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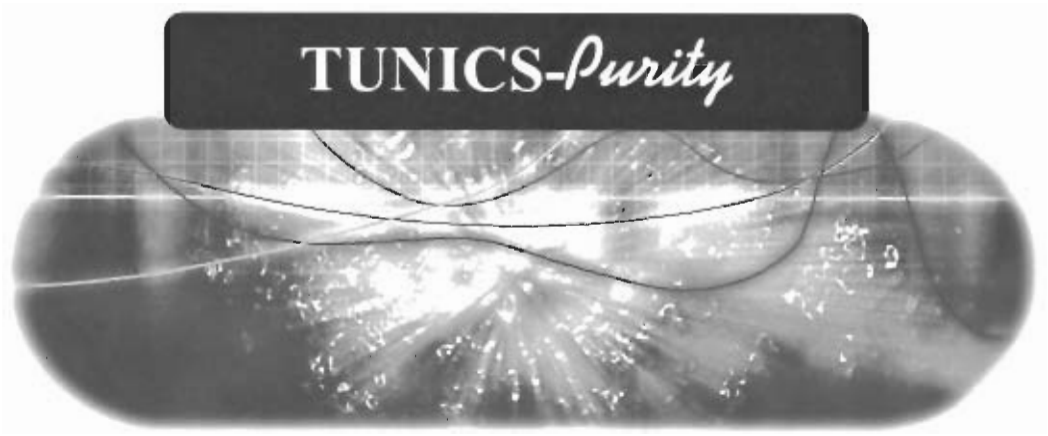
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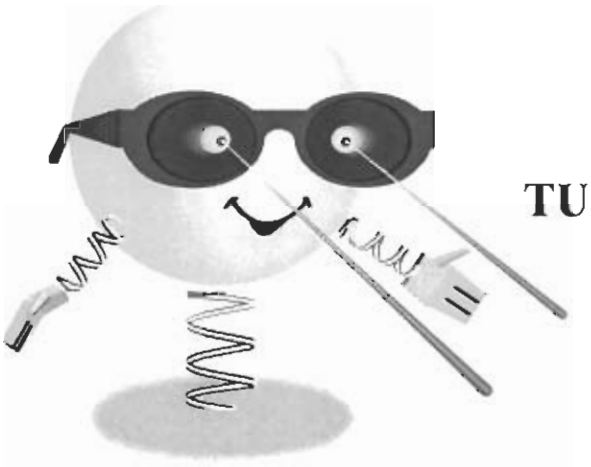
TUNABLE EXTERNAL CAVITY LASER

Instruction Manual

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April 2002

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TUNICS-*Purity*

TUNABLE EXTERNAL CAVITY LASER

Instruction Manual

NetTest Photonics Division (formerly Photonetics)

NetTest A/S
Kirkebjerg Allé 90, DK-2605 Brøndby Denmark Tel +45 72 11 22 00 Fax +45 72 11 22 10
E-mail: com@nettest.dk Web: www.nettest.com

NetTest Sales Companies
- *Australia +61 39 890 6677* • *Canada +1 905 479 8090* • *China +86 10 64 67 88 88*
- *Nordic +45 72 11 23 00* • *France +33 (0)1 61 34 34 34* • *Italy +39 02 95 12 621*
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- *Sweden +46 8 555 410 65* • *UK +44 1295 26 77 55* • *USA +1 978 983 3800*

NetTest Photonics SAS
45, avenue Jean-Jaurès, BP 81, 78344 Les Clayes Sous Bois
Tel +33 (0)1 61 34 34 34 Fax +33 (0)1 61 34 90 00 E-mail: info.photonics@nettest.com
Web: www.nettest.com

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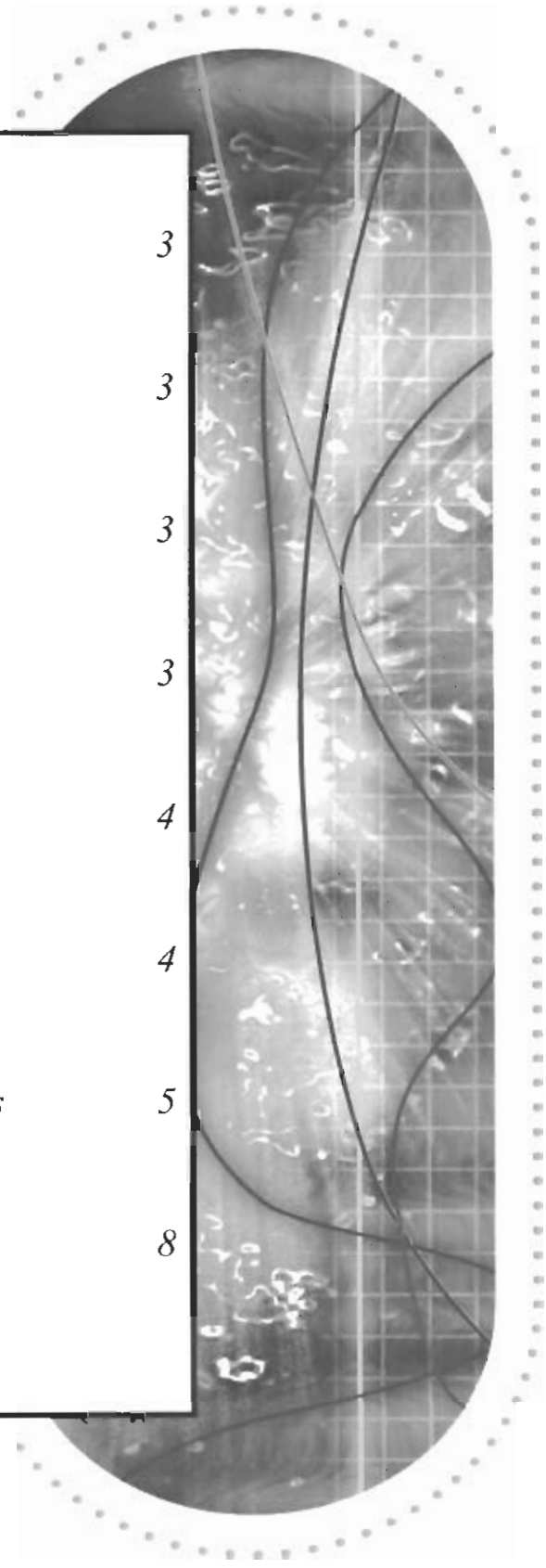
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About this MANUAL

Purpose

The purpose of this instruction manual is to explain how to set up the TUNICS-*Purity* and to utilize the various features and the available control modes:

- TUNICS-*Purity* manual mode
- RS-232C and IEEE-488.1 remote modes

Information in this manual applies to TUNICS-*Purity* series including TUNICS-*Purity* S. TUNICS-*Purity* SC and *Purity* CL models, as well as their various options.

Audience

This manual is for anyone wishing to use a TUNICS-*Purity* Tunable External Cavity Laser to test fiber-optic systems and components as well as all other performance-intensive laser source applications.

This manual's architecture and its contents are designed to appeal to professionals with the necessary technical background and prerequisites needed to use this type of laser equipment.

Prerequisites

For this instruction manual it is assumed that you:

- Are familiar with fiber optic technology.
- Are familiar with the RS-232 C and/or IEEE-488.1 interfaces used to control the TUNICS-*Purity* in the remote modes.

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About this MANUAL

Introduction

This manual is divided into:
- Contents
- Chapters
- Appendices

To aid in searching for specific information, you will find clearly marked divider pages that indicate the various sections of the manual.

Chapters/Appendices

This document consists of six chapters designed to guide you through a correct installation/operation of your laser equipment. It also introduces theoretical/design considerations and provides servicing/maintenance information, as well. In addition, you will find four appendices that contain useful information on troubleshooting the system, the valid range of parameters setting, the product certification and declarations of compliance, and a list of replaceable parts.

Chapter/Appendix	Main Topics Covered
General Information	• Product Overview • Optical Design • ASE-noise-free Operation • Benefits • Specifications
Getting Started	• Unpacking • Standard Accessories • Options • Installation & First-Time Operation
Front & Rear Panels	• Front Panel • Rear Panel
Operation	• Introduction • Most Commonly Used Functions • Advanced Functions • Internal Wavelength Referencing • Auxiliary Inputs and Outputs
Remote Control	• Introduction • RS-232 C Remote Control • IEEE-488.1 Remote Control
Service Information	• Performance Verification • Maintenance
Appendices	• Appendix A: Error and Warning Messages • Appendix B: Valid Range for Parameter Setting • Appendix C: Certification and Compliance • Appendix D: Replaceable Parts • Index

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General Safety Considerations

Terms and Symbols in this Manual

The following terms and symbols may appear throughout this manual:

	***WARNING***	Warning statements identify conditions or practices that could result in injury or loss of life.
	***CAUTION***	Caution statements identify conditions or practices that could result in damage to this product or other property.

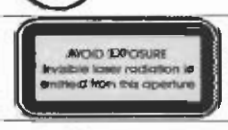
Terms on the Product

The following terms may appear on the product:

DANGER	Indicates an injury hazard immediately accessible as you read the marking.
WARNING	Indicates an injury hazard not immediately accessible as you read the marking.
CAUTION	Indicates a hazard to property, including the product itself.

Symbols and Labels on the Product

The following symbols and labels may appear on the product:

	**CAUTION**: refer to manual
	**Risk of** electric shock
	**Protective Ground (Earth) Terminal**
	**AVOID** EXPOSURE Label (located on the front panel.)
	**LASER** SYMBOL Label (located on the fiber-optic connector cover on the front panel.)
	Laser Class IIIb DANGER-Label, Electrical Warning, Fuse Description, and Standard Compliance (This label is located on the rear panel.)

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Laser Safety

The following tables provide information on general laser specifications, laser class, maximum wavelength ranges, and output power of the various TUNICS-*Purity* models and options.

General Laser Specifications

Laser type	External cavity laser diode
Laser output	Single mode optical fiber
Output divergence (full angle @ $1/e^2$)	0.18 rad

Laser Class

Standard	**Laser Class**
IEC 60825-1	Class 3A
21 CFR Subchapter J	Class IIIb

Note: TUNICS-*Purity* is a Class IIIb product (21 CFR Subchapter J) equipped with a Remote Interlock connector (See the *Auxiliary Inputs and Outputs* section).

Absolute Maximum Ratings

TUNICS Model	***Purity* S**	***Purity* SC**	***Purity* CL**
Wavelength range (nm)			
P = 0 dBm (Standard)	1430-1530	1470-1570	1525-1625
P = 3 dBm	1450-1510	1510-1570	1560-1620
Standard power range	10 mW	10 mW	10 mW
3 dBm range	15 mW	15 mW	15 mW

⚠	***WARNING***	**The use of controls or adjustments not specified herein as well as the performance of unauthorized procedures may result in hazardous radiation exposure.**
⚠	***WARNING***	**The use of optical instruments with this product will increase eye hazard.** Do **not** under any circumstances look directly into the fiber end of an optical cable attached to the optical output while the device is in use for this may cause permanent eye damage and possible loss of eyesight. Note that the laser radiation is not visible to the human eye, therefore, protective cap must always be replaced on the laser output connector after use to avoid involuntary exposure to laser radiation.
⚠	***WARNING***	**Disable the laser output before connecting or disconnecting a fiber optic cable on the instrument.**

Equipment Safety Warning

If this equipment is mishandled, abused, or used in a manner not as specified by NetTest in this instruction manual, the protection provided by the equipment may be impaired.

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Electrical Safety

	*WARNING*	**Power Supply Safety Requirements** TUNICS-*Purity* is intended to operate from a power source that does not apply more than 265 volts RMS between the supply conductors or between either of the supply conductors and the ground. TUNICS- *Purity* has a chassis connected to ground via the power supply cable. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation. To avoid the possibility of injury, insert the power cable only into a socket outlet with a protective earth contact. Before switching on the instrument, make sure the electrical installation fulfills the local safety requirements.
	*WARNING*	**Do not attempt to perform servicing or maintenance.** To avoid personal injury, do not operate this equipment without the protective cover of the chassis. Do not make any service or maintenance of any kind to the system. Refer servicing to authorized NetTest personnel only.
	*WARNING*	**Use the proper fuse.** To avoid fire hazard, use only the correct type fuse, voltage, and current ratings as specified in the *Maintenance* section in the *Service Information* chapter.
	*WARNING*	**Operate under proper environmental conditions.** TUNICS is not designed for outdoor use. To avoid the possibility of injury, do not expose the instrument to rain or excessive moisture. Do not operate the instrument in the presence of flammable gases or fumes.

Ventilation of the Unit

	*CAUTION*	**Make sure there is sufficient clearance below and at the back of the unit to ensure proper ventilation.** The apertures (under the unit) and the fan (behind the unit) are used for the inside ventilation. When used as a stand-alone benchtop unit, this product is designed so that the feet should leave enough room under the unit to enable proper ventilation. If you plan to rack-mount this unit, make sure to allow at least a 15-mm (0.6 inches) gap between two units.

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Contacting NetTest

Product Information

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Or contact us by e-mail:
info.photonics@nettest.com

Technical Information

Contact your local NetTest distributor or our Customer and Product Support Department.

Or contact us by e-mail:
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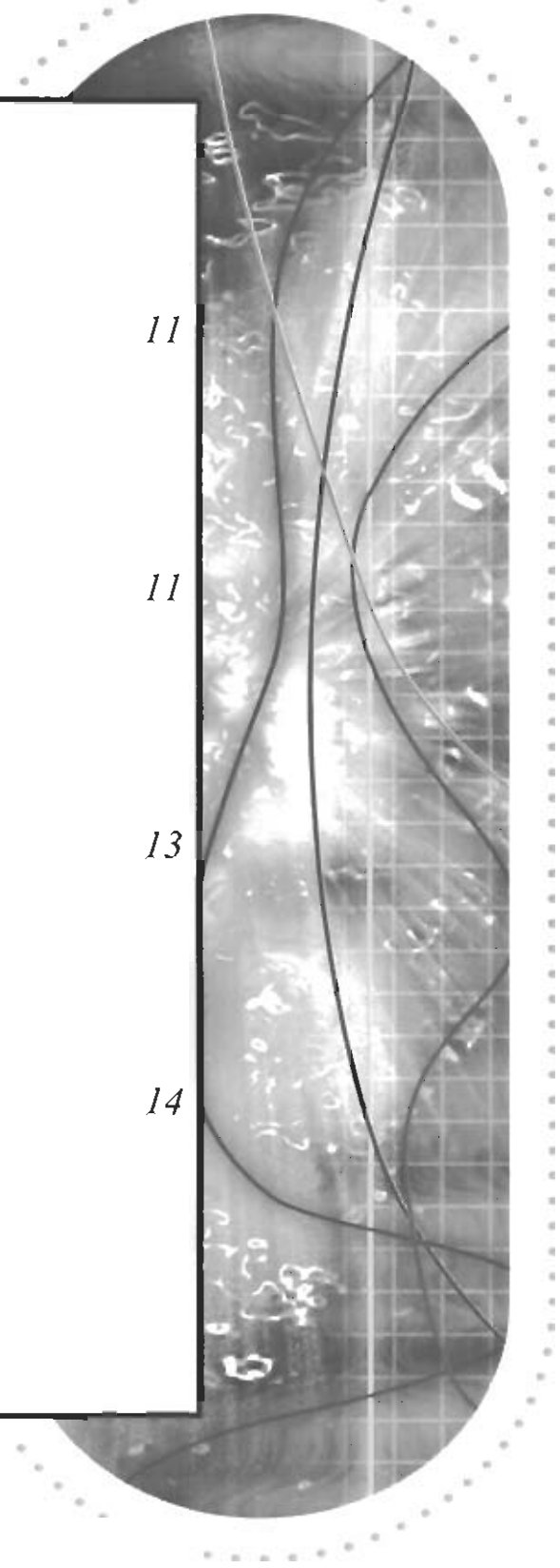
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General Information

Product Overview

TUNICS-*Purity* is a high-performance, self-aligned cavity laser that implements NetTest state-of-the-art proprietary configuration. It is your ideal partner for all your design applications of your optical communications systems.

TUNICS is a general-purpose instrument designed for fiber-optic system and component testing and for research and development in the field of optical communications. It offers maximum flexibility to cover all present and future requirements for tunable laser diode sources in the lab. TUNICS-*Purity* instruments are available in different versions providing a variety of wavelength and optical output power ranges. TUNICS-*Purity* is *the* fully integrated bench-top instrument fundamental to your lab applications. It comes with an optical head already integrated inside the electronics controller. It comes with an optical head already integrated inside the electronics controller.

TUNICS-*Purity* comes as a complete line of tunable laser diode sources with wavelength spectrum covering the S, C, and L bands, from as low as 1430 nm for your S-band applications up to 1625 nm for the L-band extended DWDM systems.

Optical Design

The optical layout of the cavity conforms to a modified Sagnac interferometer configuration. A beam-separator is placed right outside the path of laser-diode emission. Within the cavity, double-pass reflection on the grating provides maximum dispersion, while the very short cavity, which maximizes mode spacing, yields a spectrally pure and truly single-mode operation.

