SCIENTIFIC & INDUSTRIAL LASERS

INNOLIGHT

Mephisto Product Line

User's Manual

Hannover, 30.03.2009

Version 4.71

InnoLight GmbH
Garbsener Landstr. 10
30419 Hannover
Germany
Tel.: +49 511 760 727-0
FAX: +49 511 760 727-99

- When the product is received, the shipping container and its content should be inspected for any damage incurred during shipping. In case of damage, please inform InnoLight GmbH immediately!

- If any failure occurs, please contact InnoLight GmbH immediately! Do not open the modules! They do not contain any user serviceable parts!

- Read this manual carefully before starting up the laser!

- Before connecting or disconnecting any cables, switch off the control electronics!

- The Mephisto laser system is designed for applications in R&D fields. The laser must only be operated by trained personnel.

- Always wear laser goggles to protect your eyes!

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1 User Safety

1.1 Grounding the Power Supply

To minimize shock hazard, the power supply must be connected to an electrical ground. The power supply must be plugged into an approved electrical outlet using an appropriate AC power cable.

1.2 Line Voltage Selection

Before connecting the power cord, verify that the line voltage setting on the reverse side of the power supply agrees with your local line voltage.

1.3 Removing the Electronics Cover

Warning:
Dangerous voltages exist inside the power supply, even with the power switched off. Only qualified service personnel should remove the cover.

1.4 Laser Safety Warnings

Warning:
Exposure to laser radiation may be harmful. All apertures which can emit laser light in excess of levels which are considered safe are identified with the appropriate labels shown later in this section. Take extreme care when working in areas where these labels are placed.

Warning:
Always provide protective eyewear suitable for the laser's emission wavelength. The emission wavelength of your laser model may be 946 nm, 1064 nm, 1319 nm, or 1444 nm and is given in the data sheet.

Warning:
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure. The use of optical instruments with these products may increase eye hazard.

Caution:
Lasers may be damaged by improper setting of the current controls or by improper use of the modulation inputs. Check line voltage setting before connecting power.

Warning:
This laser product must not be used for any medical applications, whatsoever.

The positions of the laser safety and aperture labels affixed to the laser housing of the **Mephisto** Product Line are illustrated in the following Figure 1.1:

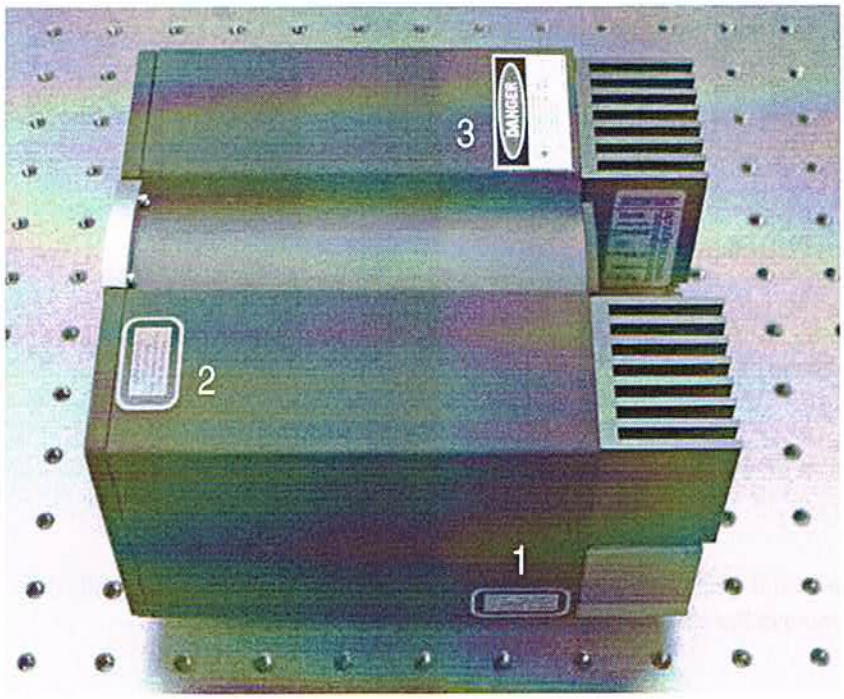
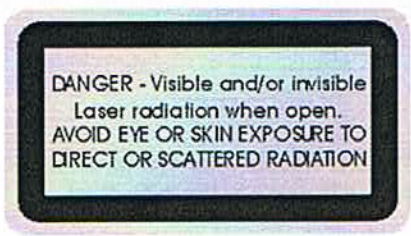
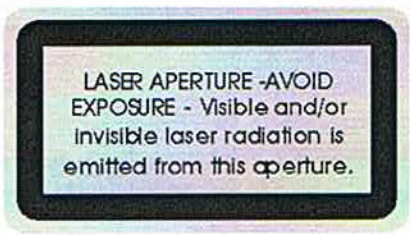


Figure 1.1: Positions of laser safety and aperture labels

Reproductions of the laser safety and aperture labels for lasers of the **Mephisto** Product Line are illustrated in the following Figure 1.2:



Label 1



Label 2

Label 3

Figure 1.2: Reproductions of laser safety and aperture labels

The maximum laser power level emitted from lasers of the **Mephisto** Product Line is 2 Watts in continuous wave operation. The nominal laser output power level for your laser model is given in the data sheet.

This laser product complies with the Federal Register 21 CFR 1040.10 Laser Safety Standard as applicable.

1.5 Servicing

There are no user replaceable parts inside the control electronics unit. Refer all servicing to qualified personnel or contact InnoLight GmbH.

1.6 Initial Activation

Read this manual carefully before operating the laser system !

The remote interlock connector must be installed at the rear panel of the control electronics unit (see Figure 2.3 and Figure 2.5). It is installed when shipped. If it is not in place, the yellow *Interlock* LED on the front of the Standard control electronics unit or the red *Error* LED on the front of the OEM control electronics unit will glow and the unit will be inoperable.

2 The **Mephisto** Laser System

2.1 Introduction

The **Mephisto** laser system consists of two self-contained units, the laser head (see section 2.2) and the control electronics unit (see sections 2.3 and 2.4). This manual is intended to provide some more detailed information on how to operate these devices properly.

Essentially the laser head consists of four components: One or two (depending on model) diode laser(s) which are electrically driven and provide the pump radiation for the monolithic Nd:YAG laser crystal. Some optics are required to focus the pump light into the Nd:YAG laser's fundamental mode. Optionally, a fraction of the generated Nd:YAG laser light is focused onto a photo detector to analyze variations of the emitted radiation. This signal, appropriately filtered and amplified by an electronic SMD board mounted inside the laser head, is fed to the diode laser pump source. Activating this feedback loop, the Nd:YAG laser's intensity noise is suppressed by a large amount close to the fundamental limit set by quantum noise (see section 4.7).

In order to operate the **Mephisto** laser system, the control electronics unit needs to be connected to the laser head. The provided electrical power is converted into coherent narrow bandwidth radiation with an efficiency of about 30 %. The remaining power heats the diode laser, which must be cooled to prevent overheating. Furthermore, the wavelength of the diode laser depends on the junction temperature. Therefore, temperature stabilization of the diode laser is essential. The wavelength of the Nd:YAG laser light also depends strongly on the crystal temperature, consequently the Nd:YAG laser crystal must be temperature stabilized as well. The control electronics unit is designed to provide all required subsystems to drive and control the **Mephisto** laser system, featuring:

- a *Laser Diode Driver* that provides a very stable, low noise injection current to the diode lasers up to a value of 3 A. This subsystem also contains the protection circuitry that is essential for reliable operation of the laser system (see sections 5.3 and 5.4) and a temperature controller that regulates the diode laser temperature.

- a *Precision Temperature Controller* that stabilizes the Nd:YAG crystal's temperature. Because of an integrated pre-stabilization stage, typical drifts of this controller are only a few 100 µK / min, corresponding to a variation of the laser frequency of less than 1 MHz / min.

