User Manual

M-NANO
M-NANO-GREEN

Nanosecond Nd-YAG (ALL-IN-ONE Laser Head)

Refers to:

M-NANO model PR133 (2W model, 1064nm)
M-NANO model PR139 (1W model, 1064nm)
M-NANO model PR147 (100Hz model, 1064nm)
M-NANO model PR148 (80mJ model, 1064nm)
M-NANO model PR153 (100mJ model, 1064nm)
M-NANO-GREEN model PR160 (30mJ, 1064nm + 532nm)
M-NANO-GREEN model PR183 (40mJ, 1064nm + 532nm)
M-NANO-GREEN model PR190 (30mJ, 1064nm + 532nm)

M-NANO customized models based on one of the above

Contents

1 Welcome!

Welcome to using a MONTFORT Laser nanosecond laser for your leading research and application!

Before starting, it is important to ensure the following:

- **Read this User Manual before installing and operating the laser head carefully.**
- **Read the laser safety section carefully (Chapter 6, "Laser Safety").**
- **Read the electrical safety section in section 6.3 carefully and ensure to fulfil proper installation of the laser unit.**
- **Check system contents*:**

1 pc. All-in-one Laser Unit

1 pc. (Optional) Power supply module (24VDC @ 9.5A out, 100-240VAC / 47-63Hz / <3.2A input) and IO-cable (interlock defeat connector and coax cables)

1 pc. Power cord (3-way, including EARTH)

3 pcs. SMC to BNC adapters

1 pc. USB to USB-mini cable 1.5m

1 pc. RS232 cable

1 pc. USB Stick (with Manual, Software and Product Test Report)

*exact system content is described in the product test report

In case of questions or problems, please be welcome to contact our distributor or us directly at:

MONTFORT Laser GmbH
Im Holderlob 6A
A-6840 Götzis, Austria

Tel: +43-720 733 462
http://www.montfortlaser.com
info@montfortlaser.com

2 List of warning symbols

The following list shows the warning symbols which are on the laser head.

Warning Symbol	*Description*	*Reference* *For more details see Chapter:*
	WARNING – read manual before using.	
	WARNING – laser radiation	Chapter 6
	WARNING – Hot surfaces possible when operated. Touch with heat resistance gloves only or allow cool down phase.	Section 6.5

3 Specifications

The following list provides standard specifications of the product. These can be modified or widened in specific cases depending on the customer-specific agreement.

Specifications	***Requirements***	***Reference*** ***For more details see Chapter:***
Environmental conditions		
Operation temperature (ambient)	5 to 40°C (non-condensing)	
Operating relative humidity	maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C	
Altitude	0 to 2000 meters	
Pollution Degree	Pollution Degree I or Degree II*	
Supply		
Supply voltage & current	24V-28V @ up to 9.5 A** Absolute minimum: 23.5 VDC** Absolute maximum: 29 VDC	Section 13.2.1
Laser output		
Wavelength (center)	1064 nm (Nd:YAG) 532 nm (SHG of 1064nm)	
Pulse energy	up to 120 mJ (depending on model)	Chapter 4
Maximum pulse energy	250 mJ (in single fault case)	
Average output power	Up to >1W, >2 W (depending on model)	Chapter 4
Pulse repetition rate	up to 100 Hz (depending on model)	Chapter 4
Pulse duration (FWHM)	8 ns (+/-5 ns tolerance), typical	
Laser beam quality M^2	2 … 3 (typical)	
Dimensions		
Dimensions***	132 x 140 x 64 mm^3 (without 532nm) 149 x 140 x 64 mm^3 (with 532nm)	Chapters 8, 13
Mounting, Cooling Requirement and Temperatures		
Mounting	Mount laser system on user-supplied submount with 6 screws into bottom plate M4x4 tapped holes see drawing in Ref.	Chapter 6.5 Chapter 8 Chapter 13.1.5
Submount temperature	5 to 40°C (non-condensing) to be ensured by user	

Submount maximum temp.	To be kept ≤40°C****
Maximal waste heat (operating)	Up to 252 W
Maximum temperature before laser operation shutdown	65°C (@ internal electronics)
Maximum laser head module temperature*****	60°C (maximum setpoint) 65°C (laser head cooling and laser operation shutdown)

Notes:

*It is recommended to use the laser in a clean environment to prevent damage to the laser exit window and ensure a long life.

**Optical output power may be reduced at input voltage <24.0VDC and current capability <9.5A.

***Not including screws, exit window, connectors. Length is longer than 149mm for some models, see drawings in section 13.1.

****waste heat generated depends on operation parameters and can approach up to 28V*9 A=~252 W, usually only reached during start-up and/or at full power operation!

*****Laser head module temperature set point can be changed by the user but it is recommended to keep the temperature setting unchanged from the value given in the product test report (PTR) for optimum performance.

4 List of models

The following list provides the product numbers (PR-number) for a family of product models for which this manual applies. For these models, the electronics and the usage is the same.

The optical layout may slightly differ from model to model. Please also note that the waste heat generated from the system may be different, as it depends on the submount and environmental temperature, as well as on the average output power.

M-NANO model PR number	***Model type***	***Typical pulse energy & repetition rate specifications***
M-NANO PR139	1W model	40 mJ @ 25 Hz 50 mJ @ 10 Hz 60 mJ @ 1 Hz
M-NANO PR133	2W model	50 mJ @ 40 Hz
M-NANO PR147	100Hz model	20 mJ @ 100 Hz
M-NANO PR148	80mJ model	80 mJ @ 12.5 Hz 60 mJ @ 24 Hz
M-NANO PR153	100mJ model	100 mJ @ 20 Hz
M-NANO-GREEN PR160	1W model 532+1064nm	~50 mJ (532nm) @ 10-20 Hz ~30-50 mJ (1064nm)
M-NANO-GREEN PR183	40mJ model	~40 mJ (532nm) @ 5 Hz
M-NANO-GREEN PR190	30mJ model 532+1064nm	~30 mJ (532nm) @ 10-20 Hz ~30-50 mJ (1064nm)

5 General

The information given in this document is subject to change without notice.

5.1 Warranty, Maintenance and Assistance

This laser device is manufactured by MONTFORT Laser GmbH with great care. It is warranted against defects in material and workmanship for a period of 12 months from the date of shipment to the customer. During the warranty period, MONTFORT Laser GmbH will, at its option, either repair or replace products which prove to be defective.

The warranty does not apply to defects resulting from improper use or maintenance by the buyer, from unauthorized modifications or operation outside the environmental specifications and from electrostatic discharge (ESD).

For warranty service or repair, the instrument should be sent to MONTFORT Laser GmbH in appropriate packing. Please ask MONTFORT Laser GmbH in advance for a RMA number. Enclose a detailed fault report including instrument type, serial number(s) and RMA number.

The M-NANO laser head is an integrated, all-in-one laser source. The external housing may only be opened by qualified service personnel from or authorized by Montfort Laser. Opening the external housing may not only result in a warranty void but can lead to personal injury. Therefore, it is recommended to not open the laser head housing without prior instruction to do so by the manufacturer MONTFORT Laser GmbH.

In case of questions or problems, please be welcome to contact our distributor or us directly at:

MONTFORT Laser GmbH
Im Holderlob 6A
A-6840 Götzis, Austria
Tel: +43-5523 52074
http://www.montfortlaser.com
info@montfortlaser.com

5.2 Intended Use

The compactness and low weight of the M-NANO Laser enable applications that were not possible with existing flash-lamp pumped technologies, including handheld applications and other applications with critical space and/or weight constraints. Applications of these compact laser sources include – besides scientific applications - laser analytics, LIBS (Laser-induced break-down spectroscopy), optical component damage testing, PIV (Particle image velocimetry), LIDAR (Light detection and ranging), photo acoustics, defense.

6 Laser and Electrical Safety, Environment Conditions

6.1 Laser Radiation

This section refers to the laser head, as it is a Class 4 laser system.

The radiation of the used laser system is invisible. The emission wavelengths and power levels are given below.

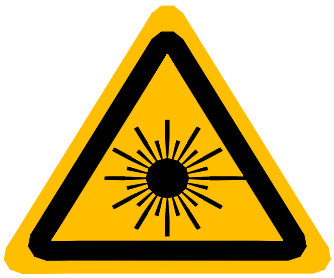
Use caution to avoid hazardous exposure to the beam. Take precautions to eliminate exposure to a direct or reflected beam. Do not look directly into the beam of the laser diode under conditions which exceeds the specified limits. Never observe the laser beam through optical instruments.

6.2 Laser Class

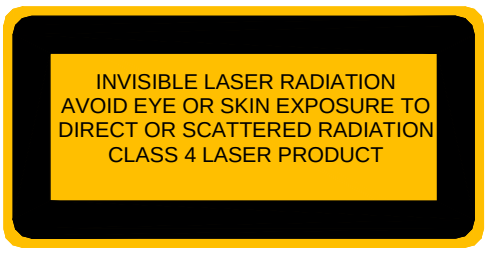
Please note the norm ISO IEC 60825-1:2014.

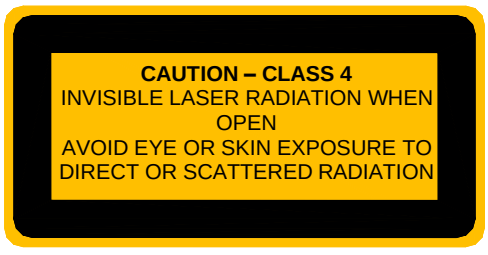
The **laser head is a Class 4 laser system.**

General warning label for laser radiation:

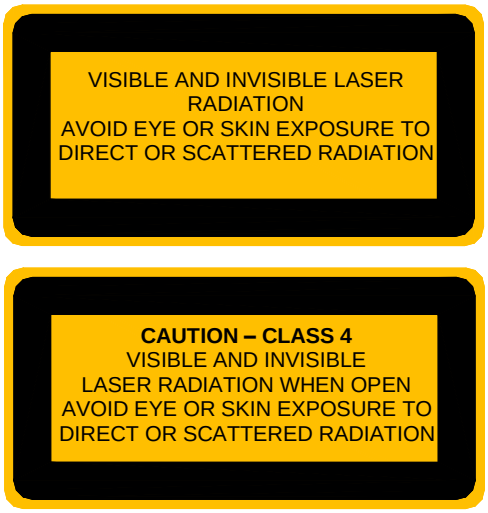


Label for laser radiation (M-NANO All-In-One Laser Head):

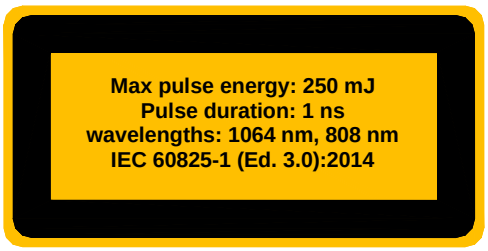




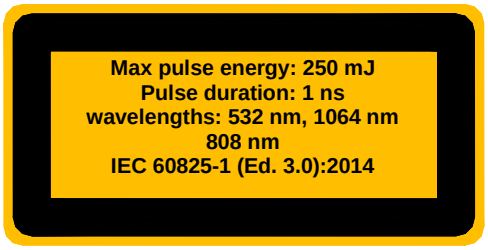
Label for laser radiation (M-NANO-GREEN All-In-One Laser Head):



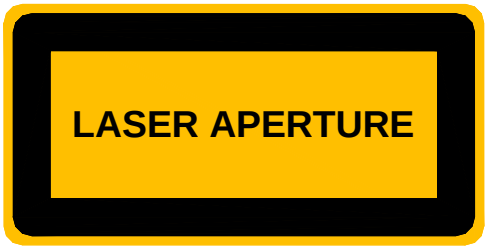
Label for relevant parameters for the M-NANO All-In-One Laser Head:



Label for relevant parameters for the M-NANO-GREEN All-In-One Laser Head:



Label shows the position of the laser aperture:



Please ensure:

- Whenever operating the laser, make sure you wear appropriate **Laser Protection Goggles**. The Laser Protection Goggles protect you against the radiation values given above.
- Use the external **interlock safety feature** (see Chapter 7, “Installation”) for optimized safety and connect it to a door switch, for example.
- Close the **shutter** by manually moving it so it is closed whenever the laser is off and/or whenever laser emission from the laser head should be suppressed.

