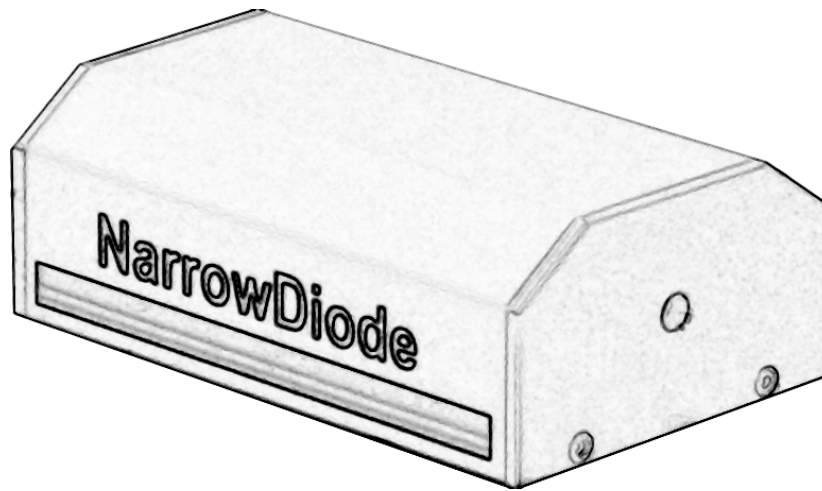


Operation and Maintenance Manual

NarrowDiode™



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Declaration of Conformity (CE)

For the following mentioned product

CW Diodelaser

Is declared under our sole responsibility the conformity with the following standards or directives as far as applicable.

This Declaration of Conformity is valid for all specimen, which are produced after the production drawings, but it becomes invalid if technical or operational modifications are introduced without the manufacturers consent.

The Declaration is in conformity with the following standards and directives:

<u>EN 55011: 1991</u>	<u>Radiated</u>
<u>EN 55011: 1991</u>	<u>Conducted</u>
<u>IEC 1000-4-2 ESD</u>	
<u>IEC 1000-4-3</u>	<u>RF EMF</u>
<u>IEC 1000-4-4</u>	<u>fast transients</u>

Following the provisions of Directive **72/23/EEC** and **89/336/EEC**

The manufacturer to whom the declaration is valid for

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08.09.2009

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Part 1.

Installation and Alignment

Chapter 1.1. Laser Safety Precautions

Caution: only operators experienced in working with lasers and trained by a Radiant Dyes service engineer should use and service the NarrowDiode laser. Otherwise the warranty may be voided.

Class 3B Laser Safety precautions

The following summary of general safety precautions must be observed by everyone working with this Class 3B laser. For a complete listing of safety standards see the ANSI booklet or other references listed at this chapters end.

General Safety Rules

- This laser equipment must be located in a locked area with access only by authorized personnel. The area must be marked by well-defined warning signs, and off limits to unauthorized personnel.
- Provide interlocks for all doors.
- This laser equipment must be operated only by qualified personnel who have also been trained by a Radiant Dyes customer service engineer.
- Laser equipment must be shut off when not in use.
- Place a fire resistant background behind target areas.
- Coat surrounding work areas with material that absorbs scattered radiation.
- Be sure there are no volatile substances in the area which the laser beam could ignite.
- Tracking of individuals, vehicular traffic, aircraft or airborne objects with the laser radiation is prohibited.

Optical Safety Rules

- Eye safety is the greatest concern. Be aware at all times that this is a Class 3B laser. Main beam reflection from a polished surface can cause severe and permanent eye damage.
- Turn off all power to the laser before beginning maintenance or repair of the **NarrowDiode** Laser.
- Always wear laser goggles appropriate for the wavelength and beam intensity generated.
- Do not wear or use any object that may reflect laser light such as watch, ring, pen, etc.

- Mark the label well with warning signs when the laser is operating and provide interlocks for all doors.
- Light the area around the laser so that the operator's pupils are constricted normally.
- Operate the laser without its covers ONLY when aligning it; replace covers promptly.

Electrical Safety Rules

- Discharge all power capacitors and turn off all power before beginning maintenance or repair operations.
- Avoid the high voltages which are present in the Laser Head and Laser Controller whenever AC power is supplied to it.

Government and Industry Safety Regulations

Radiant Dyes strongly suggests that all customers purchase a copy of the American National Standards for the Safe Use of Lasers (ANSI Z136.1-1986) in order to read and implement necessary precautions. The American National Standards Institute (ANSI), a member of the international Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), issues this booklet. Write or call the publisher listed below for information on obtaining a copy of ANSI Z136.1-1986.

Publisher: Laser Institute of America
 12424 Research Parkway, Suite 130
 Orlando, FL 32826
 (800) 345-2737

Radiant Dyes's user information complies with section 1040.10 of 21 CFR Chapter I, Sub chapter J concerning Radiological Health published by U.S. Department of Health & Human Services Center for Devices & Radiological Health, 1988.

Additional Safety References

- Regulations of the Administration and Enforcement of the Radiation Control for Health and Safety Act, 1968. US Dept. Of Health and Human Services, Public
- Health Service and Food and Drug Administration, April 1988
- American National Standard for the Safe Use of Lasers. Laser Institute of America, 1986
- Laser Safety Guide. Laser Institute of America, 1977
- A Guide for Control of Laser Hazards. American Conference of Governmental Industrial Hygienists. 1976
- Sylvania Safety Rules. Frank S. Canario, Safety Engineer, 1967

Chapter 1.2. General notes and safety remarks

Read this manual

This manual tries to describe the **NarrowDiode** dye laser system correctly and thoroughly. It can nevertheless happen that due to the progressive technical developments discrepancies between this manual and the actually delivered laser system appear.

You are strongly advised to read the handbook carefully before operating the laser for the first time. Lasers vary considerably in complexity, but all share a susceptibility to damage if not operated systematically and with a thorough knowledge of the function of each component.

Should you have problems, which this manual do not explain please feel free to contact the service engineers at Radiant Dyes any time.

