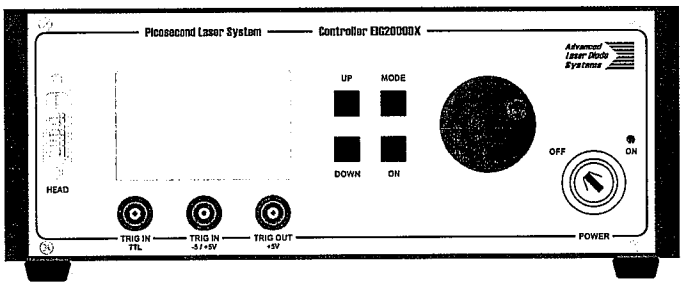
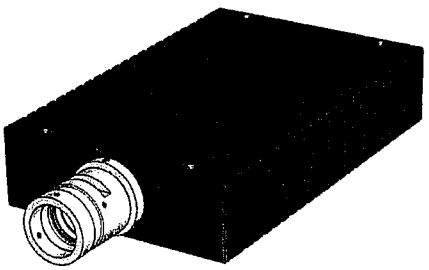
Advanced Laser Diode Systems

# Picosecond Diode Laser - PiLas

Pulse Repetition Rate 120 MHz Maximum

## Manual



# Content

# 1 General

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



## 1.1 Warranty and Assistance

This instrument manufactured by Advanced Laser Diode Systems is warranted against defects in material and workmanship for a period of 12 months from date of shipment to the customer. During the warranty period, Advanced Laser Diode Systems 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 Advanced Laser Diode Systems in appropriate packing. Please enclose a detailed fault report including instrument type and serial number.

## 1.2 Maintenance

The instrument does not require special maintenance if it is used correctly.

## 1.3 General Safety Considerations

Before switching on the instrument, make sure it has been properly grounded through the supplied AC power cable to a socket outlet with a protective earth contact. Any interruption of the grounding can result in personal injury.

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

Always replace blown fuses with the same rating and acting speed.

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.

Caution – use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

There is no scheduled maintenance necessary to keep the product in compliance.

There is no service allowed by the customer.

The driver or laser head must never be opened by the customer. Opening of laser head can be detected by A.L.S. GmbH. If the opening protection is damaged the warranty is lost.

## 1.4 Laser Safety

### 1.4.1 General Remarks

The radiation of the laser diode used in this instrument may be visible or invisible. The laser diode emits radiation in the 370 nm to 2000 nm spectral region.

***Use caution to avoid hazardous exposure to the beam. Take precautions to eliminate exposure to a direct or reflected beam. Do not view the laser beam directly or indirectly with optical instruments or human eye.***

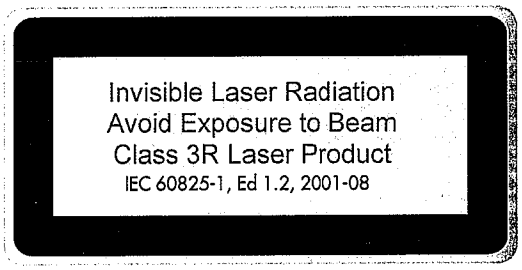
### 1.4.2 Laser Class

This PiLas laser system is classified as **class 3R laser product** according to IEC 60825-1, Ed 1.2, 2001-08 during all procedures of operation.

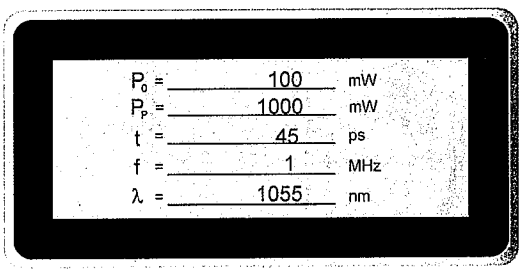
The laser radiation is emitted through the optics at the front side of the optical head or by an attached optical fiber guiding the laser light.

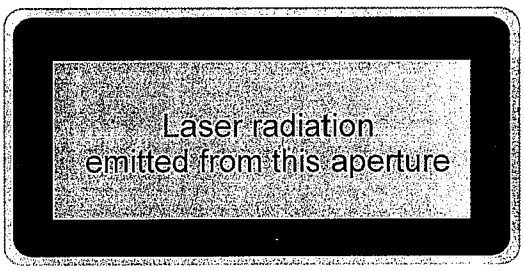
### 1.4.3 Laser Warning Label

According to laser safety regulations the following class 3R laser product ***explanatory label*** with relevant laser parameters is used. For the detailed laser parameter please see the test report.