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

6.3 Electrical Safety / High Voltage: CONNECT SUPPLY GROUND and HOUSING

The laser head contains high voltage components inside with >1 kV voltage load. Therefore a safety label “caution high voltage” is applied inside the housing, and the housing cannot be opened without a tool and without the potential loss of warranty.

Caution high voltage sign inside, on laser electronics

CAUTION – READ THE DESCRIPTION AND FOLLOW THE INSTALLATION INSTRUCTIONS IN THIS CHAPTER TO AVOID POSSIBLE ELECTRICAL HAZARD OR PERSONAL INJURY.

Please follow these instructions:

The figure below shows an isolation diagram with the following parts: laser head electronics (consisting of main controller and high voltage supply), the laser head module, external circuits (including e.g. a power supply, timing electronics for triggering etc.), a cable connection to the external circuits, and the metallic housing of the all-in-one laser system (“metallic enclosure”).

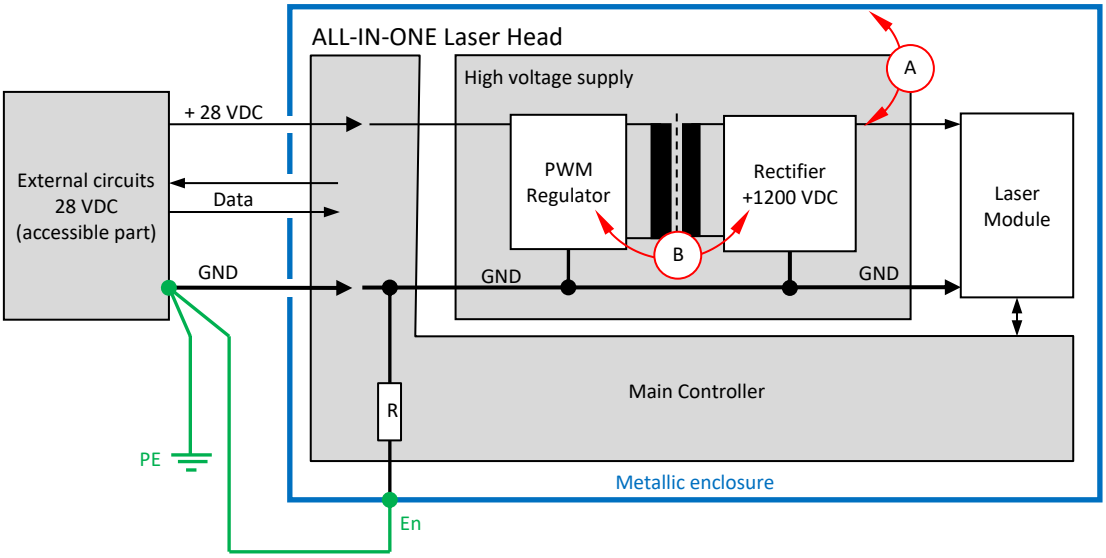


Figure showing an isolation diagram of the laser electronics and the housing. "En" denotes the GND Enclosure screw-on connector at the back panel.

The Supply GND labelled "GND" is connected to the metallic enclosure (laser housing) by an internal resistor denoted as "R" in the above figure. R has a value of 800 Ohms. The letters "A" and "B" show functional isolation of the (internal) high voltage circuits to the housing (A) and the low voltage circuits (B).

For electrical safety as per ISO EN 61010-2010 even in a single fault condition, as required, it is imperative that the user makes the following, fixed connection before operating the laser:

- Use a cable with a cross section >= 0.75 mm^2 and a total length <= 3 m
- Using such a cable, firmly ensure connection to Supply GND (if you use your own power supply, the Supply GND is at the back panel D-SUB connector pins 6,7,8 as described in the appendix section 13.2.1.
- Firmly connect the other end to the housing as described as the green line in the figure above

This allows the user to have the system's "ground star point" at any location in between the two connection points "Supply GND" and the "metallic enclosure" and gives design freedom to the user to avoid undesired ground loops.

It is important to consider the following:

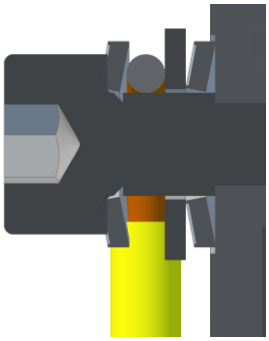
In case you provide your own power 24-28VDC to the laser device, and possibly your own input/output interface to the laser head, you must ensure that the **pins 6,7,8 (GND Supply) are connected to the metallic enclosure** as demanded above. Refer to section 13.2.1 for a pin-out of the Power-IO connector.

A screw-on ground connection to the metallic enclosure is available at the back of the laser head, labelled "Earth", with an M4x8 screw. Use this connection terminal and a >= 0.75 mm^2 cross section cable for proper connection to the housing as shown in the figures below.

Laser back panel: Ensure that your Supply GND (pins 6,7,8 of the D-SUB 15) is properly connected to the housing connection labelled "Earth" or "GND Enclosure". Refer to section 10.2.1 for a pin-out.

Laser back panel: Housing or metallic enclosure connection labelled "Earth" or "GND Enclosure": connection utilizing a M4x8 screw to properly connect to the housing

The following sketch shows such a cable (yellow) fixed with the screws and washers available at the screw-on terminal at the back panel, consisting of one M4x8 screw, 2x contact washers BN20192 by Bosshard, and 1x washer M4, or alternatively a cable lug for M4, see figures below:



M4x8 screw which clamps a ~0.75 mm^2 diameter grounding or earth cable (yellow) in between a curved contact washer (BN20192 by Bosshard) and a flat washer. Use another curved contact washer BN20192 with the orientation shown in the sketch for proper lifetime contact.

Alternatively, simply use a ground cable (>0.75mm^2) with a cable lug for M4 to be screwed on:

Ensure this connection of Supply GND to the metallic enclosure (back panel connection labelled "EARTH" or "GND Enclosure") for electrical safety even in a single fault condition as required by ISO EN 61010-2010. An improper connection may result in electrical hazard and/or personal injury.

Do **not** open the cover of the laser head, as high voltage may result in personal injury or death! Opening the laser cover may also result in a warranty void. In case you still do open the cover, make sure the laser has been powered down and disconnected from the power supply for at least 5 minutes.

6.4 Protective Earth (PE)

It is recommended to connect the housing and the Supply GND to your building's Protective Earth.

6.5 General Safety Considerations and proper mounting

This instrument must be used under specified conditions, otherwise the protection provided by the instrument could be impaired.

ESD: Electrostatic discharge (ESD) on or near the connectors can damage electronic devices inside the instrument. Personnel should touch the metal frame of the instrument for a second before touching any connector.

Proper heat sinking: The laser head needs to be properly heat sinked when powered up. Even if laser emission is switched off, the electronics and the thermal temperature stabilization of the laser head module require the generated heat to be sinked into an appropriate heat sink or submount. There are two possibilities to fix the laser head to a heat sink.

1. In the appendix of this manual is the mechanical drawing of the laser housing for purpose of making your own (e.g. water cooled) sub-mount for the laser head (section 13.1.5)
2. Contact MONTFORT Laser and ask for the custom-made water cooled sub-mount with water connections (MONTFORT Laser Part AN72185)

Ensure proper heat management of the base where you mount the laser on. For laboratory purposes, you may use a recirculating water chiller to stabilize the temperature of the sub-mount. The temperature of the sub-mount, where the laser is mounted upon, should remain within the temperature range given in the specifications list in chapter 3 or in the test report. Please note that the heat removal requirement may amount up to 240W in some cases, depending on (a) the sub-mount temperature and (b) the operating parameters. The higher the sub-mount temperature, and the higher the laser energy and/or repetition rate, the higher is the heat removal requirement.

WARNING – hot surfaces and hot components inside. Use heat resistant gloves before touching or allow the unit to cool down.

Depending on the laser head module temperature setting, the submount temperature and the laser operation parameters, the surface of the laser system could become hot during normal operation and in case of a single-fault occurring. The maximum values for touchable surfaces defined in ISO EN 61010-2010 could be exceeded.

Remark: The laser head is tested and confirmed to operate at 10 Hz / 50 mJ for a few hours when mounted on a typical optical table without further heat sinking or water cooling. But we still recommend the use of a heat sink and the submount temperature must be kept within its temperature limits defined in Chapter 3.

Mounting and alignment: The laser must be fixed on the optical table or sub-mount, so it cannot move or rotate when switched on. For example, the above-mentioned water cooled sub-mount from MONTFORT Laser (Part AN72185) can be mounted with M6 screws on the optical table. The exit window of the laser beam should be aligned in such a way that it is not a hazard (Class 4 laser system**)**.

The external power supply of the laser device must be installed in such a way that it can be disconnected from the mains at any time!

"Using the equipment in a manner not specified by the manufacturer will impair the protection"

6.6 Environment Conditions

This instrument is designed for indoor use, in areas with low humidity (non-condensing). See detailed environmental conditions in the specifications listing (chapter 3).

It is recommended to use the laser in a clean environment to prevent damage to the laser exit window and ensure a long life.

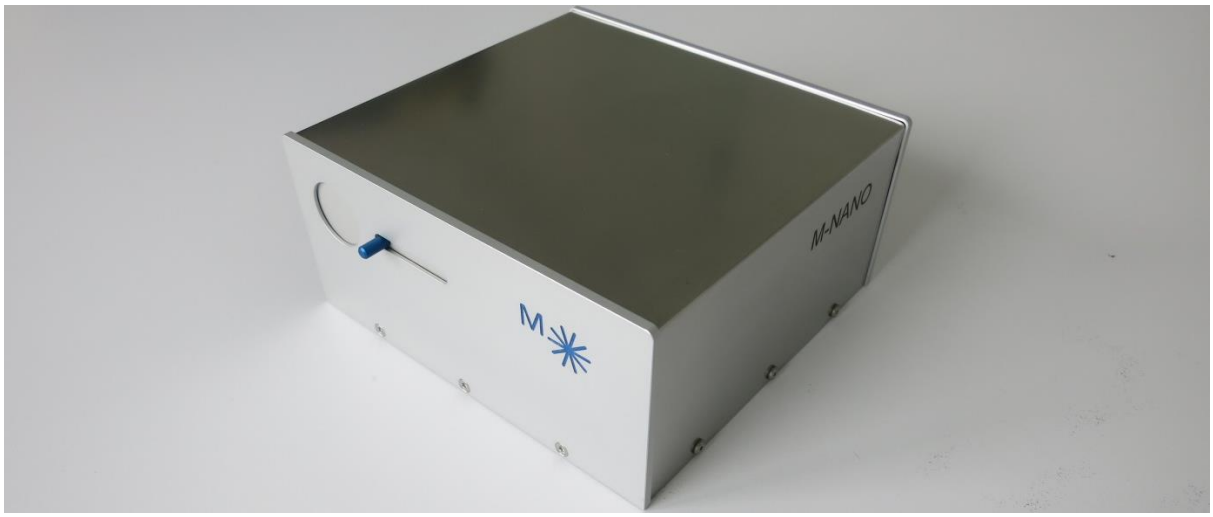
7 Quick Installation and Operation Guide

Please read the whole operating instructions before using the laser head.