Safety Remarks

Serious dangers start out from the **NarrowDiode** laser at improper use. Most of these dangers can almost completely be avoided by well-trained working with the system. Many users tend to a rather careless treatment of the safety guidelines though. You should therefore see to it that all safety rules recommended in this manual (and of course also the legally specified) are kept carefully.

Laser Radiation

The laser output is of high intensity and would cause **IRREPARABLE DAMAGE TO THE EYES** if viewed directly:

EYE DAMAGE could also result from diffuse reflections from any surface in the path of the beam. **SAFETY GOGGLES** should be worn **AT ALL TIMES** by personnel within sight of laser radiation. Ensure that the goggles are suitable for the wavelengths being emitted and that they fit snugly. Ensure that no-one can enter the area in which the laser is operating without prior warning.

Extreme care should be taken to ensure a clear path between the laser and the intended target and safe containment of the beam should it not be absorbed by the target.

All beams should be efficiently dumped as soon as possible in the optical train.

Always **DOUBLE CHECK** that there are no obstacles in the beam path likely to cause dangerous reflections.

Above all, guard against **CARELESSNESS, UNTIDINESS and IMPATIENCE.**

Great care must be taken when aligning the laser with the cover removed. Stray reflections might occur from optical surfaces or mechanical instruments used. Some of these reflections may be projected in an upward direction. It is vital that safety goggles are worn at all times when carrying out any alignment!



Chapter 1.3. Principle and Design of NarrowDiode Laser

Principle of the Laser

The NarrowDiode Laser was developed in cooperation with the “Observatoire de Paris” and Professor Rosenbusch. The technology of the laser is the latest state of the art and it has got many advantages, due to his new interference-filter-stabilized external cavity design.

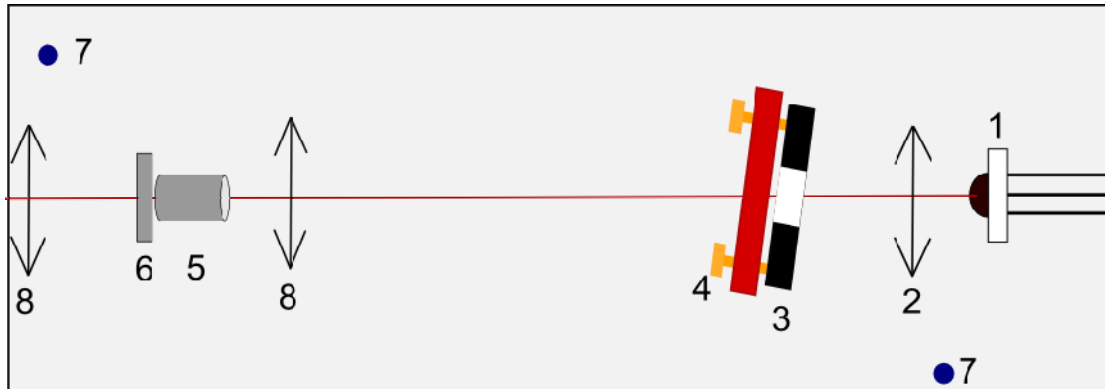


Figure 1. Drawing of the Laser Head. Components marked with numbers are: 1 - Laser Diode, 2 – Collimation Lens, 3 – Interference Filter, 4 – Screws for wavelength adjustment, 5 – Piezoelectric Actuator, 6 – Output Coupler, 7 – Thermistors, 8 – Collimation Lenses

The **NarrowDiode** laser consists of a very narrowband, low loss interference filter for the wavelength selection, and an output coupler to generate the feedback. The filter allows a linear cavity design reducing the sensitivity of the wavelength and the external cavity feedback against misalignment. By separating the feedback and the wavelength selection functions, both can be optimized independently leading to an increased tunability.

A drawing of the Laser Head design is given in Figure 1. The light emitted from the **Laser Diode** (1) passes a **Collimation Lens** (2), to compensate aberrations coming from the diode. The **Output Coupler** (6) is mounted directly onto a **Piezoelectric Actuator** (5) to vary the cavity length. It also provides the feedback into the diode. The narrowband **Interference Filter** (3) is placed between the **Collimation Lens** and the **Output Coupler**. This filter provides the wavelength selection. The two additional lenses are to focus the light onto the output coupler. The **Laser Diode** and the housing are equipped with Peltier Elements (thermoelectric coolers) for stabilizing the diode and housing to a constant temperature, and to tune the laser by temperature adjustment.

The Interference Filter

The interference filter is calculated to transmit approximately 90% of the intensity at the nominal wavelength at 6° incidence. It is factory adjusted to 6° and to the corresponding wavelength. To tune the wavelength manually with the filter, the angle has to be changed. It has to be coarse adjusted with the holding screw of the filter, and

fine tuned with the screws of the mirror holder. The achievable tuning range depends on the laser wavelength and is typically about 20 nm.

Thermoelectric Cooler and Piezoelectric Actuator

The Laser Head contains 2 thermoelectric coolers (TEC), and 1 piezoelectric actuator (PZT) to scan the wavelength of the laser.

The PZT is directly connected with the Output coupler. The Piezoelectric Actuator is a high voltage type piezoelectric tube, working with voltages up to 1000 V.

The 2 TECs are located directly inside the Laser Head; one is inside the laser diode housing to regulate the diode temperature, and the other one controls the temperature of the laser housing. It is located between the inner part of Laser Head and the ground plate. The two thermistors inside the Laser Head measure the temperature of the laser housing to stabilize it.

