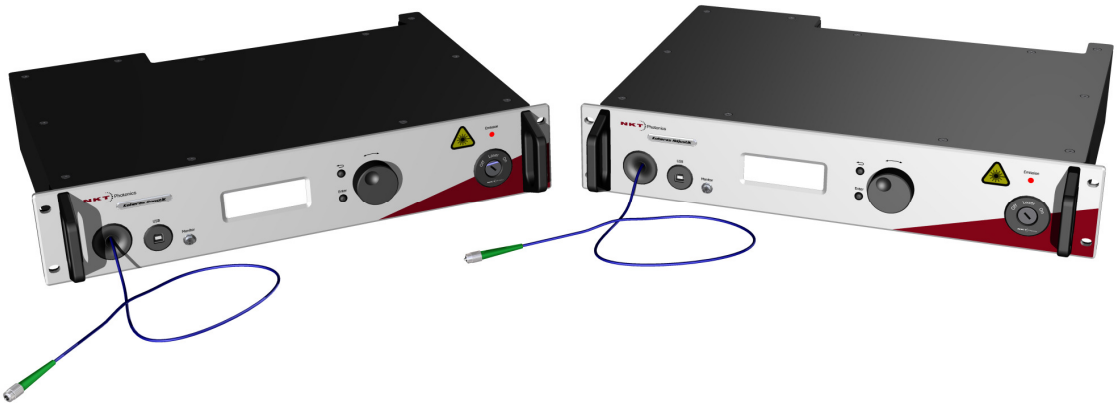
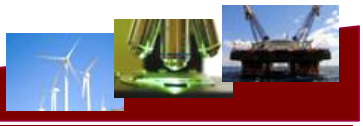


Koheras Adjustik™ System
&
Koheras Boostik™ System

Instruction Manual



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FDA (Food & Frug Administration) accession number: 9912672; Patents: US 6,151,429; US 6,449,293; US 6,603,779

Table of Contents

1 General

Introduction

Please take the necessary time to read this instruction manual, which contains important information on safety issues concerning the usage of this equipment. The safety might be seriously impaired if the instruction manual is not followed carefully.

This manual covers both the Koheras AdjustiK System as well as the Koheras BoostiK System. Where the two systems share common descriptions they are mentioned as Koheras AdjustiK/BoostiK System. Where there are differences between the two systems they are mentioned separately.

The Koheras AdjustiK System comprises a Class 3B laser and the Koheras BoostiK System comprises a Class 4 laser and only persons who are familiar with laser safety regulations are allowed to operate any of these systems.

This product is not UL-approved but all safety components are UL-approved.

Do you have any questions concerning this product, please do not hesitate to contact us at support@nktphotonics.com.

Description

Koheras AdjustiK™ and Koheras BoostiK™ Systems are narrow linewidth fiber laser turn-key benchtop systems based on a truly single mode, *single frequency* DFB (Distributed-Feedback) Fiber Laser with extremely high frequency stability and low phase and intensity noise.

The Koheras AdjustiK™ System is a single stage amplified system with up to 200 mW of output power, whereas the Koheras BoostiK™ System is based on dual stage amplification with up to 2 W of output power.

This range of benchtop laser systems is typically offered as rapidly deployable sources for research laboratories that wish to use it as a tool for scientific work and not spend time on setting up a laser system. The benchtop models are based on the Koheras BasiK™ Module seed technology and are upgradable in terms of output power. The graphical user interface GraphiK software is available as an accessory for the system for the control and read-out of numerous laser parameters on a pc such as wavelength, output power, and RIN suppression.

A part from interferometric sensing and LIDAR, these laser systems are very useful sources for various scientific applications (more information available in the application section).

2 Laser Safety

Never switch on or attempt to operate the Koheras AdjustiK/BoostiK System before reading, understanding and fully familiarizing yourself with the contents of this chapter.

Introduction

This chapter is divided into four sections:

- **General Safety Aspects**
  Explains aspects relating to the safe operation of the laser device. See section General Safety.
- **Special Safety Aspects**
  Outlines the risks specific to working procedures with and on this laser device. See section Specific Safety Aspects.
- **Safety compliance list**
  See section Safety Compliance List.
- **Overview of safety-relevant labels**
  Shows the design and describes the safety labels. See section Labels.

2.1 General Safety

2.1.1 Basic Operation and Designated Use

Basic Safety

The Koheras AdjustiK/BoostiK System has been designed in accordance with state-of-the-art standards and the recognized safety rules. Nevertheless, its use can constitute a risk to the user or third parties or cause damage to other material property.

Warning: Potential eye and skin burns! Only use the laser in accordance with its designated use.

The Koheras AdjustiK/BoostiK Systems must only be used in technically perfect conditions and in accordance with its designated use.

Follow the instructions in this manual, and let only safety conscious persons, who are fully aware of the risks involved, operate the Koheras AdjustiK/BoostiK System.

Any functional disorders, especially those affecting the safety of the Koheras AdjustiK/BoostiK System, must there be rectified immediately.

2.1.2 Organizational Measures

Laser Safety Officer

In accordance with the valid national regulations for prevention of accidents, appoint a responsible person as the Laser Safety Officer (LSO).

His responsibility is to effect the knowledgeable evaluation of laser hazards and to monitor and enforce their control.

The instruction manual must always be at hand where the Koheras AdjustiK/BoostiK System is used. In addition to the operating instructions, observe and instruct the user in all other generally applicable legal and other mandatory regulations relevant to accident prevention.

Protective Equipment

These compulsory regulations also deal with the issuing and/or wearing of personal protective equipment. The necessity of reading the instruction manual applies especially to persons working only occasionally on the Koheras AdjustiK/BoostiK System.

Use protective equipment, wherever required by the circumstances or by law.

Warning: Risk of serious injury through incorrect operation! Personnel entrusted to operate the Koheras AdjustiK/BoostiK System must have read the instruction manual and in particular the safety instructions.

Safety Labels

Ensure that all safety-relevant labels are attached to the laser device in accordance with the label location diagrams in Section Labels and local regulations. Make sure that these labels are always complete and perfectly legible.

If any labels are missing, immediately inform NKT Photonics A/S. In the event of safety relevant modifications or changes in the behavior of the Koheras AdjustiK/BoostiK System during operation, stop the laser device immediately and report the malfunction to NKT Photonics A/S.

Never make any modifications, additions or conversions which might affect safety. This also applies to the installation and adjustment of safety devices.

2.1.3 Selection and Qualification of Personnel – Basic Responsibilities

Qualified Personnel

Make sure that only authorized personnel work on or with the Koheras AdjustiK/BoostiK System. Statutory minimum age limits must be observed. Employ only trained or instructed staff and set out clearly the individual responsibilities of the personnel for operation and set up.

2.1.4 Safety Instructions Governing Specific Operational Phases

Precautions

Take the necessary precautions to ensure that the Koheras AdjustiK/BoostiK System is used only when in a safe and reliable state.

In the event of malfunctions, stop the laser device immediately and lock it. Have any defects rectified immediately.

Before starting the Koheras AdjustiK/BoostiK System ensure that nobody is at risk. Brief operating personnel before beginning special operations, and appoint a person to supervise the activities. Ensure that the operations area is adequately secured.

2.2 Specific Safety Aspects

Specific safety aspects are:

- Physical hazards related to the system. See Section Physical Hazards.
- Protection of the users of the system against these hazards. See Section Personnel Safety.
- Constructive protective measures against these hazards. See Section Constructive Safety Features.

Lasers and laser systems are classified according to their relative hazards. These classifications can be found in the American National Standard for the Safe Use of Lasers (ANSI Z 136.1-1968), FDA 21 CFR 1040.10 and 1040.11, IEC-825 and in the European Standard EN 60625.

Within this classification, the Koheras AdjustiK System is a Class 3B laser and the Koheras BoostiK System is a Class 4 (high power) laser, and must therefore be regarded as a potential hazard to the human operator. The laser beam must also be regarded as a potential fire hazard. Class 4 is the most powerful (and potentially hazardous) category of lasers. Direct and scattered radiation from Class 4 products is considered an acute hazard to the eyes and skin. Precautions include eye and skin protection, remote interlocks and warning labels.

2.2.1 Physical Hazards

Warning

The laser beam is very dangerous to the eyes and skin!