This section describes how to operate the laser with the complementary external power supply and the PC software utility, both of which were included in the shipment. This procedure is designed to be simple and quick and allows for an efficient installation and powering-up procedure of the laser head.

For a more detailed introduction as to how to operate the unit with a customer-supplied power supply (24-28VDC) please refer to the technical documentation in section 6.4 on protective grounding, and the documentation further down.

7.1 Laser head initial installation



Please follow these steps for an initial installation of the laser head (assumes above steps are completed):

(1) Operate the laser only in a clean room environment to keep the exit window free of dust. Fix the laser head on your work bench, such as an optical table or optical bread board.

(2) For higher power operation and for operation over extended times, it is important to use a sub-mount which can carry away the heat generated in the laser head (for more details look at section 6.5).

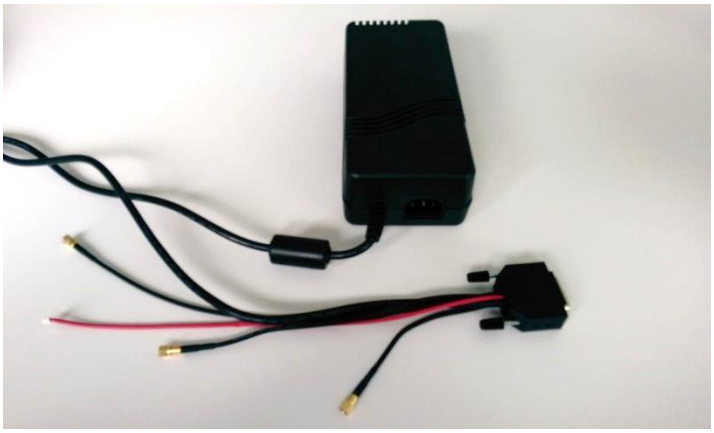
(3) Secure and fix the position and orientation of the laser head so it cannot move or rotate when switched on (for more details look at section 6.5).

(4) Place a power meter or energy meter capable of handling the energy density close to the laser head exit (emitting aperture). Alternatively, use a beam block.

(5) Open shutter of laser exit by moving the blue coloured pin

7.2 Power supply preparation

The system may have been delivered with an extra external power supply (optional) suitable for lower power operation, which produces 28VDC @ 10A from mains and has a customary connector which goes into the laser head for powering the unit up. Additionally, that customary connector contains cable pigtails for the purpose of connecting trigger inputs and outputs as well as for connecting the external interlock switch.



Complementary external power supply

Description of **cable pigtails**:

- Red cable: interlock (see below)
- Coax cable (short) with SMC connector: Trigger Input (TTL, High impedance)
- Coax cable (medium length) with SMC connector: External HV Trigger Input (TTL, 50Ohms)
- Coax cable (long) with SMC connector: Trigger Output (TTL, capable of driving 50 Ohms)

To continue **installation**, please follow the following procedure:

(1) Check the local mains voltage. The power supply is equipped with auto-ranging power supplies for a continuous input voltage from 100 to 240 V AC @ 47 - 63 Hz, 3.2A (primary).

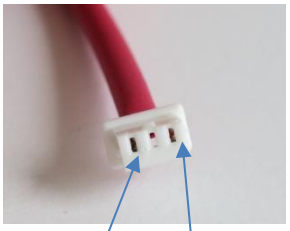
(2) To comply with the requirements by IEC 60825-1 (Ed. 3.0):2014 it is required to connect the power supply to mains via a connection which has an emergency power-off button in order to provide quick switch-off in case of an emergency. Such safety mains terminals are often available in laboratories. In case of non-availability, a mobile mains connector available on the market may work as well (see image for illustration):

(3) To fulfil the safety requirements in section 6.3 connect the metallic enclosure via its back panel screw-on connection to Protective Earth.

(4) Do NOT connect the instrument to the mains yet – or remove or disconnect from mains if already connected. Ensure that the connection to the laser head has been made properly: Insert the 15-pin DSUB female connector into the corresponding connector at the laser head back panel labelled “Power – IO” (see picture in section 0). Tighten the two screws to secure the connector in place.

(5) **Interlock**: We recommend to use the external interlock feature for safety purposes. Connect it to a safety door switch, for example. Whenever the door is opened, that door switch should be opened (open loop, not connected), which will ensure that the laser diode is switched off immediately or remains switched off.

(6) The external interlock is accessed via Pin#1 and Pin#3 of the 3-pin PicoBlade Connector at the corresponding pigtail:



Interlock connector (pigtail from DSUB connector

Pin number	Designation	Remark
1	Interlock – Pin #1	To be connected for laser operation (error otherwise)
3	Interlock – Pin #2	

If your laser safety procedures allow, you may use the interlock defeat connector supplied with the system. It provides a closed-loop for the interlock feature when plugged in.

Interlock defeat connector (connects pin #1 and pin #3).

(7) Ensure that the three coaxial connectors coming out of the DSUB connector are placed in a way so they do not pick up any voltage potential (i.e. please use an electrically isolating surface underneath).

7.3 Laser head operation

Please follow these steps to finally power up the laser head and operate it:

(1) Ensure that the power supply has been prepared according to the previous section.

(2) Ensure you wear safety goggles (see corresponding safety section 6).

(3) Provide power to the power supply mains now (100-240VAC) – the laser unit will now be powered up. An LED light can be seen to emit from the back panel in the colours (a) red for error, (b) green for ready and (c) blue for Laser ON.

(4) Prepare a Windows PC and connect it via the USB cable to the laser head (USB mini connector at back panel, see picture in section 0). Check the COM-port which was installed on your PC after the laser head was connected (even if not powered on) and read the COM port (e.g. “COM3”) in the system controls → device manager → COM & LPT → USB Serial port.

(5) Before the software GUI (graphical user interface) can be used, install the Matlab Runtime (MCR): go to the following internet page by Matlab/Mathworks, download the MCR version R2018a (64-bit version) and install from http://www.mathworks.com/products/compiler/mcr →The software just work on a 64-bit computing architecture.

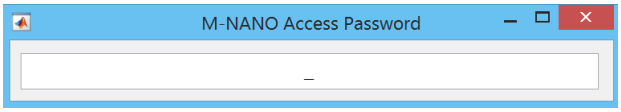
(6) When the laser head is powered on, open the software GUI (graphical user interface) which was provided in the shipment, following these steps:

a. Make a local copy of the whole folder ‘M-NANO_GUI…” on your PC and move all contents therein as well.

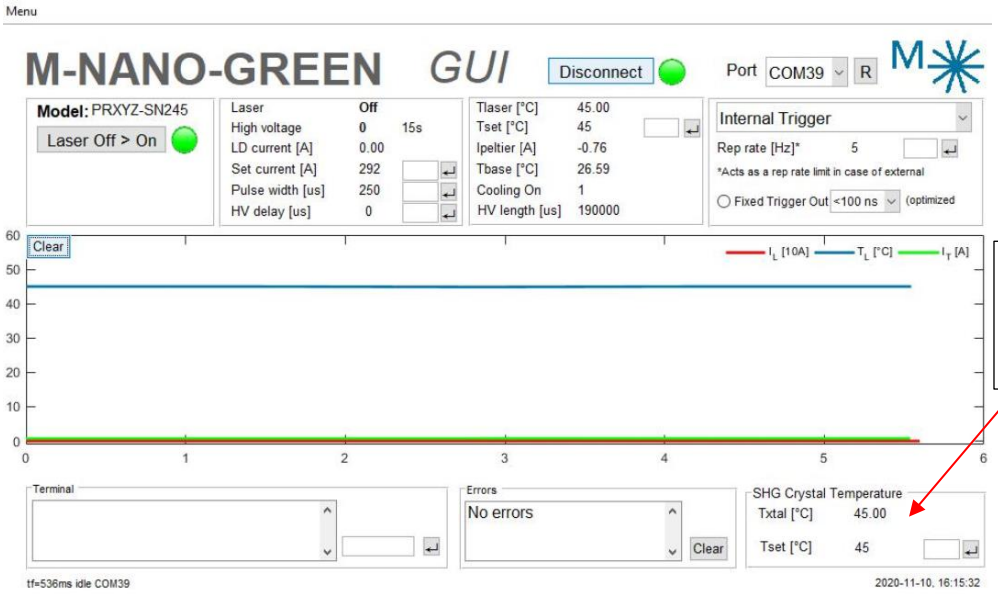
b. Start the Windows Executable “MONTFORT_M_NANO_GUI.exe”

c. A pop-up picture with the Montfort Laser Logo should appear. Wait until Matlab runtime is loaded (it requires time until the Matlab runtime is loaded). The GUI should then appear as follows:

d. Select the right COM-port for your laser head in the "*Port"* pop-up menu and push the "*Connect"* button. After the procedure a password is required (Security Master Control as mentioned in the norm ISO 60825). Enter the correct password, which comes with the delivery, to get a connection to the laser head.



(7) After successful connection, the software automatically detects, if a green conversion module for second harmonic generation is built inside the laser. If a green module is installed, an additional panel is shown in the lower right edge of the GUI and the title of the GUI will be changed to "M-NANO-GREEN". Otherwise the title stays unchanged "M-NANO"



(8) Please check typical values before proceeding to check basic function of the laser head:

i. The actual laser temperature T_{laser} should read a value within 20°C …. 55°C and move towards the set laser temperature T_{set}, which is stated in the delivered test report (by default: factory setting at delivery)

ii. "*Laser*" should read "*Off*".

iii. "*High voltage*" should read "*0"*.

iv. "*Cooling On*" should read "*1"*.

(9) A recommend warm-up time for the laser system is given in the product test report. This must be noted, before the laser is switched on.

(10) Switch the laser ON by clicking on the "*Laser Off → On"* Button in the GUI. Check that the software shows "*Laser*" is "*On*" (from previously "*Off*"). A countdown for the "*High Voltage*" delay start. When the countdown is finished, then "*High voltage*" is "*1*" from previously "*0*".

(11) Check output power / energy reading on power / energy meter and compare with value given in test report.

(12) Watch the T_{laser} temperature reading for a little while and ensure it is not running away, confirming sufficient heat sinking.

Switch-off procedure:

(13) Switch the laser OFF again by clicking on the same Button now labelled "*Laser On → Off*".

(14) Close the M-NANO GUI by clicking on "*X*" in the right top corner or push the "Disconnect" Button.

(15) Unplug the mains of the power supply to power down the unit.

