RUN keyswitch is on STANDBY, there cannot be power to the laser diode, but power can still be supplied to the laser head for temperature control.

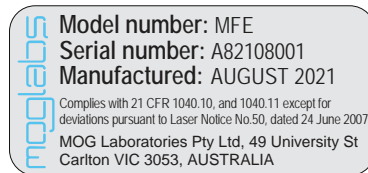*CAUTION* The supply must include a good ground connection.

CAUTION To ensure correct cooling airflow, the unit should not be operated with cover removed.

WARNING The internal circuit boards and many of the mounted components are at high voltage, with exposed conductors, in particular mains supply to various sections of the power supply. The unit should not be operated with cover removed.

NOTE The MOGLabs MFE is designed for use in scientific research laboratories. It should not be used for consumer or medical applications.

Label identification

The International Electrotechnical Commission laser safety standard IEC 60825–1:2007 mandates warning labels that provide information on the wavelength and power of emitted laser radiation, and which show the aperture where laser radiation is emitted. Figures 1 and 2 show examples of these labels and their location on the device.
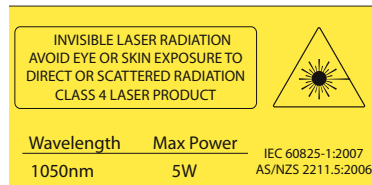
|	
Model number: MFE **Serial number:** A82108001 **Manufactured:** AUGUST 2021 Complies with 21 CFR 1040.10, and 1040.11 except for deviations pursuant to Laser Notice No.50, dated 24 June 2007 MOG Laboratories Pty Ltd, 49 University St Carlton VIC 3053, AUSTRALIA	US FDA compliance
LASER RADIATION	Emission connector symbol
INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LASER PRODUCT Wavelength Max Power IEC 60825-1:2007 1050nm 5W AS/NZS 2211.5:2006	Warning and advisory label Class 4

Figure 1: US FDA compliance and laser warning advisory labels.
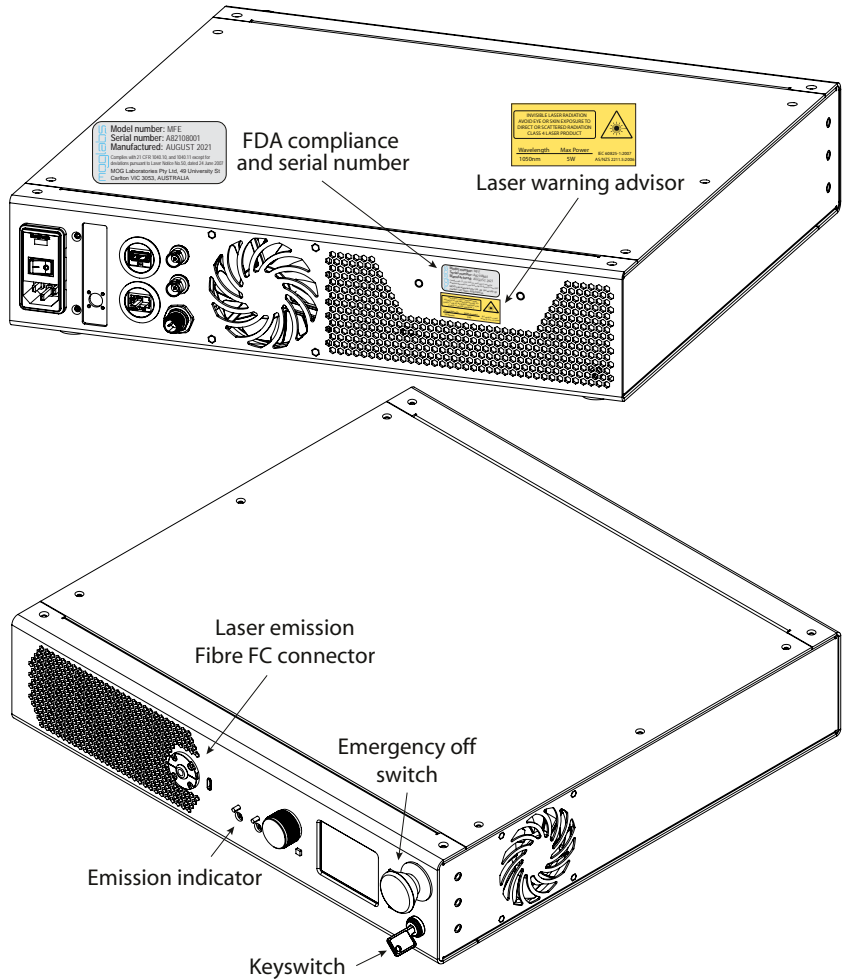
Figure 2: Schematic showing location of warning labels compliant with International Electrotechnical Commission standard IEC 60825–1:2007, and US FDA compliance label. Warning advisory label and compliance label are on the rear panel. Emission is from the front panel FC fibre connector labelled with triangular laser radiation symbol. Emission indicator is labelled AMP. Safety keyswitch and emergency off switch are also indicated.

Protection Features

The MOGLabs MFE includes a number of features to protect you and your laser.

Softstart A time delay (3 s) followed by linearly ramping the pump diode current (1 s/A max).

Circuit shutdown Many areas of the circuitry are powered down when not in use. The pump diode current supplies may be without power when the unit is in standby mode, if an interlock is open, or a fault condition is detected.