The following are hazardous,

- Direct radiation-light as it leaves the laser.
- Reflected radiation-light which has hit a surface and bounced off.
- Diffuse radiation-light, which has hit a surface, bounced off, and scattered.

Light

In case of malfunction the Koheras AdjustiK System may provide laser radiation with power levels up to 500 mill Watt. The Koheras BoostiK System may provide up to 5 Watt (in case of malfunction).

The Koheras AdjustiK/BoostiK System has single wavelength operating in the range from 980 to 2100 nm, which is emitted from the output aperture of the Koheras AdjustiK/BoostiK System. The output aperture is an optical fiber cable with FC/APC connector.

The light emitted from the aperture/optical fiber has a divergence angle close to 6 degrees. At a distance of approximately 40 cm from the output aperture the beam will then have spread to a spot size of approximately 4 cm. Despite this spread of power with corresponding lower intensity and despite the non-ionizing nature of the operating wavelengths, damage can still occur to living tissue, if exposed for too long, as a result of heat produced during radiation absorption. The radiation of the Koheras AdjustiK/BoostiK System lies outside the visible range. In general, the maximum permissible radiation exposure for the skin is several times greater than for the eye. Safety measures with regard to the radiation hazard are therefore mainly based on dangers for the eye. Not only is the direct laser beam hazardous, but unchecked reflections of laser light also constitute a potential hazard.

2.2.2 Personnel Safety

Personnel Protection

Warning:

- Koheras AdjustiK System is a class 3B laser.
- Koheras BoostiK System is a class 4 laser.

Warning:
Risk of serious injury! Always wear protective eyewear when there is a chance of exposure to radiation from the laser. Before putting on the protective eyewear, check them for any obvious defects. As the filter in the protective eyewear provides protection for only a narrow band of wavelengths, make sure you are wearing the appropriate protective eyewear for the laser device in question. Check with your Laser Safety Officer or other safety personnel for guidance in selecting the appropriate eyewear.

Radiation Safety
The Koheras AdjustiK/BoostiK System emits high power near-infrared radiation, which constitutes a hazard to personnel during periods of operation.

Protective Eyewear

The mandatory protective goggles provide protection against direct radiation, reflected radiation and standard radiation (normal operating conditions) within the respective wavelength range.

Contact a manufacturer of protective eyewear for information about appropriate protective eyewear. Specifications needed to select appropriate eyewear are: wavelength, power, and beam diameter.

The ANSI (American National Standards Institute) standard for safe use of lasers, requires that protective goggles which block the appropriate laser wavelength should be worn while operating or servicing class 4 lasers.

Clearly label the goggles with an optical density and the specified wavelength. To avoid confusion, keep these goggles separate from other safety glasses and personal protective equipment.

Using the wrong type of goggles is dangerous. It can be worse to have improper eyewear and a false sense of security than to have no eyewear and take precautions based on the absence of protection. Even if you are wearing protective goggles, never look directly into the beam; intense laser radiation is capable of destroying the protective filter.

Eye Protection

Warning:
Potential eye burns! Only use the laser in accordance with its designated use. Safety interlocks are only to be overruled by authorized personnel.

The following guidelines describe some of the actions necessary to avoid injury caused by the laser beam. Always follow these guidelines and take additional precautions if necessary.

- When eyewear is necessary, make sure it has the proper optical density for the laser wavelength.
- Order all other personnel in the vicinity of the laser to wear protective eyewear.
- Permit only qualified personnel to operate the laser.
- Never intentionally look directly into any laser beam.
- Avoid indirect viewing of direct or reflected laser radiation. Specular reflections (from reflective surfaces) can be as dangerous as the direct laser beam. Do not view the beam through optical instruments unless the optics is designed to filter the laser wavelength.
- Take precautions to ensure that there are no reflecting objects in the path

of the laser beam.

- Do not deviate from standard operating procedures when working with class 3B and class 4 laser equipment.
- Use lasers only in approved applications and locations. Take adequate precautions to prevent unauthorized personnel from entering the area where a class 3B and class 4 laser is operating. Do not use lasers around untrained personnel. Ensure that all personnel in the area observe proper safety precautions.
- Report all incidents of exposure to your supervisor.
- Clearly display warning signs indicating the laser enclosed area with an additional warning light outside the door.
- At all times adhere to local and national regulations governing the safe use of lasers.

Skin Protection

Warning:
Potential skin burns! Direct and reflected laser radiation can burn exposed skin. Only use the laser in accordance with its designated use. Safety interlocks are only to be overruled by authorized personnel.

- Although the skin can withstand considerably higher radiation intensity than the eyes, tissue may be burned to a greater or lesser degree, depending on the radiation time and the irradiation intensity.
- Avoid contact between the skin and the beam, or specular reflections of the beam. Reflections of the beam may be as dangerous as the beam itself. Wear appropriate protective clothing to protect the skin whenever necessary.

Fire Protection

Warning:
Fire hazards! Class 4 lasers are, by definition, fire hazards. The laser beam can cause flammable materials to ignite or explode. Always keep a fire extinguisher in the laser area in case a fire occurs.

Because of the high output power from the class 4 laser, a wide range of materials can be set on fire. Therefore, take appropriate fire prevention measures when the beam path is open:

- Combustible materials may be ignited by the laser beam or by electrical components inside the laser system. Flammable items must be isolated from the laser beam and from the laser system.
- Paper (circuit diagrams, leaflets, or even posters on the wall), curtains that are not coated with fire retardant, wooden panels or similar materials can be easily set on fire by direct or reflected laser radiation.
- Use only beam stops made of non flammable materials (not asbestos!).
- Many fluids and solvents (e.g. cleaning agents used for maintenance) are combustible. The intense beam of the laser can ignite vapors from these materials. Prevent the laser beam from contacting flammable materials used in the laser area.
- Move containers of flammable materials as far from the laser system as possible and shield them from the beam with opaque materials. Place these solutions and vapors under no circumstances in the beam path or near the system.

2.2.3 Constructive Safety Features

Safety Features

The laser device is equipped with the following constructional safety features:

- Appropriate Class 3B or Class 4 label affixed to laser device enclosure (see section Labels).
- All parts of the laser where laser radiation may possibly escape are marked with the appropriate adhesive danger signs (according to IEC 825).
- The Koheras AdjustiK/BoostiK System is provided with a connector (”Interlock”) on the rear panel of the laser housing, where an external interlock switch can be installed. The interlock switch shuts down the laser remotely, for instance, if a door connected with the switch is opened.

2.2.4 General Safety Features

General Safety

The Koheras AdjustiK/BoostiK System has key switch controlled laser operation. The laser device can only be switched on with the key-switch. This prevents inadvertent or unauthorized starting of the laser. It cannot be operated with the key in the OFF position and the key cannot be removed in the ON position.

2.3 Safety Compliance List

UL Approval

The Koheras AdjustiK/BoostiK System is not UL-approved but all its components are UL/UR - certified.

2.4 Labels

Front Panel

On the front panel next to the Emission LED there is the following warning laser label.

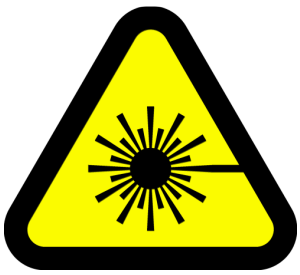


Figure 1: Front panel warning label

Laser Aperture

The following label is attached to the output fiber cable close to the optical output connector. This label tells the operator that this connector is where the Koheras AdjustiK/BoostiK System has its Class 3B/4 aperture.

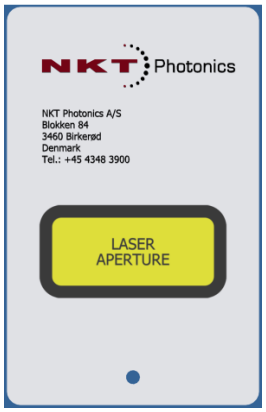


Figure 2: Aperture warning label

Classification Labels

Koheras AdjustiK/BoostiK Systems have one of the following two sets of warning labels on its top cover.

One label informs about laser classification level and that the system emits invisible laser light. The other label informs about maximum output power level and wavelength range.