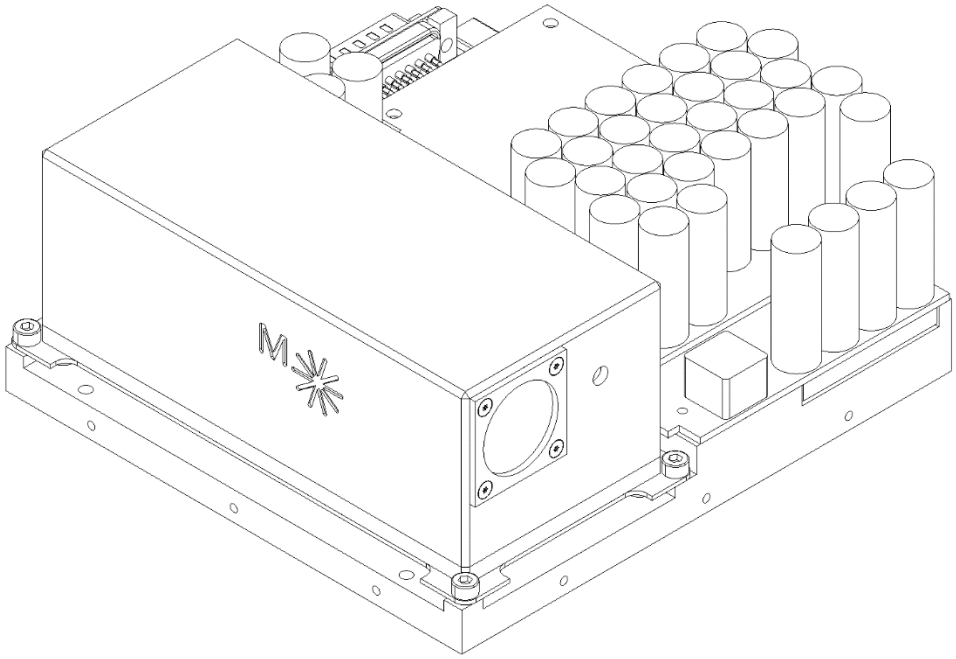
Attention: Note this must be powered down whenever the unit is left unattended and no proper heat sinking is provided, to avoid thermal runaway, which could damage the laser head and the electronics. This procedure also avoids the unauthorized use, because for every connection to the device, a password (Master Security Control) must be entered.

8 Laser head

8.1 Laser head overview

Please find technical drawings of the laser head in the Appendix, where mounting holes and dimensions are shown (section 13.1).

In the following, a perspective image of the inside of the laser shows all important components including the integrated optical laser head and the electronics. The integrated optical laser head is mounted on the baseplate via 4 holding screws. It is temperature-stabilized by Peltier elements which are mounted between the optical laser head and the baseplate. The integrated optical laser head is sealed in a gas-proof way and has a dry and dust-free ambient inside.



Perspective view of the overall laser without cover parts, showing the integrated optical laser head (left) and the electronics (right side).

This perspective view is provided for informational purposes. Please do not uncover the laser system for these reasons:

- High voltage is inside and may result in personal injury or death
- Warranty may be voided if opened

The integrated optical laser head should not be opened for these reasons:

- It was assembled in a class 100 cleanroom environment for dust- and particle free assembly
- Opening the cover is a critical procedure and may result in damage to optics
- Warranty may be voided if opened

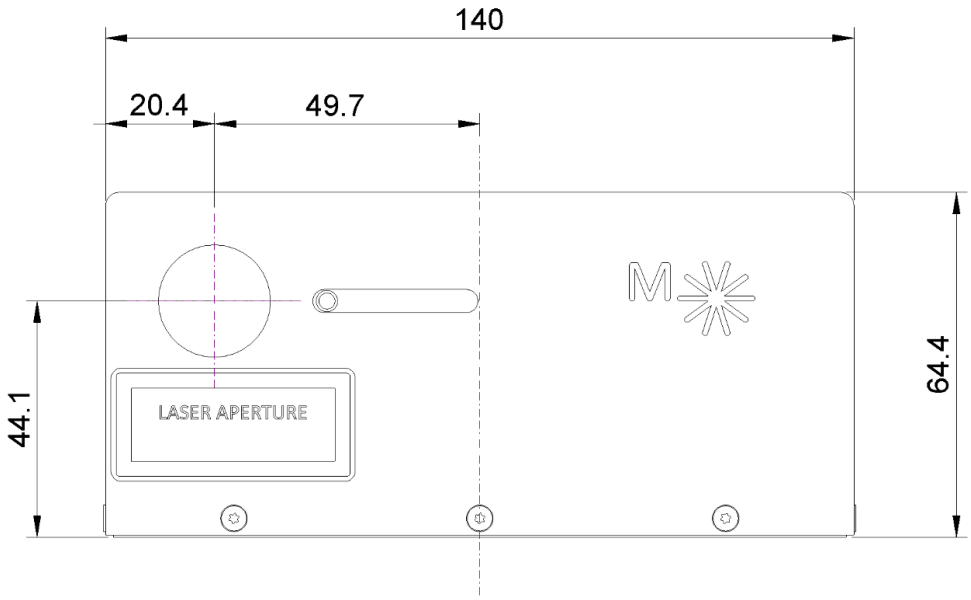
The dimensions in mm of the integrated optical laser head are as follows: **120 (l) x 56 (w) x 46 (h)**, not including connections, screws, mounting parts and exit window holder.

The electronics has a number of functions including:

- Temperature control and stabilization of the integrated optical laser head
- Current driver for the laser diode inside the integrated optical laser head

- High voltage supply and fast high voltage switching for the Pockels cell inside the integrated optical laser head.
- Timing
- Interfacing to the user via USB
- Frequency conversion crystal oven temperature control (optional: only available for M-NANO-GREEN)

8.2 Laser head front panel

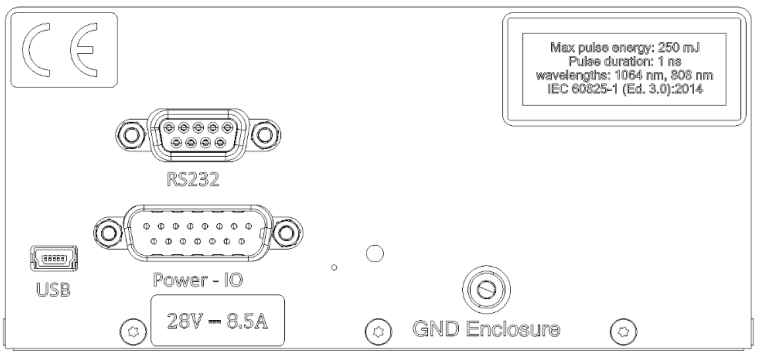


Front panel view of laser head, a moving manual shutter provides protection from laser light emitted even if the laser is ON.

We recommend to **not** use the shutter for the purpose of inhibiting the laser beam regularly, only for emergency, as the laser peak power is so high that the surface of the shutter might be ablated and could contaminate the optical window. To switch the laser off, use the communication to the laser head, or for safety use the interlock feature.

8.3 Laser head back panel

The laser head provides the following electrical interfaces at the back panel:



Back panel of laser head with USB (mini-B connector, left), Power-IO connector (D-SUB 15, female, left to middle) and Earth terminal (M4 screw, right). An additional RS-232 connector (D-SUB 9, male) may be available in addition.

A detailed pin assignment is given in the Appendix section 13.2.

9 Software utility “M-NANO GUI”

The software utility “M-NANO GUI” provides easy-to-use access to controlling the laser head, monitoring some values such as temperature and currents, as well as reporting current settings. There is no need to know the details of commands or the communication protocol.

The M-NANO GUI is a Matlab-based graphical user interface (GUI) software for Windows PCs provided by MONTFORT Laser GmbH. It is made for easy control and monitoring of the M-NANO all-in-one laser head from a computer or notebook.

Prerequisites are (a) the installation of the Matlab runtime and (b) the installation of the virtual COM port drivers when the laser head is connected to the Windows PC the first time. The latter is usually done automatically by the PC. Please follow the procedure given in section 7.3 unless done already.

M-NANO GUI for control and monitoring of key values

Summary of functions:

- **<u>Laser On-Off Button</u>**:

  Button “*Laser Off→ On*” for switching ON the laser. After pushing the button, the laser diode is switched on (command p1 1). The signal lamp gets blue and the countdown for the high voltage delay starts. When the countdown is finished, the high voltage turns on (p15 1). Once the laser is ON, this button becomes the “*Laser On→Off*” Button, which sends the commands for switching the laser diode and high voltage off (p1 0 and p15 0).

- **<u>Laser Parameter Settings:</u>**

  Settings of current, temperature, pulse width, repetition rate and high voltage trigger delay: Enter new value in the corresponding entry field and hit enter or click on the enter button nearby.

Field	Description	Unit
Set current [A]	Set laser diode current	A
T_set [°C]	Set temperature for laser head including laser diode	°C
Rep rate [Hz]	Set repetition rate of the laser	Hz
Pulse width [us]	Set pulse width of the pump laser diode	us

HV delay [us]	Set trigger delay of the high voltage	us

Note: Only the HV delay can be changed when laser is ON

- **Trigger mode**

  See section “11 Trigger Modes” for more details.

Trigger Mode	Repetition Rate [Hz]	Description
Internal Trigger	≥ 2	The pump LD and the HV is internally triggered from the electronic of the laser. Change the repetition rate in the entry field “Rep rate [Hz]”.
Internal Trigger (slow)	<2	Same as “Internal Trigger” but for lower repetition rates. Change the repetition rate in the entry field “Rep rate [Hz]”.
External Trigger	≥ 5	The pump LD is externally triggered from a provided TTL signal to the corresponding input. HV Trigger is still generated internally. The maximum repetition rate value given in the entry field “Rep rate [Hz]” acts as an upper repetition rate limit. It should be set slightly higher than the actual trigger frequency of the provided external signal. In addition the provided external trigger frequency should be within 80% of the maximum repetition rate value. Otherwise error 8 occurs! Example: If the provided external trigger frequency is 10 Hz, then maximum repetition rate value limit could be 11 Hz (80% of 11 Hz is 8.8 Hz → 10 Hz is within the range of 8.8 to 11 Hz)
External+ HV Trigger	≥ 5	The pump LD and the HV is externally triggered. Provide TTL trigger signals to the corresponding inputs. The time delay between the two signals should be approximately the pulse width of the laser diode (e.g. 250us in the example above). The Trigger Input Signal must come before the HV Trigger signal.
External Trigger (slow)	<5	Same as “External Trigger” but for lower repetition rates. The value of the maximum repetition rate is set automatically and can’t be changed. This trigger mode could be also used for single shot operation by an external push switch (see 13.3.3 for further details)
External+ HV Trigger (slow)	<5	Same as “External+HV Trigger” but for lower repetition rates. The value of the maximum repetition rate is set automatically and can’t be changed.

Notes:

- Trigger mode settings can’t be changed when laser is ON.

- **Fixed Trigger Out**

The provided trigger output signal is TLL. By activating the corresponding radio button the output signal can be programmed so that its rising edge is from <0.1us to 4.2 us prior to the actual laser pulse. Recommended for timing-critical applications where external triggering of both trigger inputs cannot be provided.

- **Monitoring graph window**

  The key values are being monitored in the propagating window:

  - red is the laser diode current I_L (command g30),
  - blue is the actual laser head temperature T_L (command g322),
  - green is the Peltier/TEC current I_T (command g320).

  To reset the graph, push the "*Clear*" button.