The high-performance optical isolator and angle-polished output fiber connector also contribute to spectral purity by protecting the laser cavity from any interference that may be generated by your equipment. In the TUNICS configuration, however, the dihedral rear reflector in the self-aligned cavity acts as a 2D *corner cube*, so that the resonator remains perfectly in tune, overriding any small misalignments and thus guaranteeing long-term stability.

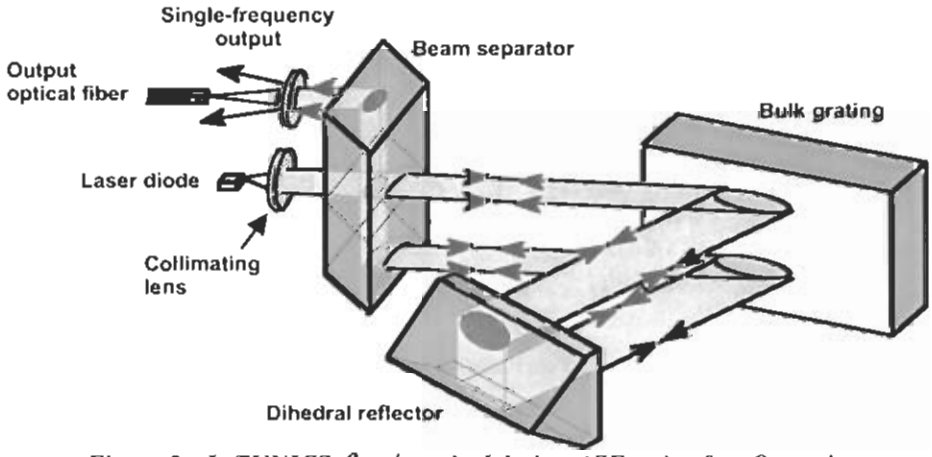


Figure 2 - 1: TUNICS-Purity optical design ASE-noise-free Operation

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TUNICS-*Purity* Emission Spectrum

Compared to traditional external cavity laser with a –45 dBm/nm average background noise, the TUNICS-*Purity* emission spectrum shows a narrow, single-mode laser line featuring residual noise typically lower than –90 dBm/nm, as shown in Figure 2 - 2.

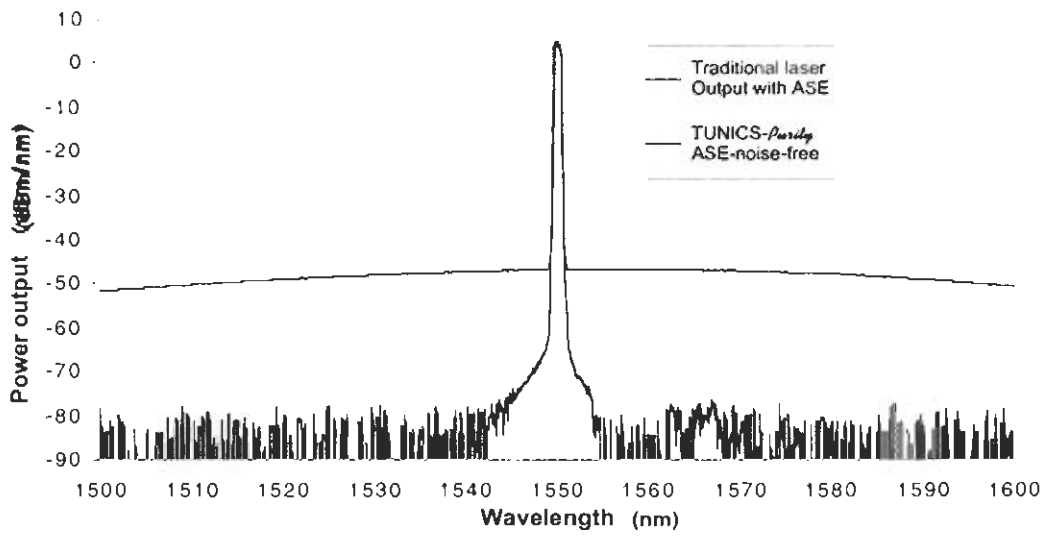


Figure 2 - 2: TUNICS-Purity emission spectrum

Filter Characterization Performance with TUNICS-*Purity*

Benefits brought by the TUNICS-*Purity* high dynamic range (>90 dB/nm) make it the ideal tool for direct spectral characterization of components such as optical amplifiers, multiplexers, and filters. Figure 2 - 3 below, shows how the ASE-noise-free TUNICS-*Purity* allows full and accurate filter characterization even in low filter-attenuation range, while other traditional external cavity laser performance is greatly limited due to ASE.

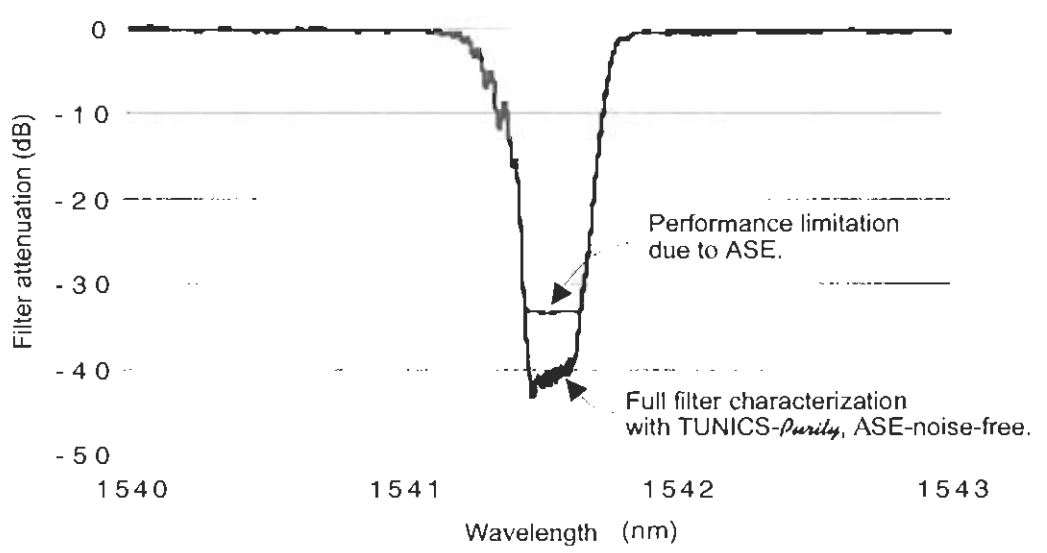


Figure 2 - 3: Filter characterization performance with and without ASE-noise-free laser

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Benefits

The proprietary optical design of the TUNICS-*Purity* Tunable External Cavity Laser provides a unique range of user benefits.

Benefit	Description
Wide, fast, and 100%-continuous tunability	Extremely smooth scans over 100 nm obtained in 1 second, with a high resolution of 1 picometer. A digitally-controlled analog fine-tuning extending the resolution beyond the one–picometer step to the sub-MHz level.
Mode-hop spacing	A wide range guaranteed to be free of any mode hopping to ensure a smooth and accurate wavelength sweep for reliable testing of narrow-band components.
ASE-noise-free operation	A unique optical design to yield intra-cavity filtering of background broadband ASE noise. More than 90 dB of dynamic range for a pure, high-power single-mode laser line.
Internal wavelength referencing	To ensure highly accurate (±50 pm) and repeatable (±5 pm, typ.) measurements, TUNICS-*Purity* features its own internal referencing system.
High output power	More than 0 dBm guaranteed over the entire spectral range in all models. +3 dBm delivered by TUNICS-*Purity* S, SC and CL over designated wavelength range (See *Specifications*).
Outstanding long-term stability	Self-aligned optical layout, single-moving-part design and all-invar construction to ensure a high level of long-term stability.
Intuitive and user-friendly controls	Optimized keyboard and display for intuitive and easy-to-implement laboratory operations. Dual parameter input (keyboard or multi-speed rotary control).
Multiple modulation capability	Easy analog and digital modulation of the optical power from DC to 1 GHz. Low frequency modulation from 10 kHz to 8 MHz. High frequency modulation from 30 kHz to 1 GHz. Mode-locked operation around 5 GHz. The 150 kHz linewidth can also be degraded to more than 100 MHz when high coherence is required.
Easy system integration	A fully integrated system featuring computer interfaces, onboard software, and analog inputs/outputs to allow all operations to be performed in remote mode and to make system integration easy.

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Specifications

Table 2 - 1 lists the technical specifications of the various the TUNICS-*Purity* Tunable Laser sources.

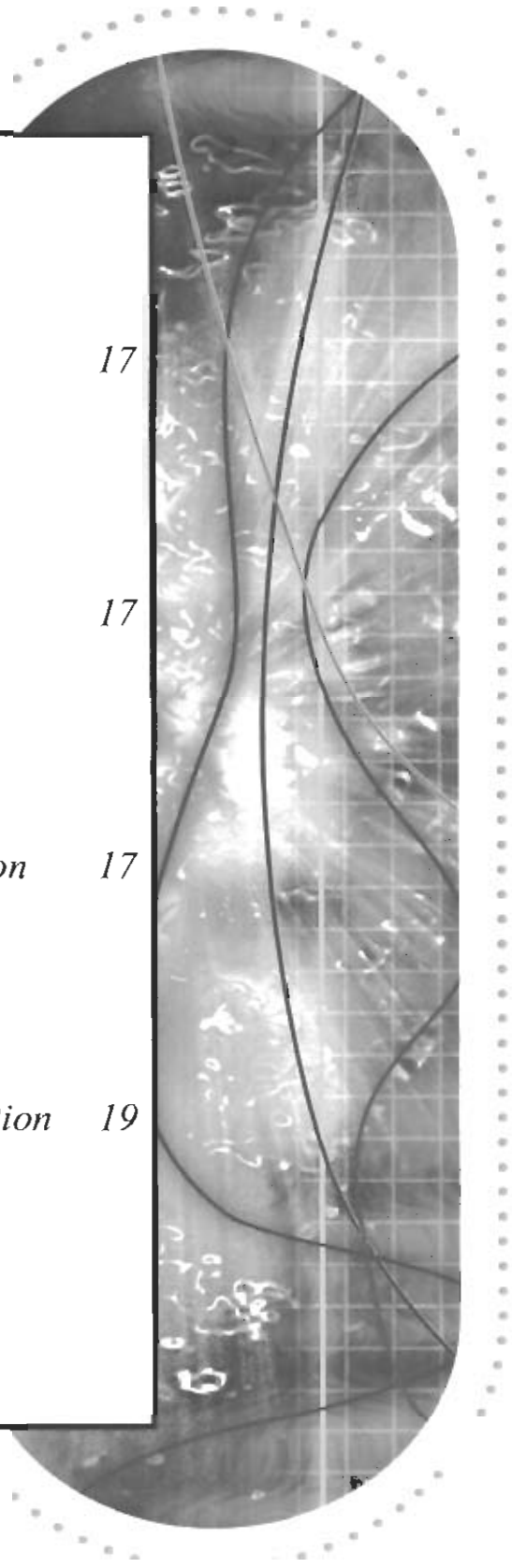
Table 2 - 1: TUNICS-*Purity* Specifications

Tuning characteristics	***Purity* S**	***Purity* SC**	***Purity* CL**
Wavelength range (nm)			
P = 0 dBm	1430-1530	1470-1570	1525-1625
P = 3 dBm	1450-1510	1510-1570	1560-1620
Mode-hop spacing	>70 nm typ.		
Absolute wavelength accuracy	±0.05 nm		
Tuning repeatability (typical)	±0.005 nm		
Wavelength setting resolution	0.001 nm		
Optical frequency fine tuning	±2 GHz		
Tuning speed (typical)	1 s (100 nm)		
Laser output characteristics			
Power stability[1]	±0.01 dB		
Linewidth (coherence control OFF)	150 kHz typ.		
Linewidth (coherence control ON)	>100 MHz		
Signal to Source Spontaneous Emission Ratio[2]	>90 dB		
Relative Intensity Noise (RIN)[3, 4]	>145 dB/Hz		
Interface			
Optical connector	FC-APC		
Output fiber	SMF-28™		
Output isolation	35 dB		
Return loss	-60 dB		
Remote control	IEEE-488-1 and RS-232 C		
Low frequency modulation			
• APC mode	10 kHz to 8 MHz		
• Direct current mode	DC to 8 MHz		
High frequency modulation	30 kHz to 1 GHz		
Mode-lock frequency	5 GHz		
Environment			
Operating temperature range	+15 to +30 °C (+60 to +85 °F)		
Power supply (auto-switch)	100 to 240 V, 50 to 60 Hz		
Dimensions (W x H x D)	448 x 133 x 370 mm[3]		
Weight	12.5 kg		

1 Over 1 hour at constant temperature.
2 Spontaneous emision measured on a 0.1 nm bandwidth at ±5 nm from the signal.
3 Measured with 0 dBm output power.
4 Measured at an electrical frequency of 100 MHz.

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GETTING STARTED



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Getting Started

Unpacking

Handle the device with care when unpacking. To pull out the unit from its packaging, hold it by its two lateral retractable handles to help you keep the unit horizontal.
After unpacking, set the device on a flat stable surface that is free of excessive vibration.

⚠	***CAUTION***	**Keep the original shipping container** for use in case the instrument needs to be returned to NetTest for repair or servicing.

Standard Accessories

The TUNICS-*Purity* Tunable External Cavity Laser comes with the following standard accessories:

- Certificate of traceable calibration
- Acceptance test report (ATR)
- FC/PC to FC/APC adapter cable
- Safety-lock key
- Instruction manual
- Power cord
- Rack-mount handles (2x)

Options and Ordering Information

TUNICS-*Purity* comes in various models and options available upon order by specifying the corresponding ordering code. Accessories may be purchased separately.

Models

Model names and main characteristics are listed below:

Table 3 - 1: Models and ordering codes

TUNICS-*Purity* Model Ordering Code	Model characteristics
S	S-band over 1430-1530 nm.
SC	S+C-band over 1470-1570 nm.
CL	C+L-band over 1525-1625 nm.

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Options

Available options include:

Table 3 - 2: Options and ordering codes

TUNICS-*Purity* Option Ordering Code	Option
M	Polarization maintaining output fiber (orientation TE in slow axis, in line with connector key)

Note: For the standard benchtop model, you do not need to specify any option.

Accessories

Available accessories include:

Table 3 - 3: Accessories

TUNICS-*Purity* Accessories
Labview driver for TUNICS-*Purity*
Fiber-optic jumper FC-APC/FC-APC
Fiber-optic jumper FC-APC/FC-PC (delivered as standard with each instrument)
Polarization maintaining fiber-optic jumper FC-APC/FC-APC
Polarization maintaining fiber-optic jumper FC-APC/FC-PC
Field carrying case (2U)

Ordering code

Ordering information must be provided in the following manner, as shown in the table below (as an example only):

Instrument name	Family		Model		Option 1		Option 2		Other options...	
TUNICS	*Purity*	/	SC	/	M	/	-	/	Other options...	/

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Installation & First-Time Operation

To remove the unit from place to place, use the handles on both sides which help to keep the instrument horizontal.

Installation

To install TUNICS-*Purity* tunable laser source proceed as follows:

1. Set the laser source on a flat stable surface that is free of excessive vibration.
2. Allow the flow of air from the cooling fan to circulate freely around the device and remove any equipment or paper that could block the air-flow.
3. Use the proper power cord for your location.
4. Make sure the key-lock switch on the front panel is in the Standby mode before applying power.
5. Connect one end of the power supply cable to the rear panel of the unit and plug the other end to the proper voltage mains supply point. TUNICS-*Purity* is equipped with a self-regulating power supply that adapts to both AC 110V and 230V voltages and 50 Hz or 60 Hz frequencies.
6. To turn ON the unit, set the main switch located on the rear panel to the "I" position.

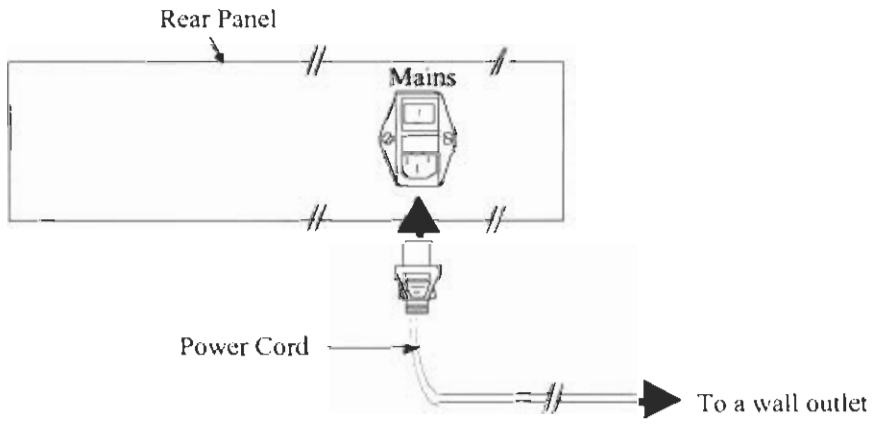


Figure 3 - 1: Connect the power cord to the rear panel of TUNICS-Purity

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Initializing the Laser

For safe operation, use the following procedure to initialize the TUNICS-*Purity* laser:

1. Make sure the key-lock switch on the front panel is in the Standby position.
2. Set the rear panel MAINS switch to ON (I) (see Figure 3 - 1).
3. Turn the front panel key to the right and set it to ON. During the initialization routine, the message **"Initializing..."** is displayed. This message clears once the laser is initialized and ready for operation.
4. The message **"Referencing..."** is then displayed to indicate that the system performs its self-calibration (internal wavelength referencing). This message clears once the laser is initialized and ready for operation.
5. Once the initialization routine is complete, the laser output is ready to enable. The message **"Disabled"** is displayed. The cavity laser is tuned on its central emission wavelength (depending on the model).