Koheras AdjustiK System

Figure 3: Koheras AdjustiK System classification label

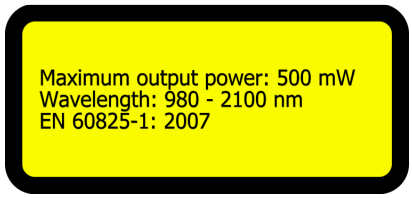


Figure 4 Koheras AdjustiK System radiation pattern

Koheras BoostiK System

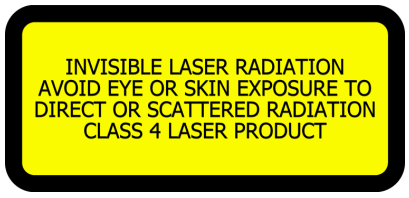


Figure 5: Koheras BoostiK System classification label

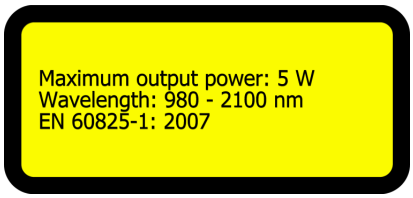


Figure 6 Koheras BoostiK System radiation pattern

3 Interface

3.1 Front Panel

Front Panel

The front panel of the Koheras AdjustiK/BoostiK System contains all optical and primary electrical connections on the system.

Figure 7: Front panel of the Koheras AdjustiK/BoostiK System

3.1.1 Output

Output Connector

The main optical output is emitted through an optical fiber cable with a narrow key FC/APC connector. For PM systems the light is emitted in the slow axis, which is aligned to the key of the connector.

Important

Note:
A FC/APC patch cable must always be connected to the output to prevent the optical connector from burning off. Failing to do so, can cause damage to the fiber facet.

3.1.2 Monitor

Monitor Output

The Koheras AdjustiK/BoostiK System features a monitor output from the seed laser in the system.

Note:
For Koheras AdjustiK Systems with amplification after the seed laser, and for Koheras BoostiK Systems the monitor output may be emitting even if the main output has been turned off.

3.1.3 Emission LED

Emission LED

Lit (red), when laser light is emitted from the system.

3.1.4 Key Switch

Key Switch

Laser emission is enabled using the key switch, i.e. the fiber laser and included power amplifiers cannot be turned on when the key is missing or in the 'Off' position. The key switch can also be used for resetting an alarm. In case of a laser emission the Emission LED on the front plate will be lit.

3.1.5 Display

Display — A display in the center of the front plate provides useful information about output power, wavelength and the status of the system. Together with the turning knob and the two push buttons the display provides an easy to use menu-driven interface for the user to monitor available signals and setup various parameters.

Marker — To the left on the display there is shown a '*', which is used as a marker to show the selected parameter in the menu. To change the selected parameter, use the turning knob and the '*' will move accordingly in the menu.

3.1.6 Turning Knob

Turning Knob — Right next to display and push buttons the system features a turning knob, which is used to browse through the menu-driven interface and to adjust a chosen parameter.

3.1.7 Push Buttons

Push Buttons — In between display and turning knob the system has two push buttons. The upper button is the Return button, which in the menu-based interface is used to return to the previous level in the menu. The Enter button is used to enter a deeper level in the menu or to change a chosen parameter.

3.1.8 USB Interface

USB Interface — The Koheras AdjustiK/BoostiK System has a USB interface for connection to a computer. Before establishing the connection between the Koheras AdjustiK/BoostiK System and a computer, a driver must be installed on the computer. The driver is available in the "USB driver" folder on the GraphiK installation CD.

Graphical User Interface — A graphical user interface, GraphiK, is available as an accessory for the Koheras AdjustiK/BoostiK System. Read the GraphiK manual for installation of the graphical user interface and how to use it.

3.2 Back Panel

3.2.1 Main Input

Power Supply

The Koheras AdjustiK/BoostiK System features its own AC/DC power supply, which provides the correct supply for the electronics inside the system.

The system has a universal main input allowing from 100 to 240 VAC, 50/60 Hz.

Main Input

The main input connector is a standard IEC C14 type of connector, which is the matching inlet type of connector for the IEC C13 type of connector. The Koheras AdjustiK/BoostiK system is a class I product, which must be earthed via the main input.

Fuse

The Koheras AdjustiK/BoostiK System holds two T2A / 250 VAC (5x20 mm) fuses for the power inlet. If one or both fuses need to be replaced, please make sure to use fuses with the same specifications.

Main Switch

Together with main input, the Koheras AdjustiK/BoostiK System has its main switch. When '0' is pressed in the system is turned off and when '1' is pressed in the system is turned on.

3.2.2 Piezo

Piezo

The Koheras AdjustiK/BoostiK System has the option for fast piezo tuning of the fiber laser wavelength.

The wavelength can be tuned by applying tensile strain to the fiber laser or by controlling the fiber laser temperature. Piezo controlled tensile strain provides fast tuning and is controlled by the voltage applied to the Piezo plug on the back panel of the Koheras AdjustiK/BoostiK System.

Piezo Tuning

The voltage applied to the piezo input must be within 0 to +200 Volts. Piezo tuning is enabled and disabled via the graphical user interface GraphiK. It is recommended to disable piezo tuning when it is not used, as noise may be picked up by the input and hereby create undesired phase noise.

The piezo voltage must be 0 Volts when piezo tuning is enabled and disabled.

The piezo tuning characteristics are given in Section Tuning Specifications. As seen in the corresponding graph, piezo tuning is associated with a certain amount of hysteresis and tolerances.

Piezo Connector

A LEMO 3-pin 0B-series connector is used for piezo connections with the pin-out shown in the figure below.

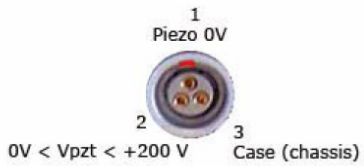


Figure 8: The Piezo female connector

Piezo Circuit

The electrical circuit for the piezo connection is shown in the figure below. Modulation can be disabled by a software controlled relay. The diodes in the circuit reduce risk of damaging the piezo if applied voltage is outside the specifications.

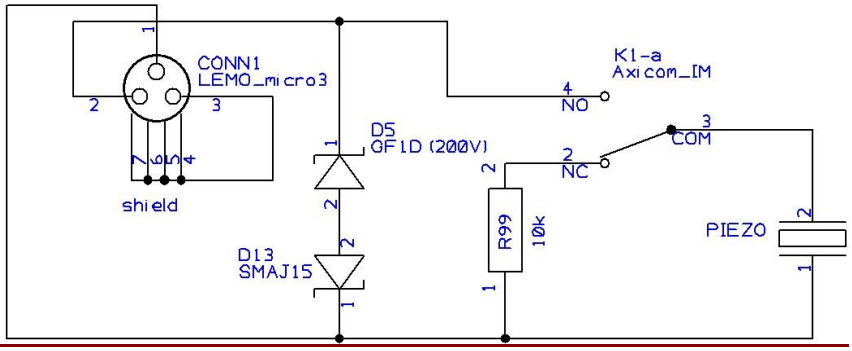


Figure 9: The Piezo input circuit

3.2.3 Interlock

Interlock Connector

On the back of the Koheras AdjustiK/BoostiK System there is an interlock connection. Laser emission can only be achieved when the two terminals of the interlock connector are short circuited.

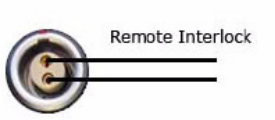


Figure 10: The female Interlock connector

This is a safety precaution that is build into the system, allowing the user to connect the system with e.g. a door switch, which will disable laser emission if someone opens the door.

3.2.4 Cooling fins

Cooling fins

Electrical power dissipated in the Koheras AdjustiK/BoostiK system is transferred to the back of system, where it has cooling fins. The cooling fins must not be covered by anything as the system otherwise may get overheated and automatically shut down.

4 Modular Design

The Koheras AdjustiK/BoostiK System is based on a modular design. The modular design enables easy replacement of specific module in case of malfunction. Each module has its own micro controller and a well defined interface between the modules. Each module can operate on its own, making them intelligent and the system in general convenient to work with. The modular concept also enables the possibility for later on power upgrades of a Koheras AdjustiK System to e.g. a Koheras BoostiK System. The system can be configured in the following ways:

Koheras AdjustiK System — The Koheras AdjustiK System features only one optical module, which is a laser module.

Koheras AdjustiK High Power System — The Koheras AdjustiK High Power System features two optical modules, which are a laser module in conjunction with a pre-amplifier module.

Koheras BoostiK System — The Koheras BoostiK System features three optical modules, which are a laser module in conjunction with a pre-amplifier and a double clad fiber amplifier module.