Current limit Sets a maximum possible pump diode injection current (one per stage).

Cable continuity If the pump diode fail and become open- or short-circuit, the system will switch to standby and disable all laser supplies.

Short circuit If the pump diode fail and become short-circuit, it will be disabled accordingly.

Temperature If the detected temperature is outside normal operating temperature, the amplifier is disabled.

Internal supplies If the internal DC power supply (+24 V) is 4 V or more below its nominal value, the respective components are disabled.

Emergency stop button In the case of emergency the entire system can be turned off by pushing the emergency stop button on the front panel. This will break the connection with mains power.

Emission indicator The MOGLabs controller will illuminate the current warning indicator LED immediately when the amplifier is switched on. There will then be a delay of at least 3 seconds before actual laser emission.

Mains filter Protection against mains voltage supply transient peaks.

Key-operated The amplifier cannot be powered unless the key-operated STANDBY switch is in the RUN position, to protect against unauthorised or accidental use. The key cannot be removed from the controller when it is in the clockwise (RUN) position.

Interlocks The main unit has an external interlock to allow the amplifier to be disabled via a remote switch.

Seed input A photodetector in the amplifier is used to detect the presence of seed laser input. The amplifier will not start unless there is sufficient input seed power.

Contents

1. Introduction

The MOGLabs MFE is a modular high–power fibre amplifier system based on Er and Yb doped active fibres. It uses an internal or external (depending on the model) seed laser and up to three amplification stages providing the output power levels from 500 mW to 20 W. The operating wavelength ranges include 1000 to 1100 nm for Yb active fibre and 1530 to 1610 nm for Er active fibre.

Every amplifier is equipped with an armoured polarisation–maintaining (PM) optical fibre cable with an anti–reflection coated (AR) end–capped FC/APC connector. The output port is located on the front panel. The fibre length can range from 2 to 5 m.

An external second harmonic generation (SHG) cavity can be connected directly to the amplifier via a standard USB-C (USB 3.0–3.2) cable. The port is located on the front panel adjacent to the fibre output.

The device can be controlled via the front panel controls and display (see below) or remotely via simple text commands communicated through USB or TCP/IP. Please refer to appendix F for further information on computer communications, and appendix E for details on the control command syntax.

1.1   Front panel controls
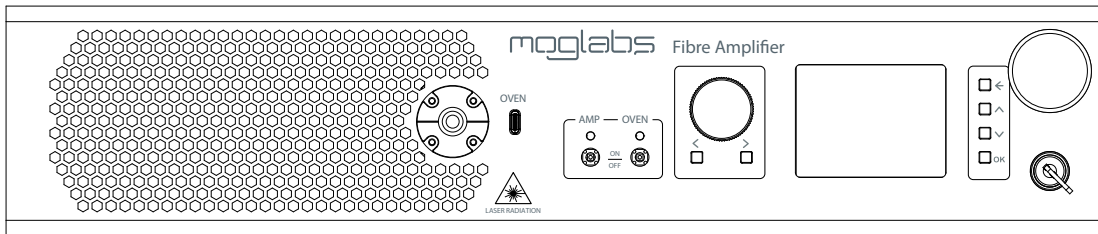
STANDBY/RUN   In STANDBY mode, the amplifier is disabled, no current is applied to the pump diodes.

In RUN mode, the internal amplification stages are placed into standby, ready to be activated. On first power–up and during the boot procedure the MFE will halt if the key is already in the RUN position, to ensure that the laser cannot be accidentally powered following a power failure. The keyswitch should be set to STANDBY and then to RUN to initiate user control. Place the unit back into STANDBY if the unit will not be operated for some time, such as overnight.

AMP OFF/ON   Amplifier on/off. The STANDBY/RUN key switch must be in the RUN position to power on the amplifier.

If the amplifier controller fails to switch to STANDBY mode (indicator does not show yellow), see Appendix B.

OVEN OFF/ON   External SHG oven on/off. The oven can be switched on and off regardless of the STANDBY/RUN key switch position.

If the oven controller fails to switch to STANDBY mode (indicator does not show yellow), see Appendix B.

ADJUST   The rotary encoder allows variation of any editable value on the display. The knob can be pressed to step through different digits of the value being edited, to allow for fine and coarse control.

EMERGENCY STOP   The entire system can be turned off by pushing the emergency stop button on the front panel. This will break the connection with mains power.
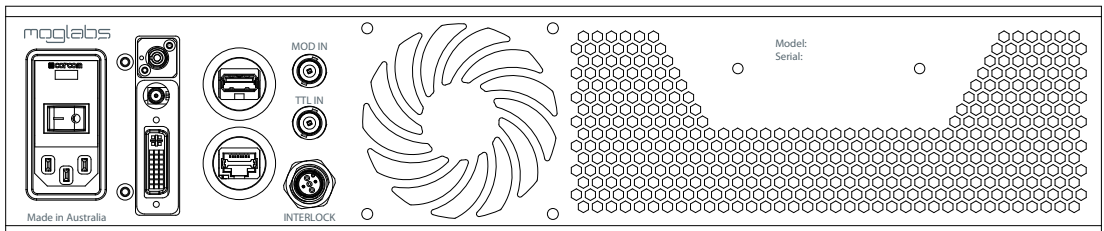
←, →   The two buttons below the adjust knob allow selection of the digit
                 of a value being edited.