TUNICS-*Purity* performs self-checks during initialization sequence. The APC LED is lit. Power setting is set to zero when the laser is powered up.

Note: User can decide to skip the self-calibration (skip Step 4 - Referencing) procedure by simply pressing the **"0"** key while the message **"Initializing..."** is displayed. Note that for optimum system performance, we recommend you to let TUNICS-*Purity* perform its self-calibration routine when turning on the system.

⚠	***CAUTION***	**Avoid switching the unit off before the system is fully** initialized.

Enabling the Laser Output

For laser safety reasons, the TUNICS-*Purity* laser output is not immediately enabled after system turn-on and initialization. After the initialization routine, TUNICS-*Purity* is in Disabled mode. TUNICS-*Purity* features an Enable key to enable/disable laser output.

1. To enable the laser output, press the **Enable** button.
2. To disable the laser output, press the **Enable** button again and check that the message "Disabled..." is displayed.

Optical Connection to the Unit

External optical equipment can connect to TUNICS-*Purity* via the FC/APC fiber-optic connector located on the front panel in the Input area.

⚠	***CAUTION***	Keeping fiber-optic connectors clean at all times is essential to achieve optimum system performance. Refer to the cleaning instructions in the *Maintenance* section. The standard output connector is an FC/APC type connector. Never connect another type of connector to the optical output.

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Shutting Down the TUNICS-*Purity* Laser

To shut down the unit, follow these steps:

1. Press the **Enable** button to disable the laser output and make sure the Enable key LED is off.
2. Turn the front panel key to the Standby position (counterclockwise).
3. The message **"Parking..."** is displayed and the optical head is automatically moved to its parking position.
4. Wait a few seconds until complete system shutdown.

	***CAUTION***	During system shutdown, DO NOT TURN OFF the system with the rear panel O/I switch.

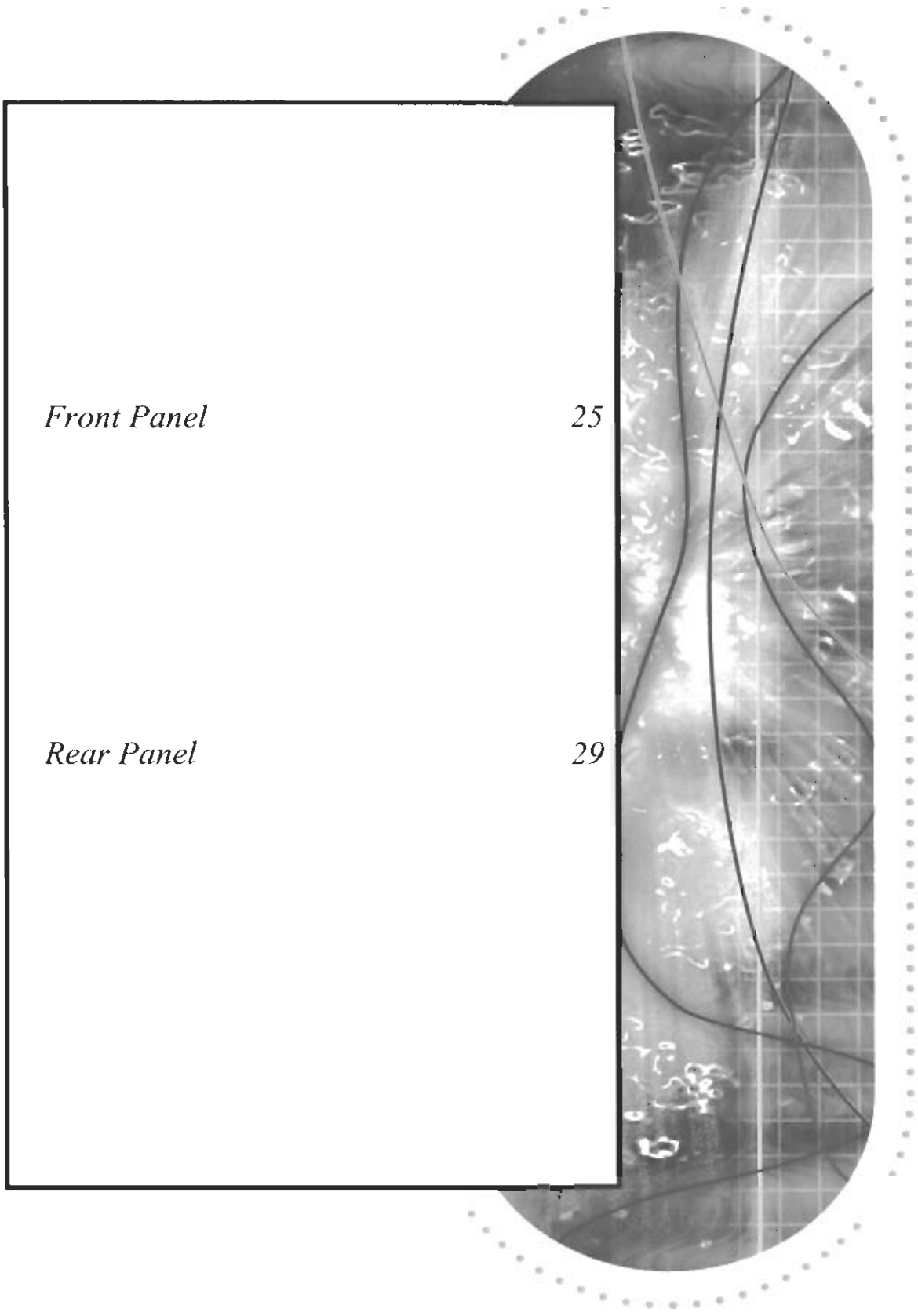
	***CAUTION***	Before moving the unit, or when the unit is not in use for a long period of time, the rear panel Mains O/I switch must be set prior to the "O" position. Be sure the system is completely turned off before transporting it

	***CAUTION***	If the TUNICS-*Purity* unit has been turned off, you must wait at least thirty seconds before initializing the laser again.

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FRONT & REAR PANELS



Front Panel 25

Rear Panel 29

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Front & Rear Panels

This section provides an overview of the operating controls of all TUNICS-Purity functions.

Front Panel

Figure 4 - 1 shows the front panel of the TUNICS-Purity Tunable External Cavity Laser.

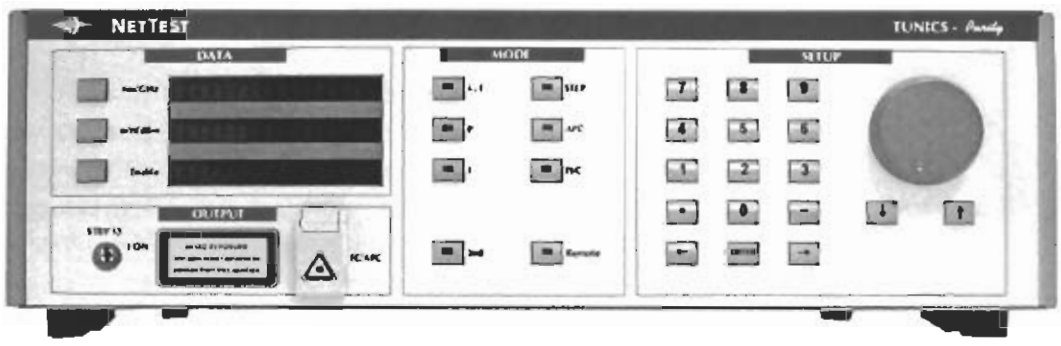


Figure 4 - 1: TUNICS-Purity front panel

Description of the Front Panel Functions Keys

The TUNICS-Purity front panel is divided into two areas, as illustrated in Figure 4 - 1:

DATA area	To display the wavelength, optical power, diode current, and messages.
MODE area	To select the operating mode. To select the system parameter to be modified.
SETUP area	User interface to enter the parameter value.

The various function keys are described below:

DATA Area

The DATA area displays the two main operating parameters, the emission wavelength (λ) (or optical frequency f), the output power (P), and the laser diode current (I); it is also used to display system-status messages.

Function Key	Purpose
nm/GHz	Displays either the wavelength in nanometer (nm) or the optical frequency in GigaHertz (GHz).
mW/dBm	Displays the power either in dBm or mW.
Enable	Enables the optical output. (Note that in Disable mode, the message "Disabled..." is displayed.)

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MODE Area

The **MODE** area includes 8 function keys that are lit when the corresponding function is active. These function keys allow the user to access and change parameters that need be configured (see the *General Parameter Setting Principle* section that follows).

λ , f	Used to edit the current value of either the emission wavelength λ or the optical frequency **f**., and to allow entry of a new value.
P	Used to edit the current value of the power output **P**, and to allow entry of a new value. Switches to the Constant-Power mode.
I	Used to edit the current value of the diode current **I**, and to allow entry of a new value. Switches to the Constant-Current mode.
STEP	Used to change the wavelength increment (STEP) value. It is also possible to increase or decrease the wavelength STEP-by-STEP, at any time, by pressing the ← or → arrows on the keypad.
APC	(Automatic Power Control) switches between constant current (APC light off) and constant power (APC light on) modes.
FSC	FSC (Fine SCanning mode) enables a complete and virtually continuous sweep of the wavelength on a ±2 GHz range. Once this mode is selected, the wavelength value can be adjusted by rotating the Modify knob located in the **SETUP** area. The wavelength sweep is displayed in the **DATA** area either in nm or in GHz accordingly. To exit the fine scanning mode, press the FSC key again
Remote	Press this button to switch between remote and manual modes when the system is connected to a remote terminal or a computer via the RS-232 C or IEEE–488.1 interface. The Remote button LED is lit when data is received by TUNICS on one of its RS-232 C or IEEE–488.1 ports. When the Remote key is on, the front panel keys become inactive. To regain manual control of the TUNICS at the front panel, press the Remote button again (the Remote LED is off).
2nd	The 2nd function key allows access to advanced functions (see the *Advanced Functions* section in the *Operation* chapter).
2nd + I	To perform system auto-calibration.
2nd + P	To perform power calibration.
2nd + STEP	To enable the wavelength scan mode.
2nd + 1	To disable/enable backlash suppression of the micrometer screw.
2nd + 2	To display the software release.
2nd + Remote	To change the GPIB address. Also to activate/deactivate the RS-232 remote mode. **Note**: to reach this option, you first need to confirm the GPIB address (via the Enter key).
2nd + FSC	Enables the coherence control function. The Coherence Control function adds noise to the optical frequency output of the laser producing an apparent broadening of the line-width. Coherence control is particularly useful to eliminate parasitic interferometers in the user setup. **Note:** This function can also be accessed by using the FSC input on rear panel. (See *Auxiliary Inputs and Outputs* section in *Operation* chapter.)

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SETUP Area

The SETUP area is used to enter or change the values of the system operating parameters. It includes:

- Numeric keypad
- ← arrow key to correct a typing error
- **Enter** key to validate the choice
- . key to enter a decimal point
- - to enter a negative value
- Rotating knob to adjust parameter values

In order to change a parameter, first select the appropriate parameter key in the MODE area. The display shows the current setting for the selected parameter, which can be readily modified by entering the new value directly at the numeric keypad or by adjusting the parameter to the desired value with the rotating Modify knob.

General Parameter Setting Principle

The various parameters may be set or changed by using one of two methods:

1. At the numeric keypad
2. By using the rotating Modify knob

Using the Numeric Keypad

To set a parameter using the numeric keypad, follow these steps:

Step	Action
1.	Press the appropriate function key in the MODE area.
Result:	The corresponding LED indicator is lit. The current parameter value is displayed. The = sign flashes to indicate that the value can be changed.
2.	Enter the required value via the keypad.
⇨	If you make a mistake while entering the value, use the arrow keys ← / → to correct your entry.
⇨	If the value entered is outside the valid range for the parameter selected, the following error message is displayed: **Value error, press Ent** Press **Enter** to continue. **Note**: The value is not changed and any scanning or calibration operation in progress is suspended.
3.	To validate your change, press the same function key in the MODE area again.
4.	Apply the new parameter value by pressing the **Enter** key.

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Using the Rotating Modify Knob

By rotating the Modify knob, you can update a parameter value in real time.
To set a parameter using the Modify knob, follow these steps:

Step	Action
1.	Press the appropriate function key in the MODE area.
Result:	The corresponding LED indicator is lit. The current parameter value is displayed. The = sign flashes to indicate that the value can be changed.
2.	**Rotate the Modify knob** until the required value is displayed.
3.	To change the basic increment/decrement applied by the Modify knob, press the ↑ and ↓ arrows.
Result:	A similar message is displayed: **Scroll 0.01** Indicates which digit can be changed using the Modify knob.
4.	To validate your change, press the same function key in the MODE area again.
Result:	The new value is applied automatically. **Important:** The backlash suppression feature applied to the tuning micrometer screw is not activated when you change a value via the Modify knob, as the parameter is changed in real time. This is indicated by a dot at the end of the wavelength displayed similar to the following. Example: λ = **1555.000 nm•**

The numeric keypad or control knob can edit the following parameters:

λ, f	Emission wavelength
P	Optical power
I	The diode current

User may also edit other parameters in the following manner:

STEP	To set the wavelength step
2nd + STEP	To activate wavelength step-mode scanning
2nd + P	Power calibration
2nd + Remote	To change the GPIB address **Note**: also used to activate/deactivate the RS-232 remote control mode.

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Rear Panel

Figure 4 - 2 shows the rear panel of the TUNICS-*Purity*.



Figure 4 - 2: TUNICS-Purity rear panel

Description of the Rear Panel Connectors

The MAINS module includes the mains power switch, power cord connection, and fuse drawer.

In addition to the MAINS module, the following connectors are available on the rear panel:

Monitor (Scaled) Outputs

- Sync (motor Sync)
- λ (wavelength)
- P (power)
- I (current)

TTL Outputs

- Mod Sync. modulation sync (TTL output)
- Mod Out modulation output (TTL output)

Inputs

- HF Mod. high-frequency modulation input (SMA connector)
- LF Mod. low-frequency modulation input (BNC connector)
- FSC (fine scanning and coherence control)
- Remote Interlock connector as required for Class IIIb laser products

Remote Interfaces

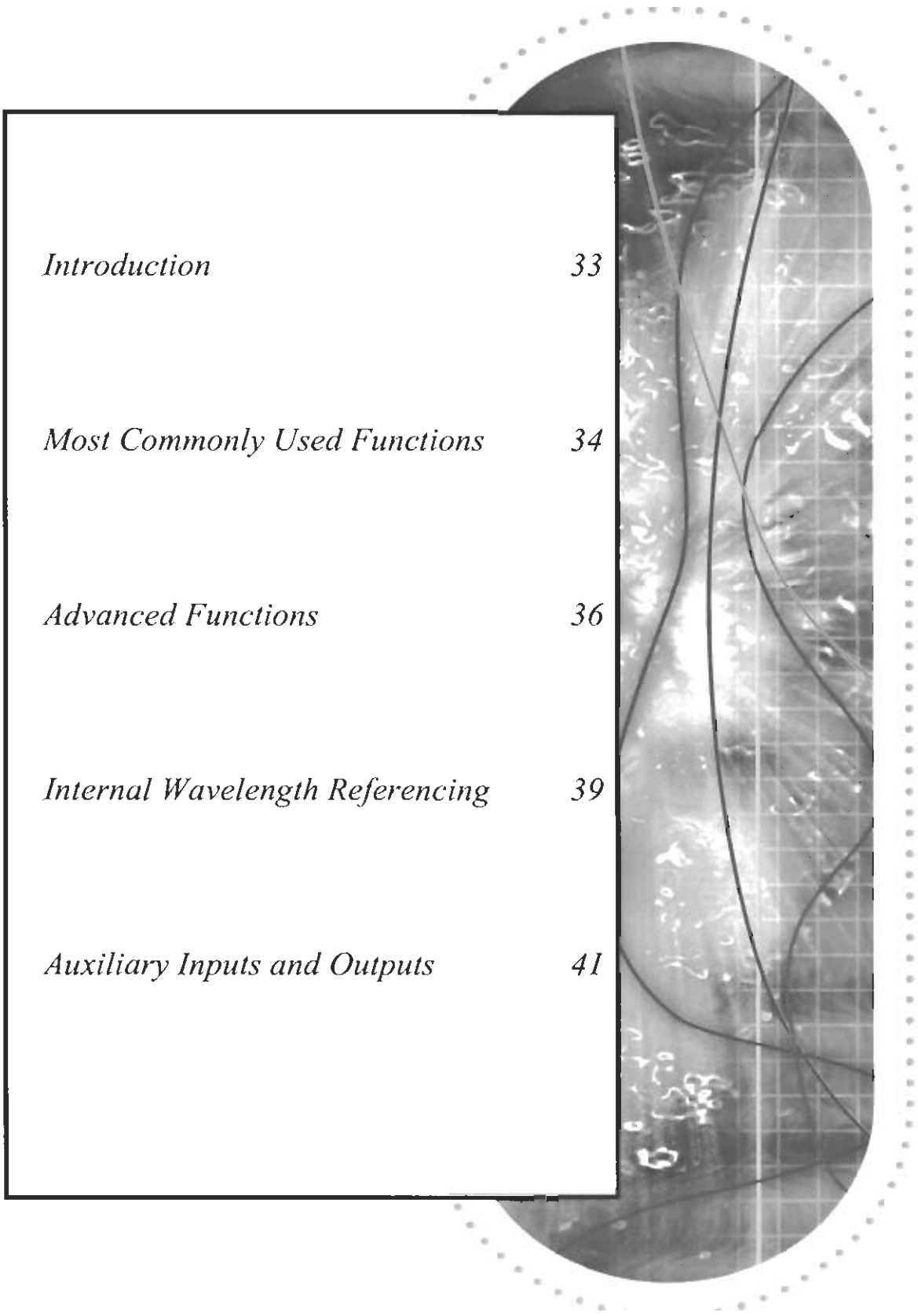
- RS-232 C connector for the remote control mode (SUBD-9).
- IEEE-488.1 connector for the remote control mode.