- **Menu**

Field	Description
Manual	Open manual document as a PDF window.
Save Settings To Device	Save all current settings to device (survives power cycle).
Get All Parameters	Initiates a transfer of all parameters and settings in the laser head, and stores it in a text file locally. The factory settings are available in the product test report (PTR) document provided along with the laser shipment.

- **Errors**
  - The lower window shows errors if there are current errors, or displays "No errors". If an error is present, the signal lamp is red.
  - The "Clear" button next to the error window clears not only the window but also sends a clear error command to the laser head (command p10 0). After pushing this button, errors only occur if they could not be cleared and are still there (such as an interlock loop that is not closed).
- **Terminal**
  - Control the laser head by sending and receiving commands (see section 10.3)

Important usage notes:

Start the M-NANO GUI only after successfully connecting the laser head with the computer and after power the laser unit up (i.e. providing power to the laser head).

Close the M-NANO GUI while the laser head is still supplied with electrical power, and then power down the power supply to the laser head.

10 Interfacing with the laser head

This section describes how you can interface with the laser head by manually sending and receiving commands from a terminal program, or from your own software.

Attention: If the laser is used with the manual communication from a terminal program, the user must take care, that the norm from ISO 60825 are fulfilled (e.g. Install your own Security Master Control to the laser as mentioned in the norm ISO 60825). Otherwise use the delivered software utility “M-NANO GUI”.

10.1 Establish connection via USB (virtual COM port)

The laser head operation can be controlled via the USB mini-B connector at the laser head back panel. The laser head implements a virtual serial port (by FTDI) which allows communication with the device from a Windows PC (or others) via the virtual COM port which is installed on the computer once connected via the USB cable.

On most recent Windows computers, the virtual COM port connection will be installed automatically after connecting the laser head to the PC (even if the laser head is powered off). Only if after 1-2 minutes no installation has occurred, the user has to install the appropriate driver himself with the following procedure:

- Disconnect laser head from PC again.
- Get the appropriate driver from the maker of the communication chip, FTDI, please see http://www.ftdichip.com/Drivers/VCP.htm or http://www.ftdichip.com/ and choose for your windows system.
- Install “CDM_setup.exe” with administrator rights; this installs the virtual COM ports for your computer system.
- Connect the laser head again via USB cable. A virtual COM port is added to the computer system which can be found in the control panels → device manager → COM&LPT, please note the corresponding number (e.g. “COM33”).

10.2 Manual communication from a terminal program

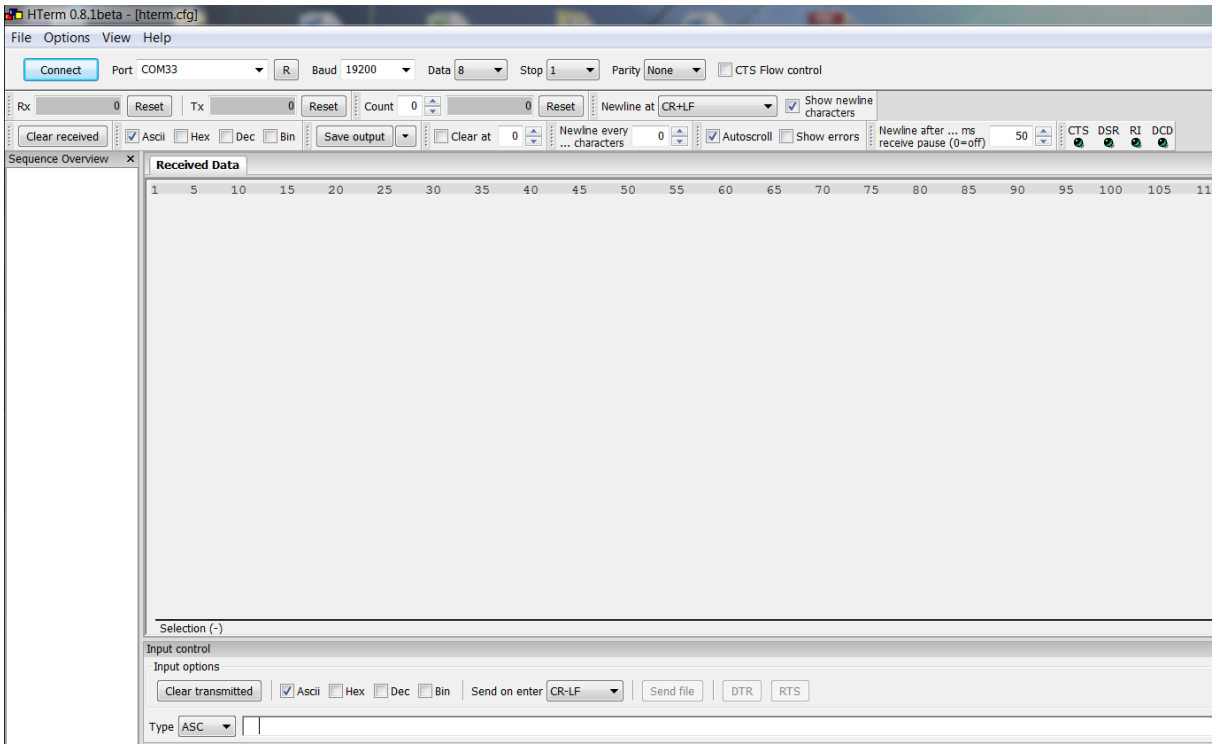
Communication is possible via ASCII commands (for a full list, please be referred to the list given in the Appendix - “Commands List” section).

To set up communication between a Windows PC and the laser head, a simple terminal program can be used such as HTERM or similar. HTERM can be downloaded as freeware from this site for example: http://www.heise.de/download/hterm.html

Any other equivalent terminal program may work as well. For the purpose of explanation, the following description assumes that you have HTERM on your PC, and the laser head is powered on following the procedure given in the previous chapters. Then follow these steps to establish communication with the laser head:

- Connect the PC with the laser head with a USB cable. A virtual COM port is added to the computer system which can be found in the control panels → device manager → COM&LPT, please note the corresponding number (e.g. “COM33”).
- Start HTERM, and set as follows:
    - Set the corresponding COM-port as the port, (e.g. COM33 in our example),
    - 19200 Baud as the speed,
    - 8 bits as the number of bits
    - 1 stop bit
    - Parity “None”

- Check “Ascii” both in the received section as well as in the input control section (twice)
- Choose “CR+LF” both as the “Newline at …” and as the “Send on enter” (i.e. twice)
- The resulting HTERM window looks as follows:



You are now set up to communicate with the laser head after powering it on.

10.3 Controlling the laser head from a terminal program

After powering the laser head on, following the procedure given in the previous chapters, you can now use the following commands to read settings and to make changes to settings.

These are the two basic types of commands:

- Get command: To read a setting or status value, use the **get** command, which is a "g" followed by the command number. The response will be two numbers, the first noting the command number again, and the second denoting the response value.
- Put command: To make a setting, use the **put** command, which is a "p" followed by the command number, a space and a value. The response will be two numbers usually, the first denoting the command number again, and the second denoting the new set value (as a confirmation).

Each command needs to be terminated by the terminator <CRLF> (0x0D 0x0A).

For a full list of the commands available, please be referred to the "Commands List" given in the Appendix.

In addition, the command "error" provides a list of all possible error numbers and descriptions.

In the following, we give step-by-step examples to walk through. These examples explain how to read the most important parameters from the laser head and how to introduce the most important settings into the laser head:

(1) Start by typing "error" in the HTERM, therefore the characters error<CRLF> will be sent to the laser head. This will be answered by a list of error numbers and descriptions such as this:

error<CRLF>

(2) Now check if there is an error that has occurred by entering the following get command:

g10<CRLF>

The answer from the laser head should now read

10 0<CRLF>

if there is no error pending. In case of an error, read in the error list above which error has occurred. Typical errors are interlock errors (if interlock loop is open) or temperature errors.

(3) Reset the error after an error has occurred by sending the following command:

p10 0<CRLF>

The answer will be

10 0<CRLF>

if the error could be cleared successfully. However the answer might be different if there is another error pending.

(4) After successfully working through all pending errors and clearing them all, we can check if the laser head is OFF by sending this get command:

g1<CRLF>

The answer should normally be

1 0<CRLF>

after a recent power up.

(5) The high voltage HV for the Pockels cell switch is normally also off after a recent power-up and can be tested via

g15<CRLF>

which should then result in

15 0<CRLF>

(6) Now let us check the temperature of the actual integrated optical laser head and laser diode by sending this command, answered by a response containing the actual temperature reading (25.5°C in this example):

g322<CRLF>

322 25.5<CRLF>

(7) In order to check if the laser temperature stabilization (cooling) is enabled, which is important for proper operation, read this setting which responds with “1” for “enabled” or a “0” for disabled:

g301<CRLF>

301 1<CRLF> (if cooling or temperature stabilization is enabled) or

301 0<CRLF> (if cooling is disabled)

(8) Enable temperature control by setting this value with the put command to “1”:

p301 1<CRLF>

The response will be for the case of successfully setting this value:

301 1<CRLF>

(9) To check the set temperature Tset of the integrated laser head, type:

g311<CRLF>

resulting in (for 25°C as the setting in this example):

311 25<CRLF>

(10) To modify the set temperature Tset of the integrated laser head, type this put command:

p311 26.5<CRLF>

which results in a successful answer

311 26.5<CRLF>

(11) Now after changing the set temperature, it might be useful to check if the actual temperature gets adjusted in a way it approaches the new set temperature, thus type this get command:

g322<CRLF>

Which may result in a temperature value closer to the new set temperature, e.g.:

322 26.1<CRLF>

(12) For a laser switch-on, both the main laser ON setting (g1) and the HV ON setting (g15) should be “1”, thus type the following two commands:

p1 1<CRLF> (response: 1 1<CRLF>)

Wait 15 seconds!

p15 1<CRLF> (response: 15 1<CRLF>)

(13) For switching the laser off, send these two put commands:

p1 0<CRLF> (response: 1 0<CRLF>)

p15 0<CRLF> (response: 15 0<CRLF>)

(14) The trigger mode settings can be changed in a procedure shown in the appendix.

(15) The trigger output can be set to become “**jitter-optimized**” by utilizing the following command:

p122 1<CRLF> (response: 122 1<CRLF>)

Attention:

Wrong manually operation can destroy the laser. Please take care of the following points:

- For a laser switch-on, this procedure must always be followed. First switch on the laser diode (p1 1). After 15 seconds, the high voltage can be switched on (p15 1)
- DO NOT CHANGE the following values when the laser is switched on:
    - Current (p3)
    - Pulse Length (p5)
    - Frequency (p7)
    - Temperature (p311)

11 Trigger

11.1 Trigger Modes

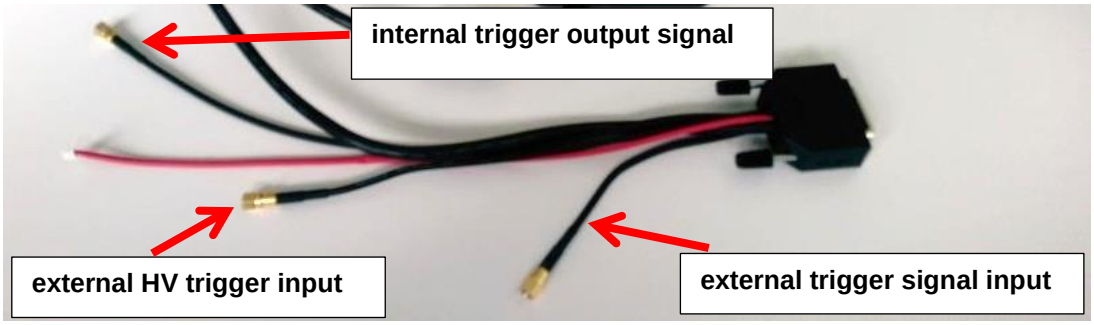
1. There is an internal trigger mode and you can use the trigger output signal to trigger your diagnostics (e.g. for LIBS). This trigger output signal is TTL and can be programmed so that its rising edge is from <0.1us - 4.2 us prior to the actual laser pulse. The **internal trigger output signal** is provided by the **longest coax cable** of the cable pigtails.