According to laser safety regulations the following class 3R laser product ***data label*** and ***aperture label*** are used (***aperture label*** maybe attached to manual due to lack of space):




| | |
|---|---|
| Average radiant power at max. rep. rate: | $P_0$ |
| Peak radiant power: | $P_P$ |
| Pulse width: | t |
| Max. pulse repetition rate: | F |
| Wavelength laser radiation: | λ |

According to laser safety regulations the following ***hazard label*** is used:

## 1.4.4 Label Location

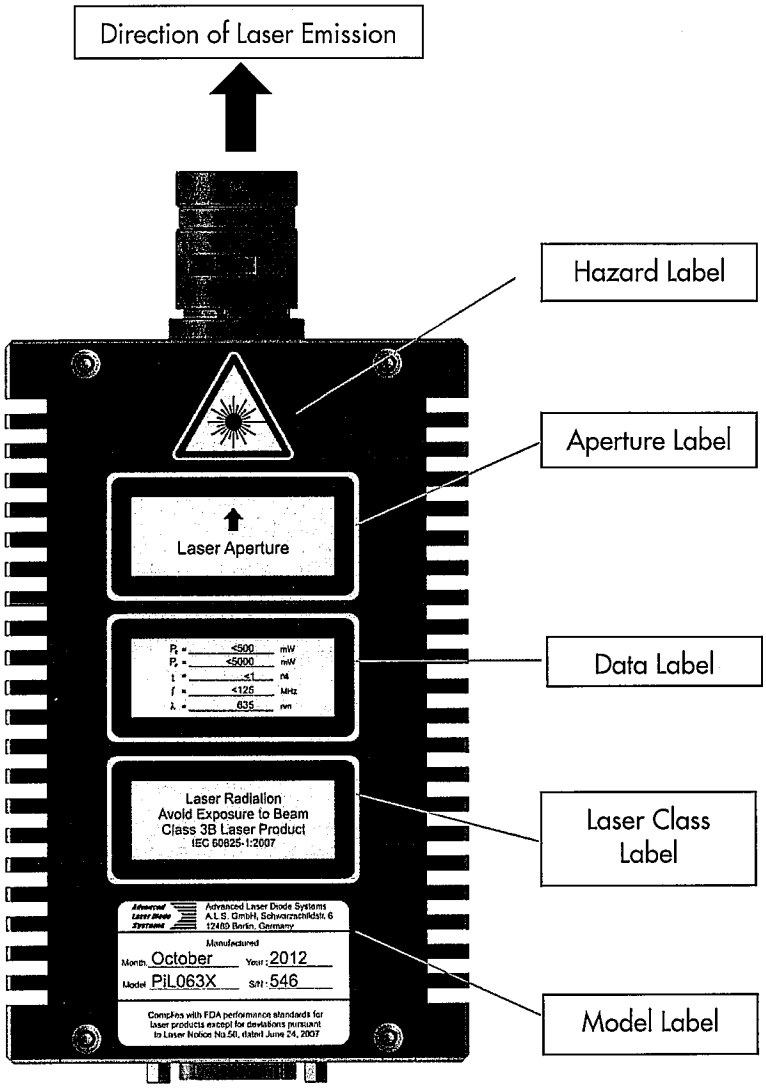



*Figure 1 Sample laser and model label location*

The shown laser head and labels are samples. Other optics (for instance fiber option) or labels (for instance cw option) are possible.

The ***hazard label*** is attached on top of the laser head near the laser emission aperture as shown in the diagram.

The ***laser aperture*** label is attached on top of the laser head with the arrow pointing towards the laser emission aperture as shown in the diagram.

The ***Laser parameter label*** is attached on top of the laser head as shown in the diagram.

The ***Laser class label*** is attached on top of the laser head as shown in the diagram.

The ***Laser head identification (model) label*** is attached on top of the laser head as shown in the diagram.