4.1 System

Frame — The frame can hold a number of optical modules such as laser module, pre-amplifier module and double clad fiber amplifier module.

Electronics — The frame also holds its own electronics and power supply. The electronics operates as the master controller in the system. This master controller provides the USB interface and the communication with the other modules inside the Koheras AdjustiK/BoostiK System.

Master Module — In the system itself, the communication module operates as a master module, which regularly scans the other modules inside the system for alarms/warnings. In case of an alarm/warning, the display on the front plate will indicate a warning.

4.1.1 Warnings

Warning States — A warning is associated with all of the below listed indicators. Every warning can have one of the following states:

- High Alarm, the given parameter exceeds its high limit
- High appearance, the given parameter earlier exceeded its high limit but is back within acceptable range
- OK, within acceptable range
- Low appearance, the given parameter earlier dropped below its low limit but is back within acceptable range
- Low Alarm, the given parameter is below its low limit

4.1.2 Functions

Reset

If one or more alarms still appear, after the parameters are back within their respective acceptable ranges, the alarms can be reset via the menu based interface.

In the main menu, select More Menus, select Warnings and following Clear Warnings.

Restore Factory Defaults

If the user has changed one or multiple controls, and wants to set everything back as when the Koheras AdjustiK/BoostiK System left the factory, this is done via the menu based interface.

In the main menu, select Restore Factory Defaults.

4.2 Laser Module

Laser Module

The laser module used in the Koheras AdjustiK/BoostiK System is a Koheras BasiK™ laser module. Please refer to the manual for the Koheras BasiK™ module for more detailed information about the laser module.

4.2.1 Controls

Control Signals

The laser module has the following control signals that can be controlled:

- Pump temperature setpoint (only via graphical user interface)
- Tuning mode
- Fiber laser setpoint
- Regulation mode
- Setpoint
- Piezo
- RIN suppression
- Laser emission

Pump Temperature Setpoint

The temperature of the pump laser diode can be controlled by a Peltier element integrated in the pump package. The electronics is only capable of cooling down the laser diode. If the module temperature is lower than the pump temperature setpoint and relatively little power is dissipated in the pump, the temperature may be lower than the pump temperature setpoint.

The pump temperature can only be changed via the graphical user interface, GraphiK.

Tuning Mode

The tuning mode selector can be set to control the fiber laser either by temperature or wavelength. The two modes are closely related to each other, as the relation between temperature and wavelength is a simple calculation based upon a calibration of the laser module when it was manufactured.

The actual wavelength may differ a bit from the setpoint. If the fiber laser has a built-in Piezo control, the Piezo voltage will change the wavelength. When the Piezo is activated there may also be some hysteresis due to charge build up in the Piezo.

Fiber Laser Setpoint

If the Tuning mode selector is set to Temperature the tuning of the fiber laser is specified in degrees Celsius. If the Tuning mode selector is set to Wavelength, the tuning of the fiber laser is in nm.

Regulation Mode

Selector which sets the laser module to be controlled by constant pump current or module output power. With the Regulation mode selector set to constant current the module will ensure a stable current in the pump laser.

If the selector set to constant power, the module will adjust the pump current to compensate for power loss variations in the various optical components.

Only for a Koheras AdjustiK System without pre-amplifier the regulation mode can be changed on the front plate for the laser module. For Koheras AdjustiK High Power Systems and Koheras BoostiK Systems the front plate control will change the regulation mode for the pre-amplifier module or double clad fiber amplifier module respectively.

Setpoint

If the Regulation mode selector is set to Constant current the setpoint is specified in mA. If the Regulation mode selector set to Constant power the setpoint is specified in mW.

Only for a Koheras AdjustiK System without pre-amplifier the setpoint can be changed on the front plate for the laser module. For Koheras AdjustiK High Power Systems and Koheras BoostiK Systems the front plate control will change the setpoint for the pre-amplifier module or double clad fiber amplifier module respectively.

Piezo

Applicable for systems purchased with piezo tuning. The piezo tuning of each laser can be enabled or disabled. It is recommended to disable piezo tuning when not used, to eliminate potential noise pick up.

RIN Suppression

Suppression of Relative Intensity Noise can be activated or deactivated by the RIN suppression control.

RIN suppression is only possible for E15 systems, and not Y10 or C15 systems.

Laser Emission

The output from the laser module can be enabled and disabled by the laser emission control.

For a Koheras AdjustiK High Power System and a Koheras BoostiK System, the laser emission control on the front plate will control emission from pre-amplifier and double clad fiber amplifier modules as well.

4.2.2 Indicators

Front Panel Monitoring

Via the display on the front panel, the output power of the system is monitored. Dependant on whether the laser is set to operate in temperature tuning or wavelength tuning, the temperature or its corresponding wavelength of the fiber laser is monitored on the front panel as well.

Graphical User Interface Monitoring

Via the graphical user interface, GraphiK, several signals can be monitored. The monitor signals are split into two rows, one for primary indicators and another one for secondary indicators.

Primary Indicators

The laser module has the following primary indicator signals that can be monitored:

- Module temperature, measured in ℃
- Pump temperature, measured in ℃
- Pump stable/tuning, indicates whether the pump temperature is stable or tuning
- Fiber laser wavelength, measured in nm
- Fiber laser temperature, measured in ℃
- Fiber laser stable/tuning, indicates whether the fiber laser temperature/wavelength is stable or tuning
- Pump current, measured in mA
- Pump PD current, measured in mA
- Module output power, measured in mW

Secondary Indicators

In addition to the above indicators, the laser module has the following secondary indicators:

- Pump peltier current, measured in mA
- Fiber laser peltier current, measured in mA. A positive current when cooling.
- Pump voltage, measured in V
- Pump driver voltage, measured in V
- Module input voltage, measured in V

4.3 Pre-Amplifier Module

Pre-Amplifier Module

In Koheras AdjustiK High Power Systems and Koheras BoostiK Systems there is a pre-amplifier connected to the output of the laser module. In Koheras AdjustiK High Power Systems the output of the pre-amplifier provides the optical output of the overall system, but on Koheras BoostiK Systems the pre-amplifier provides the input signal to the following double clad fiber amplifier module.

Amplification Stages

The pre-amplifier module is capable of holding two amplification stages. Therefore it is capable of holding two pump laser diodes. Dependant on the optical configuration of the pre-amplifier module a specific module holds either one or two pump diodes.

4.3.1 Controls

Control Signals

The pre-amplifier module has the following control signals that can be controlled:

- Pump temperature setpoint
- Regulation mode
- Setpoint
- Pre-Amplifier On/Off

Pump Temperature Setpoint

The temperature of the pump laser diode can be controlled by a Peltier element integrated in the pump package. The electronics is only capable of cooling down the laser diode. If the module temperature is lower than the pump temperature setpoint and relatively little power is dissipated in the pump, the temperature may be lower than the pump temperature setpoint.

As the pre-Amplifier module can hold up to two pump diodes, the pump temperature setpoint controls both potential pump diodes.

Regulation Mode

Selector which sets the laser module to be controlled by constant pump current or module output power. With the Regulation mode selector set to constant current the module will ensure a stable current in the pump laser.

If the selector set to constant power, the module will adjust the pump current to compensate for power loss variations in the various optical components.

Only for a Koheras AdjustiK High Power Systems the regulation mode can be changed on the front plate for the pre-amplifier module. For Koheras BoostiK Systems the front plate control will change the regulation mode for the double clad fiber amplifier module.

Setpoint

If the Regulation mode selector is set to Constant current the setpoint is specified in mA. If the Regulation mode selector set to Constant power the setpoint is specified in mW.

Only for a Koheras AdjustiK High Power Systems the setpoint can be changed on the front plate for the pre-amplifier module. For Koheras BoostiK Systems the front plate control will change the setpoint for the double clad fiber amplifier module.

Pre-Amplifier On/Off

The output from pre-amplifier module can be enabled and disabled by the laser emission control.

4.3.2 Indicators

Front Panel Monitoring

For a Koheras AdjustiK High Power System the output from the pre-amplifier module the output power of the system is monitored via the display on the front panel.

Graphical User Interface Monitoring

Via the graphical user interface, GraphiK, several signals can be monitored. The monitor signals are split into two rows, one for primary indicators and another one for secondary indicators.