For a detailed discussion on particular connectors, see the *Auxiliary Inputs and Outputs* section in the *Operation* chapter.

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OPERATION



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Operation

Introduction

This section describes how to use the TUNICS-*Purity* Tunable External Cavity Laser in manual mode. The TUNICS-*Purity* front panel allows direct access to most commonly used functions by pressing the corresponding function keys in the MODE area. In addition, a panel of advanced functions can be accessed via the 2nd function key.

The most commonly used functions are described as follows:

- To change the emission wavelength
- To change the wavelength step
- To change the beam's optical output power
- To change the diode current
- To switch between the constant-power and constant-current modes
- To use the fine scanning mode

The following advanced functions are also available:

- To implement step-mode wavelength scanning
- To perform power calibration
- To turn on backlash suppression for the micrometer screw
- To change the GPIB address
- To turn on/off the RS-232 remote control mode
- To turn on coherence control

TUNICS-*Purity* brings in a new technological enhancement:

- Internal wavelength referencing

Finally, auxiliary input and output are described at the end of this section.

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Most Commonly Used Functions

To Change the Emission Wavelength

To change the emission wavelength, proceed as follows:

Step	Action
1.	Press the **λ , f** function key in the MODE area.
2.	Enter the new value using the numeric keypad or modify knob. Make sure to enter values within the valid range for parameter setting depending on your particular TUNICS model, as specified in *Appendix B: Valid Range for Parameter Settings*.
3.	Press the **Enter** key in the SETUP area.
	You may also increase or decrease the wavelength by pressing the ← / → arrow keys in the SETUP area, which has the same effect as rotating the modify knob.

To Change the Wavelength Step

To change the wavelength step, proceed as follows:

Step	Action
1.	Press the **STEP** function key in the MODE area.
2.	Enter the new value using the numeric keypad or modify knob. Make sure to enter values within the valid range for parameter setting depending on your particular TUNICS model, as specified in *Appendix B: Valid Range for Parameter Settings*. **Note:** It is possible that the required output power cannot be reached even at the maximum allowable current. If this occurs, the TUNICS-*Purity* automatically limits the current to its maximum value and the message **"Lim"** appears at the right end of the displayed power, as shown in this example: **P = 5.4 mW Lim**
3.	Press the **Enter** key in the SETUP area.

To Change the Optical Output Power

To change the optical output power, proceed as follows:

Step	Action
1.	Press the **P** function key in the MODE area.
2.	Enter the new value using the numeric keypad or modify knob. Possible output power values range within 0.2 to 10 mW for the standard-power TUNICS-*Purity* model. Depending on which TUNICS model you are using, make sure to enter values within the valid range for parameter setting of your particular TUNICS model, as specified in *Appendix B: Valid Range for Parameter Settings*. **Note:** It is possible that the required output power cannot be reached even at the maximum allowable current. If this occurs, TUNICS-*Purity* automatically limits the current to its maximum value and the message **"Lim"** appears at the right end of the displayed power, as shown in this example: **P = 5.4 mW Lim**
3.	Press the **Enter** key in the SETUP area.

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To Change the Diode Current

To change the diode current, proceed as follows:

Step	Action
1.	Press the **I** function key in the MODE area.
2.	Enter the new value using the numeric keypad or modify knob. For possible values of the diode current, please refer to the test report provided with the system.
3.	Press the **Enter** key in the SETUP area.

To Switch Between Constant-Power and Constant-Current Modes

Pressing the **APC** function key allows the user to toggle between the constant-current and the constant-power modes.

If the APC key LED is...	Then the active mode is in...
On Result:	**Constant-power mode.** The laser-diode current is controlled to ensure an optical power output equal to the P parameter. By pressing the **P** function key, the system switches automatically to the Constant-Power mode. In this mode, it may not be possible to obtain the required power, even with the maximum allowable current. In this case: 1. The current is limited to its maximum value. 2. The optical power is lower than the user-set power value. 3. The **Lim** message is displayed to the right of the current and power values.
Off Result:	**Constant-current mode.** The diode current level is determined by the I parameter. By pressing the **I** function key, the system switches automatically to the Constant-Current mode. **Note:** Using the **P** or **I** keys switches the system automatically in the Constant-Power or Constant-Current mode, respectively.

To Use the Fine Scanning Mode

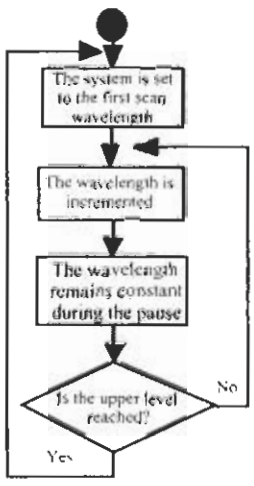
To...	Press the...
Enable the Fine Scanning mode	Press the **FSC** function key.
Result:	The wavelength can be adjusted at all times using the rotating Modify knob. The wavelength sweep is displayed in the DATA area in nm or GHz, as required.
Exit the Fine Scanning mode	Press the **FSC** function key again.

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Advanced Functions

To Implement Step-mode Wavelength Scanning

Wavelength scanning enables the TUNICS-*Purity* tunable laser to broadcast on a different wavelength at each time interval. It scans incrementally the entire wavelength scanning range specified by the user.
The wavelength scan process is illustrated in the following flowchart:



Starting from the first wavelength (lower wavelength limit set by the user), the emission wavelength increases incrementally (the wavelength increment is stored in the Step parameter and set by the user) up to the last wavelength value (upper wavelength limit set by the user). During each scan interval, the TUNICS laser broadcast at a set wavelength for the duration specified by the Pause Timer parameter (Pause Timer set by the user).

Before activating the wavelength scanning, user must set the optical output power of the TUNICS-*Purity* laser (see the *To Change the Optical Output Power* section in this chapter).

To implement wavelength scanning, follow these steps:

Step	Action
1.	Press **2nd** + **STEP** to activate the scan mode.
Result:	You are prompted to enter the lower wavelength scan limit while the current setting is displayed.
2.	Enter the lower wavelength scan limit and press **Enter**.
Result:	You are prompted to enter the upper wavelength scan limit while the existing setting is displayed.
3.	Enter the upper wavelength scan limit and press **Enter**. (For valid scan limits, see Appendix B.)
Result:	You are prompted to enter the scan STEP while the current setting is displayed.
4.	Enter the scan STEP and press **Enter**. (To know the valid range for scan STEP values, see Appendix B.)
Result:	You are prompted to enter the Pause Timer between two scan steps

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	while the current setting is displayed.
5.	Enter the Pause Timer and press **Enter**. Possible values for Pause Timer range from 0.1 to 25 seconds.
Result:	Scanning begins.
6.	To suspend the current wavelength scan, press the **STEP** key. You are then prompted to "stop scan 1/0?". To stop the scan press the numeric keys **1** + **Enter**. **Note:** Scanning stops and the emission wavelength remains set to the value applied at the time the scan was suspended. To resume scanning, press numeric keys **0** + **Enter**.

In manual operating mode, the wavelength scanning process repeats continuously until user presses the **STEP** key to suspend or stop the scan. Wavelength scans may not be performed in remote control operating mode. When you set a wavelength in remote mode, the system tunes directly to the desired wavelength without stepping.

⇒ Note that operating parameters cannot be changed while the wavelength scanning is in progress. Therefore, make sure the power output level you set can be achieved within the maximum current limits over the entire scanning range. If the desired power output cannot be reached due to current limitations, the **Lim** message is displayed to indicate the system no longer operates at constant power.

To Perform Power Calibration

The power calibration procedure calibrates the laser output power. The procedure requires the use of an optical power meter.

⚠	***CAUTION***	This procedure clears the factory-set calibration data. Do not perform this procedure unless you actually intend to erase this data.

To perform power calibration, follow these steps:

Step	Action
1.	Connect the laser output of the tunable laser to a power meter, and set the **Enable** mode (laser on).
2.	Press the **2nd** + **P** function keys to activate the power calibration procedure.
Result:	The tunable laser moves to a short wavelength within the tuning range and displays the power level corresponding to the current calibration data.
3.	Measure the power level at the first wavelength on the power meter.
4.	Enter the reading at the prompt (P =).
Result:	The tunable laser moves to a long wavelength within the tuning range and displays the power level corresponding to the current calibration data.
5.	Measure the power level at the second wavelength.
6.	Enter the reading at the prompt (P =).
Result:	The power calibration is now complete and the instructions reference the new power calibration data.

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To Turn On Backlash Suppression of the Micrometer Screw

The TUNICS-*Purity* firmware implements systematically an onboard procedure to eliminate the effect of backlash on the tuning micrometer screw. Therefore, you do not need to activate backlash suppression, which is already ON.

To Disable/Enable backlash suppression, follow these steps:

Step	Action
To disable the backlash suppression mode Result:	Press the [2nd] + [1] function keys. A dot is displayed to the right of the wavelength. Example: λ= **1555.000 nm.**
To enable the backlash suppression mode	Press the [2nd] + [1] function keys again.

To Change the GPIB Address

The default value for the GPIB address is 10.

To change the GPIB address, follow these steps:

Step	Action
1. Result:	Press the [2nd] + [Remote] function keys. The current GPIB address is displayed as you are prompted to enter the new value at the numeric keypad.
2.	Enter the new GPIB address.
3. Note:	Press [Enter] to confirm the change. You are then prompted to activate/deactivate the RS-232 remote mode. Press [Esc] or refer below for further information.

To Turn On/Off the RS-232 Remote Control Mode

To activate/deactivate the RS-232 remote control mode:

Step	Action
1.	After confirming the GPIB address (refer to previous paragraph), you reach the status of the RS-232 remote control mode.
2.	You are then prompted to specify the mode status at the numeric keypad: • Press "0" to turn the RS-232 mode "OFF". • Press "1" to turn the RS-232 mode "ON".
3.	Press [Enter] to confirm the change.

To Turn On Coherence Control

To activate the Coherence Control feature:

Step	Action
1.	Press the [2nd] + [FSC] function key. The FSC key LED then blinks. Coherence control provides an apparent broadening of the laser linewidth, which is useful in clearing out parasitic interferometers in the user setup.

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Internal Wavelength Referencing

The TUNICS-*Purity* internal referencing system ensures optimum calibration of the laser source as early as system start-up.

Note: We also recommend user to perform an auto-calibration after the first half-hour of system warm-up or use.

⚠	***IMPORTANT***	**Change of Operating Environment** When the system is subject to substantial changes of operating environmental conditions such as a sharp change in room temperature or mechanical vibrations, user must run a new system auto-calibration procedure, as specified below.

Self-calibration at start-up

TUNICS-*Purity* automatically performs a self-calibration procedure (also called Internal Referencing) during the initialization routine, which unfolds as follows:

Step	Action
1.	Turn the front-panel key to the right to begin system initialization.
2.	The system starts the initialization routine and the message **"Initializing..."** is displayed.
3.	The message **"Referencing..."** is then displayed to indicate that the system performs its self-calibration (internal referencing of the wavelength).
4.	After the initialization routine is complete, the message **"Disabled..."** is displayed which indicates that for safety reasons although the system is ready to use, the laser output is still off.

Note: User can decide to skip the self-calibration (skip Step 3 - Referencing) procedure by simply pressing the "0" key while the message "Initializing..." is displayed. Note that for optimum system performance, we recommend you to let TUNICS-*Purity* perform its self-calibration routine when turning on the system.

User-command for auto-calibration

In addition to the self-calibration performed at start-up only, user can instruct the system to perform a new auto-calibration at any time.

Follow these steps to perform system auto-calibration:

Step	Action
1.	Press the key the [2nd] + [1] combination to start auto-calibration.
2.	TUNICS-*Purity* performs its internal referencing routine and the message **"Referencing..."** is displayed.
3.	After calibration is complete, TUNICS-*Purity* restores the initial wavelength value in effect at the time auto-calibration was performed.

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Note: If auto-calibration has failed, the following message is displayed: **"Referencing error. Press Enter".** Press Enter key and calibration is canceled. The system's current internal wavelength referencing remains unchanged.

	***IMPORTANT***	**Laser Safety & Auto-calibration** While the system is performing an auto-calibration, the TUNICS produces a laser beam with an output power of 1 mW, even when the system is in *Disable* mode. To avoid eye damage, do not look into the laser output or into the end of an optical cable. Even though the laser radiation is not visible, the intense infrared light can cause eye damage.
	***IMPORTANT***	**Wavelength Referencing & Remote Interlock** For laser safety reasons TUNICS-*Purity* features a Remote Interlock connector at the rear-panel that can connect to an external remote interlock switch. When the interlock switch is open, the laser output is turned off. To enable the laser output, the interlock switch must be closed and user must press the **Enable** key. Remote interlock sets the system current and power to 0 mA and 0 mW, respectively. Therefore, while in remote interlock mode, the system cannot perform any self-calibration or internal referencing. When the system resumes from remote interlock mode into active state, we suggest user to run a new system auto-calibration procedure since the present system calibration data is still based on the previous system operating conditions.

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Auxiliary Inputs and Outputs

Figure 5 - 1 shows the auxiliary input and output connectors on the rear panel of TUNICS-*Purity*.



Figure 5 - 1: Auxiliary Input/Output Connectors on Rear Panel of TUNICS-Purity

In addition to the two remote control connectors (RS-232 C and IEEE-488.1), eight BNC connectors (λ, I, P, Mod Sync, Mod Out, Sync., LF Mod., and FSC), one SMA connector (HF Mod.), and one remote interlock connector are also available on the rear panel of the system.

External Modulation

Intensity Modulation - Low Frequency

It is possible to implement low frequency intensity modulation of the output beam from DC to 8MHz in the Direct Current mode and from 10 kHz to 8 MHz in the APC mode.

Modulation of the diode current is obtained by applying a signal anywhere between 0 and 5 volts on the BNC connector labeled "LF Mod."

LOW FREQUENCY MODULATION SETUP

To implement low frequency modulation, user can connect an external modulation source to the "LF Mod." BNC connector, as shown in Figure 5 - 2 below.

---

[5] While in wavelength monitoring configuration, the TUNICS-*Purity* tunable laser can no longer be remote operated via the RS-232 interface, but only via the IEEE-488.1 interface. If you wish to restore remote operation of the TUNICS-*Purity* via the RS-232 port, you must press the [2nd] + [Remote] keys at the front-panel and select, RS-232 IN : [ON].

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Note: The output impedance of your waveform generator must match the 50Ω input impedance of the TUNICS "LF Mod." BNC connector. Also, make sure to use a 50Ω BNC cord to connect the TUNICS and the waveform generator.