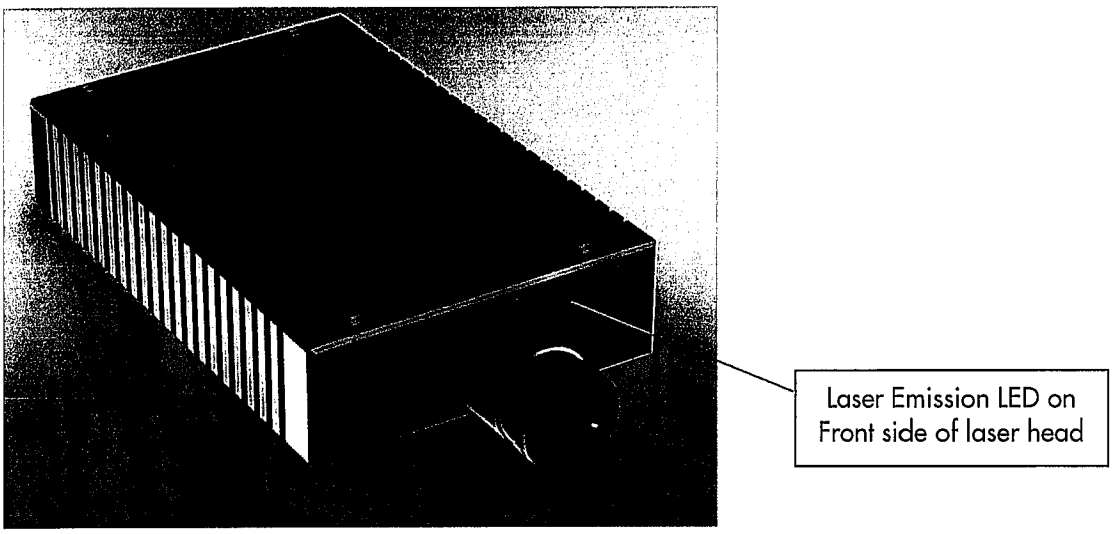



*Figure 2 Laser head front side, laser emission LED position*

## 1.5 Delivery Volume

| | |
|---|---|
| Control unit: | EIG2000DX |
| Optical head: | PiL---X ("---"corresponding to wavelength code) |
| Connection cable: | PIL-MH-02 (for connection PiL----X head with EIG2000DX controller) |
| Tools in blue box: | key switch, hexagon socket screw driver 1.5mm, 1.2mm slot screw driver 1.2mm slot screw (only for fiber coupler, fiber collimator or microfocus options), eccentric key (only for fiber coupler or fiber collimator options) |
| AC Power Cable: | EU, US, China, Japan, UK selected |
| Manual | |
| Test report | (at the end of manual) |

# 2 Introduction

The PiLas is a compact system generating ultra-short optical pulses using diode lasers. The system consists of a control unit and an optical head with the electrical driver and the laser diode. The optical head is configured to emit short light pulses within one wavelength in the spectral region between 370 nm and 2000 nm. Each head is individually adjusted to the laser diode to achieve optimal pulses emission performance down to pulse widths of 15 to 50 ps and optical peak powers between 50 and 1500mW. Different optical output options are available, including free space collimating optics, fiber coupled versions for multi- or single mode fibers and different micro foci.

Repetition rates of up to 125 MHz, very low jitter and different triggering possibilities make the PiLas a flexible and reliable system suitable for a wide range of applications.

The PiLas system uses the technique of gain-switching of laser diodes.

The laser diode represents a low impedance load, which is driven by special electronic circuit that generates an electrical pulse of high amplitude, variable pulse widths and a jitter of less than 3-4ps.

The following diagram illustrates the behavior and the relationship of electrical pumping current *i*, carrier density *n* and photon density *N*.

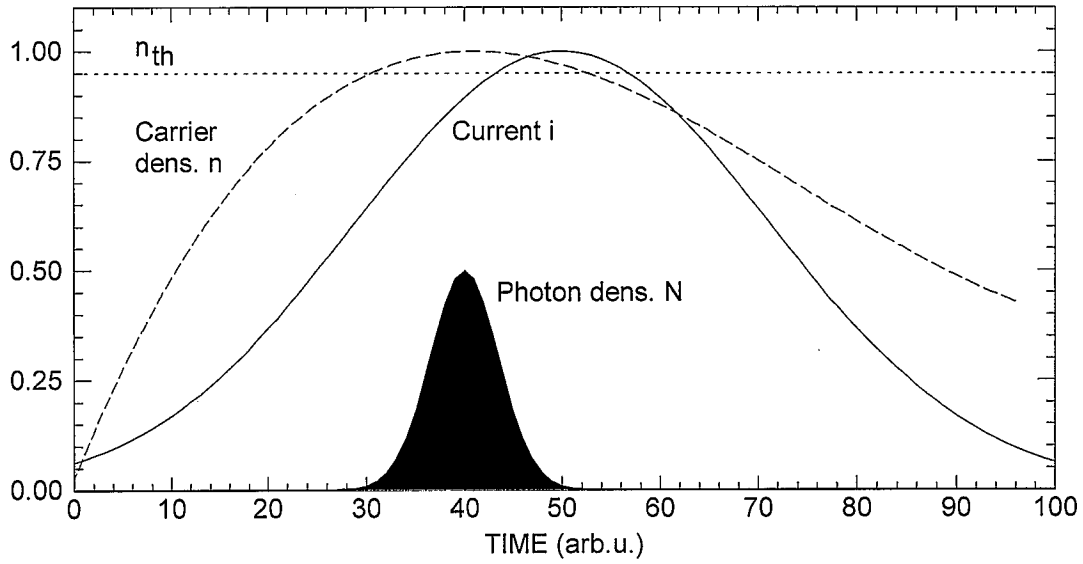



*Figure 3 Gain switch, carrier and photon density development*

The diagram shows that an increasing pumping current increases the carrier density *n*. At the carrier density threshold $n_{th}$ a population inversion results in lasing emission from the laser diode. If the pumping current *i* is switched off shortly after this event, the carrier density *n* drops below the threshold again. This results in the emission of a single optical pulse. Applying the pumping current *i* for a longer period would lead to the emission of multiple pulses. These so-called relaxation oscillations continue for a short time (0.5 to 2ns depending on the diode laser technology and electronic circuit).