- analog modulation inputs (BNC connectors) for diode laser current and laser crystal temperature to externally control output power and laser frequency of the **Mephisto** laser system.

- a diagnostics connector (D-Sub connector) to monitor all vital signals and voltages of the **Mephisto** laser system without opening the control electronics unit.

An OEM control electronics unit is available for customers, who do need the full functionality but not the full set of laser parameters to be permanently accessible as with the Standard control electronics unit.

2.2 Mephisto Laser Head

The dimensions of a laser head of the **Mephisto** Product Line are illustrated in the following Figure 2.1. The infrared laser beam is emitted from the laser aperture at the front side, which can be closed with a mechanical shutter.

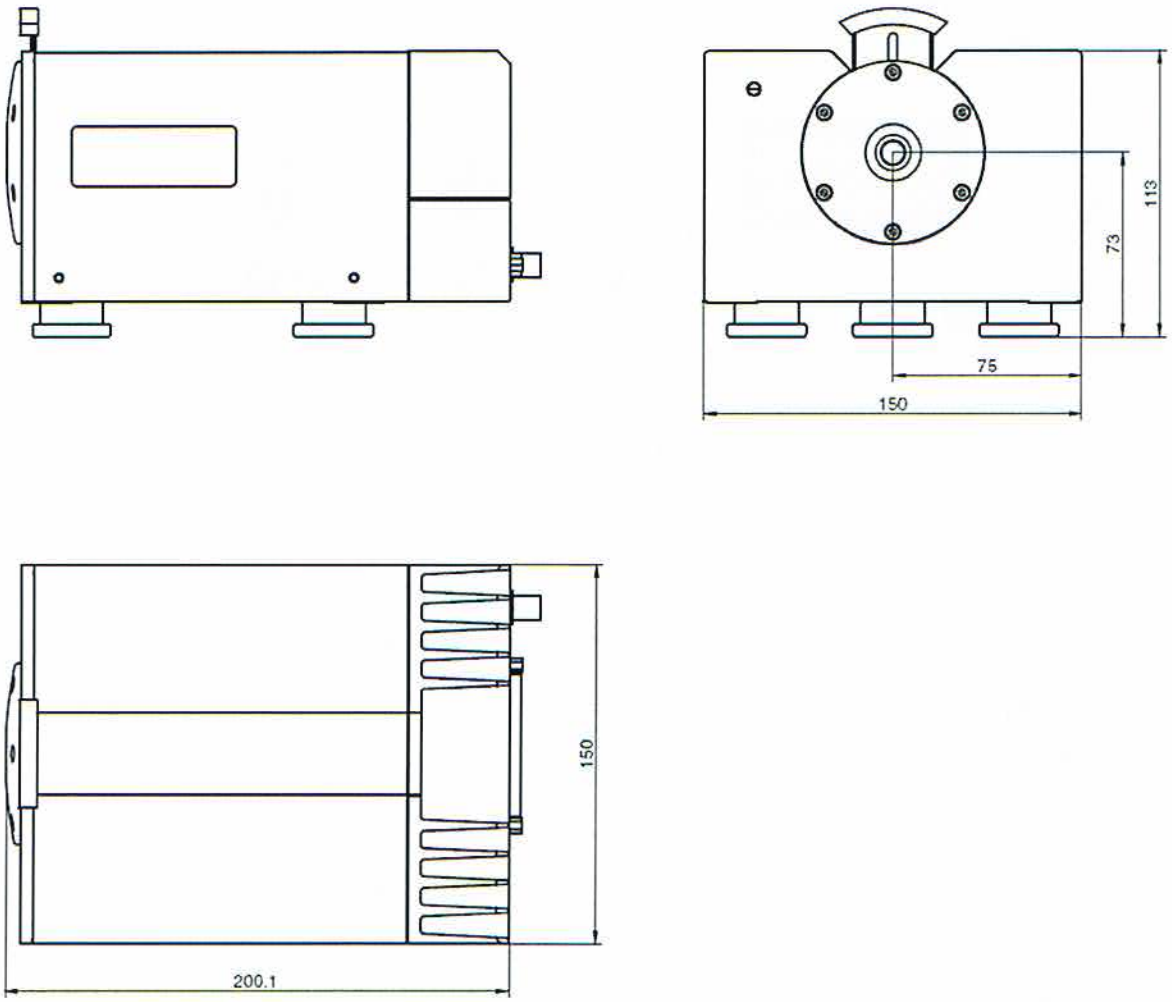


Figure 2.1: Dimensions of the **Mephisto** laser head in mm

At the rear side of the laser head, a 37 pin D-Sub connector and a BNC connector are located. While the D-Sub laser connector (see section 6.1) is used to connect the laser head with the control electronics unit, the BNC connector can be used to apply a high voltage signal in the range −100 V to +100 V to a PZT element on the laser crystal for fast tuning of the laser frequency (see section 4.2).

The two following sections illustrate the front and rear panels of both the Standard and OEM control electronics units. Having the same internal functionality, the OEM control electronics unit is intended for customers, who want to operate the **Mephisto** laser system with identical laser parameters most of the time, while the Standard control electronics unit provides the possibility to easily access and vary all laser parameters of interest at any time.

The power ratings illustrated in Figure 2.3 and Figure 2.5 are just one possible configuration to be used e.g. in Western Europe.

2.3 Standard Control Electronics Unit

Figure 2.2: Front panel of the **Mephisto** Standard control electronics unit

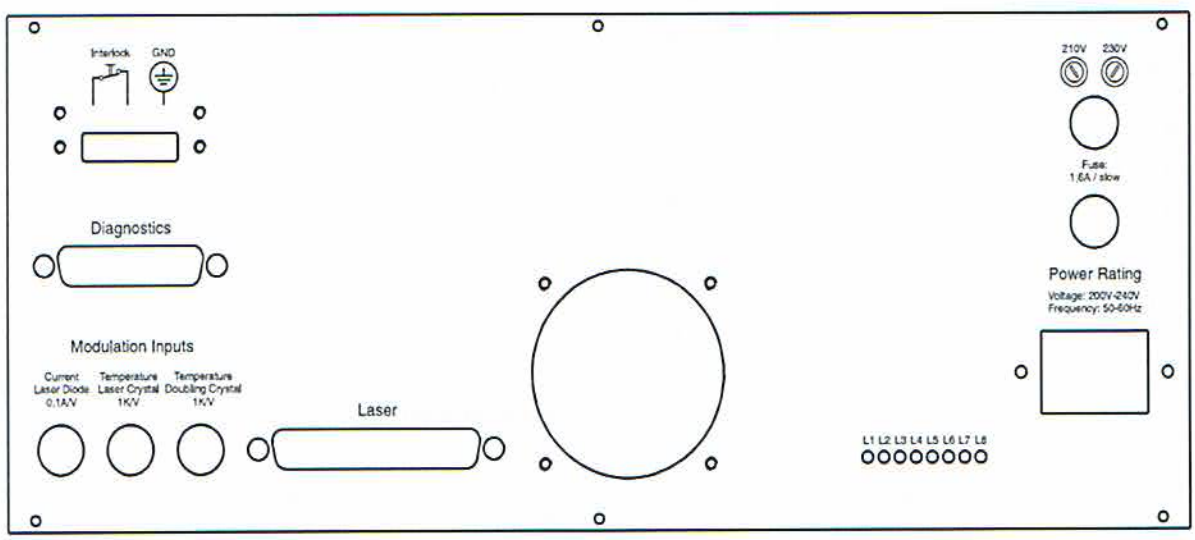


Figure 2.3: Rear panel of the **Mephisto** Standard control electronics unit

The pin configuration of the laser and diagnostics connectors as well as the voltage indicators (L1-L8) are described in section 6.