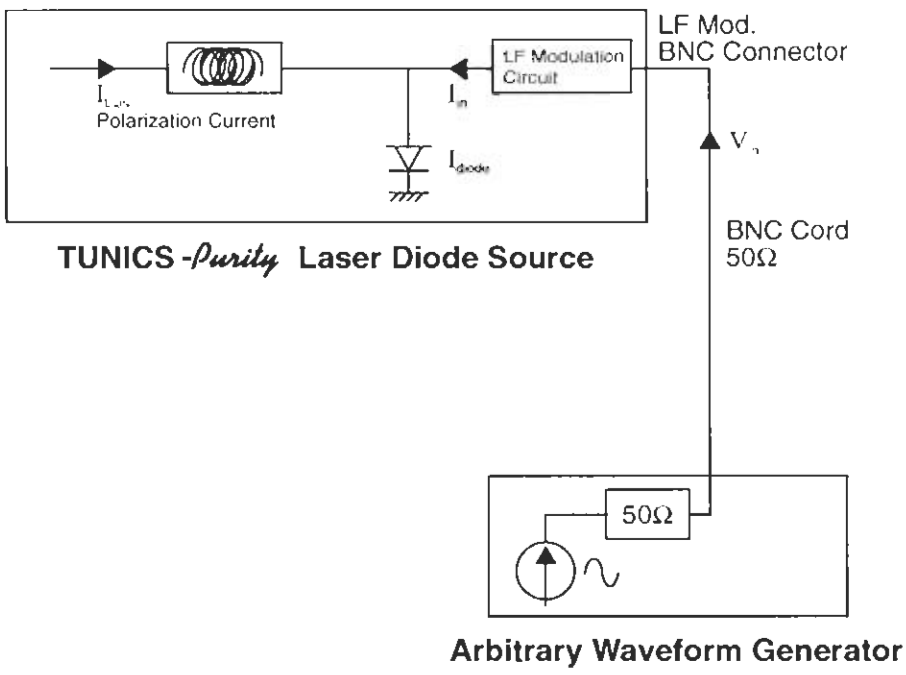


Figure 5 - 2: Low frequency modulation setup

USING LOW FREQUENCY MODULATION

User first set the operating current I_{bias} of the TUNICS in constant current mode. The relationship between the diode output current I_{diode} and the input voltage V_{in} is then given by:

Formulae: $$I_{diode} = I_{bias} - \frac{V_{in}}{R_{internal\Omega}}$$

Where: V_{in} is the input voltage applied to LF Mod. BNC input connector
(V_{in} **must always be positive and less than 5 V)**
I_{diode} is the total diode current
I_{bias} is the polarization current of your TUNICS
$R_{internal\Omega}$ is the 50Ω resistor of the LF modulation circuit

Note: The internal resistor $R_{internal\Omega}$ of your TUNICS is rated at 50Ω. Therefore, the relationship that allows you to calculate the added current based on the applied voltage becomes: $I_{in} = \frac{V_{in}}{50}$. With a maximum allowed voltage input of 5 Volts, the maximum input current that user can add to the TUNICS laser diode is 100 mA.

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RESULTING LF-MODULATED DIODE CURRENT

The laser diode of your TUNICS is characterized by its saturation current (I_{max}) and the cutoff current (I_{cutoff}). To perform a diode intensity modulation under optimum conditions, you must ensure at all times that the resulting modulated diode current obeys the following condition: $I_{cutoff} \leq I_{diode} \leq I_{max}$.

Refer to Figure 5 - 3 below for a behavioral representation the resulting modulated diode current.

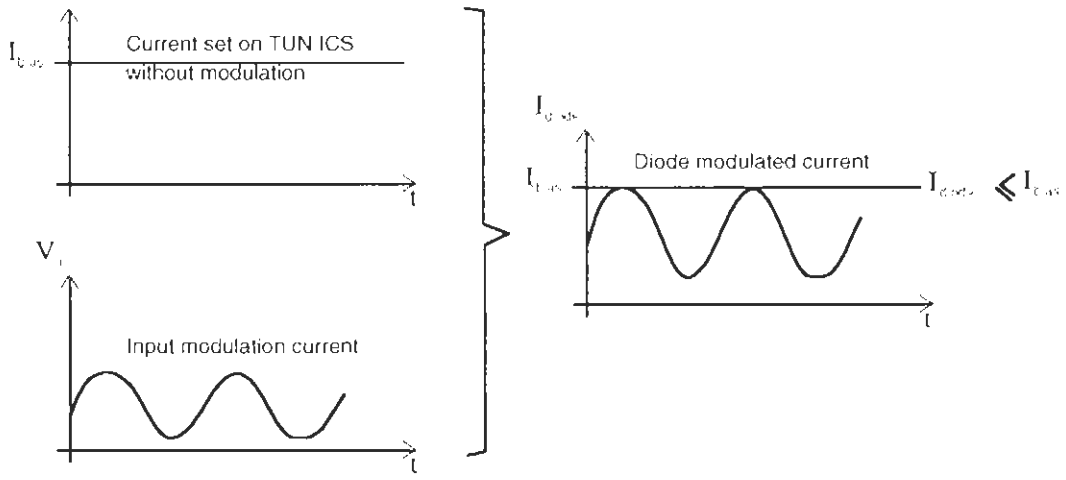


Figure 5 - 3: Resulting LF-modulated diode current

Note: In the APC mode, the output power is controlled in order to remain constant, which is in principle not compatible with a modulation of the output power. However, if the frequency of the modulation signal is well above the intrinsic frequency (≅1 kHz) of the APC loop, the average power is monitored, and remains constant. Modulation is possible in the APC mode at frequencies above 10 kHz. If a lower frequency is used, interaction between modulation signal and APC circuit will cause unpredictable modifications of the output power waveform.

Intensity Modulation - High Frequency

The "HF Mod" input allows user to increase the total diode current by applying voltage to the "HF Mod" SMA connector. A valid high frequency modulation signal applied to the SMA port can range from 30 KHz up to 1 GHz.

HIGH FREQUENCY MODULATION SETUP

To implement high frequency modulation, user can connect an external high frequency modulation source to the "HF Mod." SMA connector, as shown in Figure 5 - 4.

Make sure to use a 50Ω coaxial cord to connect your HF generator to the 50Ω input SMA connector.

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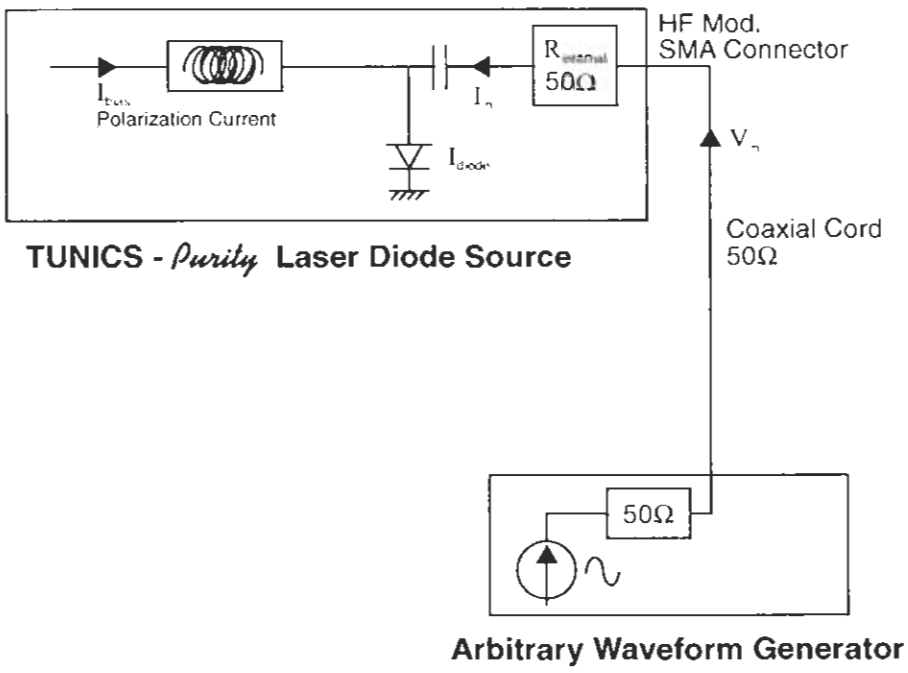


Figure 5 - 4: High frequency modulation setup

USING HIGH FREQUENCY MODULATION

The relationship between the voltage at the "HF Mod" input and the current added to the diode is given by:

$I_{in} = V_{in}/R_{internal}$

where:
I_{in} is the added current
V_{in} is the voltage applied to the "HF Mod" input
$R_{internal}$ is the 50Ω internal resistor of your TUNICS

By modulating this extra current, it is possible to modulate the optical power output within a frequency range from 30 kHz to 1 GHz. The low-frequency cutoff is 30 kHz. The modulation bandwidth is greater than 1 GHz, and this "HF Mod" input can be used for mode-locked operation as well.

⚠	***WARNING***	Since the "HF Mod" input is directly connected to the laser diode chip, user must ensure that the input voltage on the "HF Mod" connector is such that the following conditions are always met: 1. The diode laser is forward biased. 2. The current flowing through the diode is lower than the maximum admissible current (I_{max}) indicated in the system acceptance test report.

The best way to fulfill the above conditions is to measure the system bias current (I_b) through the voltage on the current monitor output, and to compute the total current using the following formula:

$$I_{diode} = I_{bias} + V_{in}/R_{internal}$$

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Where: I_{diode} *is the total current through the diode*
I_{bias} *is the bias current*
V_{in} *is the voltage applied to the "HF Mod" input*
$R_{internal}$ *is the 50Ω TUNICS internal resistor*

RESULTING HF-MODULATED DIODE CURRENT

User must monitor V_{in} to ensure that the total current remains positive and lower than the maximum admissible current:, as shown in Figure 5 - 5 below:

$$0 < I_{diode} < I_{max}$$

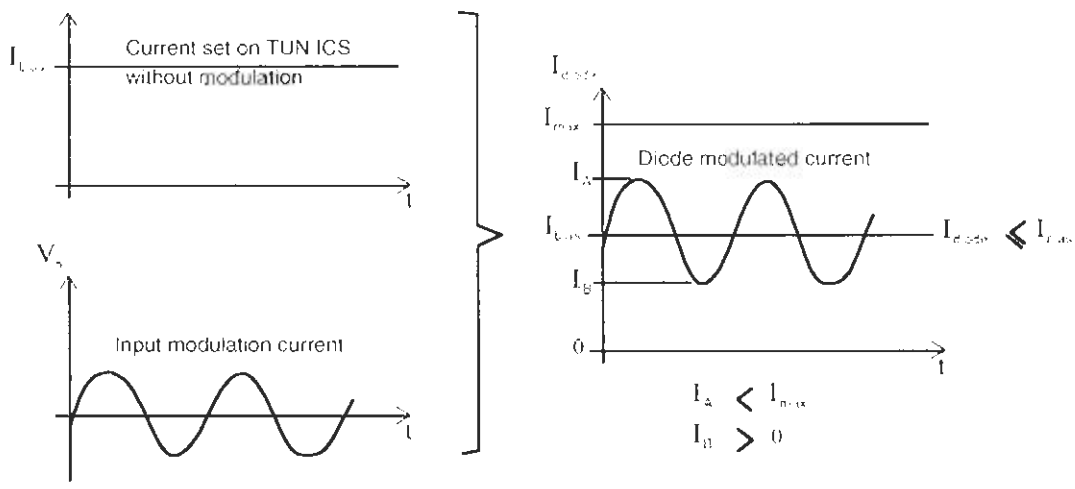


Figure 5 - 5: Resulting HF-modulated diode current

If the voltage applied to the "HF Mod" input is an AC signal with no DC component, and whose peak-to-peak amplitude is V_{pp}, the above condition becomes:

$$V_{pp} < 2 \times R_{internal} (I_{max} - I_{bias})$$
$$V_{pp} < 2 \times R_{internal} (I_{bias})$$

Therefore, Vpp must be lower than the lowest of the above two values.

Note: TUNICS constantly monitors the average optical output power and regulates the system bias current to keep the system output power constant. If a DC or low frequency (below 30 kHz) voltage is applied to the "HF Mod" input, there is no modulation on the output power, as the system automatically compensates by adjusting the bias current to cancel this modulation. However, if the frequency of the signal applied to the "HF Mod" input is well above the power control loop cutoff frequency (30 kHz), the output signal modulation will match that of the input signal, around an average power determined by the settings of the system. For that reason, user must implement a modulation frequency above 30 kHz.

⚠	***CAUTION***	The "HF Mod" SMA input is directly connected to the laser diode chip via a 50Ω resistor. It is essential that the user insure that at all times the diode is forward biased to avoid the destruction of the diode.

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Internal Modulation

A 31.2 kHz TTL modulation signal is provided at the rear panel of the electronics controller. The corresponding BNC connector is labeled "Mod Out". This TTL modulation signal can be used to digitally modulate the TUNICS by connecting back to the "LF Mod" BNC connector.

Synchronization Signal

A 31.2 kHz TTL synchronization signal is also provided on the BNC connector labeled "Mod Sync".

Wavelength Modulation

WAVELENGTH FINE SCANNING

TUNICS-*Purity* has a wavelength fine tuning capability, which can be used to adjust the wavelength very precisely, or to serve the optical frequency. This function is available via the FSC connector on the rear panel. When voltage is applied to the FSC connector, the optical frequency shifts 300 MHz for every volt applied. The maximum input voltage allowed on FSC is ±10 volts. FSC input also allows wavelength modulation, by applying a modulation signal whose frequency is lower than 10 kHz.

TUNICS-*Purity* Model	*Purity* S	*Purity* SC	*Purity* CL
Maximum input voltage	±10V	±10V	±10V
Sensitivity (typical)	300 MHz/V	300 MHz/V	300 MHz/V

Note: This input can be used for a fine adjustment of the wavelength or for optical frequency locking.

COHERENCE CONTROL

When a "noise" signal is directly fed into the "FSC" input via the **2nd** + **FSC** function to modulate the optical frequency over a range greater than ±100 MHz, this induces an apparent broadening of the laser linewidth leading to a reduction of the coherence length. This can be useful to eliminate parasitic interferometers in the user setup. This modulation is limited to low frequency (DC to 10 kHz typ.). When this function is active, the LED on the FSC key is blinking.

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Monitor Outputs

Two output connectors located on the rear panel enable continuous monitoring of actual values of current (**I** output), power (**P** output), wavelength (λ output), and detection of motor displacement (**Sync.** output). These monitor outputs use BNC connectors. Signal levels are as follows:

Monitor Output	Description	Reading
I output	Current monitoring	20 mV/mA (typ)
P output	Power monitoring	0.33 mV/μW (typ)
λ output	Wavelength monitoring	2.5 mV/nm (typ)
Sync.	Power monitoring	5 V: motor moving 0 V: motor idle

Remote Interlock

TUNICS-*Purity* is a Class IIIb product (21 CFR Subchapter J) equipped with a Remote Interlock connector. The user can attach a remote interlock switch to the Remote Interlock SUBD-9 connector located on the rear panel.

When connecting the remote interlock switch, user must provide a connector that meets the following pin assignment:

Remote Interlock Connector Pin Assignment

Pins 1-2	*Shorted*
Pins 6-7	*Connect to external switch*

Note: User must ensure the external switch is electrically isolated from other circuits, including earth ground.

Opening the interlock switch disables the laser output. The laser output may be turned on again by simply closing the interlock switch, and pressing the **Enable** key.

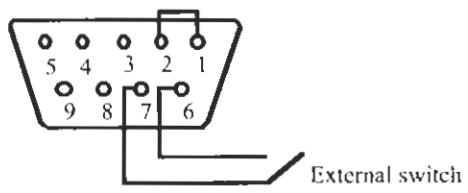
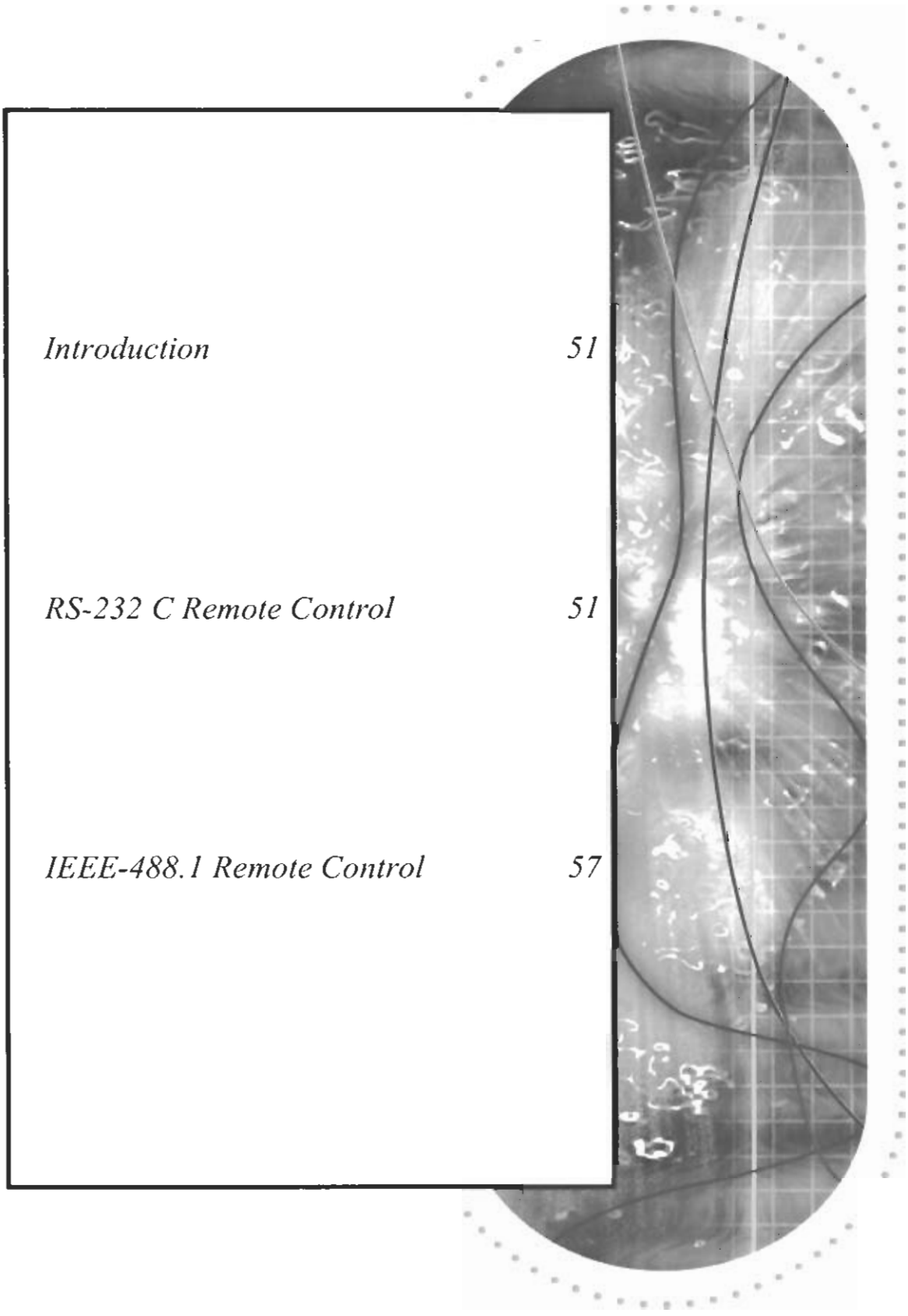


Figure 5 - 6: Remote Interlock SUBD-9 connector

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REMOTE CONTROL



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Remote Control

Introduction

TUNICS-*Purity* features two types of remote control interfaces, RS-232 C and IEEE-488.1 connectors on the rear panel. When TUNICS-*Purity* receives data from either the RS-232 C or the IEEE-488.1 interfaces, it automatically enters the remote control mode and the LED on the Remote key is lit to indicate that remote control is active. When TUNICS-*Purity* is operating in remote mode, all function keys on the front panel are disabled at the exception of the Remote key, which allows user to switch between remote and manual modes. To exit the Remote mode without breaking the cable connection to the remote terminal or computer, simply press the **Remote** key.