# 3 Operation

## 3.1 Installation

Set up controller and laser head in stable position. Connect the power supply cable to the controller (100V - 240V, 50Hz - 60Hz). Connect the laser cable PiL-MH-02 between controller and laser head. The key switch can be found in the laser head transport box. If the primary fuses are blown they can easily be replaced by the user. Before switching on the controller the rear panel power switch has to be set to "1".

### 3.1.1 Rear elements of the control unit

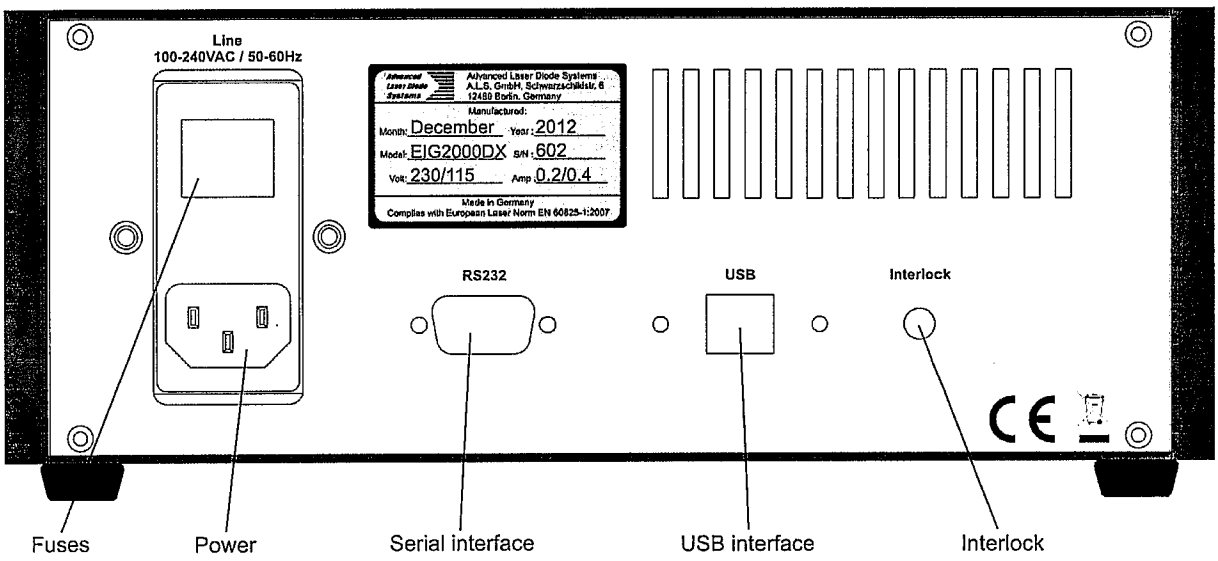



*Figure 4 EIG2000DX rear panel with sample model label*

### 3.1.2 Front elements of the control unit

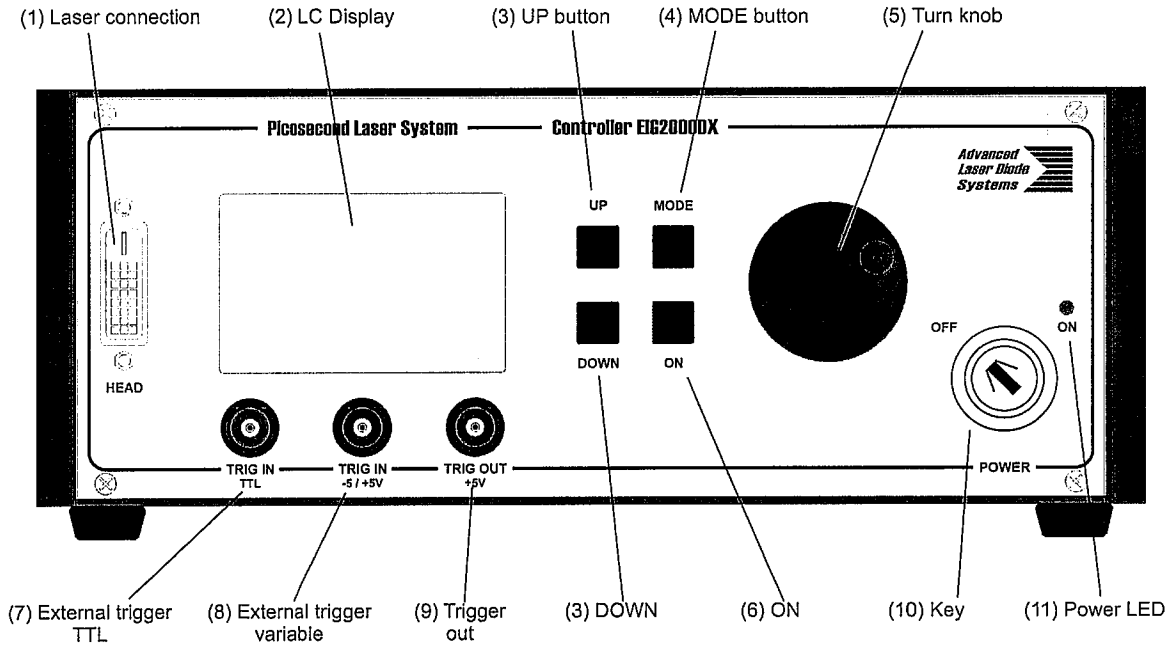



*Figure 5 EIG2000DX front panel*

1. Laser connection (to optical head)
2. Liquid crystal display (LCD), illuminated
3. UP, DOWN navigation buttons
4. MODE key, selection, confirmation and return
5. Dial knob, value setting
6. ON laser button with red laser emission LED (there is also a 2nd laser emission LED on front side of laser head)
7. Trigger input, TTL, BNC plug
8. Trigger input, variable, BNC plug
9. Trigger output, BNC plug
10. Power key switch
11. Power LED, green

## 3.2 Operation

The digital control unit of the PiLas is operated by four keys UP, DOWN, MODE, ON and Turn knob (see image).

You can select the different menus by pressing MODE keys. The UP and DOWN keys are for selections within the menus. The Turn knob will change the selected value. With the MODE button you confirm and leave the selected menu level automatically.

The ON button with red light emitting diode (LED) is for switching the laser emission On/Off. A red glowing indicates laser emission. A colored LED on the laser head front side will also show laser emission.

## 3.3 Menu

The following adjustable laser parameters will be set by software menu:

-pulse repetition frequency

-TUNE (pulse amplitude and width)

-Temperature (only with TEC option included)

-CW mode (only if ordered)

-Trigger methods a) internal 100Hz to 120MHz b) external single shot to 120MHz

-Input trigger TTL or variable

-trigger threshold and edge if trigger supplied by BNC plug (8)

### 3.3.1 Start Screen

After switching on the control unit, you get the text message:

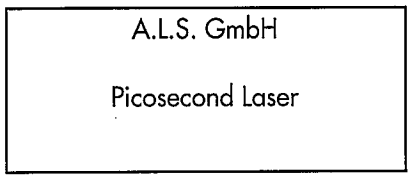



*Figure 6 Start screen*