2.4 OEM Control Electronics Unit

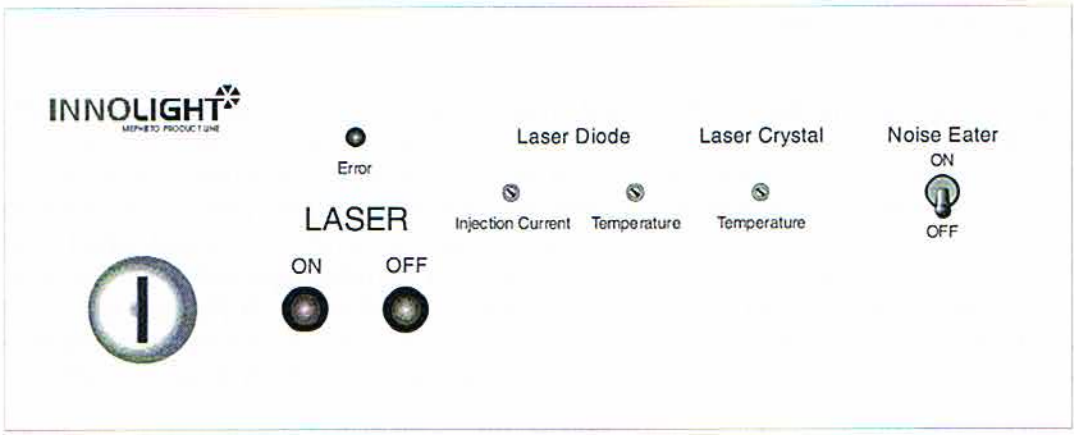


Figure 2.4: Front panel of the **Mephisto S** control electronics unit

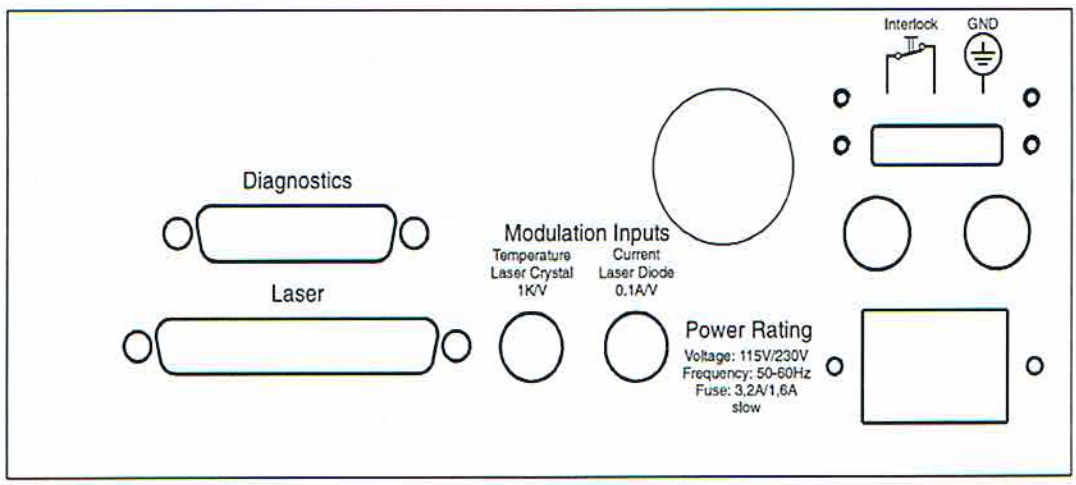


Figure 2.5: Rear panel of the **Mephisto** OEM control electronics unit

The pin configuration of the laser and diagnostics connectors is described in section 6.

3 Operating the **Mephisto** Laser System

3.1 Diode Laser Safety Precautions

Diode lasers are very sensitive devices. They consist of semiconductor material, consequently they should not be overheated. For laser operation a resonator is required, in most diode lasers (including these high power lasers) the crystal end faces serve as the resonator mirrors. Therefore, these surfaces need to be perfectly plain and clean. This is normally accomplished by cutting the semiconductor wafer along a crystal plane and by hermetically sealing the case protecting the laser from the environment. The crystal end faces are very sensitive to transient current fluctuations. Even short spikes (shorter than 1 ns) with peak current larger than the normal operation current will build up an excessively intense photon field inside the resonator, destroying the crystal surface. In this event only spontaneous emission remains, the laser behaves like an ordinary LED. Due to this possibility, the laser has to be protected against current spikes. In the **Mephisto** system, this is accomplished by a sophisticated electronic protection circuitry.

Static charge is also a well known killer of diode lasers. For this reason, the connections of the diode laser should always be shorted, if not in operation. When the laser head is not connected to the electronics unit, a built-in relay shorts the diode pins. After the control electronics unit is connected and switched on, the relay opens the short circuit when the signal power supply reaches its nominal value, ensuring proper operation of the driver circuitry. The driver is still in the inactive mode, and a power MOS-FET shorts the diode laser. Switching the unit into the active mode, the MOS-FET becomes nonconductive and the driver starts working.

If the signal power drops below its nominal value (e.g. caused by mains failure) the driver switches back to the inactive mode. This happens ***before*** the relay shorts the diode laser, so that mechanical ringing of the relay cannot cause any current spikes.

For further protection of the diode laser, a current limiting circuitry is included. The *Injection Current* is restricted to the range from zero to the internally set current limit. It is not possible to exceed this current limit with the dial on the front panel. Theoretically, this could be achieved by applying a positive voltage to the power modulation input at the back panel of the electronics unit. However, in this case, the yellow *Clamp* LED at the front panel of the Standard control electronics unit or the red *Error* LED at the front panel of the OEM control electronics unit will glow, and the actual *Injection Current* will ***not*** go beyond the internally set current limit.

To prevent the diode lasers from overheating, the control electronics unit contains a *Temperature Guard* that monitors deviations between the *Set Temperature* and the actual diode laser temperature and switches the driver into inactive mode in case of overheating (see Section 5.3).

3.2 Installing the Mephisto Laser System

Before connecting the power cord, verify that the line voltage setting on the reverse side of the power supply agrees with your local line voltage. If your laboratory environment features an interlock switch that remains off under unsafe conditions, connect it to the two left pins of the three-pole screw-type connector at the rear of the control electronics unit (see Figure 2.3 or Figure 2.5). For activating the diode driver, these pins have to be shorted. You can use the right-hand pin to ground the unit, e.g. by connecting it to the metal laboratory breadboard.

For mounting the **Mephisto** laser head on an optical table or a breadboard, use the three holding forks to fix the three pedestals. Further clamping or squeezing of the laser head is not recommended, as it may cause temporary misalignments of the optics inside. The laser head should be mounted with free surroundings.

The two units of the **Mephisto** laser system, the laser head and the control electronics unit, are to be connected only by using the suitable cable shipped with the laser system.

Caution:
Before connecting the two units, make sure the control electronics unit is switched off.

3.3 Turning the Laser on and off

For proper operation of the **Mephisto** laser system, the following activation sequence is recommended for users of the Standard electronics unit. All controls mentioned are located on the front panel of the **Standard** control electronics unit (see Figure 2.2):

1. Use the main key switch to turn on the unit. The red *OFF* button will glow and the fan will be operating.
2. Make sure, the yellow *Interlock, Guard,* and *Clamp* LEDs are not glowing.
3. Check the *Set Temperature* of the diode laser(s) by pushing the *Set* button(s) in the section *Laser Diode.* Compare the values with those given in the data sheet of the laser.
4. Check the *Set Temperature* of the Nd:YAG laser crystal by pushing the *Set* button in the section *Laser Crystal.* The correct operation temperature depends on your requirements and may be around 25 °C (consider recommendations in section 3.4).
5. Allow about 60 seconds for the temperature controllers to stabilize.
6. Make sure that the 10-turns dial of the *Injection Current* is in its zero position.
7. Choose the *Actual* injection current to be displayed at the monitor by pushing the green button in the section *Laser Diode.*
8. Pull up the shutter on the top of the laser head.
9. Activate the diode driver by pressing the green *ON* button. The button will glow green.
10. Increase the *Injection Current* until the desired value is displayed at the monitor (see data sheet).