←, ↑ , ↓, OK   Menu control buttons to navigate the menu system. ← steps back-
                 wards one me u level; ↑ or ↓ step up and down between lines on
                 any given menu; OK moves forward in the menu system or executes
                 selected system function.

1.2   Rear panel connections

IEC power in   The unit supports a wide range of input voltages and frequencies
                 from 80-264 VAC 47–63 Hz.

FIBRE INPUT   The PM fibre mating sleeve for external seed laser. Presence de-
                 pends on system model. A non–AR coated FC/APC fibre connector
                 must be used. The maximum input power must not exceed 35 mW.

CURRENT MOD   SMA input provides AC or DC coupling to an active modulation circuit
                 of the internal seed laser. Note that connection to the SMA input
                 will reduce the diode current by about 2.5 mA (B1240), with zero
                 input voltage. ± 2 V input max, 1 mA/V sensitivity and bandwidth of
                 10 kHz.

LASER DRIVER   Connection to laser driver. Presence depdends on system model.
                 External laser driver must provide diode current, temperature sense,
                 and TEC current for the internal seed laser. Compatible with MOGLabsDLC
                 controllers; a DVI-D Dual Link cable is required.

USB   USB-A hi-speed (USB 2.0) input to MFE microcontroller.

Ethernet   RJ45 10/100 twisted pair ethernet to MFE microcontroller.

MOD IN   External modulation of the output power. $0 - 1.2\,\text{V}$ input max, in-
                           verted. The input is DC-coupled. Affects the final amplification stage
                           only. The minimum output power depends on system configuration,
                           but will not reach zero. A standard $50\,\Omega$ BNC cable is required.

TTL IN   Amplifier switch off TTL trigger input. Active low, $5\,\text{V}$ tolerant.

INTERLOCK   The MFE will not power on the pump diodes unless the pins on this
                           port are **shorted**. A standard 5-pin M12 connector is provided; see
                           appendix D for pinout. The pins should be shorted using a relay for
                           integration with laboratory interlock system. Do not apply a voltage
   directly across the pins.

2. Menus

The MOGLabs MFE can be controlled via a detailed on-screen menu system. There are four push buttons to the right of the LCD display, to step through the menus. The large encoder knob can be rotated to change a value, and also acts as a push-button to select the character or digit to be adjusted.

The LCD display provides status and control information in the following pages:

Main	Critical values and settings
Report	Key parameters from each amplification stage
Oven	External SHG cavity oven settings
Options	Full settings menu system
Ethernet	Ethernet (TCP/IP) configuration
Display	Display settings

2.1 Main menu
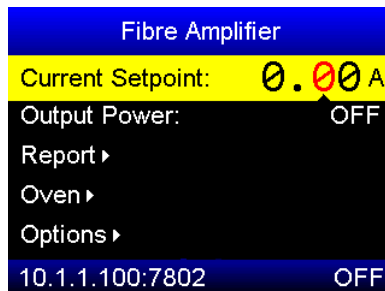
The default screen on power-up, showing the final amplification stage pump diode set current and approximate output power. The yellow bar shows that the pump diode current is selected for adjustment. Rotate the adjust knob to change the current; use the ↓ button to select a different parameter, or to move the cursor down

to the Report→ or Options→ line and press OK to enter into other menus.

2.2 Report menu

The Report menu provides access to crucial information of each amplification stage inside the fibre amplifier. The number of stages may vary depending on the model.

2.3 Oven menu

The Oven menu provides control of the external SHG crystal ove, if available.

2.4 Options

The Options menu allows access to infrequently required information, including device uptime, display settings, and firmware ver-

sions. There are also options to restore default settings, reset the settings and firmware to factory values, and to restart the device.

2.5   Ethernet settings

Ethernet Settings			Ethernet Settings	
Current IP:			IP mask:	255.255.255.0
	10.1.1.100		Gateway:	10.1.1.1
Static IP:	10.1.1.190		Port:	7802
IP mask:	255.255.255.0		DHCP:	ON
Gateway:	10.1.1.1		Restart ethernet	
10.1.1.100:7802	OFF		10.1.1.100:7802	OFF

TCP/IP network parameters. To effect new settings, select the *Restart ethernet* menu option which is initially off–screen at the bottom.

3. Operation

3.1 Getting started

The MOGLabs MFE armoured fibre connector cap should be removed before turning the amplifier on to prevent permanent damage. If the amplifier is intended to be used in conjunction with the SHG cavity then it should be connected via a hi–speed USB–C (USB 3.0–3.2) cable supporting power delivery of at least 60W.

To operate the MFE:

1. Ensure the rear power switch is on, and the STANDBY/RUN switch is in the STANDBY position. In this mode, the amplification stages are disabled. The Oven LED should turn yellow indicating that the SHG cavity can now be enabled.

2. If the amplifier comes without a built–in seed laser then ensure that the external seed FC/APC connector is plugged into the mating sleeve on the rear panel. The input power should be within the specified limits, please refer to the model specification or factory test report for details.

3. If the amplifier comes with a built–in seed laser then ensure it is turned on and the output power is stable.

4. Adjust the SHG temperature setpoint as required. It may be necessary to change the *Temperature Limit* to permit the desired setpoint temperature.