For operation the interlock cable must be connected to the rear panel 2.5mm plug. The interlock cable is delivered with the system. If the interlock is not connected, the controller displays a message. If the laser head is not connected an error message will be displayed also.

### 3.3.2 Main Menu

With interlock and laser head connected the controller shows the main menu:

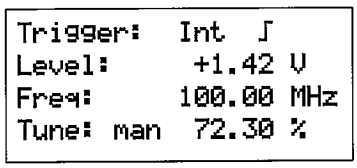



*Figure 7 Main menu*

By pressing **ON** button the laser would start working with the displayed parameter.

The TUNE value can be changed in the main menu by turning the dial knob (but only if "manual" mode is selected in menu "TUNE Setup").

Pressing The MODE button switches to Setup menu.

### 3.3.3 Setup Menu

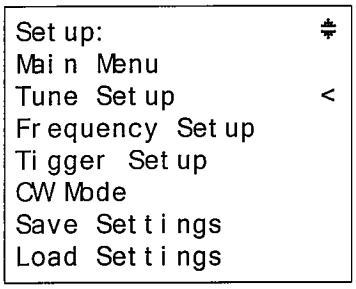



*Figure 8 Setup menu*

With the UP and DOWN keys you can navigate within the setup menu. The selected menu is marked by "<" sign on right side. This is valid also for the next menus.

For switching to desired menu press MODE button.

**Main Menu** < screen switches back to main menu

**Tune Setup** < Tune value menu

**Frequency Setup** < Selection of frequency parameter

**Trigger Setup** < Selection for external trigger parameter

**CW Mode** < Cw options (if available)

**Save Settings** < save set up

**Load Settings** < load stored setup

### 3.3.4 Tune Setup

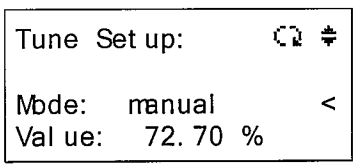



*Figure 9 Tune menu*

**Mode:** By turning the dial knob you can select between "manual" and "automatic" TUNE mode. In "automatic" mode the default TUNE values from the manufacturer are used and no change is possible. In "manual" mode the TUNE values can be changed by the user. For that press the UP or DOWN key until the "<" mark is in the row for "Value". Now the TUNE value can be adjusted by dial knob.

**Value:** The TUNE value can be adjusted between 100 and 0% (in manual mode only).

TUNE 100% low laser pulse amplitude

TUNE 0% high laser pulse amplitude

The recommended TUNE value for the optimum pulse shape can be found in the delivered test report. In some cases we recommend adjusting the TUNE value by +/- 5% to find optimum pulse parameter.

Please note that the TUNE value can also be changed in the main menu by turning the dial knob (but only if "manual" mode is selected).

For external and internal (fine mode) frequencies values not given in the test report the TUNE values will be interpolated in "automatic" TUNE mode. They can be changed manually if mode is set to "manual" in TUNE menu.