Chapter 1.4. Working with the Laser

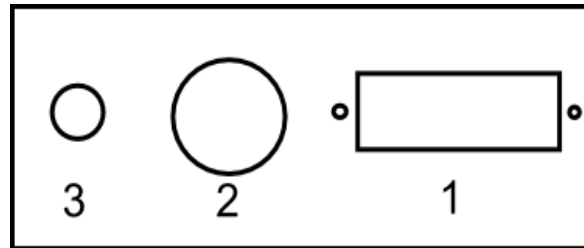


Figure 2. Cable connections located at the Laser Head. Cables have to be connected to: 1 – Temperature Control module, 2 – Current Control module, 3 – PZT Driver module

Switching on the Laser

To turn on the laser, first connect the Laser Head with the controller. Connect the Sub-D15 cable between the TECs Sub-D connector (1) on the Laser Head with the Temperature Control module connector „**LASER HEAD**“. Secondly connect the laser diode BNC cable first with the connector „**LASER DIODE CURRENT OUT**“ at the Current Control module, and then connect it to the Laser Head BNC connector (2). Be careful as **laser diode is very sensitive to ESD**. Finally connect the SMA cable between the SMA connector (3) on the Laser Head and the connector „**HV PZT**“ on the PZT Driver.

Before turning on the power switch on the back side of the Laser Controller, make sure that the switch „**LASER DIODE CURRENT OFF**“ at the Current Control is turned off, as well as the switches „**HS-OFF-LD**“ on the temperature control board.

Never start the controller when the “LASER DIODE CURRENT OFF” switch is turned on!



After the Controller is turned on, first regulate and turn on the temperature control. For that turn the switch right beside the LED display to the position “ERROR”. The switch on the left side next to the LED display switches between Laser Head (LH) and laser diode (LD) temperature errors.

Both temperatures can be regulated with the precision potentiometers below the LED display; laser diode temperature can be additionally set with 9-position coarse switch. Adjust both potentiometers and coarse switch to set both errors near zero, and then turn on both temperature regulators with switches “HS-OFF-LD”. Now, temperatures of the laser diode LD and housing HS should regulate to zero within some minutes.

Make sure the temperature control is turned ON, when Laser Diode Current is switched on!



When the temperature errors are changed to zero, turn on the current of the Laser Diode. Turn on switch „**LASER DIODE CURRENT OFF**“ on the Current Control

module. To adjust current, turn the coarse and fine tuning precision potentiometers on Current Control module.

To regulate the PZT voltage turn the adjusting precision potentiometer „**VOLTAGE**“ on the PZT Driver module; the actual voltage is shown on the LED display in volts.

Modulation of Laser Diode and PZT

The Laser Controller is equipped with a Sinus Generator module that gives a frequency from 2.5 Hz to 75 Hz with adjustable amplitude; maximum amplitude is 10 V_{pp}

a) PZT actuator modulation for mode hop free scanning

To modulate voltage of the piezoelectric actuator with sinus voltage, connect the output „**SIN OUT**“ on the Sinus Generator with the input „**MOD IN**“ on the PZT Driver. Amplitude and frequency of the sinus signal can be adjusted on the Sinus Generator. Amplitude can be switched with the switch „**ATT**“ to off, 0 dB or -20dB. If „**ATT**“ switch is turned on (positions 0 dB or -20 dB), the PZT voltage is modulated by the sinus signal. The laser is now scanning mode hop free over a maximum range of 9 GHz.

To observe the sinus signal on the oscilloscope, use the BNC connector „**REF OUT**“ on Sinus Generator. BNC connector „**MON OUT**“ on the PZT Driver can be used actual modulation of the PZT voltage.

b) Laser diode current modulation

The laser diode current can also be modulated by the Sinus Generator. In that case connect Sinus Generator output „**SIN OUT**“ with the Current Control module input „**MOD**“. On the Current Control module the modulation can separately be turned on/off and the modulation level can be reduced by 20dB. The actual current of the laser diode can be observed from output „**MON OUT**“ with a Oscilloscope.

Tuning the Wavelength of the Laser

The wavelength of the **NarrowDiode** laser can be tuned by changing the interference filter angle, the PZT voltage, the diode and laser housing temperature and the diode current. In general, the laser diode is emitting light in a range of about 30 nm. To achieve lasing of the laser at the wavelength required, all parameters have to be adjusted to the right value/position.

Tuning the filter

The interference filter is changing the wavelength of the laser by varying the angle of the filter. The laser is delivered with the filter factory setting under 6 degrees. It can be coarse tuned with the mirror mount fixing screw in the housing, and fine tuned by adjusting screws of the mirror holder. The tuning range is about 20nm. Tuning the laser mechanically with the filter is not mode hop free.

Tuning the wavelength by temperature

The temperature of the laser diode has got an effect on the diodes emission peak position. The temperature variation leads to a different diode length and thereby to the change of the diode gain.

If the laser is fixed to the wanted wavelength with the filter position, a fine tuning can be made by changing the temperature of the laser diode. It is necessary to change the diode temperature on the Temperature Control module with the coarse tuning switch and fine tuning potentiometer.

The laser housing temperature change influences the cavity length of the laser resonator, but as its effect is very slow because of the long temperature stabilization time, it is not usually used to adjust the wavelength of the laser.

Changing the wavelength of the laser by temperature is mode hop free over very small temperature range.

Tuning the wavelength by PZT voltage

The PZT voltage changes the position of the output coupler, and thus, the cavity length of the laser is varied. The tunability with the PZT voltage is about 9 GHz and it can be adjusted with temperature and current adjustments mode hop free. To adjust the PZT voltage, the precision potentiometer “**VOLTAGE**” on the PZT Driver module has to be turned; the actual voltage is shown on the display.

The wavelength is also changed by the laser diode current change. But these changes are not normally used for adjustment of the laser wavelength. It should be noticed, that the wavelength of the laser is also modulated when the laser current is modulated. The modulation factor is approximately 70 MHz/mA, depending of the used laser diode and wavelength.

Scanning the Laser

The **NarrowDiode** Laser can be scanned for at maximum 9 GHz mode hop free by the modulation of the PZT voltage. Sinus Generator can be used to scan the PZT voltage if connected with the PZT Driver. Sinus amplitude and frequency can be changed on the Sinus Generator, and the offset of the PZT voltage on the PZT Control module, to adjust the scanning parameters. The actual voltage value shown now on the PZT Driver display is approximately the middle voltage of the scanning range. If the sinus amplitude is not at its maximum value, the scanning range is below 9 GHz, but can be shifted over the whole range, by changing the offset voltage on PZT Control.