5. Start the SHG cavity controller by pressing the ON/OFF button below the Oven LED. Once the SHG cavity controller is running the LED will turn green.

6. Switch from STANDBY to RUN. The AMP LED should turn yellow indicating that the amplifier can now be switched on. If the indicator is still off, this indicates an interlock failure.

7. If the key is switched back to STANDBY, the amplifier will be disabled.

8. Navigate to Setpoint Current or Output Power depending on the operation mode:constant current (CC) or constant power (CP). The mode can be changed in the Options menu.

9. Adjust the current setpoint (or output power) as required, using the display or `mogmfe` application. If the MFE was purchased as part of a laser system, this will have been factory-set as required.

   To use the display, move the cursor down to *Current Setpoint* using the buttons on the right-hand side, and then turn the rotary encoder to adjust the value.

10. Switch the amplifier on by pressing the ON/OFF button below the AMP LED. The LED below AMP will turn blue, indicating that the current supply is starting. After three seconds the output current will ramp up to the desired setpoint value.

11. Once the current has hit the setpoint the LED will turn green, indicating the amplifier is operational.

Note that the interlock must be enabled and no errors can be present for the amplifier to successfully power on. Consult Appendix B for assistance with diagnosing problems.

3.2   Interlocks

The MFE includes a number of safety features for the protection of both personnel and equipment. These interlocks must be active during normal operation, as even a momentary interruption will trigger amplifier shutdown.

3.2.1   Rear-panel interlock

The back-panel interlock connector is a standard M12 5-pin plug. Pins 2 and 4 must be shorted to enable the MFE. Intended for inte-

gration with controlled-entry systems such as door interlocks.

3.2.2 Key switch

The key switch on the front-panel must be set to *Run* to enable the MFE outpu. As a safety procedure, it is necessary to manually toggle the key switch after power-cycling the unit; it cannot simply be left in the ON position.

For integration into control systems, toggling the key switch can be performed through the command TOGOVERRIDE, however to be compliant with safety regulations this function should only ever be used in accordance with a user prompt confirming manual override.

3.2.3 Photodiode interlock

The input power in every amplification stage is constantly monitored and compared to safe limits, for systems with either internal or external seed laser. Refer to the model specifications or factory test report for acceptable seed power limits.

Some amplifier stages include a photodiode sensor that monitors the approximate output power. An unexpected decrease in output power at a given current is an indication that the amplification stage is operating unseeded, which can irreversibly damage the stage at high drive currents.

In the case of a device malfunction, a Report menu on the main screen will provide information on the cause of the system shutdown.

3.2.4 Internal interlocks

Internal amplification stage interlocks include overcurrent protection, power supply voltage monitoring and open/short circuit detection. Momentary triggering of any protection mechanism will shutdown the amplifier and set the respective flag in the stage report message.

In the case of a device malfunction, a R<small>EPORT</small> menu on the main screen will provide information on the cause of the system shutdown.

4. MOGMFE application

The host software program `mogmfe` provides a graphical user interface that allows remote control of the MFE amplifier.

It may be necessary to install a firmware update (section 4.4) before being able to use the `mogmfe` software. If the software detects an incompatibility it will offer to install the update, which can be obtained from the MOGLabs website.

4.1 Device discovery

Upon starting `mogmfe`, a device discoverer is displayed (Figure 4.1) which searches for MFE devices. Simply select the device with the correct serial number and click *Connect*.
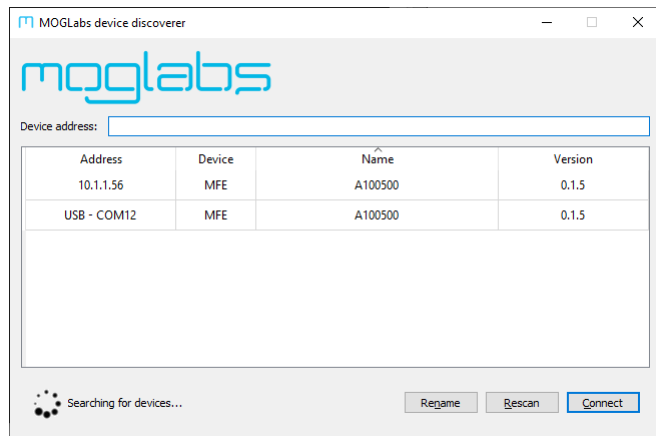

Figure 4.1: Example of the *device discoverer* window.

If the network does not permit device discovery and/or your MFE does not appear in the list, type the IP address of the unit (as displayed on the LCD screen) in the *Device address* box and click *Connect*.
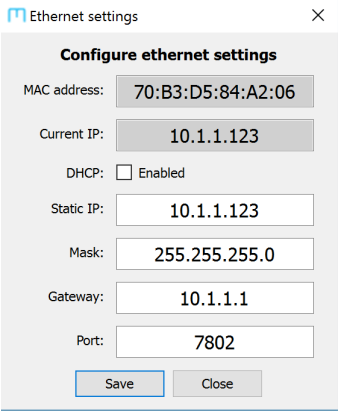
13

4.2   Main display

TBD.

4.3   Menu options

TBD.

4.3.1   Config

TBD.