Please note: Confirming with the MODE key will jump back to the setup menu also.

### 3.3.5 Frequency Setup

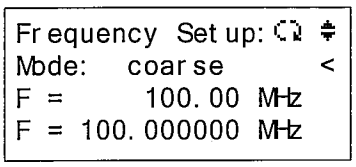



*Figure 10 Frequency menu*

The maximum adjustable frequency can be found in the test report or purchase information.

In the second row you can select between "coarse" and "fine" frequency resolution for internal triggering. Selection is done with the dial knob.

**Mode coarse:** With this option the frequency is adjusted in the 3d row in steps of about 10MHz and below 1MHz in smaller steps.

**Mode: fine:** With this option the frequency is adjusted in the 4th row in fine steps. For most applications "coarse" is the better option.

By pressing the UP and DOWN key you can navigate to the frequency rows.

**F:** If "coarse" is selected the frequency for operation is adjusted in this 3d row by dial knob.

**F:** If "fine" is selected the frequency for operation is adjusted in this 4th row. Continue pressing UP and DOWN for selecting the digits of the frequency in 4th row. The digit value is adjusted by dial knob.

Confirm selected frequency value with MODE key.

Please note: Confirming with the MODE key will jump back to the setup menu also.

### 3.3.6 Trigger Setup

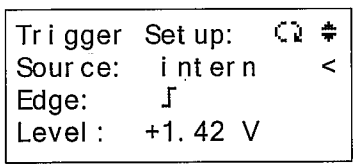



*Figure 11 Trigger menu*

**Source**: With the dial knob you can switch between: "internal", "ext. TTL" (external TTL) and "ext. Adj" (external adjustable) mode.
At "internal" setting the oscillator of the controller is used for generating the frequency. The "Edge" and "Level" is only used for external triggering.

For "ext. TTL" a trigger signal to the TTL BNC plug has to be provided. An external oscillator will give the clock.

For "ext. Adj" a trigger signal up to +5/-5V BNC plug has to be provided. An external oscillator will give the clock.

Lowest jitter is provided by "internal" clock.
"ext. TTL" provides the lowest jitter for external clock.
For variable clock signal (low) amplitudes use "ext. Adj" input with slightly increased jitter.

Please note that external oscillators may have worse frequency stability than internal clock (50ppm). This can lead to increased jitter of following pulses. Low external clock signal amplitude can also lead to increased jitter or bad laser pulse signal quality.

The impedance for all BNC plugs is 50Ohm. The external trigger sources must provide an impedance of 50Ohm. Other values can lead to impedance mismatch and failure in external triggering.

The applied external clock frequency must not be higher than the device maximum allowed frequency (see purchase information).

The following settings are only used for "ext. Adj" triggering.

**Edge**: Select leading or trailing edge for external triggering.

**Level**: Select trigger threshold level in Volt for "ext. Adj" triggering.
The applied external clock is measured and the frequency is displayed in the main menu. If external triggering does not work the laser cannot switched on and frequency shows 0Hz.

For external and internal (fine mode) frequencies values not given in the test report the TUNE values will be interpolated in "automatic" TUNE mode. They can be changed manually if mode is set to "manual" in TUNE menu.

Please note: Confirming with the MODE key will jump back to the setup menu also.

### 3.3.7 CW Mode

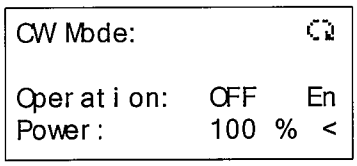



*Figure 12 CW menu*

**Operation**: The CW option can be switched on or off if available.

**Power**: The optical CW power in % can be adjusted if available.

Please note: Confirming with the MODE key will jump back to the setup menu also.

### 3.3.8 Save / Load Menu

Within this menu you have the option storing some working parameters like TUNE and frequency. There are three memory slots.

Please note: Confirming with the MODE key will jump back to the setup menu also.

# 4 Optical Head

The optical head is electrically connected to the Laser connector (1) of the control unit with the cable PIL-MH-02. Please attach the screws of the cable to the control unit and the optical head. To fix the head mechanically, please use the thread in the base plane of the optical head.

For detailed parameters please see the test report as a reference. There are three main versions:

-collimating optics (free space laser beam)

-removable fiber coupling optics (removable fiber coupler and fiber)

-internal fiber coupling (fixed fiber)

The laser head can be mounted by five M4 threads on the bottom plate for mounting. Please check thread length!