Frequency Stabilization by Absorption Spectroscopy

To stabilize the laser wavelength onto a peak of for example an atomic absorption line of a Rubidium Cell, a spectroscopy setup with a photodiode is required. The photodiode must be able to detect a 100 kHz signal, as the current of the laser diode is modulated with a 100 kHz signal.

To set up the laser and controller for spectroscopy use, the following actions have to be taken:

a) Start the Laser as described in Chapter „Switching on the Laser“.

b) To stabilize the Laser the following steps are needed:

- Modulate the PZT voltage: connect BNC cable between Sinus Generator “**SIN OUT**” and the Integrator module „**PZT- MOD IN**“. Next connect with BNC cable Integrator connector “**PZT OUT**” and PZT Driver connector “**MOD IN**”.
- Modulate the diode current: connect Lock In Amplifier “**MOD OUT**” BNC with Integrator “**CURRENT MOD IN**” BNC connector. Connect Integrator “**CURRENT OUT**” BNC with Current Control BNC “**MOD**”. Turn on the modulation of the diode on the module Current Control with switch “**MOD-OFF**”.
- Connect the spectroscopy photodiode to the Photodiode Amplifier by the Sub-D connector “**PHOTODIODE**”. The signal can be monitored on an Oscilloscope via the Photodiode Amplifier output „**MON OUT**“. Photodiode signal DC level can be estimated at „**MON OUT**“; DC level up to 10 V is acceptable.
- Connect with BNC cable the „**AC OUT**“ on the Photodiode Amplifier to the “**SIG-IN**” on the Lock In Amplifier“.
- Connect with the BNC cable the „**SIG-OUT**“ on the Lock-In Amplifier module to the “**SIG-IN**” on the Integrator module. Laser Controller picture with all cables necessary for spectroscopy connected is presented in Figure 3.
- Watch the photodiode signal at Photodiode Amplifier „**MON OUT**“ on an oscilloscope as a function of the PZT modulation signal (“**REF OUT**” on the Sinus Generator).
- Watch also the Lock-In Amplifier „**MON-OUT**“ signal on the oscilloscope as a function of PZT modulation signal from “**REF OUT**”.
- Adjust PZT voltage near to the center value (325 V).
- Turn on the “**ATT**” switch on the Sinus Generator; switch it to the position “**0dB**” first, turn amplitude to the maximum value and frequency to 20 Hz.
- Now try to find the spectroscopy absorption line(s) with help of the Oscilloscope by adjusting laser diode temperature. If the absorption spectrum is visible on the Oscilloscope screen, adjust maximum of the chosen absorption line to the middle of the screen with changing PZT DC offset.
- Now watch Lock-In Amplifier „**MON-OUT**“ signal; it has to be adjusted with control elements on the Photodiode Amplifier and Lock-In Amplifier to be the derivative of the spectroscopy signal measured with photodiode.
- Adjust the Lock-In Amplifier signal „**MON-OUT**“ slope to its maximum and zoom in by varying the following parameters:
 - Frequency and amplitude of the Sinus Generator. Amplitude should be reduced to zoom in and to make visible only the area of interest in signal.
 - Gain of the photodiode. Change the gain of the photodiode on Photodiode Amplifier, until the slope is maximized, but signal is not in saturation.

- Amplitude of the current modulation at Lock-In Amplifier. Turn the potentiometer „**MOD LEVEL**“ to maximize the slope of the „**MON OUT**“ signal on Lock-In Amplifier; switch on/off „**MON FILT OFF**“ to find, which position suits better for monitoring the signal.
- Phase adjustment at Lock-In Amplifier. Using switches „**PHASE 90**“, „**PHASE 180**“ and potentiometer „**PHASE ADJ**“ change phase of the Lock-In amplifier until the slope of the derivative signal is maximized.
- Adjust the signal peak now with the „**PZT VOLTAGE**“ to the middle of the sinus signal from „**REF OUT**“. In Figure 4 the screenshot of the Oscilloscope screen with correctly adjusted signals is presented.
- To start the stabilization process:
 - Turn off the PZT modulation switching the „**ATT**“ to the position „**OFF**“ on the Sinus Generator module.
 - Adjust the level of the „**MON OUT**“ signal on Lock-In Amplifier to zero value with the „**OFFSET**“ potentiometer.
 - Turn on two switches „**PZT OFF**“ and „**CURRENT OFF**“ on the Integrator module. First switch always on „**PZT OFF**“ and only then „**CURRENT OFF**“.

The Laser should now be holding the wavelength of absorption line maximum. If the PZT Voltage jumps to 0 V or to 650V, the absorption line is lost. In that case, change some of the parameters until stabilization process can be started successfully