Go through the following steps to switch off the **Mephisto** laser system:

1. Decrease the *Injection Current* to 0 mA.
2. Deactivate the diode driver by pressing the red *OFF* button. The button will glow red.
3. Switch the unit off with the main key switch.

For customers of the **OEM** control electronics unit (see Figure 2.4), the following, somewhat shorter procedure is valid:

1. Use the main key switch to turn on the unit. The red *OFF* button will glow.
2. Make sure, the red *Error* LED is not glowing.
3. Allow about 60 seconds for the temperature controllers to stabilize.
4. Pull up the shutter on the top of the laser head.
5. Activate the diode driver by pressing the green *ON* button. The green LED will glow.

Go through the following steps to switch off the **Mephisto** laser system:

1. Deactivate the diode driver by pressing the red *OFF* button. The red LED will glow.
2. Switch the unit off with the main key switch.

The preset injection current, temperatures and error signals of the OEM control electronics unit can be monitored at the diagnostics connector at the rear panel of the unit (see Figure 2.5). The pin configuration and the voltage coefficients are described in Table 6.3 of section 6.2. To change these preset values, use the individual trimmers at the front panel (see Figure 2.4).

Both the Standard and OEM control electronics units feature a soft-start that smoothly increases / decreases the laser diode's current if the *LASER ON / OFF* buttons are pressed. Because of the limited heat conductivity inside the diode laser's heat sink, a rapid increase of the injection current has to be avoided.

Caution:
Lasers may be damaged by improper setting of the current controls or by improper use of the modulation inputs.

3.4 Recommended Operation

The laser head as well as the control electronics unit should not be operated in an environment warmer than 25 °C, which would result in a lot of stress for the electronics and diminished operation efficiency of the laser.

The laser head contains several optical components which are carefully aligned for best performance. Therefore, the laser head should be handled very carefully; any mechanical shock is hazardous ! Misalignment will cause the optical power to decrease and should not be cured by the operator ! Check the output power using a power meter.

In the case of low optical output power or poor beam quality, please contact InnoLight GmbH immediately. Do not attempt to fix the problem on your own!

When mounting the laser head, any mechanical stress inside the case can cause temporary misalignment of the optics. Thus squeezing the case should be prevented.

Warning:
Be aware that the laser might disturb equipment that is sensitive to magnetic fields.

Be careful when operating the laser head in humid environment. Condensation of water must be strictly avoided, since the optics cannot be cleaned by the operator.

Caution:
The *Set Temperature* of the Nd:YAG crystal should never be more than 5 °C below room temperature. Under humid conditions, only operation above room temperature is recommended.

Warning:
Keep in mind that a hazardous amount of invisible laser radiation might be diffracted in any direction!

Warning:
Always wear suitable laser goggles to protect your eyes!

3.5 Trouble Shooting

The control electronics unit for the **Mephisto** laser system includes a sophisticated safety circuitry to protect the diode lasers against current spikes or overheating and switches the diode driver into inactive mode in case of problems. This is indicated by the yellow LEDs at the front panel of the Standard control electronics unit and the red *Error* LED of the OEM control electronics unit, respectively. Check for the following possible causes:

- *Interlock*

  Diagnosis: The two pins of the Interlock connector at the rear panel of the control electronics (see Figure 2.3 and Figure 2.5) are not connected.

  Reaction: Short the two pins of the Interlock connector or check the Interlock switch in your laboratory.

- *Guard*

Diagnosis: The temperature controller is not able to stabilize the diode laser temperature at the given value.

Reaction: Try to increase the set temperature for the diode laser slightly using the trimmer at the front panel of the control electronics unit, especially if it is set below room temperature. Otherwise contact InnoLight GmbH.

- *Clamp*

Diagnosis: The injection current of the diode lasers is driven above its internal limit.

Reaction: Reduce the injection current by about 50 mA using the dial or trimmer at the front panel of the control electronics unit or reduce the voltage at the power modulation input at the rear panel of the control electronics unit (see sections 2.3 and 2.4).

The presence of all supply voltages required for reliable operation of the **Mephisto** laser system is indicated by a set of LEDs at the rear panel of the Standard electronics unit (see Figure 2.3).

If any of the LEDs L1 to L8 is not glowing, the corresponding supply voltage is not present (see section 6.3) and the laser system will not work properly. In that case contact InnoLight GmbH.

4 Laser Specifications

The general specifications apply to all continuous wave (cw) lasers of the **Mephisto** Product Line and are summarized in the following Table 4.1:

General specifications:	
Beam quality	TEM_{00} (M^2 <1,1)
Beam roundness	1,1
Thermal tuning coefficient [GHz/K]	-3
Thermal tuning range [GHz]	30
Thermal response bandwidth [Hz]	1
PZT tuning coefficient [MHz/V]	>1
PZT tuning range [MHz]	± 100
PZT response bandwidth [kHz]	100
Emission spectrum	single-frequency
Spectral linewidth [kHz/100 ms]	1
Coherence length [km]	>1
Frequency drift [MHz/min]	1
Relative Intensity Noise, RIN [dB/Hz]	<-100
Noise eater option, RIN [dB/Hz]	<-140
Intensity noise, 10 Hz to 2 MHz [% rms]	< 0,1
Waist location (inside laser head) [mm]	105
Laser head size, w · h · d [cm]	15 · 11,3 · 20
Laser head weight [kg]	3,85
Standard electronics size, w · h · d [cm]	35 · 14 · 34
Standard electronics weight [kg]	10
OEM electronics size, w · h · d [cm]	24 · 9 · 34
OEM electronics weight [kg]	3,5

Table 4.1: General specifications of the **Mephisto** Product Line

Some of the laser specifications and the available options of the **Mephisto** Product Line are illustrated in the following sections.

4.1 Beam Quality

The following Figure 4.1 illustrates a typical beam quality measurement of a **Mephisto** laser operating at 1064 nm. The laser beam is focused with a lens and the beam radius of the caustic is measured at various distances with a laser beam analyzer.

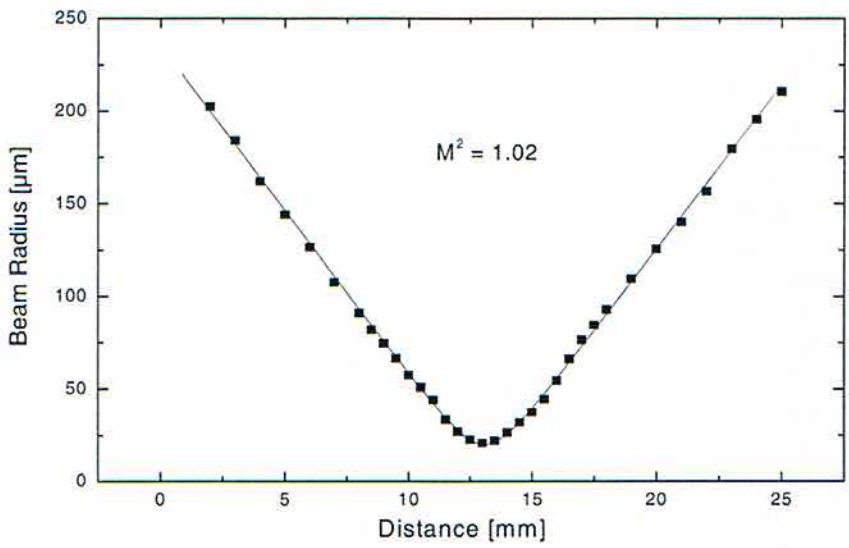


Figure 4.1: Beam quality measurement of a **Mephisto** laser

The filled squares represent the measurement points while the solid line is a theoretical calculation with the beam quality factor "M^{2}" as fitting parameter. Using the least error squares approach for determining the fitting parameter, an "M^{2}" factor of 1.02 is obtained. Hence, the output beam of the laser is 1.02 times "diffraction limited".