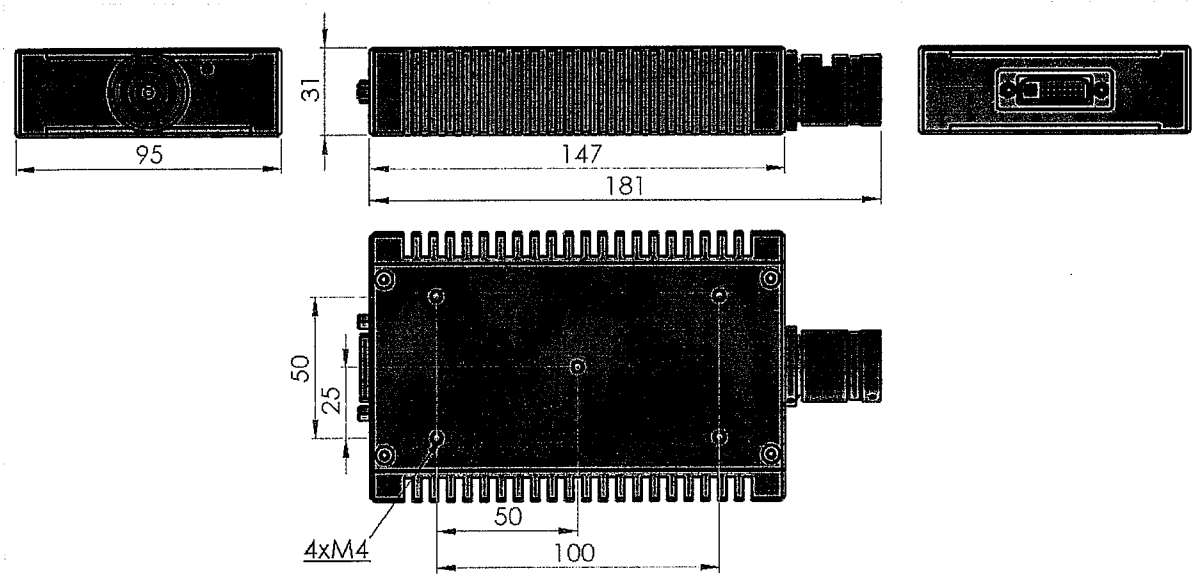



*Figure 13 Laser head dimension and mounting scheme*

## 4.1 Handling and Adjustment

The following chapters describe the main optics shown in the picture above that can be used in conjunction with PiLas-systems. You will find the optics used for your system in the PiLas-test report attached to the manual.

## 4.2 Optics

A.L.S. GmbH uses high quality laser optics from ©Copyright Schäfter + Kirchhoff GmbH Germany.

### 4.2.1 Collimating Optics

This is the standard version and included in laser head sales price. The collimating optics delivers an elliptical collimated beam.

The inner tube, which holds the lenses, is fixed to the main housing with two hexagon socket set screws on top. For re-focusing, first loosen these screws, and then use the delivered hexagon socket screw driver to

turn the optics. By slowly rotating the tool, the inner tube is slightly moved longitudinal in the main housing. After re-focusing, tighten the two screws again.

### 4.2.2 Micro Focus

A micro focus can be used for focusing the collimated laser beam to a small spot size in a certain distance in dependence of laser source, distances and focal lengths. The micro focus is inserted into the standard collimating optics by an adapter and is fixed with three small slotted headless screws at the front end of the main housing of the optics. The Adapter is needed for focal lengths from f=2.7 to 20mm and is delivered with the micro focus optics.

### 4.2.3 Fiber Coupler (removable)

The PiL---SM option is delivered with a fiber coupling unit and an aligned single or multimode mode fiber attached to it as standard. The single mode fiber can be a PM fiber (polarization maintaining) or standard single mode fiber. The fiber coupling unit is plugged into to the main optics housing delivered with the standard collimating head. The laser beam coupler is fixed to the main housing with three hexagon socket set screws at the end of the main housing (same screws for holding the micro focus).

In case of removing the fiber coupler, using another fiber or misalignment, the coupler needs be optimized by customer. For a detailed fiber coupling description please contact A.L.S. GmbH.

***For most cases it is sufficient to optimize the tilt adjustment only with the three counter hexagon socket set screws parallel to optical axis and no to touch the lens position.***

The inner tube of the fiber coupler, which holds the lens, is fixed to the housing with two small slotted set screws in the middle. For re-focusing to the fiber connector end surface, first loosen these screws, than insert the delivered adjusting tool with an eccentric aligning plug in the right position into the hole of the housing of the laser beam coupler. By slowly rotating the tool, the inner tube is slightly moved longitudinal in the main housing. After re-focusing, tighten the two screws again.

The optical axis of the laser beam coupler is aligned to the optical axis of the collimated laser beam (paraxial fiber coupling). This is done by slightly adjusting the three hexagon head cap screws clockwise. Near optimum power coupling the three counter hexagon socket set screws are for locking and fine adjustment. All six screws are located parallel to the optical axis.

Please note, that the fiber connector of single mode fibers attached to the coupler is tightened with a small slotted set screw. Before screwing off the fiber connector this small screw must be loosen and after connecting again it has to be tightened again with less pressure.

In case of polarization maintaining fiber the laser diode polarization is aligned to the slow axis. The slow axis is aligned to the connector key as shown in the picture. Most common PM fiber type is PANDA.