2. There is an external trigger mode where you supply *one single* trigger signal to the laser (TTL level, High Impedance). In this case the laser will make the timing for the laser pulse and the Q-switch. In this mode, the laser pulse is emitted approx. 250 us after the rising edge of your TTL trigger input signal. In this mode you can also use the trigger output signal as described in (1). The **external trigger** must be provided to the **shortest coax cable** of the cable pigtails.

3. There is another external trigger mode where *two trigger signals* need to be supplied to the laser head, one for triggering the laser diode, and one to trigger the Q-Switch, and they need to be spaced apart by some 250us. In this trigger mode the laser pulse is emitted approx. 0.2 us after the rising edge of the Q-switch trigger signal (rising edge). You provide two trigger signals: One into “external Trigger input” (TTL, High Impedance) as described in (2) and in addition an “**external HV trigger input**” (TTL, 50 Ohms) for triggering the Q-switch into the **medium length coax cable**. In the GUI you need to check that the “External+HV Trigger” option is selected in the pop-up menu.

Important remarks:

- Please note that the repetition rate given in the “Rep rate [Hz]” field (internal frequency) in the GUI or by command p7<CRLF> acts as an upper repetition rate limit even in the “external trigger” or “External+HV Trigger” mode. So it should be set slightly higher than the actual trigger frequency.
- In the external trigger or external+HV Trigger mode the provided external trigger frequency should be within some percent of the internal frequency (e.g. factory setting is 80% → p172 80). If it is outside the range, error 8 “external triggerfrequency too low” is generated.



Trigger Mode	Repetition Rate [Hz]	Description
Internal Trigger	≥ 2	The pump LD and the HV is internally triggered from the electronic of the laser. Change the repetition rate in the entry field “Rep rate [Hz]”.
Internal Trigger (slow)	<2	Same as “Internal Trigger” but for lower repetition rates. Change the repetition rate in the entry field “Rep rate [Hz]”.

External Trigger	≥ 5	The pump LD is externally triggered from a provided TTL signal to the corresponding input. HV Trigger is still generated internally. The maximum repetition rate value given in the entry field “Rep rate [Hz]” acts as an upper repetition rate limit. It should be set slightly higher than the actual trigger frequency of the provided external signal. In addition the provided external trigger frequency should be within 80% of the maximum repetition rate value. Otherwise error 8 occurs! Example: If the provided external trigger frequency is 10 Hz, then the maximum repetition rate value limit could be 11 Hz (80% of 11 Hz is 8.8 Hz → 10 Hz is within the range of 8.8 to 11 Hz)
External+ HV Trigger	≥ 5	The pump LD and the HV is externally triggered. Provide TTL trigger signals to the corresponding inputs. The time delay between the two signals should be approximately the pulse width of the laser diode (e.g. 250us in the example above). The Trigger Input Signal must come before the HV Trigger signal.
External Trigger (slow)	<5	Same as “External Trigger” but for lower repetition rates. The value of the maximum repetition rate is set automatically and can’t be changed. This trigger mode could be also used for single shot operation by an external push switch (see 13.3.3 for further details)
External+ HV Trigger (slow)	<5	Same as “External+HV Trigger” but for lower repetition rates. The value of the maximum repetition rate is set automatically and can’t be changed.

Notes:

- Trigger mode settings can’t be changed when laser is ON.

12 Maintenance

The M-NANO has been designed for “hands-off” operation, requiring minimal maintenance.

WARNING: Maintenance which requires the opening of the external housing should be performed by a qualified MONTFORT Laser technician who is aware of the hazards involved. Opening the external housing may result in a warranty void.

12.1 External housing

When the external housing is cleaned, then it must be done with a cleanroom dry wiper. Close the shutter and plug off the power supply before cleaning the housing.

12.2 Optical exit window

The contamination of the optical window in the front of the laser head can lead to destruction of the window. Inspect the exit window periodically under ample light to verify the cleanliness. If the window needs to be cleaned, we recommend the following procedure:

- Unplug the mains of the power supply to power down the unit.
- Use powder-free clean room gloves or cotton gloves when handling optics. Remember not to touch any contaminating surface while wearing gloves (you can transfer oils and acids onto the optics).
- Use clean and dry air to remove the dust from the optical exit window (e.g. Thorlabs CA3 - Duster w/ Integrated Nozzle or)
- Inspect the cleaned optic under ample light to verify the optic got cleaner.

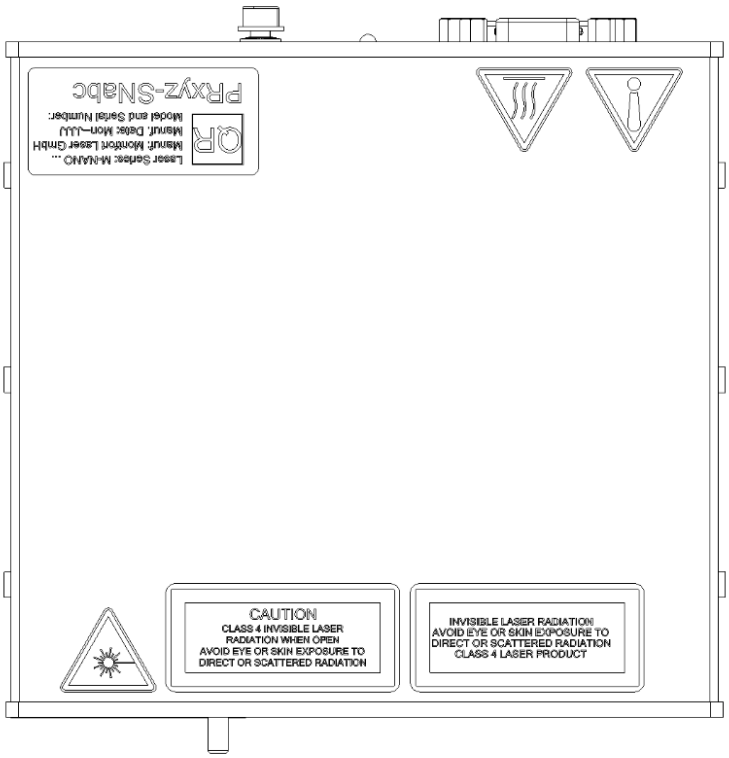
If the window is still dirty, a qualified MONTFORT Laser technician should clean or replace it.

13 Appendix

13.1 Dimensions (M-NANO)

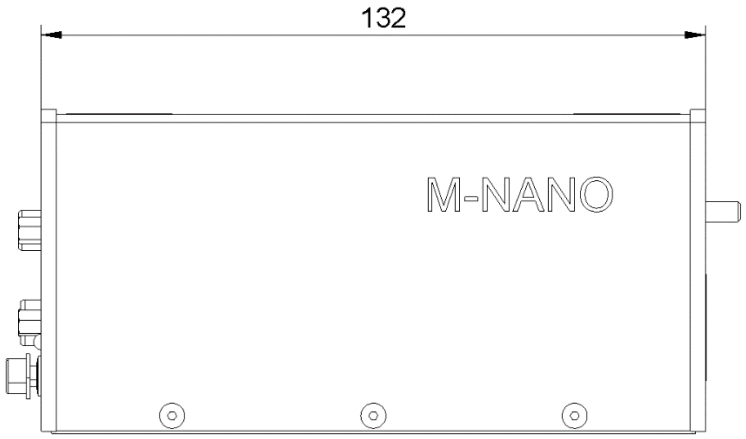
Dimensions in mm.