4.2 Frequency Tuning Capabilities

The frequency of the **Mephisto** laser can be tuned by changing the temperature of the monolithic laser crystal. This can either be done directly at the front panel of the control electronics unit using the appropriate dial or trimmer (see Figure 2.2 and Figure 2.4) or by applying a voltage to the Laser Crystal temperature modulation input at rear panel of the control electronics unit (see Figure 2.3 and Figure 2.5).

The typical tuning characteristic of a standard **Mephisto** laser operating at 1064 nm is shown in the following Figure 4.2. The filled dots represent operation on a single longitudinal frequency, while the open dots indicate the mode-hops, where the laser frequency changes from one longitudinal mode to the next.

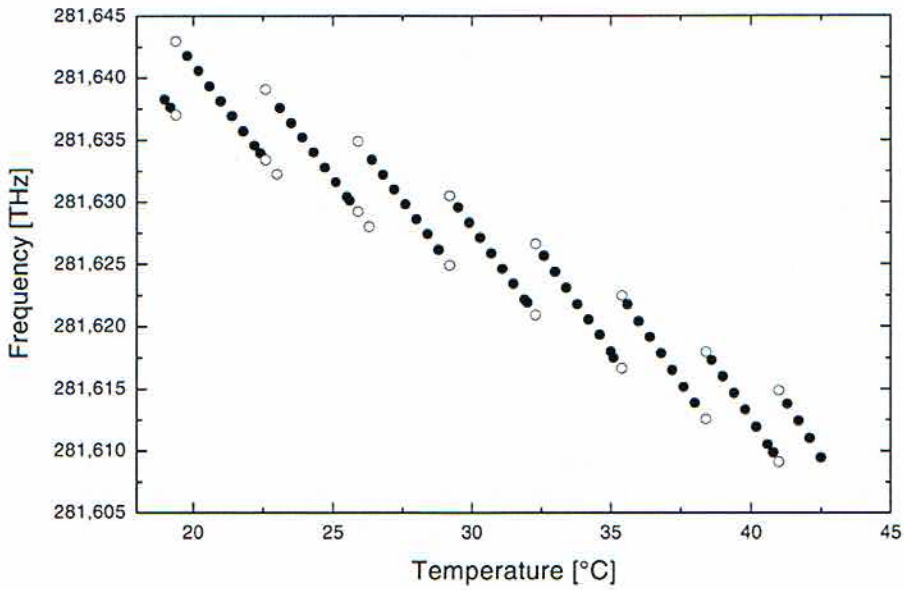


Figure 4.2: Typical frequency tuning by crystal temperature of a **Mephisto** laser at 1064 nm

As can be seen, the laser frequency can be tuned continuously by 6 – 8 GHz between the mode-hops covering an overall frequency tuning range of more than 30 GHz. The thermal tuning coefficient at 1064 nm is about –3 GHz / °C, for longer wavelengths it is slightly smaller. However, due to the large time constants of the thermal tuning, the response bandwidth is limited to fractions of a Hertz.

A significantly larger continuous tuning range of more than 15 GHz at a reduced output power can be achieved with the *Extended Tuning Range* (ETR) option as illustrated in the next Figure 4.3:

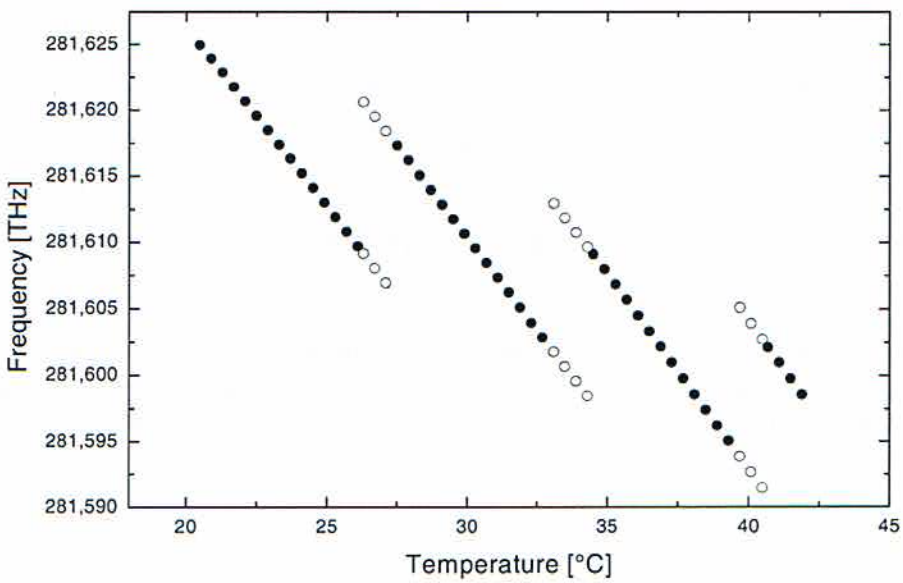


Figure 4.3: Typical frequency tuning by crystal temperature of a **Mephisto** laser at 1064 nm with ETR option

Fast frequency tuning of a **Mephisto** laser can be achieved by applying a high voltage signal in the range of –100 V to +100 V to a PZT crystal element on the laser crystal, using the BNC connector at the rear side of the laser head (see Figure 2.1). Higher voltages will misalign the laser cavity or even destroy the PZT crystal. Especially RF signals will heat up the PZT and damage it.

Depending on the actual laser crystal and the modulation frequency, the PZT tuning coefficient is about 1 to 2 MHz / V with a response bandwidth of about 100 kHz. The combination of the slow temperature tuning with a large range and the fast tuning with a high bandwidth is ideally suited for stabilizing the laser frequency to reference cavities or molecular absorption lines.

4.3 Emission Spectrum

A common feature of all models of the **Mephisto** Product Line is the reliable emission on a single longitudinal frequency. This can be investigated using an optical spectrum analyzer like a confocal Fabry Perot Interferometer (FPI) as illustrated in the following Figure 4.4. The free spectral range (FSR) of the device was 2 GHz as indicated:

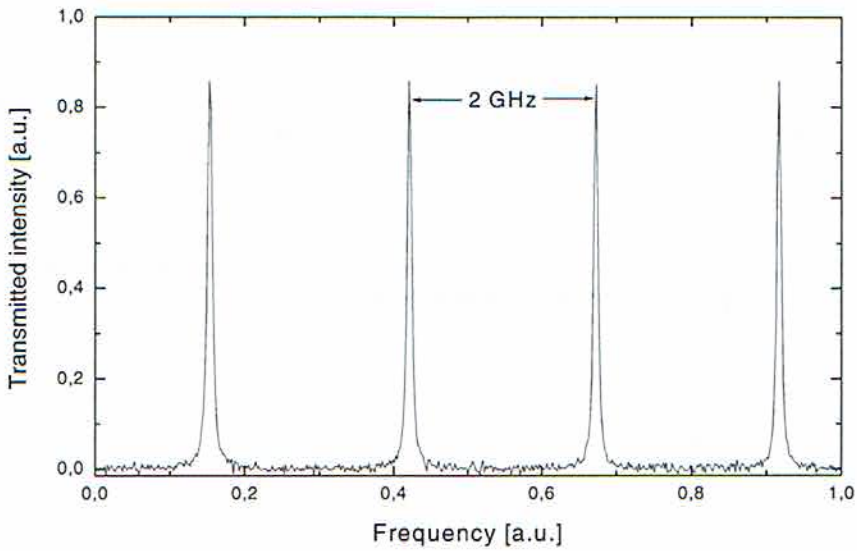


Figure 4.4: Emission spectrum of a **Mephisto** laser using a scanning Fabry Perot interferometer (FPI)

The absence of any peaks between the main resonances of the interferometer clearly indicates the operation on a single longitudinal frequency. Hence, the **Mephisto** laser system resembles the optical equivalent of a quartz oscillator in the frequency range of nearly 300 THz, providing the required precision for applications like interferometry or spectroscopy.