Network   Allows configuration of network connection settings (IP address, mask, gateway and port). Particularly useful for configuring the network settings over USB. Changing the *Static IP* only has an effect if DHCP is disabled, or if DHCP name resolution fails. Changing the ethernet

settings will require the application to be restarted, and may also require the device to be rebooted. The port should be unchanged at 7802 to ensure that the `mogmfe` suite of programs can continue to communicate with the device.

4.3.2   Help

About   Displays device information.

Update   Initiates firmware update (section 4.4).

Manual   Opens web browser pointed at the MOGLabs support website to read the most up-to-date version of the manual.

4.4   Firmware update

From time to time, MOGLabs will release a firmware update to improve functionality. Updates are available from the MOGLabs website and should be installed on the device using the `mogmfe` application.

The firmware update procedure is started by selecting *Update* from the *Help* menu, or will be automatically activated if the software detects incompatibility with the current firmware version (Figure 4.2).
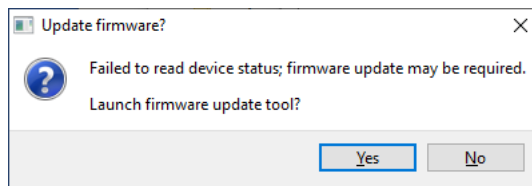
Figure 4.2: When `mogmfe` detects a version incompatibility it will offer to install a firmware update. Alternatively the *Update* option can be selected from the *Help* menu.

It is recommended to update firmware using a network connection, but USB can be used. When using USB it may be necessary to unplug the USB cable when the process appears to have become stalled at the "Waiting for reboot..." stage.

The MFE should not be in use while applying a firmware update; neither the front-panel interface nor a separate device connection should be used to interact with the unit simultaneously. The MFE

must not be powered off or interrupted during the firmware update or the firmware could become corrupted.

Firmware is distributed as a ZIP file that contains different firmware components. Upon opening the firmware update tool (Figure 4.3), click the *Select* button and browse for the firmware ZIP file. The tool will identify the components that need upgrading, which will by installed by clicking the *Update all* button.
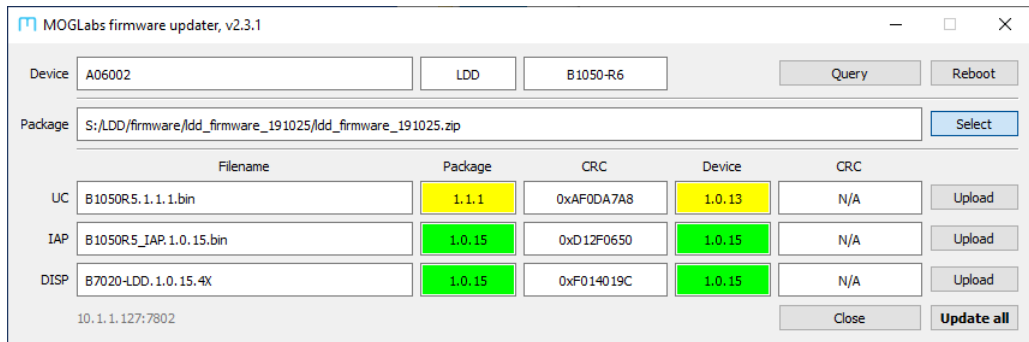
Figure 4.3: The firmware update tool shows the current versions of the firmware components, indicating which are up-to-date (green) and which require updating (yellow or red).

The firmware update process typically requires the device to reboot several times. A prompt is displayed once the process is complete. Closing the firmware update tool will then allow `mogmfe` to be used.

A. Specifications

Parameter	Specification
Power amplifier	
Output current	0 to 10 A
Output power	Up to 20 W
Display resolution	± 10 mA, ± 10 mW
Noise	TBD (10 Hz − 1 MHz, depending on the seed laser)
Stability	1% rms
Warmup time	30 minutes
Analogue modulation	$0 - 1.2$ V max, 10 kHz bandwidth, inverted
Operating temperature	$20 \pm 10 \,°C$

Note: The maximum output power/current depends on the model and the operating wavelength. Refer to the factory tset report provided with the amplifier.

Parameter	Specification

SHG oven controller	
Operating temperature	Ambient to 150 °C
Accuracy	±0.02°C
Long-term stability	±0.05°C
Regulator type	PID, hysteresis
Warmup time	15 minutes

Computer interface	
Ethernet	10/100 TP, RJ45
USB	USB 2.0, plug type USB-A
Display	2.8″ 240x320 TFT

Connectors	
Oven	USB-C (USB 3.0–3.2) full-speed with 60W PD feature

Protection	
External interlock	M12 5-pin connector
Key interlock	STANDBY/RUN
Delayed soft-start	3 s delay + 1 s/A ramp (to 10A)
Photodetector	Seed/amplification stage failsafe
Internal protection	Open/short circuit, overcurrent, power supply monitor

Parameter	Specification
Mechanical & power	
Fan	Dual 24 V DC ball-bearing
IEC input	80 to 264 V 47 – 63 Hz
Dimensions	WxHxD = 422 × 88.5 × 400 mm
Weight	7 kg (excluding cables)
Power	15 W (standby) 36 W to 200 W, configuration-dependent

B. Troubleshooting

The MOGLabs MFE detects a wide range of fault conditions and deactivates related circuitry accordingly. The front panel LEDs provide indication of the state of these functions.