Primary Indicators

The laser module has the following primary indicator signals that can be monitored:

- Pump1 temperature, measured in °C
- Pump2 temperature, measured in °C
- Pump1 current, measured in mA
- Pump2 current, measured in mA
- Pump1 PD current, measured in mA
- Pump2 PD current, measured in mA
- Module input power, measured in mW
- Module output power, measured in mW

Secondary Indicators

In addition to the above indicators, the laser module has the following secondary indicators:

- Module temperature, measured in °C
- Pump1 peltier current, measured in mA
- Pump2 peltier current, measured in mA
- Pump driver voltage, measured in V
- Module input voltage, measured in V

4.4 Double Clad Fiber Amplifier Module

Double Clad Fiber Amplifier Module

In Koheras BoostiK Systems there is a Double Clad fiber amplfier module connected to the output of the pre-amplifier module. The double clad fiber amplifier module provides the optical output signal for the overall Koheras BoostiK System.

4.4.1 Controls

Control Signals

The double clad fiber amplifier module has the following control signals that can be controlled:

- Regulation mode
- Setpoint
- Booster On/Off

Regulation Mode

Selector which sets the double clad fiber amplifier module to be controlled by constant pump current or module output power. With the Regulation mode selector set to constant current the module will ensure a stable current in the pump laser.

If the selector set to constant power, the module will adjust the pump current to compensate for power loss variations in the various optical components.

Setpoint

If the Regulation mode selector is set to Constant current the setpoint is specified in A. If the Regulation mode selector set to Constant power the setpoint is specified in W.

Booster On/Off

The output from the double clad fiber amplifier module be enabled and disabled by the Booster On/Off control.

4.4.2 Indicators

Primary Indicators

The double clad fiber amplifier module has the following primary indicator signals that can be monitored:

- Module temperature, measured in °C
- Pump temperature, measured in °C
- Pump current, measured in A
- Input power, measured in mW
- Reflected power, measured in mW
- Output power, measured in W

Secondary Indicators

In addition to the above indicators, the double clad fiber amplifier module has the following secondary indicators:

- Pump voltage, measured in V
- Module input voltage, measured in V

Input Power

To ensure stable and reliable operation, the input power to the double clad fiber amplifier module must be above a pre-defined minimum level. To ensure this, the double clad fiber amplifier module continuously monitors the input power level. If the input power level is below the threshold level, the double clad fiber amplifier, and hereby the output of the Koheras BoostiK System cannot be activated. If the input power level in case of a malfunctioning drops below the threshold level, the double clad fiber amplifier is automatically deactivated. If the input power for some reason increases above the input power threshold level, the double clad fiber amplifier stays deactivated and wait for the operator to activate manually.

Reflected Power

To ensure stable and reliable operation, the level of reflected power (e.g. from Stimulated Brillouin Scattering) must be below a pre-defined maximum level. To ensure this, the double clad fiber amplifier module monitors the reflected power level. If the reflected power level exceeds the threshold level, the double clad fiber amplifier is automatically deactivated. To activate the amplifier, and hereby the output of the Koheras BoostiK System, again the alarm must be cleared via either the turning knob, push buttons and the menu-driven interface or the GraphiK user interface.

5 Operation

5.1 Operation Precautions

5.1.1 Clean Surfaces!

Output

Due to the high power transmitted through the single mode fiber surface of the FC/APC connector it is **important to keep the connector surface extremely clean**. For this reason a clean patch cable must be connected to the output at all time when used. In this way the connector in the other end of the patch cable is the one that most likely will be exposed to impurities.

Please note which fiber type has been applied on the laser and match the patch cord accordingly.

Wipe with clean lens tissue soaked in alcohol and dry with another piece of dry clean lens tissue. Keep unit turned off while cleaning.

5.2 Turning the Koheras AdjustiK/BoostiK System On

Turning The System On

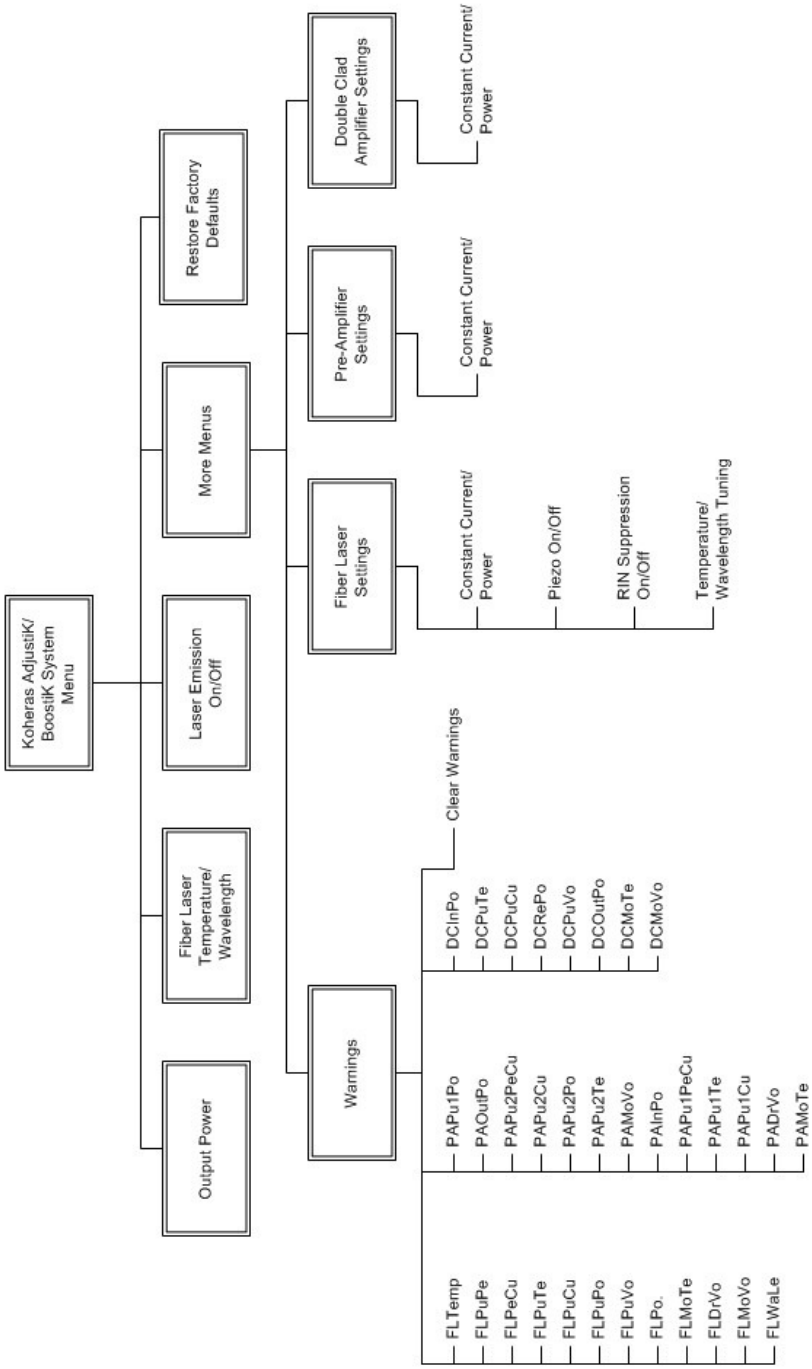
Use the following procedure to turn the system on.

Step	
1	Connect the Interlock according to safety regulations.
2	Clean and connect the optical output connector from the Koheras AdjustiK/BoostiK System to what system or instrument it is desired to be used with.
3	Connect 115/230 VAC, 50/60 Hz to the main inlet.
4	Switch the key switch from 'Off' to 'On' position.
5	Control the unit either by the menu-driven interface or the GraphiK user interface that is available for the system.

5.3 Koheras AdjustiK/BoostiK System Menu

Menu-driven Interface

In this section the menu-driven interface is described how it works and where to find a certain parameter.



In the top of the menu the user has the possibility to monitor and adjust output power and wavelength. Furthermore there is the possibility to turn on/off laser emission, select more menus or restore factory defaults.

Outputpwr

To adjust the output power level use the turning knob to move the '*' cursor to the outputpwr line and press the Enter button. The display window changes and a scrolling bar will show up for either the pump current or output power setpoint dependant on whether the system is set to operate in constant current or constant power mode. Use the turning knob to change the adjustment and press Enter to accept the change.