4.4 Spectral Linewidth

Another important feature of the **Mephisto** Product Line is the extremely small spectral linewidth of the laser due to the monolithic cavity. An upper limit for the intrinsic spectral linewidth of such a laser can be obtained by optically heterodyning two identical lasers and analyzing the beat signal with a spectrum analyzer as illustrated in the following Figure 4.5:

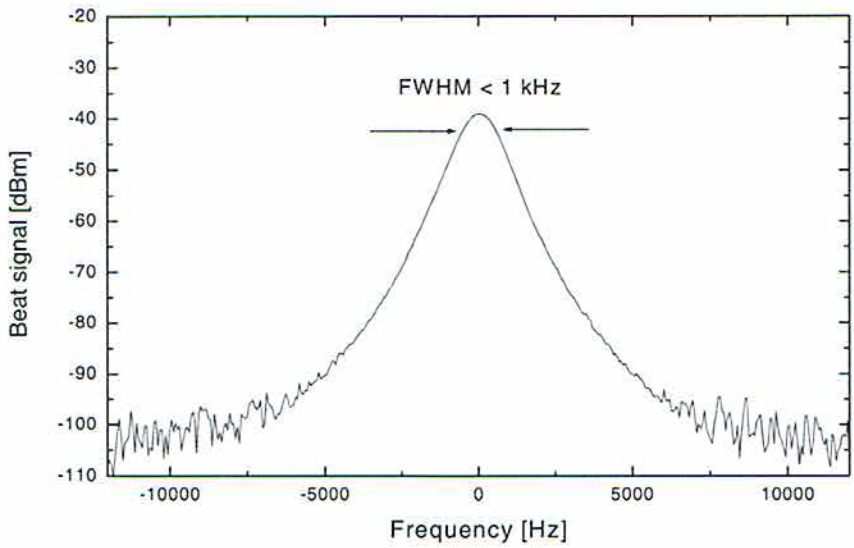


Figure 4.5: Heterodyne beat signal of two identical **Mephisto** lasers

The typical full width at half maximum (FWHM) or –3 dB linewidth derived from such a measurement is about 1 kHz, giving an upper limit for the intrinsic spectral linewidth of the two individual lasers, limited by the spectral resolution bandwidth of the measurement system.

The combination of reliable single longitudinal frequency operation at nearly 300 THz with an extremely small linewidth of less than 1 kHz is the key feature for using lasers of the **Mephisto** Product Line as optical length and frequency standards.

4.5 Beam Polarization

The output beam of the **Mephisto** Product Line is elliptically polarized with an intensity ratio $I_s/I_p \cong 5/1$ and the main axis oriented perpendicular to the mounting table (s-pol). As this polarization state represents an eigenmode of the monolithic ring laser cavity, it can be transformed without loss into any linear polarization state by means of a suitable combination of quarter-wave and half-wave plates. The resulting polarization extinction ratio is typically ~ 300/1.

4.6 Frequency Drift

As the frequency of a **Mephisto** laser at 1064 nm can be tuned with a large temperature tuning coefficient of more than 3 GHz per degree (see section 4.2), temperature controllers with micro-kelvin stability are required to obtain a high frequency stability and a low frequency drift of the free running laser. This can be investigated, again by optically heterodyning two identical single-frequency lasers, one actively stabilized to a reference cavity or a molecular absorption line, the other one just passively stabilized.

The following Figure 4.6 illustrates such a beat frequency measurement of two identical **Mephisto** lasers using a precision frequency counter over a period of three hours:

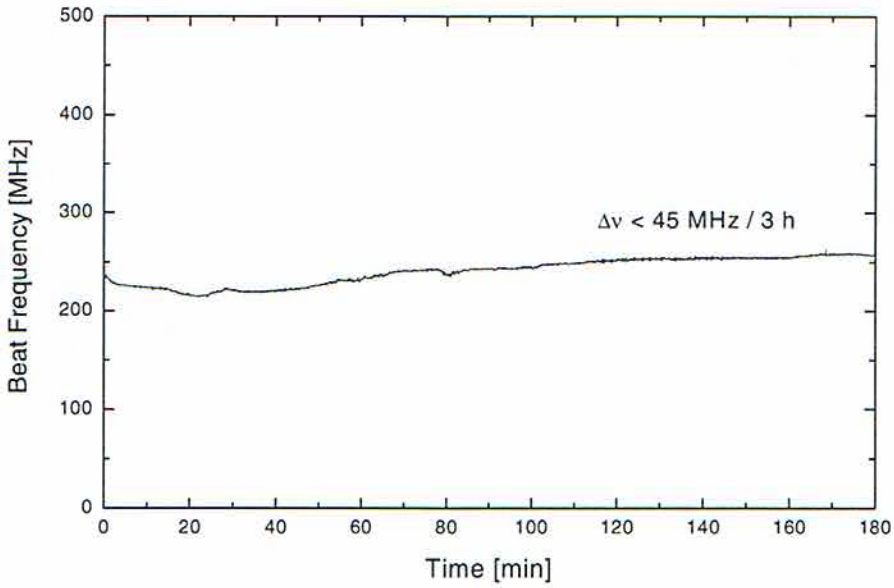


Figure 4.6: Frequency drift of a free running **Mephisto** laser against a stabilized reference system

The resulting frequency variation of the free running laser over the full period is less than 45 MHz, corresponding to a relative frequency stability of about $1.6 * 10^{-7}$. If a higher frequency stability is required for a certain application, the **Mephisto** Product Line provides the necessary inputs for active frequency stabilization to reference cavities or molecular absorption lines (see section 4.2).

4.7 Relative Intensity Noise (RIN)

Optionally, all lasers of the **Mephisto** Product Line can be equipped with an integrated intensity noise reduction system. This option reduces intensity fluctuations of the laser beam by several orders of magnitude. These fluctuations are largely due to a phenomenon called relaxation oscillations, owing to the ability of the laser's energy to oscillate between atomic level population and laser cavity field.

The spectrum of these fluctuations resembles the spectral behavior of a white-noise-excited classical oscillator, featuring a large peak and a significant amount of low frequency noise as illustrated in the trace "Free running" of the following Figure 4.7:

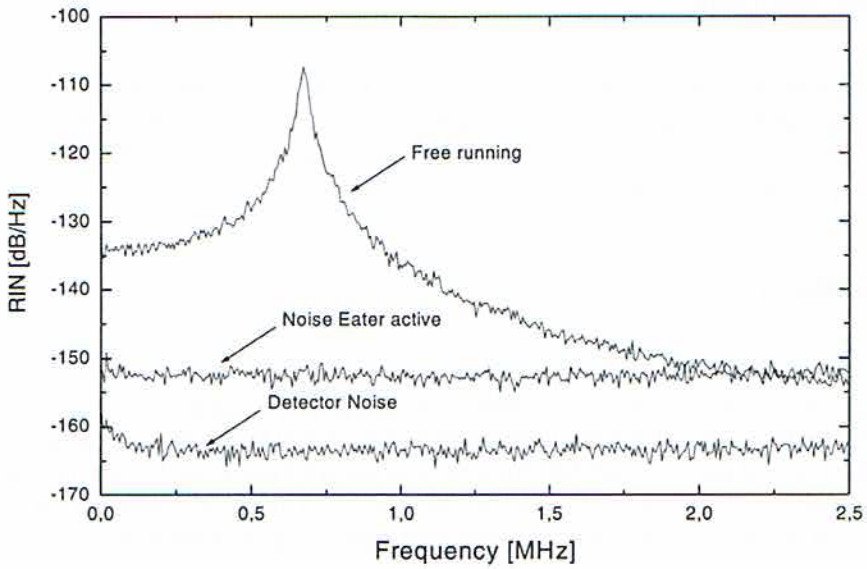


Figure 4.7: Relative Intensity Noise measurements of a **Mephisto** laser with and without Noise Eater option

Both these spectral components can be significantly reduced by using the *Noise Eater* option as illustrated by the trace "Noise Eater active" in Figure 4.7. To achieve this, a fraction of the generated Nd:YAG laser light, transmitted through a mirror, is focused onto a photo detector to analyze the variation of the generated output power. This signal, appropriately filtered and amplified by an electronic SMD board, is fed to the diode laser current to stabilize the output power.