RS-232 C Remote Control

To operate in RS-232 C remote mode, connect a VT-100 compatible terminal or a PC equipped with a terminal emulation program to the RS-232 C port on the rear panel of the TUNICS-*Purity*.

Note: you first need to activate the RS-232 remote control mode, as explained in the Front & Rear Panels chapter, in the Mode Area, page 26.

When the Remote key LED is lit, all front panel manual commands are rerouted to the remote terminal or computer via the RS-232 C interface. In addition, user interface specific commands are also available in remote mode.

Physical Interface

The cable link is a crossover three-wire RS-232 C type that connects the TUNICS SubD-9 connector to a computer serial port. Make sure the RS-232 C cable connection meets the following pin assignment on the TUNICS-*Purity* SubD-9 connector:

- Pin 2: RX (Data received by TUNICS-*Purity* on pin 2)
- Pin 3: TX (Messages sent out by TUNICS-*Purity* via pin 3)
- Pin 5: GND (The ground is through pin 5)

Note that no other connector-pin is used.

Make sure to configure the computer's terminal emulation program with the following parameters:

Data transmission rate	9600 bauds
Number of bits	8
Parity	None
Stop bits	1

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The following table shows how to connect the TUNICS-*Purity* system (DCE) to your PC (DTE):

Table 6 - 1: Crossover, 3-wire RS-232 serial connection to TUNICS-*Purity*

Digital Communications Equipment (DCE)		Digital Terminal Equipment (DTE)	
1	o	o	1
(RXD) 2	o	o	2
(TXD) 3	o	o	3
4	o	o	4
(GND) 5	o	o	5
6	o	o	6
7	o	o	7
8	o	o	8
9	o	o	9

Message Format

All commands sent by the computer to the TUNICS-*Purity* are composed of a string of ASCII alphanumeric characters followed by a "carriage return" character (CR, or ASCII code 13). When the TUNICS-*Purity* receives such an instruction, the character string is decoded and the relevant procedure is carried out.

After completion, the TUNICS-*Purity* returns a message to inform the computer that the requested procedure has been performed or that an error situation has occurred. This response message is always ended with the same end-of-message group: "↵" (carriage return), ">" (greater than), and " " (space character).

These three characters indicate that the TUNICS-*Purity* system is ready to receive a new instruction.

Table 6 - 2: Example of dialog between the computer and the TUNICS-*Purity* (RS-232 C)

Computer/Terminal → TUNICS-*Purity*		TUNICS-*Purity* → Computer/Terminal	
Command String	**Instruction**	**Response Message**	**Description**
APCON	Set Constant Power (APC) On.	OK↵ >	Instruction performed correctly. TUNICS is awaiting another instruction.
P = 30↵	Change power output value to 30 mW.	Value error↵ >	Power output is over the maximum allowed. TUNICS is awaiting another instruction.
L?↵	What is the present wavelength value?	L = 1523.32↵ >	Present wavelength value. TUNICS is awaiting a new instruction.

The message syntax described above eases the management of the TUNICS/Computer interface since the computer must always await the acknowledgement before sending a

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new instruction. In addition, the response from the TUNICS is always ended with the three characters "⏎", ">" and "space", enabling user to easily spot the end of a message.

Note 1: The TUNICS-*Purity* user interface commands are not case sensitive.

Note 2: Multiple commands may be sent in single line and should have instructions separated by a semicolon ";", and a command string must always end with a carriage return character "⏎". The various instructions are processed by the TUNICS-*Purity* as soon as the "⏎" character is entered and executed in the order corresponding to the command string sequence (make sure sequential instructions are logically placed within a command string). However, responses generated by multiple command strings are ended with the carriage return character "⏎". Only the last response is ended with the end-of-message group "⏎", ">" and "space".

Note 3: The TUNICS-*Purity* input buffer is 255 characters long. Therefore, if you enter a command string more than 255 characters long, or submit a new command before previous strings have been processed, the buffer will be cleared, all received instructions lost, and the message "command error" will be sent.

Note 4: "White space"[6] characters are allowed in some places inside the command strings sent to the TUNICS-*Purity*. They can be placed at the beginning of an instruction, after an instruction, as well as before, after, or in place of the "=" sign. They cannot be inserted within an instruction mnemonic, within a numeric value, or between a mnemonic and the "?" mark.

Response Messages

All successful instructions resulting in a parameter change or a change of operating mode produce an "OK" statement ended with "⏎", ">", or "space".

If a command string is not recognized by the TUNICS-*Purity*, the message returned will be **"COMMAND ERROR"**. If a command requesting a new parameter setting is correctly formulated, but the specified value is outside the allowed limits for that parameter, the setting will remain unchanged and the response is **"VALUE ERROR"**.

Format of Numerics

Some command messages include a value. The format rules for these values are as follows:

- No spaces (see *Note 4* above) are allowed within values; leading zero ("0") characters are allowed at the beginning of a value.
- Digits after the decimal point may be sent or omitted.
- Digits after the decimal point are sent after the characters "." or ",".
- Values are ended with the "CR" character.
- Do not specify any units to parameter values. All values take the default units, factory-set for the TUNICS.

---

[6] On the RS232 C interface, all characters with ASCII codes lower than or equal to 32, except the carriage return character (ASCII code 13) are considered as white space characters.

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Table 6 - 3 provides some correct and incorrect examples of the message formats for numerics.

Table 6 - 3: Examples of message formats with numerics (RS-232 C)

Entry	Correct/Incorrect	Meaning
I=5	Correct	Set diode current to 5.0 mA
P=0.22	Correct	Set power to 0.22 mW.
L=1530.2	Correct	Set wavelength to 1530.200 nm.
P=01	Correct	Set power to 1 mW.
P= 0.65	Correct (spaces before the numeric are allowed.)	Set output power to 0.65 mW.
P=0.65 mW	Incorrect (unit abbreviations are not allowed.)	Command error
L=1 520.31	Incorrect (spaces within the numeric between "1" and "5" are not allowed.)	Command error

Changing Parameter Settings

When "nn.n" occurs below, it stands for the transmitted numerical value. All commands must end with the "CR" character.

Responses sent by the TUNICS-*Purity* may be as follows:

OK	Command successfully executed
VALUE ERROR	Value outside valid range
COMMAND ERROR	Syntax error

Table 6 - 4 lists the commands for each parameter setting of the tunable laser.

Table 6 - 4: Command parameters (RS-232 C)

Command	Action
I=nnn.n	Sets the laser current level (in mA) and switches to the constant-current mode.
P=nn.nn[7]	Sets the optical power (in mW) and switches to the constant-power mode.
P=±nn.nn[7]	Sets the optical power (in dBm) and switches to the constant-power mode.
L=nnnn.nnn	Sets the emission wavelength (in nm). The laser is tuned directly to the desired wavelength without step-mode scanning. An "OK" statement is received when the emission wavelength has stabilized.
F=nnnnnn.n	Sets the optical frequency (in GHz). The laser is tuned directly to the desired optical frequency without step-mode scanning. An "OK" statement is received when the emission wavelength has stabilized.
FSCL=nn.n	Switches to the Fine Scanning mode (canceled by any other command). "nn.n" is the wavelength change in picometers (pm).
FSCF=n.nn	Switches to the Fine Scanning mode (canceled by any other command). "n.nn" is the optical frequency change in GHz.

[7] The units (dB or mW) should be first selected with the appropriate DBM or MW command.

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Command	Action
B_SUPPR=n	0=Eliminates the effect of the tuning micrometer screw backlash. 1=Restores the backlash suppression procedure.
PCAL1=nn.nn	Sets the calibration power (@ first wavelength).
PCAL2=nn.nn	Sets the calibration power (@ second wavelength).

Changing the Operating Mode

Table 6 - 5 lists the commands that change the TUNICS-*Purity* operating mode.

Table 6 - 5: Operating mode commands (RS-232 C)

Command	Action
APCON	Switches system operation to the Automatic Power Control (APC) also known as "constant-power" mode.
APCOFF	Cancels the APC and switches system operation to the "constant-current" mode. **Note:** Using the APCON and APCOFF commands is the same as pressing the **APC** key in manual operating mode to toggle between constant power and constant current mode.
AUTO_CAL	Launches the system auto-calibration sequence. (Same as pressing the **2nd** + **I** keys in manual mode.) **Note 1:** Using either the AUTO_CAL or INIT commands forces the system into performing an auto-calibration. **Note 2:** If the auto-calibration has failed, the message "referencing error" is displayed for a few seconds, and the TUNICS resumes normal operating status. Unlike the **2nd** + **I** command that stalls the system when a referencing error occurs, there is no need to press Enter to restore the system.
DBM	Sets dBm as the unit for optical power values.
MW	Sets mW as the unit for optical power values.
INIT	Starts the initialization of the optical head (this takes at least 10 s). **Note:** The INIT command is available in RS-232 C mode only. It generates the answer "Software Vn.nn" which stands for the software version. (Using this command in IEEE-488 mode would cancel all the pending commands stored in the GPIB buffer.)
ENABLE	Enables the optical output.
DISABLE	Disables the optical output.
CTRLON	Sets the linewidth coherence control ON.
CTRLOFF	Sets the linewidth coherence control OFF.

Note: Wavelength scans can only be performed manually via the command keys at the TUNICS-*Purity* front panel.

Reading System Parameters

Table 6 - 6 lists the queries for system parameters of the TUNICS-*Purity* tunable laser.

User can monitor system parameters such as laser output power, current level, and emission wavelength at any time during operations by typing appropriate parameter queries. A valid parameter value query consists of the command name immediately followed by the "?" mark.

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Table 6 - 6: System parameters (RS-232 C)

Query Statement	Action	System Response
I?	Returns the present diode-current level.	"I=nnn.n" (in mA) or "disabled" if the Enable mode is not active.
P?	Returns the present laser output power level	"P=nn.nn" (in mW) or "P=±nn.nn" (in dBm) or "disabled" if the Enable mode is not active.
L?	Returns the present emission wavelength value.	"L=nnnn.nnn" (in nm).
F?	Returns the present optical frequency value.	"F=nnnnnn.n" (in GHz).
LIMIT?	Returns the status of the current limitation feature.	"Yes" if the current is limited and "No" otherwise.
B_SUPPR?	Returns the status of the backlash suppression.	0 = the backlash suppression procedure is not in use. 1 = the backlash suppression procedure is in use.
PCAL1?	Returns the calibration power (@ first wavelength).	"PCAL1=nn.nn" (in mW).
PCAL2?	Returns the calibration power (@ second wavelength).	"PCAL2=nn.nn" (in mW).
ENABLE?	Returns the state of the laser output.	"ENABLE" or "DISABLE"
*IDN?	Returns system ID.	

Other System Commands

Table 6 - 7 lists the other system commands available on the TUNICS-*Purity* tunable laser.

Table 6 - 7: Other system commands (RS-232 C)

Command	Action
ECHON	Activates "echo" mode. When this mode is active, TUNICS sends an echo of each character received back through the serial cable. Since some terminals and terminal emulation programs do not feature local echo, this function can be useful for visual monitoring of the characters keyed in at the terminal or for having a secure link.
ECHOFF	Cancels "echo" mode. **Note:** The default system setting is ECHOFF. In addition, ECHON mode is restored to ECHOFF when user presses the **Remote** key to return to manual-mode operation.
LOCAL	Switches back to local mode.

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IEEE-488.1 Remote Control

GPIB Overview

The "GPIB" (General Purpose Interface Bus) communications link of TUNICS-*Purity* is compatible with the IEEE-488.1 Standard. The purpose of the normalized IEEE-488 bus is to allow communications between instruments and computers through a specialized parallel interface. The data transfer rate is as high as 1 Mbytes/s, and the information transfer is highly secured. The GPIB link is often used to automate measurement processes.

The standard configuration is composed of a controller device (which is usually a computer equipped with a GPIB interface board and corresponding IEEE-488 terminal emulation software) linked to various instruments. The controller manages the flow of information to, from, and between devices. One "talker" device and one or more "listener" devices may be present at any time on the GPIB link. Data sent on the bus is encoded in ASCII strings.

Each instrument on the bus is identified by its own GPIB address. The GBIP address is an integer in the range of 1 to 30. For each instrument, different control registers can be used to determine the instrument operation state. The default TUNICS-*Purity* GPIB address is 10 but it can be changed (see *Changing the GPIB Address* on page 62).

GBIP Functions Available on TUNICS-*Purity*

TUNICS-*Purity* supports the following GPIB functions, as listed in the table below:

Table 6 - 8: Supported GBIP functions

Mnemonic	Meaning	Implementation
SH1	Source handshake	Complete
AH1	Acceptor handshake	Complete
T5	Talker	Complete
L3	Listener	Complete
SR1	Service request	Complete
RL1	Remote / Local	Complete
PP0	Parallel poll	No
DC1	Device clear	Complete
DT0	Device trigger	No
C0	Controller	No

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Checking System Status with the Status Word Variable

Definition of the Status Word

The status word is an 8-bit value that reflects the status of the TUNICS-*Purity*. It contains a number of binary indicators, which can be used by the computer/terminal for optimal synchronization with the TUNICS-*Purity* unit. They indicate to the computer/terminal the nature of the current operations as well as the errors encountered. The only way to read the status word is to perform an operation called serial polling.

Table 6 - 9: Bit layout in status word (GPIB)

Bit #	Mnemonic	Meaning
7 (MSB)	(Bit not used)	Bit 7 is not used.
6	SRQ (Service ReQuest)	Set when a service request has been sent by the instrument. This bit is cleared when the bus controller reads the status register.
5	ESB	(Reserved for future use.)
4	MAV (Message AVailable)	Set when a message is placed in the output buffer. This bit remains set for as long as the output buffer is not polled.
3	LIM (Current LIMitation)	Activated when TUNICS-*Purity* is current-limited while in APC mode. Deactivated in all other cases.
2	ERRV (ERror in Received parameter Value)	Indicates that the value entered as a parameter could not be read, exhibits an invalid format, or is outside the valid range (e.g.: I=160). (For example, a parameter value becomes invalid when the parameter's unit is provided.) (The indicator is disabled when a correct instruction is received.)
1	ERRC (ERror in Received Command)	Indicates that an invalid command has been received. (Disabled when a valid command is received.)
0	OPC (OPeration Complete)	Indicates that the execution of the last command is complete. TUNICS-*Purity* is ready to receive new instructions. Activated when no task is currently performed by TUNICS-*Purity*. Deactivated when handling commands (and when shifting the drive to modify the wavelength emission). Particularly, during a wavelength scan operation, the OPC bit-value is 0 each time the motor is moving and 1 during the pause between two successive steps.

Note: when a condition is in effect, the corresponding binary indicator takes a bit-value of (1); otherwise, the default bit-value is (0).