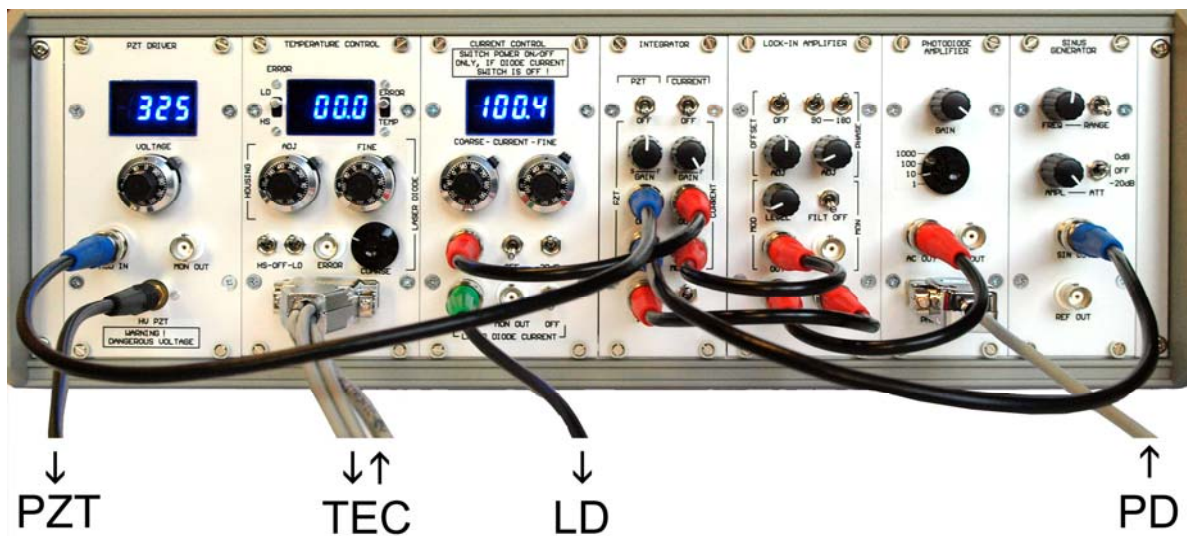


Figure 3. Laser Controller with all cables connected which are necessary for absorption spectroscopy. PZT – piezoelectric actuator in the Laser Head, TEC – thermoelectric coolers in the Laser Head, LD – laser diode and PD – signal from photodiode preamplifier



Figure 4. Image of correctly adjusted spectroscopy signals. Yellow line is the spectroscopy absorption signal from the photodiode, green line is derivative signal form the Lock-In Amplifier and red line is PZT scanning voltage from the Sinus Generator. Slope of the green line in the center of the screen has to be adjusted to be maximally steep with midpoint at zero crossing.

Switching OFF the Laser

Before switching off AC power of the Laser Controller, always the following actions have to be taken:

- Switch off current modulation with “**MOD OFF**” and turn down to zero the current of the laser diode.
- Turn off the switch “**DIODE CURRENT OFF**”.
- Turn off the temperature controllers.
- Turn PZT voltage to zero.
- Only now turn off AC power switch on the back side of the Controller.

Part 2. Diode Laser Controller

Chapter 2.1. Mainframe



Figure 5. Front panel of the Diode Laser Controller

Warning! Dangerous voltages up to 1000 volts are present in the controller, use extreme caution whenever the covers of the laser controller are removed!



The Laser Controller was carefully designed to be fully analog to achieve minimum noise levels of all modules used to control a diode laser – no digital IC-s are used to avoid switching and clock noises. The Laser Controller has modular architecture allowing easy customization according to customer demands. The Controller is available in two different main configurations; a 84TE size supply rack for the set of the laser control modules (Current Control, PZT Driver, Twin Temperature Control) and typical spectroscopy applications (Sinus Generator, Photodiode Amplifier, Lock-In Control and Laser Control); and 42TE size supply rack for 3 main laser control modules only. Supply rack provides all necessary voltages for plug-in modules – HV power supply for PZT Control and different bipolar voltage supplies for all other modules. In Figure 5 is represented front panel view of the Controller.

Chapter 2.2. Current Control

The operation of a diode laser requires a highly stable and very low noise current source. The Current Control module (CC) with advanced circuit design and careful layout was built to meet these requirements. An external analog modulation input of the CCM allows precision control of the laser diode current; an additional BNC connector is provided for current monitoring.

In Figure 6 the front panel of the CCM is represented.

Controls and indicators:

- “**LASER DIODE CURRENT – OUT**” BNC connector provides the electrical connection to the laser diode
- “**LASER DIODE CURRENT – MON OUT**” BNC connector can be used to monitor laser diode current actual value and modulation amplitude. **It is strongly recommended to disconnect everything from that output if very low noise laser current is wished to obtain!**
- “**LASER DIODE CURRENT – OFF**” short circuits “**LASER DIODE CURRENT – OUT**” BNC connector to protect laser diode when Controller AC mains power is switched on or off. **Always adjust laser current value to zero, before switching “LASER DIODE CURRENT – OFF” on or off!**
- “**MOD**” BNC input allows modulating of the current with external analog voltage
- “**MOD OFF**” switches current modulation on or off
- “**MOD -20dB**” switch decreases effective modulation amplitude 20dB (10 x)
- “**COARSE**” precision trimmer allows coarse tuning of the current
- “**FINE**” precision trimmer allows fine tuning of the current, full scale of the fine adjustment is typically 4 mA
- LED display shows actual value of the current



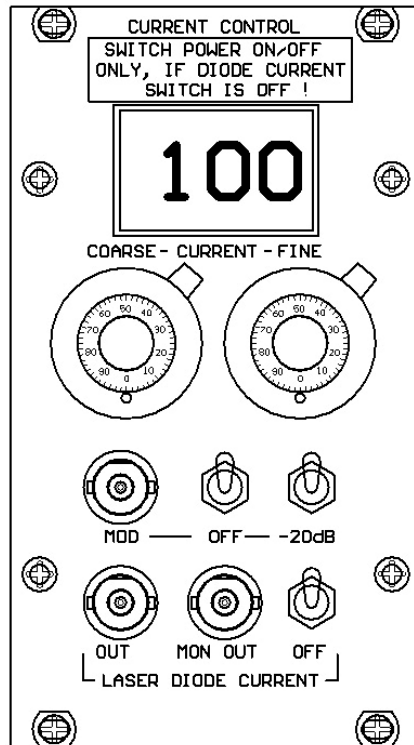


Figure 6. Front panel of the Current Control module

Specifications:

- Output current range: 0...+150mA (polarity is factory set, different polarity and current are available by request)
- Coarse and fine tuning of output current via separate precision trimmers, fine tuning range is typically 4 mA
- LED display for monitoring actual output current value
- Modulation sensitivity 1 mA/V
- Modulation frequency range: DC to 350 kHz @ -3dB
- Monitor output sensitivity 68 mV/mA
- Switches to decrease external modulation sensitivity 20 dB and to switch off external modulation
- Protection circuits for the laser diode
- Low noise: typically < 1 μ A RMS (DC to 125 kHz)

Chapter 2.3. Twin Temperature Control

The Temperature Control module (TCM) contains two separate bipolar Thermoelectric Cooler (TEC) controllers to regulate temperature of the laser diode and the laser housing. Laser housing (HS) temperature is usually held at the environmental temperature or near that to achieve long term stable operation of the laser. Laser diode (LD) temperature is used to fine tune laser frequency or to set mode-hop free work of the laser. Temperature is regulated typically better than 1 mK. The set value of the housing temperature is adjusted by a precision potentiometer. The set value of the laser diode is course adjusted by switch and fine adjusted by a precision potentiometer. The temperature range of the TCM is typically 15 °C to 35 °C for laser housing temperature and 14 °C to 40 °C for laser diode temperature. Bipolar control allows fast and stable stabilization of the temperature even near or equal to room temperature. LED indicator is added to monitor HS or LD temperature error. Depending of the laser configuration (installed laser diode type) also temperature of the housing or temperature of the laser diode can be monitored.