Activating this feedback loop by the switch at the front panel of the control electronics unit (see Figure 2.2 and Figure 2.4), the Nd:YAG laser's intensity noise above a few 100 Hz is suppressed by up to 40 dB. The noise level is moved somewhat into the proximity of the quantum noise limit.

5 Standard Accessories

5.1 Laser Frequency Modulation

By applying an analog voltage signal in the range –10 V to +10 V to the modulation input labeled "Temperature Laser Crystal", using the BNC connector at the rear panel of the control electronics unit (see Figure 2.3 and Figure 2.5), the temperature of the laser crystal can be changed by +1 K / V, corresponding to a frequency change of about –3 GHz / V at 1064 nm. Due to the large time constants of the thermal tuning, the response bandwidth is limited to fractions of a Hertz.

5.2 Output Power Modulation

By applying an analog voltage signal in the range –10 V to +10 V to the modulation input labeled "Current Laser Diode", using the BNC connector at the rear panel of the control electronics unit (see Figure 2.3 and Figure 2.5), the injection current of the diode lasers used to pump the laser crystal can be modulated by 0.1 A / V. The response bandwidth of this modulation input is limited to about 5 kHz.

5.3 Temperature Guard

Failure to regulate the temperature of the diode lasers will result in diminished performance and lifetime. Hence, to ensure long term operation of the diode lasers, the **Mephisto** laser system is equipped with an integrated *Temperature Guard* that monitors deviations between the *Set temperature* and the *Actual temperature* of the *Laser Diode Driver*. It protects the laser diode against failure by switching the driver into inactive mode in case of any deviation between the two values for more than 1 minute. This is indicated by the *Guard* LED at the front panel of the Standard control electronics unit (see Figure 2.2) or the red *Error* LED at the front panel of the OEM control electronics unit (see Figure 2.4), respectively.

5.4 Safety Interlock

If your laboratory environment features an interlock switch that remains off under unsafe conditions, connect it to the left two pins of the three-pole screw-type connector at the rear of the unit. For activating the diode laser driver, these pins have to be shorted. The **Mephisto** laser system is shipped with a jumper installed. The present status of the *Interlock* is indicated by a yellow LED at the front panel of the Standard control electronics unit (see Figure 2.2) or the red *Error* LED at the front panel of the OEM control electronics unit (see Figure 2.4), respectively. If the *Safety Interlock* is activated, e.g. by disconnecting the two pins, the LED glows and the *Laser Diode Driver* will switch into inactive mode.

6 Pin Configurations

6.1 Laser Connector

The two units of the **Mephisto** laser system, the laser head and the control electronics unit, are to be connected only with a suitable cable, shipped with the laser system. The following Figure 6.1 illustrates the 37 pin D-Sub connector at the rear panel of both the Standard and OEM control electronics units:

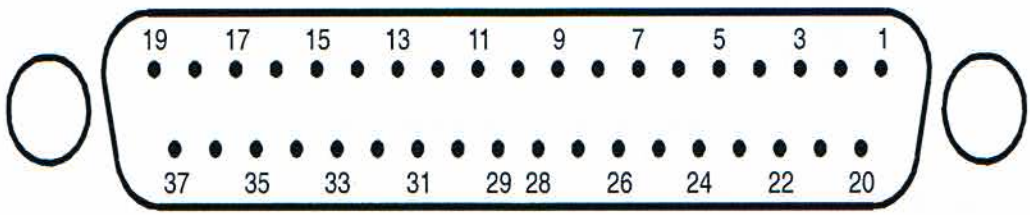


Figure 6.1: Laser connector (37 pin D-Sub) at the rear panel of the control electronics unit

The description of the individual pins of the laser connector is given in the following Table 6.1:

Pin	Description
1	Diode laser cathode
2	Diode laser 1, TEC anode
3	Diode laser 1, TEC cathode
4	Diode laser 2, TEC anode
5	Diode laser 2, TEC cathode
6	Laser crystal, TEC anode
7	Laser crystal, TEC cathode
8	n/c
9	n/c
10	Diode laser 1, monitor diode, cathode
11	Diode laser 1, monitor diode, anode
12	Laser crystal, NTC reference voltage 6,85 V
13	Laser crystal, NTC ground
14	n/c
15	Diode laser 1, NTC reference voltage 6,85 V
16	Diode laser 1, NTC ground
17	Diode laser 2, NTC ground
18	n/c
19	n/c
20	Diode laser anode
21	Supply voltage +12 V
22	Relay, negative supply voltage
23	GND
24	Relay, positive supply voltage
25	Supply voltage -12 V

Pin	Description
26	Noise Eater, monitor
27	Noise Eater, switch
28	n/c
29	Diode laser 2, monitor diode, cathode
30	Diode laser 2, monitor diode, anode
31	n/c
32	Interlock
33	GND
34	Diode laser 2, NTC reference voltage 6,85 V
35	n/c
36	n/c
37	n/c

Table 6.1: Pin description of the laser connector

6.2 Diagnostics Connector

All vital information about the status of the **Mephisto** laser system can be monitored without opening the control electronics unit, using the diagnostics connector. The following Figure 6.2 illustrates the 25 pin D-Sub connector at the rear panel of the Standard and OEM electronics units:

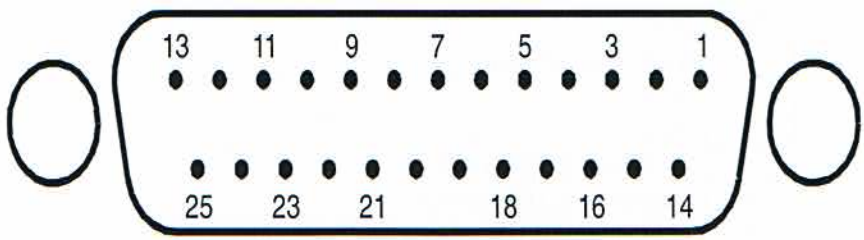


Figure 6.2: Diagnostics connector (25 pin D-Sub) at the rear panel of the control electronics unit

A description of the individual pins of the diagnostics connector for the **Standard** control electronics is given in Table 6.2:

Pin	Description
1	Diode laser 1, power monitor, 1 V / W
2	Diode laser 2, power monitor, 1 V / W
3	Laser crystal, TEC error signal, 10 V / °C
4	n/c
5	n/c
6	Diode laser 1, TEC error signal, 10 V / °C
7	Diode laser 2, TEC error signal, 10 V / °C
8	Diode laser 1, temperature guard
9	Diode laser 2, temperature guard
10	n/c
11	n/c
12	Noise Eater, monitor
13	Interlock
14-25	GND

Table 6.2: Pin description of the diagnostics connector of the **Standard** control electronics

The description of the individual pins of the diagnostics connector for the **OEM** control electronics is given in Table 6.3:

Pin	Description
1	Diode laser, current limit, 1 V / A
2	Diode laser, injection current, 1 V / A
3	Diode laser, set temperature, 10 mV / °C
4	Diode laser, actual temperature, 10 mV / °C
5	Diode laser, TEC error signal, 10 V / °C
6	Laser crystal, set temperature, 10 mV / °C
7	Laser crystal, actual temperature, 10 mV / °C
8	Laser crystal, TEC error signal, 10 V / °C
9	Error flag
10	Piezo monitor (Seeder option only), 10 mV / V
11	S & H voltage (Seeder option only), 1 V / V
12	Remote input (Seeder option only)
13	+12V / Monitor trigger (Seeder option only)
14-25	GND

Table 6.3: Pin description of the diagnostics connector of the **OEM** control electronics unit

6.3 Supply Voltage Indicators

In order to quickly check the presence of all supply voltages required for reliable operation of the **Mephisto** laser system without opening the control electronics unit, they are indicated by a set of 8 LEDs at the rear panel of the Standard control electronics unit (see Figure 2.3). The description of the indicators is given in the following Table 6.4:

LED	Description
L1	Negative supply voltage, temperature controllers
L2	Positive supply voltage, laser crystal temperature controller
L3	Positive supply voltage, diode laser 2 temperature controller
L4	Positive supply voltage, diode laser 1 temperature controller
L5	Supply voltage, diode lasers
L6	Supply voltage, noise eater
L7	Negative supply voltage, electronics
L8	Positive supply voltage, electronics

Table 6.4: Description of the supply voltage indicators at the rear panel of the control electronics unit

7 Warranty

InnoLight GmbH gives a 24 months warranty on its products, excluding the diode laser pump sources. The warranty period on the diode laser pump sources is 6 months. The warranty shall not cover any damage incurred during shipping. When the product is received by the customers, the shipping container and its content should be inspected for any damage incurred during shipping. In order to obtain service under this warranty, the customer must notify InnoLight GmbH of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. In all cases the customer will be responsible for properly packaging and shipping the product back to InnoLight GmbH, with shipping charges prepaid. If the product is not properly packed, it may be damaged in shipping and the warranty will be voided.