Temp/Wavelen

To adjust the fiber laser wavelength use the turning knob to move the '*' cursor to FL Temp/Wavelen line and press the Enter button. The display window changes and a scrolling bar will show up for either the fiber laser temperature or wavelength dependant on whether the system is set to operate in temperature or wavelength tuning mode respectively. Use the turning knob to change the adjustment and press Enter to accept the change.

Laser On/Off

In the top menu, move the '*' cursor to the third line from the top to enable/disable the output. Click on the enter button to change the state. Laser On means that output is enabled and Laser Off means that output is disabled.

Please notice that in Koheras AdjustiK High Power and BoostiK Systems laser emission from the seed laser is not disabled, but only amplification in the last output stage. In these cases limited laser emission from the seed laser will pass through the amplification stage.

More Menues

Move the '*' cursor in the top menu to the More Menues line and click on Enter to get into the More Menues menu. The following menu gives the user the possibility to choose between following:

- Warnings
- Fiber laser settings
- Pre-amp settings
- DC amp settings

Warnings

Move the '*' cursor to the Warning line to view the actual status on all warning flags in the system.

Warning flags related to the laser module begins with FL.

- FLTemp: Fiber laser temperature
- FLPuPe: Pump peltier current
- FLPeCu: Fiber laser peltier current
- FLPuTe: Pump temperature
- FLPuCu: Pump current
- FLPuPo: Pump power
- FLPuVo: Pump voltage
- FLPo: Module output power
- FLMoTe: Module temperature
- FLDrVo: Driver voltage
- FLMoVo: Module input voltage
- FLWaLe: Calculated laser wavelength

Warning flags related to the pre-amplifier module (for Koheras AdjustiK High Power and BoostiK Systems) begins with PA.

- PAPu1Po: Pump 1 power
- PAOutPo Module output power
- PAPu2PeCu: Pump 2 peltier current
- PAPu2Cu: Pump 2 current
- PAPu2Po: Intermediate power
- PAPu2Te: Pump 2 temperature
- PAMoVo: Module input voltage
- PAInPo: Module input power
- PAPu1PeCu: Pump 1 peltier current
- PAPu1Te: Pump 1 temperature
- PAPu1Cu: Pump 1 current
- PADrVo: Driver voltage
- PAMoTe: Module temperature

Warning flags related to the DC amplifier module (for Koheras BoostiK Systems) begins with DC.

- DCInPo: Input power
- DCPuTe: Pump temperature
- DCPuCu: Pump current
- DCRePo: Reflected power
- DCPuVo: Pump voltage
- DCOutPo: Module output power
- DCMoTe: Module temperature
- DCMoVo: Module input voltage

Fiber Laser Settings

In More Menues, move the '*' cursor to the Fiber laser settings line and click on Enter, to get control of more functions in the laser module.

With the '*' cursor in the top line, click on Enter to change between Constant current and Constant power. With the fiber laser module set to operate in Constant current mode, the current in the pump laser is held constant. With the module set to operate in Constant power, the power out of the fiber laser module is held constant.

With the '*' cursor in the second line from the top, click on Enter to enable or disable the piezo input to the fiber laser (option). When the display reads out Piezo ON, this means that there is connection from the piezo connector on the back of the system to the piezo in the fiber laser. When the display reads out Piezo OFF the piezo in the fiber laser is shorted and the connection to the piezo connector on the back of the system is disconnected.

Move the '*' cursor to the third line from the top and click Enter to enable or disable RIN suppression (only for E15 systems). With the display reading out RIN suppression ON, an electronic circuit suppresses the intensity noise at the RIN peak. With RIN suppression OFF the electronic suppression is disabled.

With the '*' cursor in the fourth line, click on Enter to shift between Temperature tuning and Wavelength tuning. With the display reading out Temperature tuning, the system will read out the fiber laser temperature in the main menu of the system and setpoint changes to the fiber laser is made in degrees Celsius. With the display reading out Wavelength tuning, the system will read out the estimated fiber laser wavelength and setpoint changes is made in nanometers.

Pre-Amplifier Settings

For Koheras AdjustiK High Power and BoostiK Systems, move the '*' cursor to the pre-amplifier setting line in More menues and click on Enter to control settings in the pre-amplifier module.

Click on the Enter button to shift between Constant current and Constant power. With the pre-amplifier module set to operate in Constant current the current in pump 1 is held constant. With the module set to operate in Constant power the output power of the pre-amplifier module is held constant.

Double-Clad Amplifier Settings

For Koheras BoostiK Systems, move the '*' cursor to the DC Amplifier Settings in More menues and click on Enter to control settings in the Double-Clad Amplifier module.

Click on the Enter button to shift between Constant current and Constant power. With the Double-Clad Amplifier module set to operate in Constant current the current in the pump is held constant. With the module set to operate in Constant power the output power of the Double-Clad Amplifier module is held constant.

Clear Warnings

If the system has indicated a warning and the reason for this warning has disappeared, the warning can be cleared in More menues by moving the *'* cursor to Clear Warnings and clicking on the Enter button.

Restore Factory Defaults

To bring back the system in its original configuration, move the '*' cursor to Restore Factory Defaults in the top menu, and click on Enter.

6 Service

Output

The Koheras AdjustiK/BoostiK System does not contain any user serviceable parts. If the system starts to malfunction, consult NKT Photonics A/S. The unit is sealed with a label “WARRANTY VOID IF REMOVED” and the chassis should under no circumstances be opened.

The chassis may be cleaned with a damp cloth. The connector of the optical cable going into the optical output may be cleaned by rubbing it with clean lens paper soaked in clean ethanol and subsequently with clean lens paper. This will remove any dust and grease.

The primary output power connector must be protected at all times against accumulation of dust or grease and against mechanical damage.

7 Accessories

7.1 Interlock and Piezo Plugs

Interlock Plug

A cable plug for the Interlock connection on the back of the system is provided with the Koheras AdjustiK/BoostiK System. This plug is a LEMO connector type FGG.0B.302 with art. no. 927-302-00.

Piezo Plug

For Koheras AdjustiK/BoostiK Systems that feature piezo modulation a LEMO connector type FGG.00.303 is provided with the system as well for connection with the Piezo connector on the back of the system. The connector has art. no. 927-303-00.

Figure 11: Interlock and Piezo plug

The two types of LEMO plugs are of the same size and type. The only difference between the two plugs, is that the Interlock plug is a 2-pole connector whereas the Piezo plug is a 3-pole connector. Please make sure to use match the plugs and connectors correctly.

7.2 Connection to a PC

PC Interface

For easy interface to a PC, the following optional accessories are available:

Accessories (Art. no. 205-506-00)	
Art. no.	Description
920-001-01	USB cable AB, 2m
510-001-06	GraphiK Installation CD

7.2.1 USB Cable

USB Cable

To connect the Koheras AdjustiK/BoostiK System to a standard computer, a standard USB cable A to B is available.

Figure 12: USB cable A to B

Before installing and trying to run the graphical user interface for the Koheras AdjustiK/BoostiK System, it is recommended to install the USB driver first, which is available in the “USB driver” folder on the GraphiK Installation CD.

7.2.2 GraphiK

GraphiK

A graphical user interface called GraphiK is available for Windows XP. This application enables together with the USB cable an easy control and monitoring of the Koheras AdjustiK/BoostiK System.