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Use of the Service Request (SRQ)

The SRQ (Service Request) line is part of the definition of the IEEE-488.1 standard. The SRQ line can be triggered by any device on the bus. It alerts the central controller that a particular device requests to perform a specific operation.

When the controller detects that the SRQ line is active, it can probe all of the devices present on the bus to determine which device has initiated the service request and for what reason. This operation by which the controller reads the status word of each device is called "serial polling". The controller then monitors the bit-value of each indicator within the status word (see below).

The IEEE-488.1 standard specifies that when a device sends a service request, bit-value # 6 is set to 1. The other bits of the status word can reflect the state of different logical indicators of the system.

To help synchronize operations between the TUNICS-*Purity* and the computer/terminal, the latter can instruct the TUNICS-*Purity* to send a service request whenever certain bit-values are set to 1, as defined by the user. This can be achieved by using the instruction *SRE. Therefore, user does not need to repeatedly prompt for the status word since the TUNICS-*Purity* automatically notifies the computer/terminal when a particular event occurs.

User can configure the *SRE instruction to perform a particular service request. The transmitted parameter associated with the instruction *SRE is an integer that takes a value between 0 and 255. The *SRE can also be presented as an 8-bit binary value, each bit-value is either 0 or 1 depending on whether the corresponding status indicator is off or on.

For example, if the instruction *SRE=16 is received by the TUNICS-*Purity*, this corresponds to the binary value 00010000, as shown in Table 6 - 10. Since in this example the bit indicator #4 is set to 1 (Bit #4 = MAV = Message Available), the SRQ line will be automatically activated each time a message becomes available.

The following table provides examples of SRE values when individual indicator bit-values are set to 1.

Table 6 - 10: Examples of single-indicator SRE values

Indicator	SRE decimal value	Bit position #	Binary value
MAV	16	indicator #4	00010000
LIM	8	indicator #3	00001000
ERRV	4	indicator #2	00000100
ERRC	2	indicator #1	00000010
OPC	1	indicator #0	00000001

To calculate the parameter value to send with the instruction *SRE, simply add together the decimal values found in Table 6 - 10 of each individual indicators you would like to combine. For example, to obtain a service request each time an error is made, you must send the instruction "*SRE=6", obtained by adding the corresponding values of the two error indicators, which are ERRV(4) and ERRC(2).

Once the TUNICS-*Purity* has activated a service request, the status word is no longer automatically updated, until the controller performs a new serial poll on the GPIB link.

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As the status word indicators remain unchanged, this allows the status word to provide reliable system-status information at the time of service request.

IMPORTANT: Since the processing of an instruction begins with the deactivation of the OPC indicator, no new instruction can be processed until the computer has performed the serial poll. Therefore, user should perform a serial poll as soon as a service request is received by the computer. Once the status word is read, the service request is deactivated and the TUNICS-*Purity* can resume normal operation.

Syntax for Parameter Commands

Syntax and Message Conventions

Each data is sent over the bus as an ASCII character string. The following syntax applies to message send and receive:

- Each message string sent by the computer/terminal to the TUNICS-*Purity* is ended with the "line-feed" character (LF, ASCII code10), or the "EOI" (End Of Instruction) GPIB control line, or both.
- Instructions syntax is not case sensitive.

Instructions are divided into two groups:

- **Commands** are used to configure the TUNICS-*Purity* by selecting operating modes and setting operating parameters such as laser output power, and more. (For example, to set the laser output power to 5 mW, user simply needs to type in the command string "P=5".)
- **Queries** are used to monitor parameter values at any time during system operation. (For example, the command string "P?" probes the level of laser output power. The TUNICS-*Purity* is addressed as the "talker" and returns the present parameter value, for example, "P=5" if the power output is 5 mW at the time of query.)

Each command/query is immediately handled by the TUNICS-*Purity* microprocessor.
"Instruction_string" consists of a keyword with or without a question mark "?". Some commands require a parameter. The parameter and the keyword are separated by a "=" sign or a "white space".

Response messages

Upon completion of an instruction, TUNICS-*Purity* does not return any response message unless the command string is a query.

Value format

The following format rules apply to parameter values:

- Messages may contain one or more instructions. When a string containing several messages is sent, consecutive instructions must be separated by the semi-column ";" character.

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- Numeric, non-integer values such as the laser output power (P) must be transmitted in a fixed-decimal-dot format (for example, P=5.1). However, integer values such as the validation byte of the request condition for service of the SRE instruction do not take a decimal-dot.

- White space[8] characters are allowed in some places inside the strings sent to the TUNICS-*Purity*. They can be placed at the beginning of an instruction, after an instruction, as well as before, after, or in place of the "=" character. They cannot be inserted either in an instruction mnemonic and a numeric value, or between a mnemonic and the "?" character.

- Leading zero "0" characters are allowed at the beginning of a value.

- Digits after the decimal point may be sent or omitted.

- Decimal coma is not equivalent to decimal point.

- Values are ended with the "line-feed" character.

- Do not specify any units to parameter values. All values take the default units, factory-set for the TUNICS as shown in Table 6 - 11 below.

Table 6 - 11: Sample command syntax (GPIB)

Entry	Correct/Incorrect	Description
L= 1 530.2	Incorrect (no space allowed between "1" and "5")	Command error
L=1530.2	Correct	Set wavelength to 1530.200 nm
L=1530,2	Incorrect (no decimal coma allowed)	Command error
P=1 mW	Incorrect (unit abbreviations "mW" are not allowed)	Command error
P=1	Correct	Set power to 1 mW.
P=01	Correct	Set power to 1 mW.

Synchronization of Messages

To accelerate and secure the exchange of information between the computer/terminal and the TUNICS-*Purity*, we recommend using the value of the status word obtained by serial polling (see *Definition of the Status Word*).

This status word contains the information letting the computer/terminal know the status of commands received by the TUNICS-*Purity*, and therefore decide when a new instruction can be sent or when the requested parameter can be read.

Various flags in the status byte register (STB) indicate the outcome of the command last processed and the type of error event, if any (see also Table 6 - 9).

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[8] On the IEEE-488 interface, all characters with ASCII codes lower than or equal to 32, except the line-feed character (LF, ASCII code10), are considered as white space characters.

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Message synchronization is essential in the following two cases:

- **To ensure that a pending command has been completely executed before proceeding to perform other operations.** This can be checked through the OPC flag (bit 0 of STB). This flag remains false (0) as long as a command line has not been completely executed, and is set to true (1), afterwards. The computer should test this flag until it becomes true, and only then, proceed with the next instruction. In this case the STB byte must be read through a serial poll.

- **When a query statement has been sent, the computer must wait until the response is actually available before reading it.** This is signaled by the MAV flag (bit 4 of the STB byte). In this case the STB byte must be read through a serial poll. This flag remains false (its bit value is 0) until a complete message is available for reading. Therefore, the computer should constantly check this flag until it becomes true (bit value equal to 1), and only then, the response message associated with the query becomes available.

Error Handling

Two types of errors can occur in the transmission of instructions: command errors and value errors.

The system detects command errors each time a command string received by TUNICS-*Purity* is invalid due to a syntax error or to the use of an unknown mnemonic. The ERRC indicator in the status word is then activated.

A value error occurs when the command is valid, but the value of the parameter is incorrect, either because it could not be read or because it is outside the valid range. In both cases, the provided command is ignored and the ERRV indicator in the status word is activated.

Both ERRC and ERRV indicators are automatically reset when a new valid command is received.

Changing the GPIB Address

The TUNICS-*Purity* system GPIB link primary address is factory-set to 10. However, user can change the GPIB link address at any time by pressing the [2nd] + [**Remote**] keys. The current GPIB address is then displayed on the TUNICS-*Purity* screen, and a new value can then be entered. A valid GPIB primary address must be in the range of 1 to 30.

GPIB address change can also be performed in IEEE remote mode by typing the command: "GPAD=nn", where "nn" is an integer within the 1-30 range.

The new GPIB address is then stored in flash memory, and becomes the new default system setting. TUNICS-*Purity* retains the new GBIP address even after system turn-off.

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Local Lockout

When the TUNICS-*Purity* receives a message via its IEEE-488.1 interface, it switches automatically to the remote operation mode, and the Remote LED on the front panel is lit. In remote operating mode, all other keys of the TUNICS front panel become inactive. TUNICS can return into local (or manual) operating mode by pressing the **Remote** key.

If the "Local lockout" instruction is provided via the GPIB interface, the local (or manual) mode can no longer be restored via the TUNICS front panel Remote key (pressing the Remote key will trigger a "Local lockout" message on the TUNICS display). To return into local mode, user must enter the GBIP command "**Go to local**".

IEEE-488.1 Control Commands

IEEE Standard Commands

The following standard commands of the IEEE-488.1 interface can be processed by TUNICS-*Purity*:

Note: These correspond to basic commands whose syntax varies depending on the particular GPIB driver software you are using. For the exact syntax of standard commands, please refer to the user's manual that comes with your GPIB hardware and software.

Table 6 - 12: IEEE Standard commands

Function	Description
Remote change	Switches from remote to local mode or local to remote mode
Local lockout	Disables all controls from the front panel
Status reading	Conduct a serial poll.
Write	Write data to a device
Read	Read data from a device
Clear	Reset a specific device

Changing Parameter Settings

Table 6 - 13 lists the commands for each parameter setting of the TUNICS-*Purity*. Each "n" represents a numeric value between 0 and 9.

Table 6 - 13: Parameter commands (GPIB)

Parameter Command	Meaning
I=nnn.n	Sets the laser current level in mA.
P=nn.nn[9]	Sets the laser output power to nn.nn mW.
P=±nn.nn[9]	Sets the laser output power to ±nn.nn dBm.
L=nnnn.nnn	Sets the emission wavelength to nnnn.nnn nanometers.
F=nnnnnn.n	Sets the emission optical frequency to nnnnnn.n GHz.
FSCL=nn.n	Switches to the Fine Scanning mode. (canceled by any other command). nn.n is the wavelength change in picometer (pm).

[9] The units (dBm or mW) should be first selected with the DBM or MW command.

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Table 6 - 13: Parameter commands (GPIB) *(cont'd)*

FSCF=n.nn	Switches to the Fine Scanning mode. (canceled by any other command). n.nn is the optical frequency change in GHz.
*SRE=nnn	Defines the conditions under which the TUNICS-*Purity* will automatically send a service request (SRQ) to the computer/terminal.
GPAD=nn	Sets the GPIB address of the TUNICS-*Purity*.
B_SUPPR=n	0=Eliminates the effect of the tuning micrometer screw backlash. 1=Recovers the backlash suppression procedure.
PCAL1 =nn.nn	Sets the calibration power (@ first wavelength).
PCAL2 =nn.nn	Sets the calibration power (@ second wavelength).

Note: Wavelength scans can only be performed manually, via the command keys at the TUNICS-*Purity* front panel.

Changing Operating Mode

Table 6 - 14 lists the TUNICS operating mode commands.

Table 6 - 14: Operating mode commands (GPIB)

Command	Action
APCON	Turns on the Automatic Power Control.
APCOFF	Turns off the Automatic Power Control. **Note:** Using the APCON and APCOFF commands is the same as pressing the **APC** key in manual operating mode to toggle between constant power and constant current mode.
AUTO_CAL	Launches the system auto-calibration sequence. (Same as pressing the **2nd** + **I** keys in manual mode.) **Note 1:** Using the AUTO_CAL command forces the system into performing an auto-calibration. **Note 2:** If the auto-calibration has failed, the message "referencing error" is displayed for a few seconds, and the TUNICS resumes normal operating status. Unlike the the **2nd** + **I** command that stalls the system when a referencing error occurs, there is no need to press Enter to restore the system.
DBM	Switches power units to dBm.
MW	Switches power units to mW.
ENABLE	Enables the laser output.
DISABLE	Disables the laser output.
CTRLON	Sets the linewidth coherence control ON.
CTRLOFF	Sets the linewidth coherence control OFF.

System and Parameter Queries

Table 6 - 15 lists the TUNICS-*Purity* system parameter queries. User can send queries to monitor system parameters in real time as well as prompt for current software version.
Note: A valid parameter value query consists of the command name immediately followed by the "?" mark.

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Table 6 - 15: System parameter queries (GPIB)

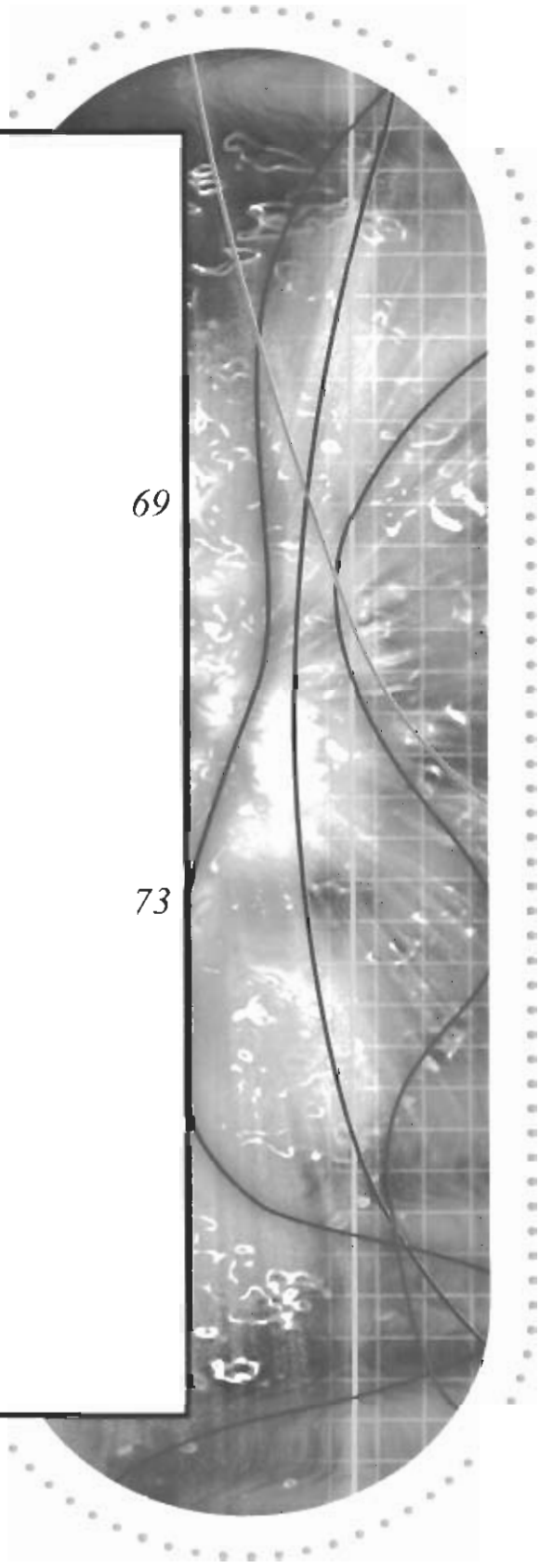
Queries	Result
I?	Returns the value of the laser-diode current (mA).
P?	Returns the value of the optical output power (mW or dBm)[10].
L?	Returns the value of the emission wavelength (nm).
F?	Returns the value of the optical frequency (GHz).
*IDN?	The TUNICS returns the message "NetTest, TUNICS Purity, 0,n.nn" where n.nn is the software release.
B_SUPPR?	Returns: "0" when backlash suppression is On; "1" when backlash suppression is Off.
ENABLE?	Returns the state of the laser output (ENABLE/DISABLE).
LIMIT?	Returns the status of the current limitation feature. "Yes" means the current is limited or "No" otherwise.
PCAL1?	Returns the calibration power at first wavelength LCAL1.
PCAL2?	Returns the calibration power at second wavelength LCAL2.

[10] The units (dBm or mW) should be first selected with the DBM or MW command. (See *Table 5-9: Operating mode commands.*)

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SERVICE INFORMATION



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Service Information

Performance Verification

Use the procedures in this section to verify the following warranted specifications of the TUNICS-*Purity* Tunable External Cavity Laser:

- Absolute wavelength accuracy
- Wavelength range and output power
- Signal to source spontaneous emission ratio
- Tuning repeatability
- Return loss

The recommended calibration interval is one year.

⚠	***WARNING***	To avoid eye damage, do not look into the laser output or into the end of an optical cable. Even though the laser radiation is not visible, the intense infrared light can cause eye damage. Always disable the laser output while connecting and disconnecting the fiber-optic cable.

Equipment Required

Table 7 - 1 lists the equipment to carry out the performance verification procedures. The type and amount of connectors needed may vary depending on the particular equipment you use as well as the distance between the test equipment and the TUNICS tunable laser under test.

Table 7 - 1: Test equipment

Description	Minimum Requirements	Example Products
Optical power meter	Wavelength range: 1260 nm to 1640 nm	RIFOCS 578L ANDO AQ 2140
Optical Spectrum Analyzer (OSA)	Wavelength range: 1450 nm to 1650 nm	NETTEST WALICS
Wavemeter	Wavelength range: 1260 nm to 1650 nm	BURLEIGH WA1000
Jumper	FC/APC to FC/PC	
Inline optical adapter	FC to FC	

Preparation

Warm up the TUNICS-*Purity* tunable laser under test and the test equipment for 2 hours at an ambient temperature (between 20° and 30° C).