This warranty shall not apply to any defect, failure, or damage caused by improper use, failure to observe proper operating procedures per the product specifications (see section 3), or improper / inadequate maintenance. InnoLight GmbH shall not be obligated to furnish service under this warranty 1) to repair damage resulting from attempts by personnel (other than InnoLight GmbH's representatives) to repair or service the product; 2) to repair damage resulting from improper use or connection to incompatible equipment; 3) to repair damage resulting from operation outside of the operating environment specifications of the product; 4) to repair damage resulting from improper packaging of the product in order to return it to InnoLight GmbH.

Hannover, 30.03.2009

Version 4.71

InnoLight GmbH
Garbsener Landstr. 10
30419 Hannover
Germany
Tel.: +49 511 760 727-0
FAX: +49 511 760 727-99

MITSUBISHI ELECTRIC
German Branch
Mitsubishi Electric Europe B.V.
EMC Division

PRODUCT STATE REPORT

No. 210292 Revision A

☒ FINAL MEU / EMC ☐ TEMPORARY

Product : Mephisto/Prometheus Laser Series III
Factory : Innolight Innovative Laser und Systemtechnik GmbH
Vahrenwalder Str. 7, 30165 Hannover
Dept. : Technik
Attn : Herr Dölle
Copy :

Written by : M. Ferriani
Date : 01.10.01

faxed on :	mailed on :
No. 0511 93 57 179 4.10.2001	4.10.2001

Examination				Test Report		
Product related approval and MEU Lab.No. MEU	passed	not passed	passed with below mentioned Modification	obtained	mark or number to be fixed to the product	Date of issue
210292a – Rev.A	☒	☐	☐	☒	CE according to directive 89/336/EEC	01.10.2001
210292b – Rev.A	☒	☐	☐	☒		01.10.2001
210292c – Rev.A	☒	☐	☐	☒		01.10.2001
210292d – Rev.A	☒	☐	☐	☒		01.10.2001
210292e – Rev.A	☒	☐	☐	☒		01.10.2001
210292f – Rev.A	☒	☐	☐	☒		01.10.2001
210292g – Rev.A	☒	☐	☐	☒		01.10.2001

Report / Remark : The above mentioned product was tested in accordance to the following standards:

EN 55022 Class B: 1998 (IEC CISPR 22: 1997, modified)
EN 61326-1: 1997 + A1: 1998, including:
EN 61000-4-2: 1995 + A1: 1998; EN 61000-4-3: 1996 + A1: 1998; EN 61000-4-4: 1995;
EN 61000-4-5: 1995; EN 61000-4-6: 1996; 61000-4-11: 1994;
EN 61000-3-2: 1995 + Corrigendum:1997 + A1: 1998 + A2: 1998 + A14: 2000; EN 61000-3-3: 1995

Enclosures: - Testschedule No 210292 Revision A
- Test Reports No. MEU 210292 a-g Revision A

According to the German EMC Law §4, chapter (1), point 4 and point 6 and § 6, chapter (6), point 1 an information about the operating restrictions (see Annex 1) must be attached or indicated to each set ! According to the directives 89/336/EEC and 93/68/EEC a declaration of conformity must be issued for this product !

M. Ferriani
Signed by M. Ferriani

i.A.V. Briddigkeit
Reviewed by *V. Briddigkeit*

Mitsubishi Electric Europe B.V.
Accredited EMC-Test Laboratory

Deutscher Akkreditierungs Rat DAR TTI - P - G129 / 96 - 00

Types species	**Laser System**
Type name	**Mephisto/Prometheus Laser Series III**
Serialnumber	**210292 attached**
Manufacturer	**siehe Auftraggeber** **see Applicant**
Applicant	**Innolight Innovative Laser und Systemtechnik GmbH** **Vahrenwalder Str. 7, 30165 Hannover**
Test Standards	**Immunity:** **EN 61326-1 : 1997 + A1: 1998 including:** EN 61000-4-2: 1995 + A1: 1998 EN 61000-4-3: 1996 + A1:1998 EN 61000-4-4: 1995 EN 61000-4-5: 1995 EN 61000-4-6: 1996 EN 61000-4-11: 1994
	Emission: **EN 55022 Class B: 1998** (IEC CISPR 22: 1997, modified) **EN 61000-3-2: 1995 + Corrigendum: 1997** **+A1: 1998 +A2: 1998+A14: 2000** **EN 61000-3-3: 1995**
Configuration and operating mode	*see Test Reports*

Performance Criteria : (Immunity)

A - Normal operation within the specified operation conditions.

B - Temporary functional impairment, EUT returns to normal operation without operator intervention

C - System reset or impairment of function during the test which requires operator intervention.

Testschedule and Results Immunity and Emission

Test requirements 230V/50Hz

Enviromental phenomena	Basic standard	Test specification and units	Ports	Performance criteria	Test results	Performed at
ESD	EN 61000-4-2	8 kV Air	touchable, nonconductive parts	B	A	MEU Test Report No.: 210292b Rev. A
ESD	EN 61000-4-2	4 kV Contact	touchable, conductive parts	B	A	MEU Test Report No.: 210292b Rev. A
BURST	EN 61000-4-4	1 kV 5 kHz	Power input (AC)	B	A	MEU Test Report No.: 210292b Rev. A
SURGE	EN 61000-4-5	sym.: 1 kV unsym.: 2 kV	Power input (AC)	B	A	MEU Test Report No.: 210292d Rev. A
Radio-Frequency common mode AM	EN 61000-4-6	0.15 ... 80 MHz 3V, 80% AM (1 KHz), 150Ω impedance	Power input (AC)	A	A	MEU Test Report No.: 210292e Rev. A
Radio-Frequency common mode AM	EN 61000-4-6	0.15 ... 80 MHz 3V, 80% AM (1 KHz), 150Ω impedance	Signal Lines	A	A	MEU Test Report No.: 210292e Rev. A
DIPS	EN 61000-4-11	>95% Red. (0,5 periods)	Power input (AC)	B	A	MEU Test Report No.: 210292f Rev. A
Mains Harmonics	EN 61000-3-2	Eq. Class D $3 \leq n \leq 40$	Power input (AC)	≤ 4%	complied	MEU Test Report No.: 210292g Rev. A
Flicker	EN 61000-3-3	d,max	Power input (AC)	Limits of EN 61000-3-3	complied	MEU Test Report No.: 210292g Rev. A
EM Field	EN 61000-4-3	80...1000 MHz 3V/m, 80% AM horiz. & vertic.	Enclosure and connected cords	A	A	MEU Test Report No.: 210292c Rev. A
Interference Voltage	EN 55022	0.15 ... 30 MHz	Power input (AC)	Limits of EN 55022 Class B	complied	MEU Test Report No.: 210292a Rev. A
Interference Radiation	EN 55022	Class B 30 - 1000 MHz	Enclosure 3m Testsite	Limits of EN 55022 Class B	complied	MEU Test Report No.: 210292a Rev. A