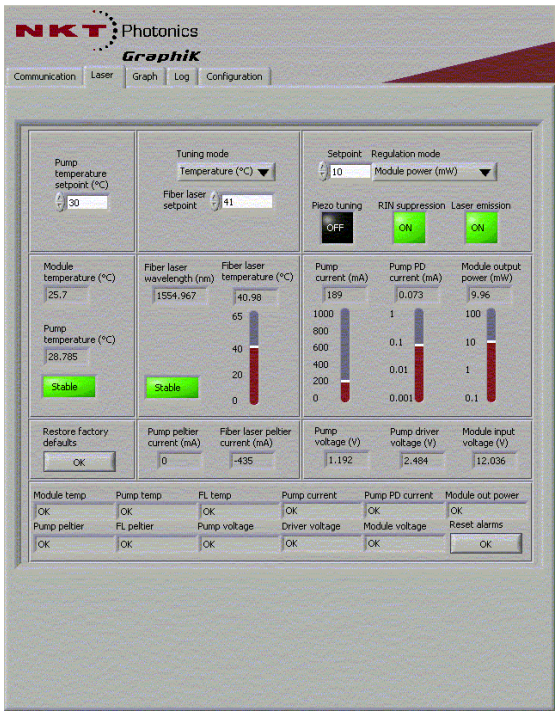


Figure 13: GraphiK user interface

8 Specifications

8.1 Environmental Specifications

Parameter	Conditions	Value	Unit
Temperature, operating	Module temperature measured with internal sensors	15 to 50	°C
Temperature, storage		-20 to 50	°C
Humidity	Non condensing	0 to 70	% RH
Vibration	@ 15 to 200 Hz	0.2	G

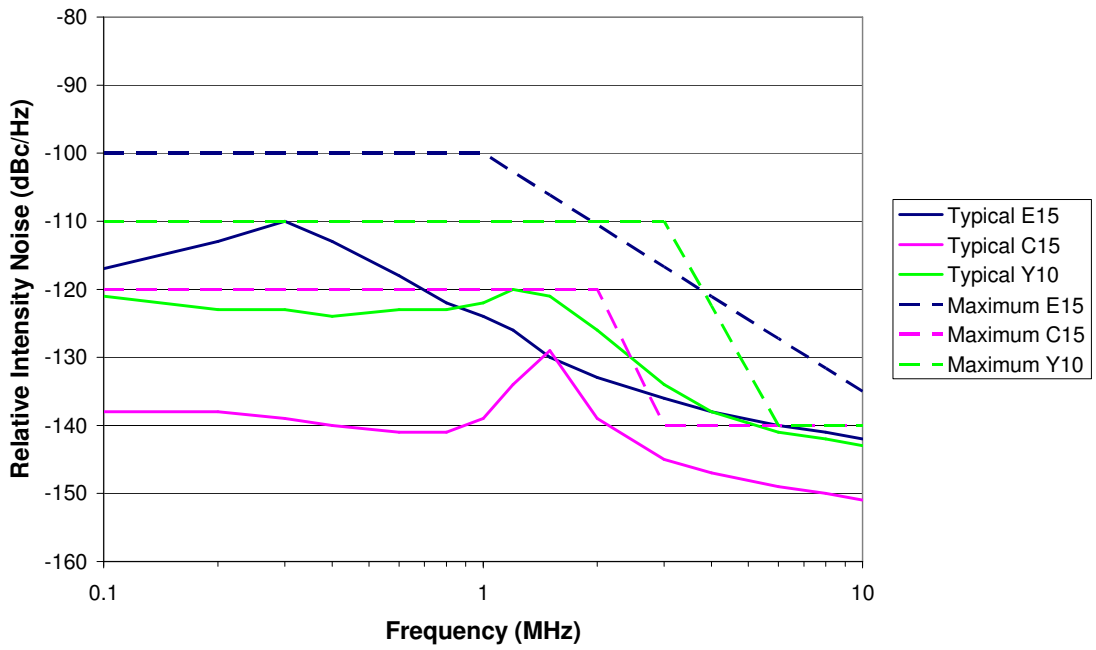
8.2 Tuning Specifications

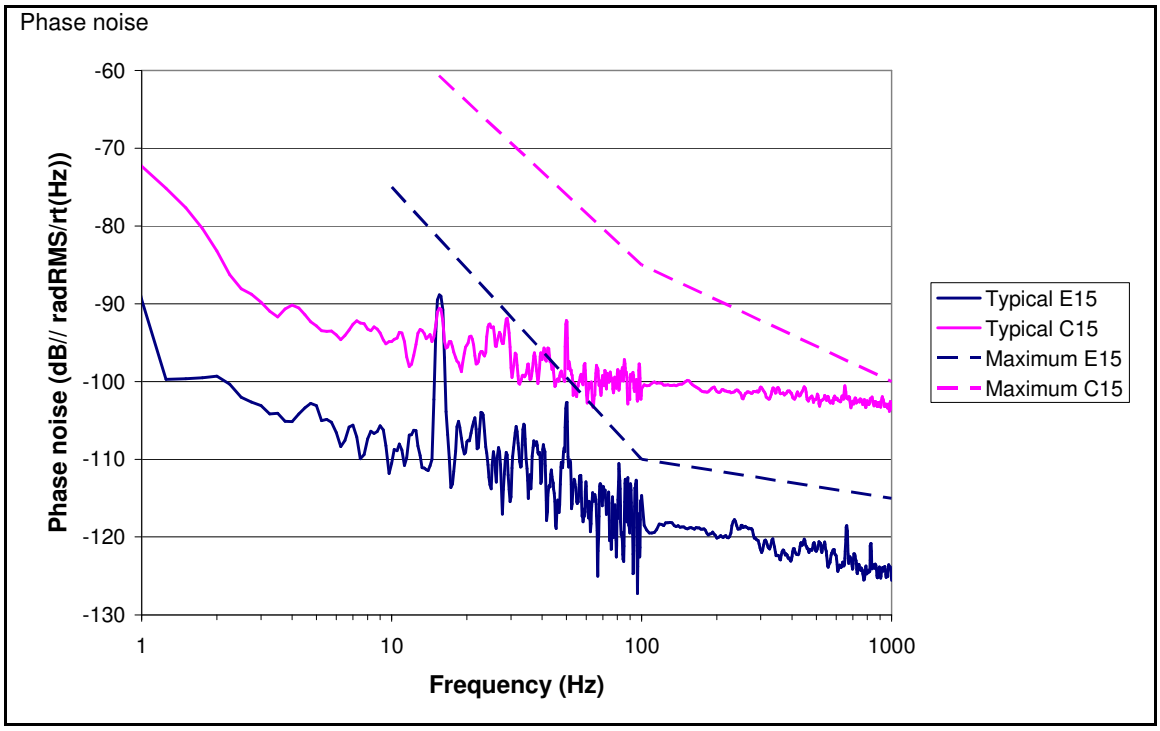
Parameter	Conditions	Value		Unit
		Standard	Wide piezo tuning range (option)	
Thermal tuning range @ room temperature	E15/C15	Min. +200/-400		pm
	Y10	Min. +150/-300	Min. +60/-120	pm
Wavelength accuracy	Deviation from specified wavelength. Piezo disabled.	Typ. <+/-20 Max. +/-50		pm
Piezo tuning range (option)	E15/C15	Min. 16, Typ. 22		pm
	Y10	Min. 9, Typ. 14	Min. -150, Typ. -250	pm
Piezo input capacitance (option)		Typ. 32	Typ. 920	nF
Piezo modulation frequency (option)	Sinusoidal mod. signal	Max. 20		kHz
Piezo-electric slew rate (option)	Sinusoidal mod. signal	Max. 100	Max. 4	V/ms

8.3 Other Optical Specifications

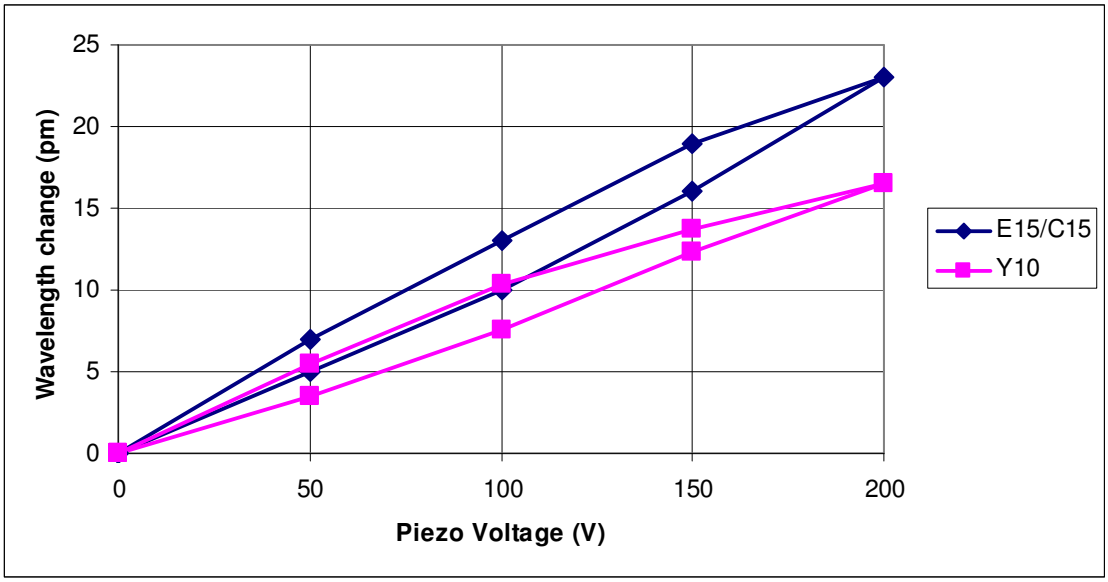
Parameter	Conditions		Value	Unit
Warm-up time	Stable wavelength and output power		Typ. 5, Max. 20	Minutes
Signal to ASE @ 50 pm resolution	Koheras AdjustiK System	E15	Min. 50, Typ. 55	dB
		C15	Min. 70, Typ. 75	
		Y10	Min. 65, Typ. 70	
	Koheras AdjustiK High Power and Koheras BoostiK System		Min. 50, Typ. 55	
Polarization Extinction Ratio (option)	Lowest value measured over 1 minute		Min. 16, Typ. 22	dB
Power variation @ 6 hours	Nominal power		Typ. <0.1, Max. 0.3	dB
Line width, 120 µs, HWHM	E15		Max. 1	kHz
	C15		Max. 60	
	Y10		Max. 80	