B.1   AMP indicator

Colour	Status
DARK	Deactivated; check interlock and key switch
YELLOW	Standby mode, ready to be enabled
BLUE	Current ramping up to setpoint
GREEN	Current stable at setpoint
RED	Error state; check Report screen for more information

B.2   OVEN indicator

Colour	Status
DARK	Deactivated
YELLOW	Standby mode, ready to be enabled
BLUE	Ramping to the temperature setpoint
GREEN	Temperature setpoint reached; Operational
RED	Error state; check screen for more information

B.3   Error states

If an error is detected, the LCD display will provide an explanatory message from the table below.

Error Message	Solution
Firmware update in progress	Amplifier cannot be enabled during the firmware update. Restart the device after the firmware update is finished.
Interlock disabled	The rear interlock is open circuit. Make sure the rear-panel interlock is shorted.
Key switch disabled	Key switch was turned off during operation.
Re-enable interlock	The key needs to be turned off and on again before operation.
Power is not good	The power supply is malfunctioning.
Stage interlock triggered	The interlock was triggered by one of the amplification stages. Refer to Report screen for more information.

B.4   State flags

State flags are used to monitor the amplification stages and can be very helpful in troubleshooting. The flags are constantly updated in the Report menu. These flags are represented by two numbers separated by space. Both numbers are in hexadecimal format.

The first number is called a global (or board) flag and provides information about global triggers (interlock, power good and TTL signals). The second number is called a stage flag and provides the information about the pump diode current source and internal monitors. Some bits in the flags are constantly updated showing the current state of the signal. Other bits are showing if a certain signal has been triggered, which helps to determine what signal caused the shutdown. The trigger signals can only be reset by re-enabling the interlock.

A detailed description of each flag is given below.

B.4.1   GLOBAL flag

Flag name	HEX	Description
INTLK	0x01	Interlock enabled
PGOOD	0x02	Power is good
TTL_nOFF	0x04	TTL is enabled
INTLK_TRIG	0x08	Interlock has been triggered
PGOOD_TRIG	0x10	Power good signal has been triggered
TTL_TRIG	0x20	System was switched off by external TTL input

B.4.2   STAGE flag

Flag name	HEX	Description
SUDDEN_DROP	0x01	Output power has dropped by more then 20%
ILIM_TRIG	0x02	Overcurrent protection has been triggered
ILIM_EN	0x04	1:Overcurrent protection enabled
INPUT_POWER_LOW	0x08	Seed input power too low
INPUT_POWER_HIGH	0x10	Seed input power too high
SHORT_CIRCUIT	0x20	Output is short circuit
OPEN_CIRCUIT	0x40	Output is open circuit.

For additional assistance please contact MOGLabs. Please include the device serial number and firmware versions.
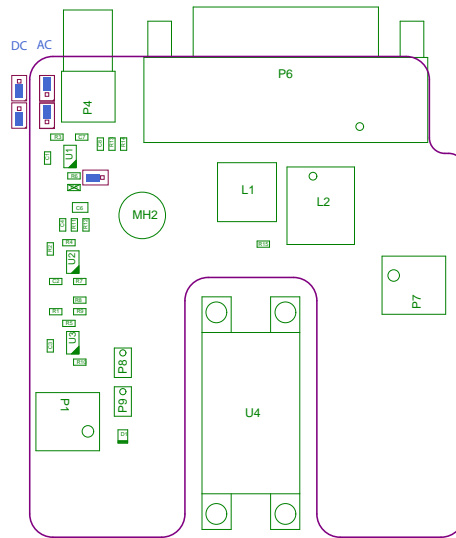
C. Laser head board

Amplifiers with internal seed laser will have a laser head interface board that provides connection breakout to the laser diode, TEC, temperature sensor, and laser head interlock. It also includes a protection relay and passive protection filters and an SMA connection for direct diode current modulation.

The B5185 headboard provides high bandwidth active current modulation for wide bandwidth frequency stabilisation and sub–Hz linewidth narrowing, for example using a high finesse optical cavity or polarisation spectroscopy.

C.1   B5185 headboard

Headboard type B5185 provides high-speed active modulation of the diode current. It uses 500 MHz opamps and very low latency circuitry to reduce phase delay to around 12 ns. The B5185 allows for closed-loop bandwidth of about 4 MHz (without phase advance), which is helpful in achieving sub-Hz linewidth reduction by locking to a high-finesse optical cavity. The B5185 also allows direct-ground connection or buffered; the latter is about 10% slower but reduces problems with ground-loop noise.

Note that connection to the SMA input will reduce the diode current, even if the control voltage is at zero.

Figure C.1: B5185 enhanced laser head board. Jumpers at top left can be configured for AC or DC coupling. An additional jumper "Buff" for direct or buffered (differential) ground coupling, shown connected for differential coupling; change to pins 1 and 2 for direct. Modulation input via SMA connector, sensitivity 2.5 mA/V.

C.1.1 SMA input

The B5185 SMA input provides AC or DC coupling to an active mod-ulation circuit. Note that connection to the SMA input will reduce the diode current by about 2.5 mA, with zero input voltage.