13.1.1 Top view

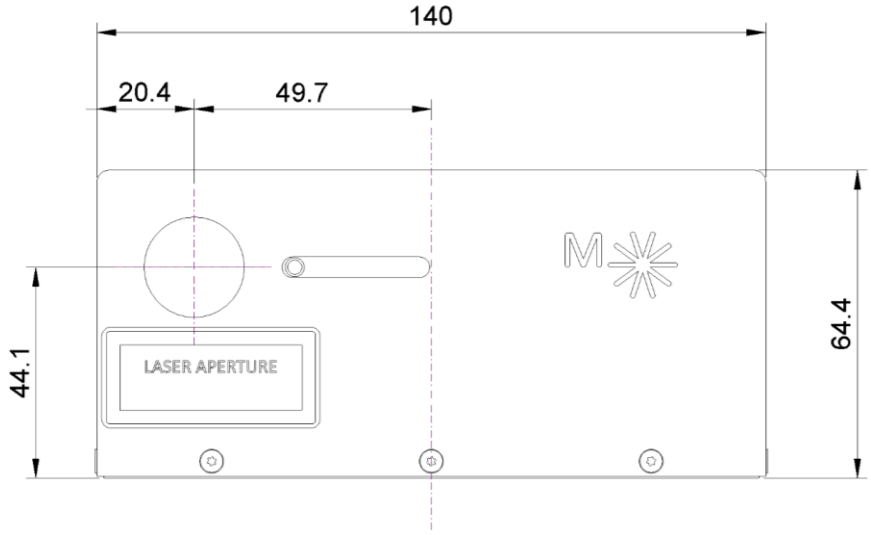


13.1.2 Left Side view

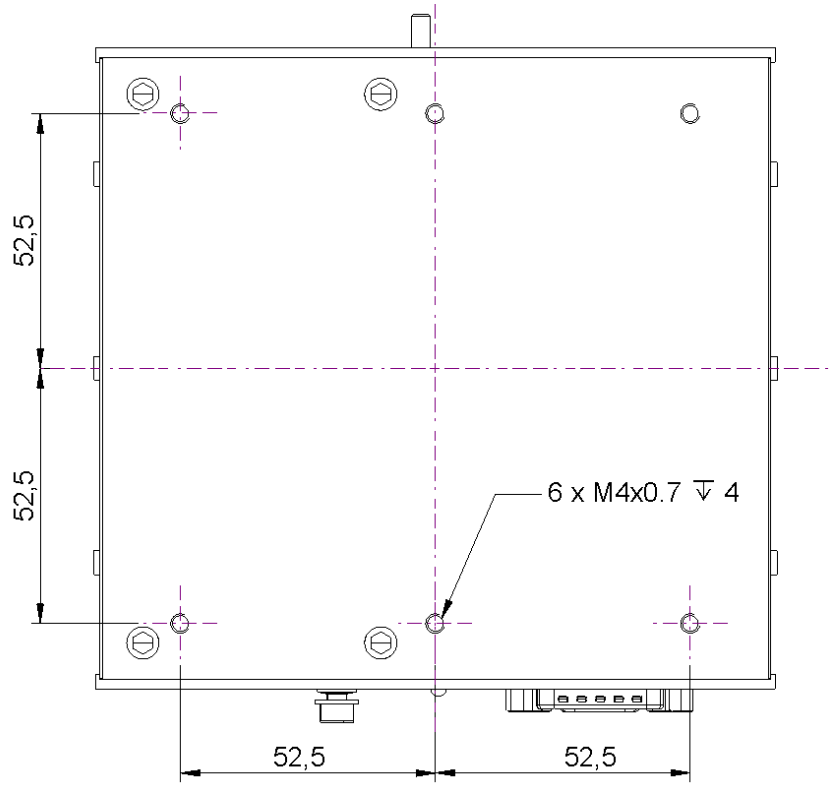
13.1.3 Right Side view



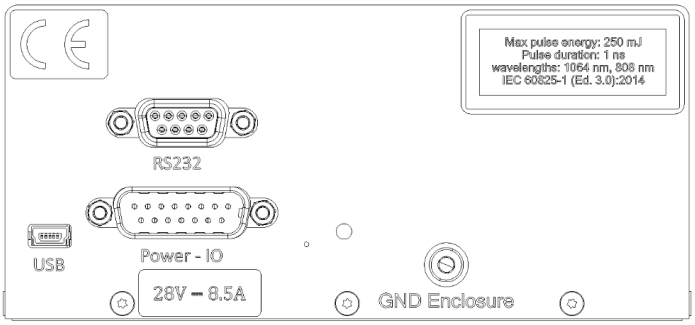
13.1.4 Front panel view



13.1.5 Bottom view and mounting holes



13.1.6 Back panel view



13.2 Dimensions (M-NANO-GREEN)

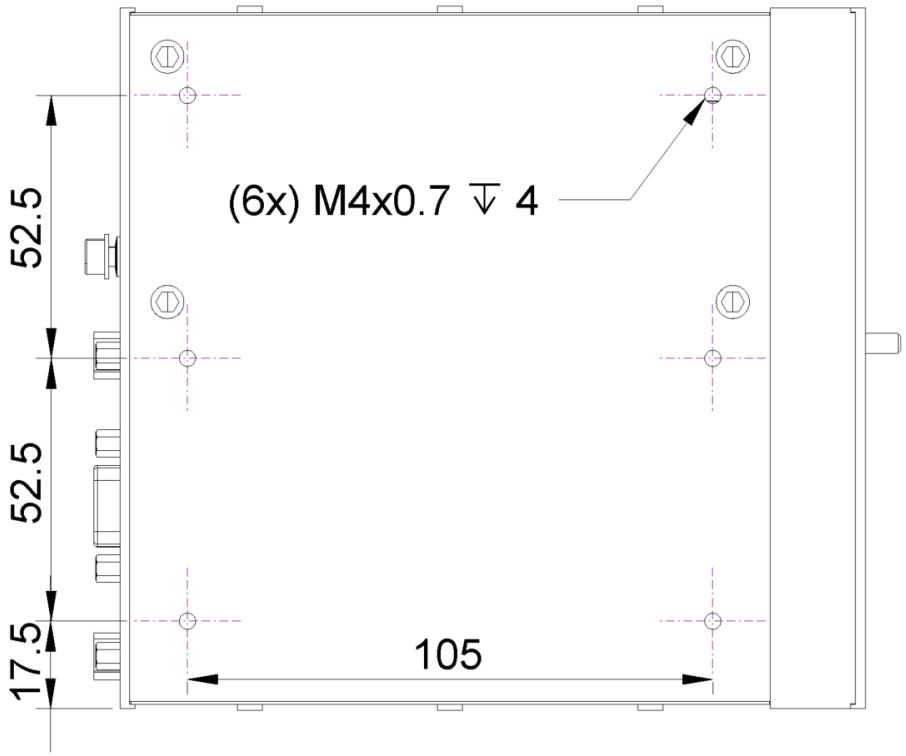
Dimensions in mm.

13.2.1 Top view

13.2.2 Right Side view

**Lengths could change depending on the model

13.2.3 Bottom view and mounting holes



13.2.4 Back panel view + Front panel view

Same as M-NANO → See 13.1.4 and 13.1.6

13.3 Laser head back panel connections

13.3.1 Power-IO (D-SUB 15 male connector)

Pin	Description	Rating
1	External HV Trigger Input (5V TTL into 50 Ohms)	TTL, ≤5 V
2	Signal GND (i.e. for pins 1, 9, 10)	
3	Interlock loop #2, contact #1 (refer to other contact at pin 11)	≥0V, ≤Vcc
4	Interlock loop #1, contact #1 (refer to other contact at pin 12)	≥0V, ≤Vcc
5	Key switch input 24V for Switch-On (if key switch mode selected)	≥0V, ≤Vcc
6	GND supply (<5A) – connect to PE for safety reasons	0V
7	GND supply (<5A) – connect to PE for safety reasons	0V
8	GND supply (<5A) – connect to PE for safety reasons	0V
9	Trigger Out (TTL, capable to drive 50 Ohm inputs)	0-5V
10	Trigger Input (TTL, High impedance)	0-5V
11	Interlock loop #2, contact #2	0V … Vcc
12	Interlock loop #1, contact #2	0V … Vcc
13	24-28V DC supply (<5A) = Vcc	≥23.5V , ≤29V
14	24-28V DC supply (<5A) = Vcc	≥23.5V , ≤29V
15	24-28V DC supply (<5A) = Vcc	≥23.5V , ≤29V

Pins 6-8 and pins 13-15 provide the electrical power to the laser head, rated at up to 5A each per pin. Nominal maximum current is 9.5A. Connect Pins 6-8 to GND Enclosure as described in Section 6.3 for safe operation.

➔ Therefore any D-SUB connector used should be rated at 5A per pin.

Technical data (electrical):

- Approved Supply voltage 24…28 VDC
- Nominal supply current 9.5 A

Interlock function:

- Interlock loop #1 needs to be closed for laser operation (pins 3 and 11)
- Interlock loop #2 needs to be closed for laser operation (pins 4 and 12)

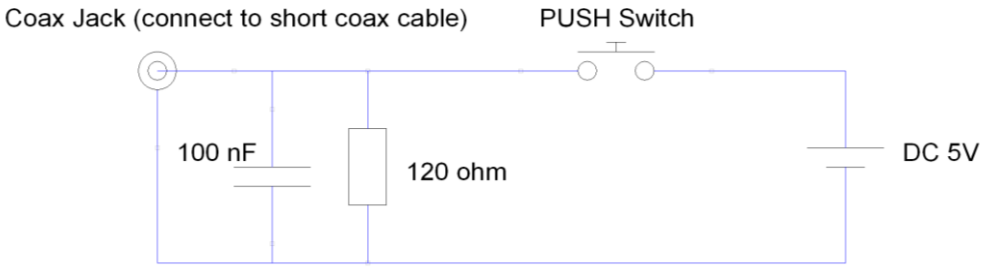
13.3.2 Key switch function for laser switch-on without communication to laser head

- In case you would like to provide laser switch-on by an external key switch (user provided switch), you may connect pin 5 (“Key switch input”) to 24-28V for switching on the laser without any further communication to the laser head.

- For this to work, the laser needs to be switched into the External Laser On Mode. This can be done with the following series of put commands (commands description see further down):
    - p108 1<CRLF> (response: 108 1<CRLF>)
      for switching to Key Switch mode
    - p14 1<CRLF> (response: 14 1<CRLF>)
      for saving this new setting.
- In this “External Laser On Mode” or “Key Switch Mode”, the laser emission is switched on when your Key Switch connects pin 5 to 24-28V. Any errors that may not have been cleared so far will be cleared beforehand (only if they are clearable).

13.3.3 Single Shot operation by an external push switch

In the case you would like to provide single shot operation by an external push switch please use the following cable as describe in the picture below (→ Contact MONTFORT Laser for questions or ask for the custom-made single shot cable AN74293):



Electrical cable for single shot operation by an external push switch

Connect the cable to the shortest coax cable of the cable pigtail. After that please change the trigger mode in the M-NANO-GUI to “External Trigger (slow)” and switch the laser on by pushing the button “*Laser Off→ On*”. After that procedure the laser shot out one laser pulse when the switch is pressed.

13.3.4 RS-232 (D-SUB 9 female connector)

The first possibility to control the electronic of the laser head is via RS-232 serial communication. A standard RS232 cable can be used. The pin assignment is at follows:

Pin	**Description**
2	TXD (Output Laser, Input PC)
3	RXD (Input Laser, Output PC)
5	GND

The virtual COM port settings are as follows (factory settings): 19.200 baud, 8 data bits, 1 stop bit, no parity, no flow control.

13.3.5 USB (USB Mini-B connector)

The second possibility is the usb mini-b connector. This connector at the laser head back panel provides connectivity to a computer via USB. It is a USB 2.0 connector, and utilizes a virtual serial connection by an FTDI chip. For installation refer to the section 10.1 .

The virtual COM port settings (@USB) are as follows (factory settings): 19.200 baud, 8 data bits, 1 stop bit, no parity, no flow control.

13.3.6 Protective Earth / GND Enclosure

This screw-on connector at the back panel (M4 screw terminal) is required to be connected to GND Supply according to section 6.3 for safety reasons. The unit must not be powered on before this connector is properly connected. It can additionally be connected to the building's Protective Earth (PE). See section 6.3 for more details.

13.4 Communication to laser head

The communication protocol is an Ascii command protocol with <CRLF> as the terminator both for commands as well as for responses. <CRLF> refers to the character carriage return followed by the character line feed or in hexadecimal values 0x0D 0x0A (decimal 13 and 10).

13.4.1 Commands and response syntax

The formal syntax for put or get commands is:

{p|g}(command number)<SPACE>(command value)<CRLF>

{p|g} command 'g' to read a setting or status value or 'p' to make a setting

(command number) is an integer number between 1 and 999

<SPACE> is the space character (0x20)

(command value) is an integer or a float number with decimal point (0x2E) or a string, depending on the command number, always in ASCII.

<CRLF> is the command terminator sequence consisting of the two characters "carriage return" and "line feed" (0x0D 0x0A)

The formal syntax for the command response is:

<SPACE>(command number)<SPACE>(response value) <CRLF>

<SPACE> is the space character (0x20)

(command number) is an integer number between 1 and 999

(response value) is an integer or a float number with decimal point (0x2E) or a text or string, depending on the command number, always in ASCII.

<CRLF> is the response terminator sequence consisting of the two characters "carriage return" and "line feed" (0x0D 0x0A or ASCII values 13 10)

- To read a setting or status value, use the **get** command, which is a "g" followed by the command number. The response will be two numbers, the first noting the command number again, and the second denoting the response value.
- Put command: To make a setting, use the **put** command, which is a "p" followed by the command number, a space and a value. The response will be two numbers usually, the first denoting the command number again, and the second denoting the new set value (as a confirmation).
- **Important note:** use the dot "." (0x2E) as the decimal point and not comma "," !

13.4.2 Commands

The commands of the M-NANO laser head are available as “get” or “put” commands, which either get a value from the lser head or put (i.e. set) a value in the laser head. For example to get the actual laser head temperature, send the following Ascii command (where <CRLF> represent the two character carriage return (ascii 13) and line feed (ascii 10):

g322<CRLF>

The device will answer with the command number and the actual temperature reading value in °C:

322 25.5<CRLF>

To read the set temperature Tset of the laser head, the command is

g311<CRLF>

The laser head will answer with (assuming Tset is 25°C):

311 25<CRLF>

To set the set temperature Tset of the laser head to a value of 25.4 °C, the command is as follows (note there is a space character between the two numbers):

p311 25.4<CRLF>

Successful acceptance of the new value will be answered by the laser head as follows:

311 25.4<CRLF>

This shows the basic concept of the commands.