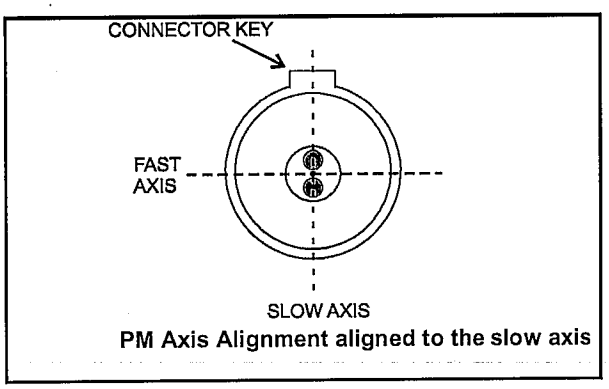



*Figure 14 Polarization maintaining fiber, direction*

### 4.2.4 Fiber Coupler (fixed)

The PiL---SM option can also be delivered in fixed version. In case of fixed fiber option the laser diode light is coupled inside the laser head into a fiber. This option offers better long term stability but is not available for all wavelengths.

### 4.2.5 Fiber Collimator

A fiber collimator can collimate the divergent output beam of the fiber. Insert the connector of the fiber gently in the right position (watch the aligning plug) to the reception of the collimator. Only tighten it lightly. Always use a protective cap for unused connectors or receptions, in order to avoid damage to the optics and to the bare fiber end, and to keep all parts clean.

The fiber connector can be fixed to the laser beam collimator with a small slotted headless screw. This screw is located at the flattened end of the laser beam coupler and is pushing towards the outer metal sleeve of the FC/PC-connector. For some collimators the lens position is adjustable to compensate connector and wavelengths changes and to optimize the collimation. It is even possible to use the collimators for weak focusing (minimum about 0.2mm spot size) or defocusing.

### 4.2.6 Micro Focus

A micro focus can be used for focusing the collimated laser beam delivered by fiber collimator to a small spot size (<0.2mm). The focus spot is roughly one focal length f away. Focus spot size depends on wavelength, lens combination and fiber type.

The micro focus is inserted into the fiber collimator and is fixed with three small slotted headless set screws at the front end of the main housing of the fiber collimator.

## 4.3 Cleaning

The need for cleaning of any precision optics should be reduced to a minimum by covering the optics and by use of a protective bag in order to avoid degrading. We recommend that dust is blown off only. Fingerprints need to be removed immediately with several steps of appropriate solvents such as alcohol.

# 5 General Specifications

## 5.1 Control Unit EIG2000DX

| | |
|---|---|
| **Internal trigger:** | |
| Repetition rate | 100Hz to 125 MHz |
| Frequency resolution | <0.1 ppb |
| Frequency stability | <50 ppm |
| **External trigger input (TTL):** | |
| Amplitude | +5 V max. |
| Trigger level states | TTL |
| Input impedance | 50 Ω |
| Pulse width | >3.5 ns |
| Connector type | BNC |
| Frequency range | Single shot to 125 MHz |
| Delay(1) | 33ns |
| **External trigger input (variable):** | |
| Amplitude | ±10 V max. |
| Trigger level states | -4.8 V ... +4.8V |
| Input impedance | 50 Ω |
| Pulse width | >3.5 ns |
| Connector type | BNC |
| Frequency range | Single shot to 125 MHz |
| Delay(1) | 38ns |
| **Synchronization (trigger) output:** | |
| Amplitude | +2.5 V @ 50 Ω load |
| Output impedance | 50 Ω |
| Pulse width | 50 % duty cycle for internal oscillator<br>>3.5 ns for external trigger |
| Connector type | BNC |
| Delay(2) | 24ns |
| **Remote Interlock** | |
| Voltage | +5 V |
| Loop resistance | <1 Ω |
| Connector type | 2.5mm mono TS (jack connector) |
| **Remote control:** | |
| Connector type | USB 2.0 |
| Connector type | RS232 |
| **Temperature:** | |
| Temperature drift trigger delay | 10 ps/K |
| Warm up time (operating) | 15 min |
| **Power:** | |
| Line voltage | 100 V ... 240VAC |
| Line frequency | 50 Hz ... 60 Hz |
| Power consumption | <20 W |
| Fuses rating for 230V AC | 500 mA slow acting (5mmx20mm) |
| Connector type | standard IEC C13/C14 Power Plug |
| **Environment (operating), also for the Optical Head:** | |
| Temperature | 25 °C ± 10 °C |
| Relative humidity | 30 % to 70 % |
| **Size of Control Unit:** | 236 x 89 x 316 (width x height x depth, $mm^3$) |
| **Size of Optical Head (w/o optics):** | 95 x 31 x 147 (width x height x depth, $mm^3$) |
| **Weight:** | |
| Control unit and head | 5 kg |

Notes:

(1) Delay between electrical signal at trigger input BNC plug and optical pulse at last optical surface.

(2) Delay between electrical signal at trigger out BNC plug and optical pulse at last optical surface.

# 6 Image Content



# 7 Test Reports (followed after blue separation sheet)