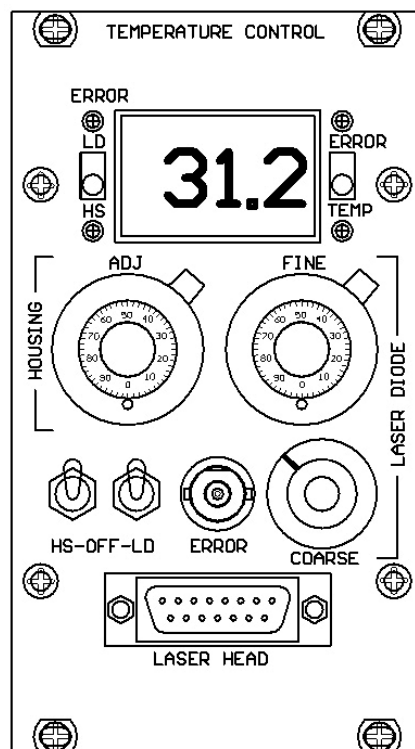


Figure 7. Front panel of the Temperature Control module

Controls and indicators:

- “**LASER HEAD**” provides the connection to the TECs and thermistors located in the Laser Head
- “**HS OFF**” switches on/off temperature control of the laser housing
- “**LD OFF**” switches on/off temperature control of the laser diode

- “**ERROR**” BNC output allows monitoring temperature error signal; tracked signal depends of “**ERROR LD – HS**” switch position – BNC signal and LED display signal are the same error signals
- “**LASER DIODE COARSE**” 9-position switch allows coarse adjustment of laser diode temperature
- “**LASER DIODE FINE**” precision potentiometer allows fine regulation of laser diode temperature
- “**HOUSING ADJ**” precision potentiometer allows smooth adjustment of laser housing temperature
- “**ERROR – TEMP**” enables to monitor on the LED display error signal of temperature controllers or the value of temperature in °C. Depending of the installed laser diode type, laser diode or laser housing temperature is displayed
- “**ERROR LD – HS**” enables to monitor either the error signal of the laser diode temperature controller or the laser housing temperature controller
- LED display allows monitoring error signals or temperature

Specifications:

- LED display for monitoring actual temperature of the laser diode or laser housing, depending of the type of installed laser diode; or for monitoring laser diode or laser housing temperature error
- The SubD-15 female connector marked “**LASER HEAD**” provides the connection to both TECs and thermistors as well as temperature monitoring IC LM35
- The Sub-D9 connector pin description:
 - 1 – LD TEC “-“ terminal
 - 9 – LD TEC “+” terminal
 - 2 – NC
 - 10 – NC
 - 3 – LD thermistor
 - 11 – LD thermistor
 - 4 – LM35 temperature pin
 - 12 – LM35 VCC pin
 - 5 – LM35 GND pin
 - 13 – LH thermistor
 - 6 – LH thermistor
 - 14 – NC
 - 7 – NC
 - 15 – LH TEC “+” terminal
 - 8 – LH TEC “-” terminal

Laser housing temperature control:

- Maximum output current: 1.5 A
- Maximum output power: 9 W
- Long-term drift: typically 1 mK
- Temperature sensor: thermistor 2 x 5 kΩ
- Temperature selection range: typically 15...35 °C
- Tuning of output current via precision trimmer

Laser diode temperature control:

- Maximum output current: 1.5 A
- Maximum output power: 9 W
- Long-term drift: <1 mK
- Temperature sensor: thermistor 10 k Ω
- Temperature selection range: typically 14...40 °C
- Fine tuning of temperature via precision trimmer: typically 2...3 °C
- Coarse tuning of temperature via 9-position switch: typical step 2...3 °C, measured values of typical laser diode for switch positions (°C):
15.2, 17.9, 20.8, 23.7, 26.7, 29.8, 33.1, 36.6, 40.2

Chapter 2.4. PZT Driver

The PZT Driver module provides stable, low noise level voltage to the PZT actuator located in the Laser Head. Driver can be used to output fixed voltage 0...+650 V to the PZT actuator. The output voltage is adjustable with precision potentiometer and actual value of the voltage is visible on a LED display. Inputs for modulation and for monitoring the output voltage are installed. For modulation DC and AC can be used. In case of AC only modulation is used, necessary reference voltage have to be set with potentiometer “**VOLTAGE**”.

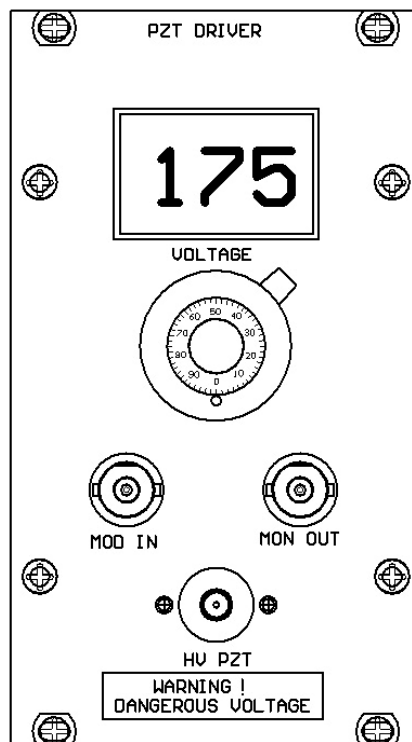


Figure 8. Front panel of the PZT Control module

Controls and indicators:

- “**HV PZT**” SMA connector for PZT actuator. **For safety reasons cable between SMA connector on Laser Head and on the PZT Driver can only be connected if the Controller AC mains power is switched off!**
- “**MOD IN**” BNC connector for analog modulation signal; AC and DC signals can be used
- “**MON OUT**” BNC output enables to monitor the PZT voltage. Voltage value is 1/100th of the actual PZT voltage
- “**VOLTAGE**” precision potentiometer to adjust DC level of PZT voltage
- LED display indicates actual PZT voltage in volts



Specifications:

- Modulation sensitivity 65 V/V; AC voltage 10 Vpp with DC level at 5 V on modulation input causes output value to change from 0 to 650 V
- Modulation frequency range for full scale (650 Vpp) modulation: DC to 70 Hz @ -3dB (at 70 Hz large distortion is visible)
- Modulation frequency range for 10 Vpp PZT modulation (PZT connected without output coupler): DC to 25 kHz without remarkable distortion
- Monitor output sensitivity 10 mV/V
- Low noise: typically < 2 mV RMS (DC to 30 kHz)

Chapter 2.5. Integrator (Laser Control)

Integrator module (also called Laser Control) allows together with Lock-In Amplifier and Photodiode Amplifier stabilizing of the laser frequency to the atomic absorption line or to the Fabry-Perot' interferometer transmission line. Principally the Integrator module represents a PI controller with adjustable integration times. Internally the PZT integrator input is connected with the current integrator output. Phase of both integrators can be inverted changing positions of jumpers inside the module. Turning "GAIN" potentiometers clockwise decreases integration time and to the faster changes of the laser wavelength (current/PZT voltage) can be reacted. To use Integrator module, switch "SIG OFF" should be always in the position on. To start the integration, first "PZT OFF" and secondly "CURRENT OFF" have to be switched on. In Figure 9 the front panel of the Integrator is presented.

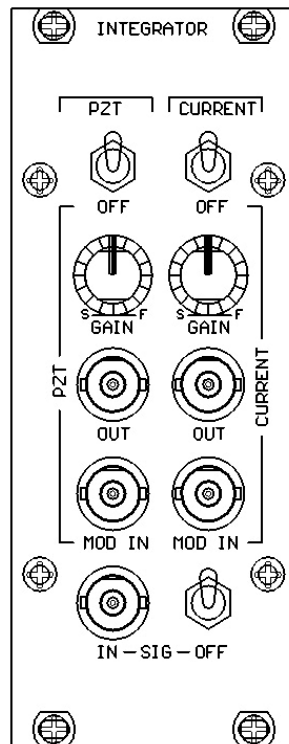


Figure 9. Front panel of the Integrator (Laser Control) module

Controls and indicators:

- "SIG IN" BNC input connector to the error signal; normally error signal is taken from a Lock-In amplifier, but different configurations are possible. The Integrator module always tries to correct laser diode current or PZT voltage to drive input signal on "SIG IN" to zero
- "SIG OFF" allows to connect the integrator input to zero and temporarily stop the Integrator module reacting to the changes of the input signal

- “**PZT MOD IN**” BNC input is used to direct PZT modulation signal to the “**PZT OUT**”. Signal level remains unchanged. Signal in that input has to be switched off before the Integrator is switched to the working mode
- “**PZT OUT**” BNC output to drive PZT voltage through PZT Driver
- “**PZT GAIN**” potentiometer allows changing the integration time of the PZT integrator. Turning potentiometer clockwise decreases the integration time
- “**PZT OFF**” switch resets to zero and disables PZT integrator
- “**CURRENT MOD IN**” BNC input is used to direct 100 kHz current modulation signal from Lock-In Amplifier through the Integrator module to the “**CURRENT OUT**”. Modulation signal level in the output is reduced 10 times to compare with the modulation signal in the “**CURRENT MOD IN**”
- “**CURRENT OUT**” BNC output to drive laser current through Current Control module
- “**CURRENT GAIN**” potentiometer allows changing the integration time of the current integrator. Turning potentiometer clockwise decreases the integration time
- “**CURRENT OFF**” switch resets to zero and disables current integrator

Specifications:

- PZT integrator time constant is adjustable from 0.1 s to 2 ms
- Current integrator time constant is adjustable from 1 ms to 20 μ s
- Estimated locking bandwidth: 20 kHz
- Amplification factor of PZT modulation signal: 1
- Amplification factor of current modulation signal: 0.1

Chapter 2.6. Lock-In Amplifier

Lock-In Amplifier module (LA) is designed for stabilization of the laser wavelength to an atomic resonance line or to the transmission line of a Fabry-Perot interferometer. The LA contains a 100 kHz sinus generator, a phase shifter and a phase sensitive detector. In the typical application the sinus generator is used to modulate the laser frequency; the absorbed laser intensity is measured with a photodiode to generate a phase dependent signal and the phase sensitive detector is used to detect phase difference between modulation and measured signal. Applying phase difference signal to the Integrator module (Laser Control) allows laser locking to the maximum or minimum of the absorption line (top-of-fringe). In Figure 10 is presented front panel view of the Lock-in Amplifier. In Figure 10 front the panel of the Lock-In Amplifier is presented.