	B5185
Input range	± 2.0 V max
Input coupling	DC (direct)
	AC/DC (buffered)
AC time constant	15 μs (10 kHz)
Phase delay	< 20 ns (direct)
	< 30 ns (buffered)
Gain bandwidth (-3 dB)	20 MHz
Input impedance	AC buffered: 1 k at 10 kHz
	DC buffered: 1 k
	Direct: 1 k
Current gain	1 mA/V
Laser diode voltage	2.5 V max

C.2   Headboard connection to controller

Note

The MOGLabs laser cable is a digital DVI-D DL (***dual link***) cable. There is a bewildering assortment of apparently similar cables available. Most *computer display* DVI cables will ***not*** work because they are missing important pins; see diagram below. Only high quality digital ***dual–link*** DVI-D DL cables should be used.

Pin	Signal	Pin	Signal	Pin	Signal
1	TEC −	9	DIODE −	17	DISC +
2	TEC +	10	DIODE +	18	DISC −
3	Shield	11	Shield	19	Shield
4	TEC −	12	DIODE −	20	STACK +
5	TEC +	13	DIODE +	21	STACK −
6	T_{sense} −	14	Relay GND	22	
7	T_{sense} +	15	+5V in	23	NTC −
8		16	Interlock out	24	NTC +

LASER Socket: DVI-D DL (Dual Link)   Plug: DVI-D SL (Single Link)
                                            Do not use SL cables
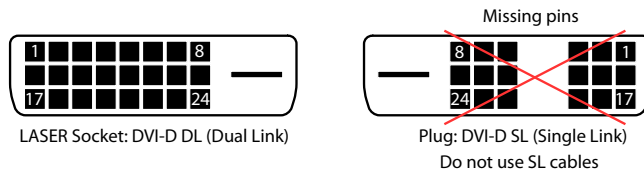
Figure C.2: Headboard connector. Note that the pinout is different to that of the matching connector on the rear of the DLC controller.

A 10 k thermistor should be connected to NTC+ and NTC−, but an AD590 or AD592 temperature sensor can instead be connected to T_{sense}. Pin 15 should be connected to a +5 V supply. To activate the laser diode, relay GND (pin 14) should be grounded to open the relay that otherwise short–circuits the diode current. +5 V (pin 15) is internally connected to pin 16 (Interlock), normally with a permanent connection.

D. Connector pinouts

WARNING: The OVEN connector is intended for connection to a MOGLabs SHG cavity. It can provide high currents that may damage other devices. Considerable care should be taken if connecting to non–MOGLabs equipment.

Only high quality USB–C (USB 3.0–3.2) cables with a power delivery feature of at least 60W should be used.

D.1 Interlock

1	$+3.3\,\text{V}$ via $1\,\text{k}\Omega$
2-4	No contact
5	Interlock input
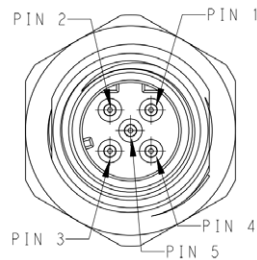
Figure D.1: M12 5-pin connector for Interlock. Pin 1 and Pin 5 should be short-circuited to enable amplifier.

Note: Do not apply a voltage across the interlock pins, or the MFE may be irreversibly damaged!

E. Command language

The MFE is controlled via a text–based communications protocol which allows for simple integration into existing control systems.

Please note: the command language is being continuously updated across firmware releases to improve functionality and add features. When upgrading firmware, please refer to the most recent version of the manual available at `http://www.moglabs.com`.

Commands are formed by a comma–separated list of parameters, as listed below. The parameters shown in square brackets are optional, and commands that are called without parameters are treated as queries.

Commands respond with a string that begins with either "OK" or "ERR" to indicate whether it was successful. Queries (such as measured temperature) return a value with units.

In some cases, the *actual* value may be different from the *requested* value due to parameter limits.

E.1 General functions

INFO `INFO`
Report device identification, including running firmware version and serial number. Please include this information in all correspondence with technical support.

VER `VER`
Report currently running firmware versions.

HELP `HELP[,cmd]`
Returns a list of available commands and short descriptive messages. Commands that have subcommands are indicated with >>, and the subcommands can be listed by specifying the `cmd` parameter.

STATE STATE
Responds with current state of the amplifier.

REPORT REPORT[,num]
Returns a dictionary (comma-separated list of key-value pairs) of present amplification stage settings and measured values. num selects the amplification stage. The order of entries in the dictionary is subject to change at any time.

AMPL AMPL[,on/off]
Activates (AMPL,on) or deactivates (AMPL,off) the amplifier, or returns the status of the amplifier if onoff is absent.

INTERLOCK INTERLOCK
Report remote interlock status. Returns either ON indicating the interlock is present, or OFF when the interlock is missing.

KEY KEY
Report keyswitch status. Responds ON if the keyswitch is set to RUN, OFF if the keyswitch is set to STANDBY, or TOGGLE if the keyswitch must be manually toggled to re-enable operation.

TOGOVER TOGOVERRIDE
Overrides the requirement to toggle the keyswitch. In order to remain compliant with safety regulations, this command should only ever be issued in response to direct user intervention, such as an interactive alert or prompt.

POWER POWER
Reports the measured output power. The power measurement photodetector is calibrated for a particular wavelength. Please refer to the factory test report for details. The accuracy should be verified by comparison with an independent external power meter.

VMON VMON,[num]
Reports the actual measured voltage drop across the pump diode for num amplification stage. Should be lower than the set compliance voltage.