Important note: use the dot “.” as the decimal point and not comma “,”

13.4.3 Commands list (Laser Head)

These commands work in the same way as described in the examples of the previous section or in chapter 10.

Put or Get	**Nr.**	**Description**	**Value / Unit**	**Available[1]**	**Config Level[2]**
error		Returns list of possible errors (note: use “g10” to read the current error, which should return “10 0” if no error has occurred.)			
help		Returns list of all possible commands			
g	1	Laser status On/Off			
p	1	Laser On	1		
p	1	Laser Off	0		
g	3	Nominal (set) current in Amps	Amps		
p	3	Set the nominal (set) current			
g	5	Pulse duration (**note**: usually 250 us)	us		
p	5	Set pulse duration			

g p	7 7	Pulse frequency in Hertz Set pulse frequency	Hz		
g	9	Limit current	A		
g p	10 10	Get Error number Reset errors	 0		
g	12	Frequency input enabled (**note**: has to be 0!)	0!		
g p p	13 13 13	Get configuration level (1=user, 2=service*, 3=Montfort) Set configuration level (requires code if >1) Set configuration level to user *Access code to level 2: p13 108.05	 n.a. 0		
p	14	Save all (survives power cycle)			
g p p	15 15 15	Get High Voltage (Pockels Cell) On / Off Set High Voltage On Set High Voltage Off	 1 0		
g	19	Disable Softstart (**note**: must be 1!)			
g p	27 27	Get slow pulse frequency Set slow pulse frequency	Hz		
g	30	Actual LD Current	Amps		
g	40	Laser On Time	Hours		
g	42	Time Power On	Hours		
g	43	Temperature main pcb (electronics)	°C		
g	50	Serial number electronics			
g	51	Firmware version electronics			
g	52	Article code electronics			
g	54	Laser head article number/ serial number of Montfort Laser			
g	55	Flash version			
g	56	Product and serial number of laser			
g p p p	102 102 102 102	Get Internal Trigger Mode (0=int, 1=ext, 2=int slow) Set Trigger Mode to internal (> 2 Hz) Set Trigger Mode to external Set Trigger Mode to slow internal (0.1 to 10 Hz)	 0 1 2	 v8	
g p p	103 103 103	Get Trigger slope (ext. trigger) Set Trigger slope rising Set Trigger slope falling	 1 0		
g	104	Get External HV Trigger Mode			

p	104	Set HV Trigger Mode to internal	0		
p	104	Set HV Trigger Mode to external	1		
g	108	Get External Laser On Mode (by Key Switch)			
p	108	Set External Key Switch Mode On	1		
p	108	Set External Key Switch Mode Off (factory set)	0		
g	111	Get start point HV Trigger	us		
p	111	Set start point HV Trigger			2
g	112	Get length HV Trigger	us		
p	112	Set length HV Trigger			2
g	122	Trigger out mode (0=normal, 1=direct/fixed, i.e. jitter free)			
p	122	Set Trigger out mode = normal	0		
p	122	Set Trigger out mode = direct/fixed (jitter free). Trigger rising edge 0.4us to 4.2us before pulse.	1….20		
p	122	Set Trigger out mode = direct (jitter free). Trigger rising edge <100 ns	21	v12	
g	127	Get start point Trigger out	us		
p	127	Set start point Trigger out			
g	128	Get length Trigger out	us		
p	128	Set length Trigger out			
g	129	Invert Trigger out (0=normal, 1=invert)			
p	129	Set Invert Trigger out =normal	0		
p	129	Set invert Trigger out = invert	1		
g	170	Get number of pulses without HV Trigger after Laser On	#pulses	v9	
p	170	Set number of pulses without HV Trigger after Laser On		v9	2
g	172	Get lowest external trigger frequency in percent of internal frequency	%	v10	
p	172	Set lowest external trigger frequency in percent of internal frequency	0 or 55….95	v10	2
g	301	Main TEC (T Laser Head) On(1)/Off(0)			
p	301	Set Main TEC On	1		
p	301	Set Main TEC Off	0		
g	311	Main TEC nominal temperature (Tset)	°C		
p	311	Set Main TEC nominal temperature (Tset)	5….40		
g	312	Main TEC tolerance window	°C		
p	312	Set Main TEC tolerance window	0….100		
g	320	Main TEC actual current	A		

g	322	Main TEC actual temperature	°C		
g p	360 360	Main TEC I MAX (max. Peltier current) Set Main TEC I MAX	A 0…100		 2
g	381	MAIN TEC 2 temperature maximum	°C		3
g	383	MAIN TEC temperature maximum	°C		3

[1] Command is supported from firmware version (and upwards). Use “g51” to read the current firmware version of the laser system.

[2] Command is available in service configuration level 2 (requires code to change the configuration level)

13.4.4 Errors list (Laser Head)

Use “g10” to read the current error or look at the error menu at the GUI.

Error	Error-Number	Description	Shutdown		
			Laser	HV	TEC
PCB temperature	1	Shutdown due to high temperature on the printed circuit board	x	x	x
PCB temperature	2	Shutdown due to low temperature on the printed circuit board	x	x	x
Internal error	3	Internal power loss to high	x	x	x
Interlock 2	4	Interlock 2 circuit is not closed	x	x	x
Interlock 1	5	Interlock 1 circuit is not closed	x	x	x
HV Interlock	6	Interlock from the HV PCB is not closed	x	x	
External Frequency too low	8	external triggerfrequency too low	x	x	
Laser head temp-erature warning	29	Temperature main TEC (laser head) not yet reached after power-up (warning only, self-clearing)			
Temperature error main TEC	30	Temperature main TEC out of tolerance	x	x	x
Temperature error main TEC	31	Temperature main TEC higher absolute maximum	x	x	x

13.5 Communication to temperature oven (SHG)

Temperature oven is only in M-NANO-GREEN models with second harmonic generation (SHG) available!

The communication protocol is an Ascii command protocol with <CRLF> as the terminator both for commands as well as for responses. <CRLF> refers to the character carriage return followed by the character line feed or in hexadecimal values 0x0D 0x0A (decimal 13 and 10).

13.5.1 Commands and response syntax

The formal syntax for put or get commands is:

CANID:**{p|g}(command number)<SPACE>(command value)<CRLF>**

where CANID is the CAN ID RX with the value “c1000”

{p|g} command ‘g’ to read a setting or status value or ‘p’ to make a setting

(command number) is an integer number between 1 and 999

<SPACE> is the space character (0x20)

(command value) is an integer or a float number with decimal point (0x2E) or a string, depending on the command number, always in ASCII.

<CRLF> is the command terminator sequence consisting of the two characters “carriage return” and “line feed” (0x0D 0x0A)

The formal syntax for the command response is:

CANID**:(command number)<SPACE>(response value) <CRLF>**

where CANID is the CAN-BUS ID TX with the value “c1001”

<SPACE> is the space character (0x20)

(command number) is an integer number between 1 and 999

(response value) is an integer or a float number with decimal point (0x2E) or a text or string, depending on the command number, always in ASCII.

<CRLF> is the response terminator sequence consisting of the two characters “carriage return” and “line feed” (0x0D 0x0A or ASCII values 13 10)

- To read a setting or status value, use the **get** command, which is a “g” followed by the command number. The response will be two numbers, the first noting the command number again, and the second denoting the response value.
- Put command: To make a setting, use the **put** command, which is a “p” followed by the command number, a space and a value. The response will be two numbers usually, the first denoting the command number again, and the second denoting the new set value (as a confirmation).
- **Important note:** use the dot “.” (0x2E) as the decimal point and not comma “,” !

13.5.2 Temperature oven controller commands

The system has one temperature oven control for the frequency conversion crystal. This functional module can be addressed as shown in the following examples and following command list:

For example, in order to retrieve the actual temperature of the temperature oven, use this command:

c1000:g322<CRLF>

The unit responds with

c1001:g322 35.001<CRLF> *(value in degrees C, i.e. 35°C in this case)*

To read the set value for this temperature oven, the command is

c1000:g311<CRLF>

The laser head will answer with (assuming the set temperature is 35°C):

c1001:g322 35.001<CRLF>

To set the set temperature of the temperature oven to a value of 45.6°C, the command is

c1000:p311 45.6<CRLF>

Please note that the following list shows the commands **without** the CAN-BUS ID “c1000 ”and **without** the terminator <CRLF> for simplicity.

Put or Get	**Command number**	**Description**	**Value / Unit**
g	10	Get Error number	
p	10	Reset Errors	0
g	13	Get config. level (1=user, 2=service*, 3=Montfort)	
p	13	Set configuration level (requires code if >1)	n.a.
p	13	Set configuration level to user	
		*Access code to level 2: p13 108.05	1
p	14	Save all (survives power cycle)	1
g	50	Heater serial number	
g	51	Heater Software version	
g	53	Heater revision number	
g	55	Heater flash version number	
g	55	Flash version	
g	60	Heater CAN-BUS TX ID	
g	61	Heater CAN-BUS RX ID	
g	311	Nominal temperature of temperature oven (SHG)	°C
p	311	Set nominal temperature of temperature oven (SHG)	5….60
g	320	Actual duty-cycle heater control	%
g	322	Actual temperature of temperature oven (SHG)	°C
g	383	Heater temperature maximum	°C

13.5.3 Errors list (temperature oven)

Use the command “c1000:g10” to read the current error.
The command “c1000:p10” clear the error (only if they are clearable!).

Error	**Error-Number**	**Description**	**Shutdown Heater**
NTC failure	0	NTC broken or shorted	X

Heater over maximal temperature	1	Heater temperature is over the maximal set temperature (g383)	X
UART buffer overflow	2	UART buffer overflow	
CAN buffer overflow	3	CAN buffer overflow	
PCB over maximal temperature	4	Temperature of the PCB heater electronic is over the maximal temperature of 85°C	X

13.6 Glossary

CRLF	Carriage return and Line Feed, characters 0x0D (dec. 13) and 0x0A (decimal 10)
ESD	Electrostatic discharge
GND	Ground
GUI	Graphical User Interface (Software tool)
HV	High voltage (Pockels cell voltage)
IO	Input/Output
LD	Laser Diode
LH	Laser head (module)
mJ	milli Joule (1/1000 Joule)
SHG	Second harmonic generation
TEC	Thermo-electric cooler for laser head
TTL	Transistor-transistor logic
RMA	Return Merchandise Authorization (number)
PCB	Printed Circuit Board
PE	Protective EARTH
TEC	Thermo-electric cooler for laser head

Document Version History:

v20111	Manual M-NANO-GREEN was added, Exact description of command syntax (SHG+LH)	2020-11-11 (ES)
v190802	Description of trigger modes changed, Changes in the command list,	2019-08-31 (ES)
	Matlab Runtime changed from 2016A to 2018A, single shot operation by external push switch	
	RMA added	
v180905	Error list and supply current updated.	2018-09-05 (ES)
v170921	Commands and details were added to command list. Note for manual operation	2017-09-21
V170802	changes related to power supply; revision of labeling details; re-arrangement of details and specifications for better readability	2017-08-02
v1706	added PE and GND connection details for safety per ISO 61010.	2017-06-14
v1703	added PE and GND connection details	2017-06-14