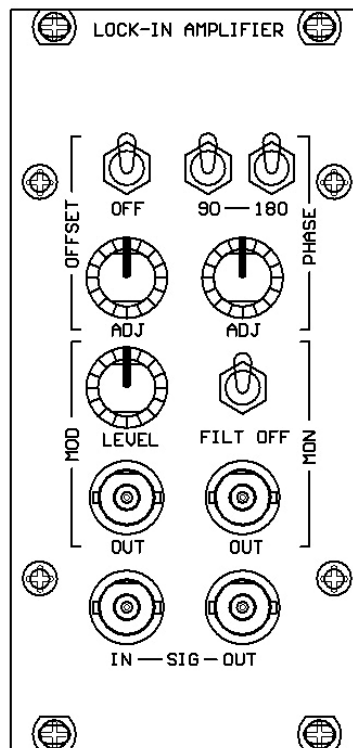


Figure 10. Front panel of the Lock-in Amplifier module

Controls and indicators:

- “**SIG IN**” BNC input of the amplified photodiode signal, phase of that signal is compared to the phase-shifted modulation signal
- “**SIG OUT**” BNC output of the phase detector
- “**MOD OUT**” BNC output of the modulation signal
- “**MOD LEVEL**” potentiometer allows smooth adjustment of the modulation signal amplitude
- “**MON OUT**” BNC output to monitor the filtered phase detector output

- “**MON FILT OFF**” switches filter cut-off frequency of “**MON OUT**” signal between 2 kHz (position ON) and 12 kHz (position OFF)
- “**OFFSET ADJ**” potentiometer regulates a DC offset of the “**SIG OUT**” signal
- “**OFFSET OFF**” enables to switch off “**SIG OUT**” offset adjustment
- “**PHASE ADJ**” potentiometer regulates smoothly phase shift of the phase detector reference signal (derived from the modulation signal) in the range 0° to 100°
- “**PHASE 90**” switches phase of the reference signal 90°
- “**PHASE 180**” switches phase of the reference signal 180°

Specifications:

- Modulation frequency: fixed 100 kHz (different frequencies available by request)
- Maximum modulation amplitude: 3.8 Vpp
- Continuous phase adjustment 100°
- Switches for 90° and 180° phase shift
- Set point adjustment for control loop

Chapter 2.7. Photodiode Amplifier

Photodiode Amplifier module allows easy amplification and monitoring of the photodiode signal. Sub-D9 connector is used to connect and power up external photodiode preamplifier. Preamplifier power consumption is limited to 50 mA for both voltages +15V and -15 V. Amplification can be changed in wide range (up to 5000 times). In Figure 11 front the panel view of the Photodiode Amplifier is presented.

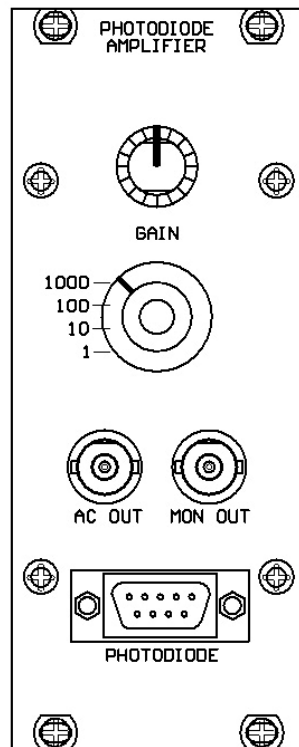


Figure 11. Front panel of the Photodiode Amplifier module

Controls and indicators:

- “**PHOTODIODE**” 9 pin Sub-D connector for photodiode signal input and to provide with supply current the photodiode preamplifier
- “**AC OUT**” BNC output of the amplified photodiode signal. AC amplifier is equipped with high pass filter with cutoff frequency 1.5 kHz. Upper cutoff frequency of the amplifier is 120 kHz
- “**MON OUT**” BNC provides the buffered and amplified output of the photodiode signal
- “**GAIN 1-10-100-1000**” 4 position switch selects photodiode amplification factors 1, 10, 100 or 1000
- “**GAIN**” potentiometer enables smooth adjustment of the amplification of a AC amplifier

Specifications:

- The Sub-D9 female connector for a photodiode preamplifier
- The Sub-D9 connector pin description:
 - 1 – Signal GND
 - 2 – Photodiode signal input
 - 3 – -15 V, max 50 mA power supply for a preamplifier
 - 4 – +15 V, max 50 mA power supply for a preamplifier
 - 5 – Power GND
 - 6, 7, 8, 9 – NC
- Special transition connector from Sub-D9 to BNC is included
- Amplification from photodiode input to monitor output: 6
- Amplification from photodiode input to AC output: 0.25 to 5000
- Cutoff frequencies of the AC amplifier @ -3dB: low 1.5 kHz @ -3 dB, high 120 kHz @ -3 dB

Chapter 2.8. Sinus Generator

Simple Sinus Generator module (SG) is added for driving the PZT voltage or the laser diode current. BNC monitor output with constant level sinus signal is useful for synchronization of the oscilloscope or measurement devices to the process under observation. In Figure 12 the front panel of the Sinus Generator is presented.

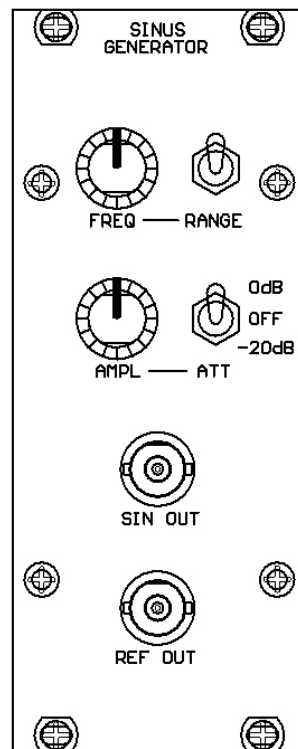


Figure 12. Front panel of the Sinus Generator module

Controls and indicators:

- “**REF OUT**” BNC output allows monitoring of the generator signal. Amplitude has fixed value 5 Vpp
- “**SIN OUT**” BNC is the output of the generator
- “**AMPL**” potentiometer allows smooth adjustment of the output signal amplitude
- “**AMPL ATT 0dB - OFF- -20dB**” allows switching off the signal amplitude (no output is generated) or reducing the amplitude by 20 dB
- “**FREQ**” potentiometer allows smooth adjustment of the generator frequency
- “**FREQ RANGE**” switches between two frequency ranges; the lower range is from 2.5 Hz to 13 Hz and the higher range from 13 Hz to 75 Hz

Specifications:

- Frequency continuously adjustable 2.5 Hz to 13 Hz, or 13 Hz to 75 Hz depending of the position of frequency range switch
- Maximum output amplitude: 10 Vpp
- Reference output sinus signal amplitude: 5 Vpp
- By request scan generators with different frequency ranges and/or signal shape are available