IMON `IMON,[num]`
Reports the actual measured current through the pump diode for `num` amplification stage.

TMAX `TMAX,[num]`
Reports the maximum measured temperature for `num` amplification stage.

FAN `FAN,[num]`
Reports the actual measured fan speed in RPM for `num` amplification stage. Consists of two numbers separated by a space, representing the speed of each fan respectively.

FLGS `FLGS,[num]`
Reports the Global and Stage state flags of `num` amplification stage. Consists of two numbers separated by a space. The numbers are in hexadecimal. Please refer to section B.4 for more information.

E.2 Ethernet settings

ETH,STATIC `ETH,STATIC[,"xxx.xxx.xxx.xxx"]`
Set IP default address based on decimal dotted-quad string (for example "10.1.1.180"). The double-quotes are required.

ETH,MASK `ETH,MASK[,"xxx.xxx.xxx.xxx"]`
Set IP mask based on dotted-quad string (for example "255.255.255.0").

ETH,GATE `ETH,GATE[,"xxx.xxx.xxx.xxx"]`
Set IP gateway based on dotted-quad string (for example "10.1.1.1").

ETH,MAC `ETH,MAC[,"xx:xx:xx:xx:xx:xx"]`
Set hardware MAC address based on colon-separated hexadecimal numbers (for example "70:b3:d5:84:a0:00").

ETH,PORT `ETH,PORT[,port]`
Set the TCP/IP port number for device communication.

ETH,DHCP   `ETH,DHCP[,onoff]`

Enable or disable DHCP. Set to non-zero to enable DHCP; zero to use static IP address.

F. Communications

The MFE can be connected to a computer by USB or ethernet (TCP/IP) and integrated into existing control software. If you are experiencing difficulty in connecting to your MFE, please review the detailed instructions available at www.moglabs.com/support/software/connection

F.1   Protocol

Communication follows a query/response protocol, where the user sends a text string to the unit, and the unit returns a text response.

Messages are CRLF-terminated; that is, all commands must end with ASCII code 0x0D 0x0A. The C syntax is \r\l. Most terminal applications automatically append these characters. Responses from the unit should be buffered until CRLF is received. It is strongly recommended to check command responses to ensure correct operation.

Statements are either **commands** or **queries**. A command is a statement that causes some action to occur, and the unit will respond with either "OK" or "ERR" depending on whether the command succeeded or not. For example,

```
> AMPL,ON
< ERR: Interlock disabled

> AMPL,ON
< OK
```

Queries are statements to return a value, either returning the value requested or a message beginning with "ERR". For example,

```
> TEMP
```

```
< 22.635 C

> TEMP
< ERR: Temperature sensor missing
```

F.2   TCP/IP

When ethernet is connected, the MFE will attempt to connect to the network using saved values, which can be altered using the front-panel menu system. If DHCP is enabled the device will first try to obtain an IP address via DHCP. If DHCP fails, the static settings will then be used. In both cases, the current address will be shown on the display.

F.2.1   Changing IP address

If your network does not use a DHCP server, you may need to manually change the IP address. This is easily done via the front-panel menu system in *Settings → Ethernet*.

F.3   USB

The MFE can be directly connected to a host computer using a USB cable (type A-male). The correct USB device driver is packaged with the `mogmfe` software package or can be downloaded from `www.moglabs.com/support/software/connection`.

Connecting the MFE will install a new COM port on the machine. To determine the port number of the device, go to Device Manager (Start, then type `Device Manager` into the Search box). You should see a list of devices including "Ports" (Figure F.1).

The MFE can be identified as a COM port with the following name,
```
    STMicroelectronics Virtual COM Port (COMxx)
```
where `xx` is a number (typically between 4 and 15).
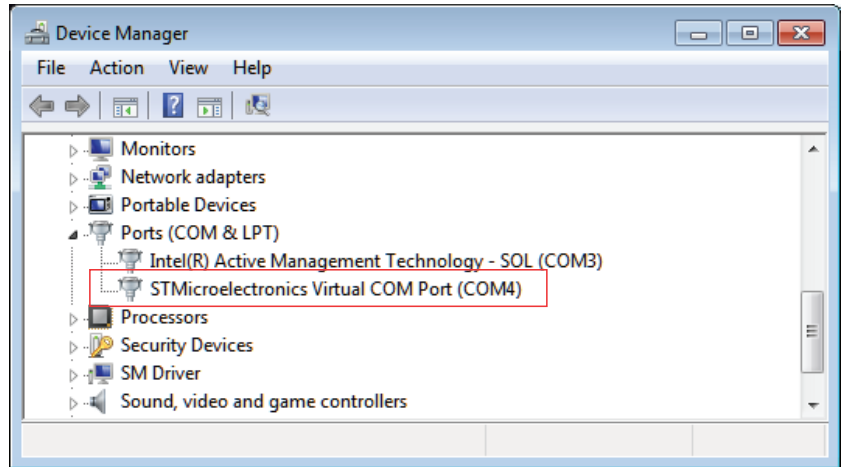
Figure F.1: Screenshot of Device Manager, showing that the MFE can be communicated with using COM4. The port number might change when plugging into a different USB port, or after applying a firmware update.

If the port appears in Device Manager with a different name, then the driver was not successfully installed. If this occurs, disconnect the MFE from the host computer and reinstall the device driver.