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Initializing the System

To ensure safe operation, use the following procedure to initialize the system:

- Make sure the key on the front panel is in the Standby position.
- Connect the power supply cable to the rear panel of the TUNICS-*Purity* unit on one end and to the proper power outlet on the other end.
- Set the rear panel MAINS switch to ON.
- Turn the front panel on/off key to the right. During the initialization phase, the message "**Initializing**..." is displayed.
- The message **"Referencing..."** is then displayed to indicate that the system performs its self-calibration (internal referencing of the wavelength). This message clears once the TUNICS-*Purity* tunable laser is initialized and ready for operation.
- At the end of the initialization routine, the tunable laser is ready to enable. The message "**disabled**..." appears on the display.

⚠	***IMPORTANT***	Once the initialization process is complete, the laser is still not enabled for safety reasons, and the message "disabled..." is displayed. To enable the tunable laser, user must press the **Enabled** key on the TUNICS-*Purity* front panel.
⚠	***CAUTION***	Avoid switching the unit off before the system is fully initialized.

Connecting the Laser Output

To connect the laser output, remove the protective cap and use an optical fiber with a FC/APC type connector.

⚠	***CAUTION***	To avoid damage to the laser output, always use a FC/APC type connector. To connect other types of connectors such as FC/PC, make sure to use the appropriate FC/APC converter. To help protect the laser output, leave a fiber-optic cable connected to the unit while making connections to other devices. When the laser output is not connected, always install the protective cap.

To achieve optimum system performance, optical connections must be clean and free of contamination. Cleaning instructions for optical connections can be found in the *Maintenance* section in this chapter.

Enabling the Laser Output

For safety reasons, the laser output is enabled only when user presses the **Enabled** key.

- To enable the laser output, press the Enable key. The Enable LED is lit to indicate that the TUNICS-*Purity* is emitting a laser output.
- To disable the laser output, simply press the Enable key again and check that the Enable LED went off.

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Shutting Down the Laser

To shut down the laser, turn the front panel key counterclockwise to the Standby position. The message "**Parking...**" is displayed and the optical head is moved automatically to its parking position. Wait a few seconds till the system shuts down by itself.

⚠	***WARNING***	Do not unplug the fiber-optic cable from the laser output connector while the laser is still enabled, as exposure to the laser beam is potentially harmful.

⚠	***CAUTION***	Follow these guidelines while shutting down the system: • Do not turn on and off the system repeatedly and too rapidly, and particularly after turning off the laser, wait at least thirty seconds before initializing the laser again. • Avoid switching off the unit before the system is fully initialized.

Absolute Wavelength Accuracy

This procedure verifies that the wavelength settings agree with the measured wavelengths over the entire specification range. If these values do not match the absolute wavelength specification, user may calibrate the lower and upper wavelength setting limits by using an external wavemeter, as described below:

- Connect the laser to the wavemeter.
- Set the output power to 0 dBm using the front-panel power controls: (Press P > 0 > ENTER).
- Set the wavelength of the tunable laser to the lower limit of the wavelength range according to the TUNICS-*Purity* model (see *Appendix B: Valid Range for Parameter Settings*).
- Enable the laser output and verify the wavelength at the lower limit ±0.05 nm.
- Repeat the check for each increment of 5 nm from the lower limit to the upper limit listed in *Appendix B: Valid Range for Parameter Settings*.
- Verify that the measured wavelength is no greater than ±0.05 nm away from each wavelength setting.

Wavelength Range and Output Power

This procedure verifies that the laser output can achieve the rated power at the specified limits of the wavelength range. If the power settings do not exactly match the measured power, you may calibrate the power settings from the front panel, as follows:

- Disable the laser output.
- Connect the laser to the optical power meter.
- Set the wavelength of the tunable laser and the power meter to the lower limit of the wavelength range listed in Table 2 - 1 in the *General Information* chapter.
- Enable the laser output and adjust the power setting as necessary to verify that the laser can achieve the rated output power at the lower limit of the wavelength range.

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- Set the wavelength of the tunable laser and the power meter to the upper limit of the wavelength range listed in Table 2 - 1.
- Enable the laser output and adjust the power setting as necessary to verify that the laser can achieve the rated output power at the upper limit of the wavelength range.

Signal to Source Spontaneous Emission Ratio

This procedure verifies the ASE-noise of any wave emissions that are more than 5 nm away from the selected wavelength. This procedure requires the use of an optical spectrum analyzer:

- Connect the laser output to the optical spectrum analyzer.
- Set the laser wavelength at mid-range of the wavelength specification range listed in Table 2 - 1 in the *General Information* chapter.
- Set the laser output power to 0 dBm
- Configure the optical spectrum analyzer as follows:

Control	Setting
Center wavelength	Same as laser wavelength
Span	20 nm
Resolution	0.1 nm
Reference level	0 dBm
Level scale	10 dB/div
Scan	Repeat

User can now verify that at wavelength deviations larger than 5 nm from the centered wavelength of the laser peak, the power level of any residual emissions should be lower than -90 dB down from the peak level.

Wavelength and Power Calibration

During the course of the performance verification it is possible that the settings for wavelength and power may not agree with the measured values. If this occurs, you may calibrate wavelength and power settings from the front panel.

⚠	***CAUTION***	**The procedures to calibrate the wavelength and power settings erase factory-set calibration data. Do not perform these procedures unless** you have calibrated sources.

To perform the wavelength and power calibration procedures, refer to the *Wavelength Calibration and Power Calibration* sections in the *Operation* chapter.

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Maintenance

User maintenance of the TUNICS-*Purity* is limited to the following:

- Cleaning optical connectors for optimum power
- Checking the performance of optical connections and cables
- User calibration
- Replacing the line fuse

⚠	***WARNING***	DO NOT MAKE ANY SERVICE OR MAINTENANCE TO THE TUNICS-*Purity* LASER HEAD: Under no circumstance must the user make any service or maintenance repairs of any kind to the TUNICS-*Purity* laser head. The user must not remove the protective cover of the TUNICS-*Purity* laser head. Refer servicing to authorized NetTest personnel only.

Cleaning and Caring for Optical Connectors and Fibers

- Handle optical fiber with appropriate care and keep optical connectors free of outside contaminant to preserve optical-signal integrity.
- Use the following items to clean the optical connectors:
  - clean compressed air
  - fiber-optic cleaning swabs
  - isopropyl alcohol
- Follow these steps to clean the optical connectors:

1. Hold the can of compressed air upright and spray the can into the air to purge any propellant.
2. Spray the clean compressed air on the connectors to remove any loose particles or moisture.
3. Moisten a clean optical swab with isopropyl alcohol, then lightly swab the surfaces of the connectors.
4. Spray the clean compressed air on the connectors again to remove any loose particles or isopropyl alcohol.

Note: Cleaning kits for optical connectors are available from many fiber optic suppliers.

⚠	***CAUTION***	To optimize the performance of the system and to prevent loss of optical power or damage to the optical connectors, keep the connectors clean at all times. When cleaning the connectors with a swab, use gentle circular motions. Use only high quality cleaning supplies that are non-abrasive and leave no residue. To reduce the need for cleaning, immediately replace protective caps on the optical connectors when not in use. Do not over stress or sharply bend optical fiber beyond tolerances specified by the manufacturer.

- To clean the internal connector, unscrew the plug, slightly pull it towards you, and clean the internal connector. Then put every thing back in place. This operation must be made carefully in order not to damage the internal connector near the fiber cable.

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Cleaning of the Instrument

If necessary, follow these steps to clean the TUNICS-*Purity* unit:

- Unplug the power cord from the mains supply before cleaning.
- Clean the case with a slightly damp cloth with an isopropyl alcohol liquid.

⚠	***CAUTION***	**Do not use chemically active or abrasive materials to clean the instrument.**

User Calibration

To externally verify the performance of the TUNICS-*Purity*, refer to the procedure described in the *Wavelength Calibration and Power Calibration* sections in the *Operation* chapter. If the performance does not meet warranted specifications, a complete calibration of the instrument may be required.
Some calibration steps require the adjustment of internal components including the laser head. Therefore, a complete calibration must be performed by authorized NetTest personnel only.

Replacing the Line Fuse

Before replacing the line fuse, be sure to unplug the power cord.

- Insert a small flat-blade screwdriver into the notch just inside the power cord socket of the line filter (see Figure 7 - 1).
- Use the notch to pull the fuse holder straight out to remove the fuse.
- Replace the fuse (4.0A 250V SLOW/(T)) in the fuse holder and snap the fuse holder back into the lined filter.

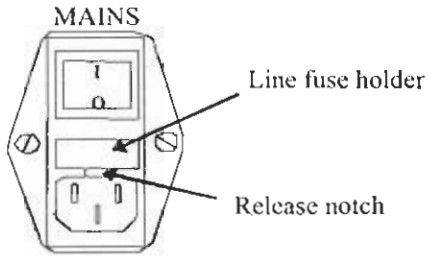


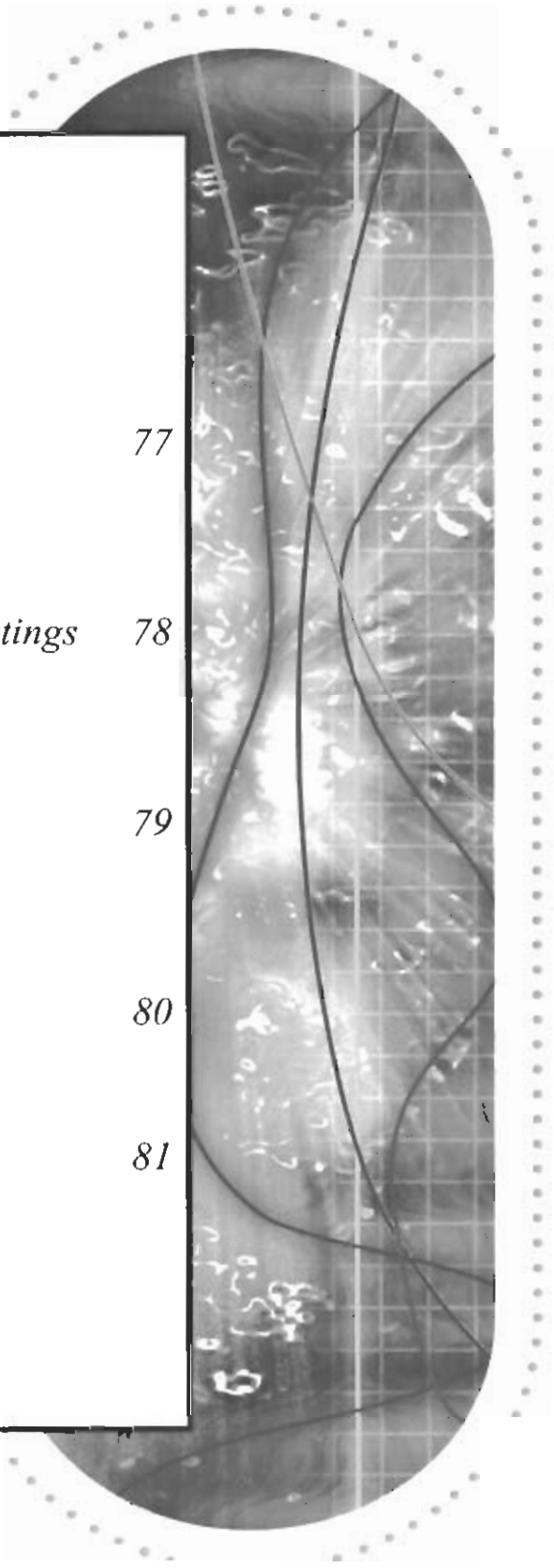
Figure 7 - 1: Replacing the line fuse

Packaging for Shipment

When you receive the instrument, please keep the original packaging for potential use.
Use the original packaging in case you need to return the TUNICS-*Purity* tunable laser source unit to NetTest for servicing or calibration. For instructions on returning the instrument, please contact NetTest (see *Contact Information* on page 8).

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Appendices

Appendix A: Error and Warning Messages

Message	Possible cause	Troubleshooting
WARNING: User calib. Err press "enter"	User calibration is not correct.	As the user calibration is not valid, the TUNICS-*Purity* implements the default calibration value instead.
ERROR: No factory calib. Turn Power off	No factory calibration.	Turn off the system and check the integrity of electrical connections. If this error message shows continuously, please contact a service engineer immediately.
Referencing error. Press Enter	The system's internal wavelength referencing operation has failed.	Press Enter to restore the current system settings. Internal wavelength referencing remains unchanged.
VALUE error Press Enter.	The system parameter you are trying to configure is outside the valid range. (See *Appendix B: Valid Range for Parameter Setting*)	Press Enter. All changes are discarded and the previous parameter value is restored.
Limit Switch Turn Power off	Mechanical problem.	Turn off the system and contact a service engineer immediately.
EEPROM error Turn Power off	Electrical problem.	Turn off the system and contact a service engineer immediately.

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Appendix B: Valid Range for Parameter Settings

TUNICS-*Purity* Model	*Purity* S	*Purity* SC	*Purity* CL
Laser diode current level (I)	See attached test report	See attached test report	See attached test report
Beam output power (P)			
Standard power range	0.2 – 10 mW	0.2 – 10 mW	0.2 – 10 mW
+3 dBm range	0.2 – 15 mW	0.2 – 15 mW	0.2 – 15 mW
Upper and lower wavelength scan limits (nm)			
Standard power range	1430-1530	1470-1570	1525-1625
+3 dBm range	1450-1510	1510-1570	1560-1620
Wavelength scan steps (nm)	0.001-140	0.001-140	0.001-140
Time at each scan step (Pause Timer)	0.1 - 25 sec	0.1 - 25 sec	0.1 - 25 sec

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Appendix C: Certification and Compliance

Category	Standards or Description
EC Declaration of Conformity-EMC	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Union: Directive 89/336/EEC for Electromagnetic Compatibility. EN 50081-1 Emission: EN 55022 Class B Radiated and Conducted Emissions EN 50082-1 Immunity: EN 61000-4-2 Electrostatic Discharge Immunity IEC 60801-3 RF Electromagnetic Field Immunity EN 61000-4-4 Electrical Fast Transient/Burst Immunity
EC Declaration of Conformity-Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Union: Low Voltage Directive 73/23/EEC, amended by 93/68/EEC. EN 61010-1: 1993/A2: 1995 Safety requirements for electrical equipment for measurement control and laboratory use. EN 60825- 1/A1: 1994 Safety for Laser Products, Part 1. Equipment classification requirements and user's guide.
U.S. Nationally Recognized Testing Laboratory Listing	UL3111-1 Standard for electrical measuring and test equipment.
Canadian Certification	CAN/CSA 1010-1-92 including MOD: 1997 Safety requirements for electrical equipment for measurement, control, and laboratory use.

Safety Certification and Compliance

Equipment Type	Test and Measuring
Safety Class	Class 1, as defined in IEC-61010-1 annex H-Grounded product.
Mains supply voltage	100-240 V AC with ±10% fluctuation max.
Installation (overvoltage) category	Overvoltage category II, as defined in IEC 61010-1, annex J. Local-level mains (wall sockets). Equipment at this level includes appliances, portable tools, and similar products. Equipment is usually cord-connected.
Pollution Degree	Pollution Degree 2, as defined in IEC 61010-1. **Note:** rated for indoor use only. Normally only dry, nonconductive pollution occurs. Occasional and temporary conductivity caused by condensation may occur. This location is a typical office/home environment. Temporary condensation occurs only when the product is left unused.
Safe operating temperature range	+5°C to +40°C.
Maximum relative humidity	80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C.
Altitude (maximum operating)	2000 meters.

The above certification and compliance approvals of the TUNICS-*Purity* external cavity laser series are pending.

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Appendix D: Replaceable Parts

For information about replaceable parts, contact your NetTest sales representative.

Standard Accessories

Name	Description
Fuse	4A T 250V
Manual, tech: instruction	TUNICS-*Purity* instruction manual
PM optical fiber cable	Single-mode polarization maintaining cable
Optical fiber cable	Single-mode cable
Power key	Front panel keylock
Rack-mount handles	2 rack-mount handles

Optional Power Cords

Name		Description
North America	110 V, 60 Hz	CSA STD C22.2 NO21-M1984, ECN 436C approved, 5-15P attachment plug cap molded onto No18 AWG, type SVT,SJT flexible cord, 2 meter (78.7 inch), 125V/10A AC, US
Universal European	220 V, 50 Hz	DIN 49441/2, CEE7, DIN 0625, VDE approved, IEC attachment plug cap, HO5VV-F3G 0.7 mm^2 flexible cord, 2.5 meter (98.4 inch), 250V/10A AC, EUROPEAN
United Kingdom	240 V, 50 Hz	BS4491.EN60.320,BASEC BS6500, ASTA BS 1363A, VDE, SEV, BSI approved, 1.0 mm^2 flexible cord, 2 meter (78.7 inch), 250V/10A AC, 25.4 mm fused UK plug (13A fuse)

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