Relative Intensity Noise

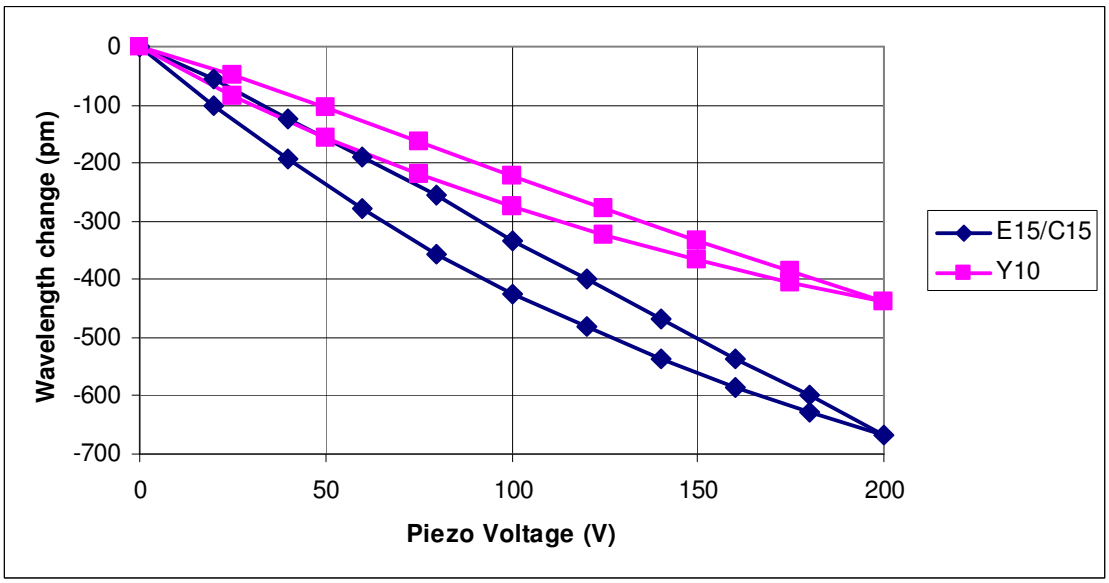



Phase noise
-60
-70
-80
-90
-100
-110
-120
-130
Phase noise (dB// radRMS/rt(Hz))
1
10
100
1000
Frequency (Hz)
Typical E15
Typical C15
Maximum E15
Maximum C15

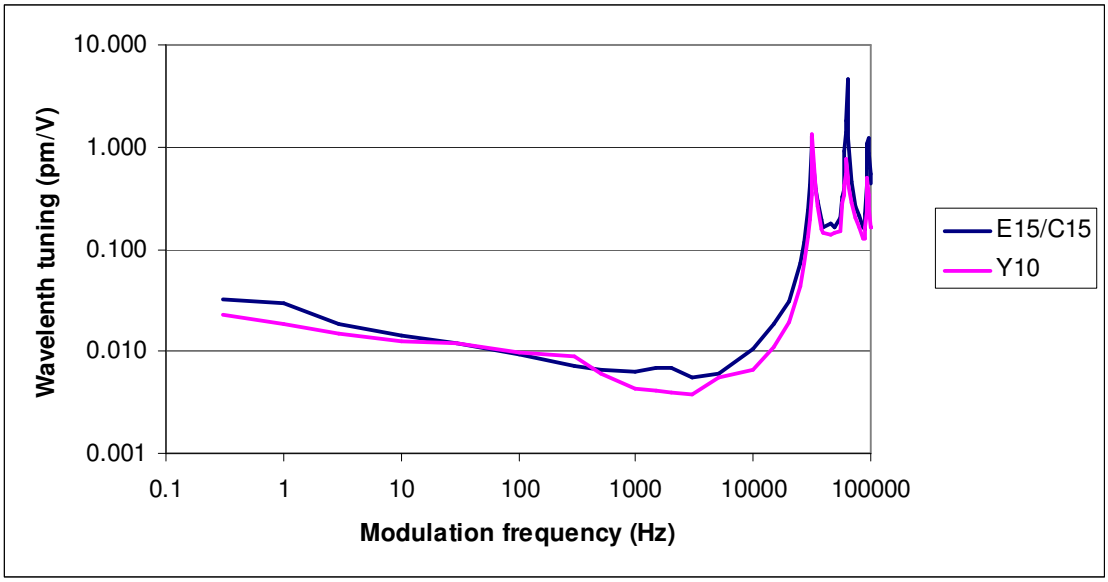
Typical Standard piezo tuning @ DC (option)



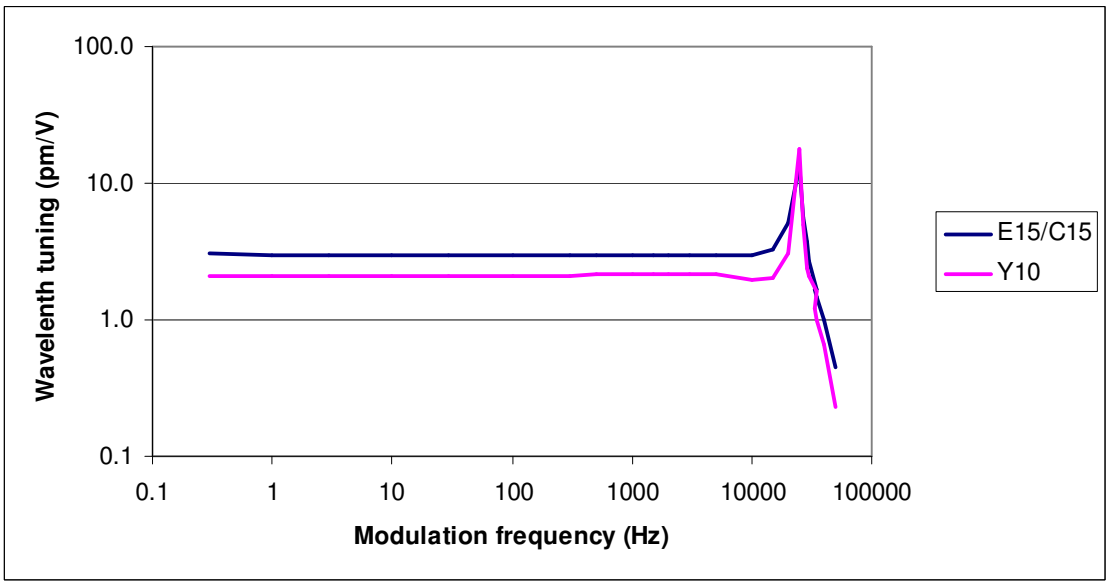
Typical Wide piezo tuning @ DC (option)



Typical Standard piezo response (option)



Typical Wide piezo response (option)



8.4 Electrical Specifications

Parameter	Conditions	Value	Unit
Supply voltage		85 to 264	VAC
Supply current		Max. 1	A
Piezo input voltage (option)		0 to 200	V

8.5 Mechanical Specifications

Parameter	Conditions	Value	Unit
Size		See drawing below.	
Weight		Typ. 6.5-8.5	kg
Optical fiber cable length		Typ. 1	m

8.5.1 Mechanical Drawing