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# 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, 8166A/B Lightwave Multichannel System

User Guide

KEYSIGHT TECHNOLOGIES

# Notices

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# Contents


## 1 Getting Started

**Safety Considerations** 18

- Safety Symbols 18
- General 18
- Operating Environment 19
- Line Power Requirements 19
- Input/Output Signals 20
- Line Power Connectors 20
- Instrument Markings 21

**Laser Safety Information** 23

- Laser Safety Labels 31

**8163A/B Lightwave Multimeter** 34

**8164A/B Lightwave Measurement System** 35

**8166A/B Lightwave Multichannel System** 36

**A Description of the User Interface** 37

- Password 38
- User Interface Features 39
- How to Navigate/Modify the Display 40

**How to Change the Value of a Parameter** 54
How to Select a Parameter 54
How to Accept the New Value of a Parameter 54
How to Make a Big Change to a Continuous Parameter 54
How to Make a Small Change to a Continuous Parameter 55
How to Change a Discrete Parameter 56
How to Set All Parameters to Their Default Values 57
If You Make a Mistake 57
If the Parameter Changes to Different Value 57

**A Sample Session** 58
How to Measure the Power of a Modulated Signal 58

2 Additional Information

**Using the System Utilities** 62
How to Set the Backlight 63
How to Set the Date & Time 65
How to Lock/Unlock the High-Power Laser Sources 67
How to Set the Trigger Configuration 68
How to Configure Startup Applications 69
How to Configure your Foot Pedal 70
How to Set the GPIB Address 72
How to Configure LAN 73
How to Set the Speed of the Serial Interface 87
How to Update a Module 88
How to Select the Printer Type 89
How to Change the Password 91
If You Forget Your Password 91
How to Get Information About Modules 91
How to Get Information About the Mainframe 94

**How to Connect an External Monitor** 95

**How to Connect a Printer** 97

## 3 Power Measurement

**How to Measure Power** 100

The Power Value 100
How to Set the Power Unit 101
How to Set the Calibration Offset 102
How to Set the Reference Level 103
How to Set the Wavelength 106
How to Remove Electrical Offsets 106
How to Choose the Range Mode 109
How to Set the Range 110
How to Set the Averaging Time 115
How to Choose the MinMax Mode 116
How to Turn Off MinMax Mode 118
How to Hold the Screen 119
How to Use Triggers 119
Dual Power Meters - Master and Slave Channels 122

## 4 Laser Sources

**How to Use Laser Source Modules** 124

The Laser Wavelength Value 124
How to Enable/Disable Laser Output 125
How to Set Attenuation 126
How to Modulate the Optical Output 127
How to Use the Internal Modulation 127
How to Use Triggers 130

## 5 Tunable Lasers

**What is a Tunable Laser?** 134

How to Set the Power 134
How to Set the Output Power of a CW Signal 134
What is Excessive Power ? 139
How to Set the Laser to the Dark Position 140
The Analog Output 141

**How to Set the Wavelength** 143
Wavelength Range 143
How to Set the Wavelength Directly 143
How to Set a Relative Wavelength 144

**How to Perform a Wavelength Sweep** 147
What is a Wavelength Sweep ? 147
How to Set the Wavelength Sweep 147
How to Perform a Sweep 149

**How to Modulate a Signal** 155
How to Use the Internal Modulation 155
How to Use External Modulation 156
How to Configure the Modulation Output 161

**How to Use Triggers** 163
How to Use Input Triggering 163
How to Use Output Triggering 165

**How to Use Auxiliary Functions** 167
Automatic Realignment 167
How to Perform a Lambda Zero 169
Auto Cal Off 170

6 Compact Tunable Lasers

**Compact Tunable Laser modules** 174

**How to Use a compact Tunable Laser** 175
The User Interface 175

## 7 Return Loss Measurement

**Getting Started With Return Loss** 178

What is Return Loss? 178
What is Insertion Loss? 178
Equipment required 179
How to Choose a Light Source 180
Return Loss Modules 181

**Calibration Measurements** 183

**Return Loss Measurement** 184

Patchcord on RL module Output 184
Setup 184
Calibrating the Return Loss Module 188
Calibration using the Keysight 81000BR Reference Reflector 189
Calibration using the Keysight 81610CC Reference Cable 192
How to Measure Return Loss 198
Viewing the Calibration Values 199

**A Background to Return Loss Measurement** 203

Measuring the Reflected Power from a Component with Known Reflection Factor 203
Measuring the Power Transmitted Through the Reflection Reference 204
Measuring the Power when there are No Reflections 205
Measuring the Power Transmitted Through the Measurement Patchcord 205
Measuring the Reflections from the DUT 206
Measuring the Power Transmitted Through the DUT 206
Calculating the Return Loss of the DUT 207
Calculating the Front Panel Delta 209
Calculating the Insertion Loss of the DUT 211

8 Setting Attenuation and/or Power Levels

**Keysight 8157xA Variable Optical Attenuator modules** 214

**How to Use a Variable Optical Attenuator module** 216

The User Interface 216
How to Control the Shutter 219
How to Set Attenuation 220
How to Set a Power Level 224
**Calibrating Test Setups that use an 81570A/71A/73A/78A Attenuator module** 225
How to Compensate for Wavelength Dependencies in your test setup 229
How to Construct a λ Offset Table 231
How to Use the Power Control Feature 233
Attenuator Menu Options 233
Attenuator Status Indicators 236

9 Switching Optical Routes

**Keysight 8159xB Optical Switch modules** 238

Options 238

**How to Use an Optical Switch module** 240

The User Interface 240
Dependent and Independent Routing 242
How to set Route A 242
How to set Route B 243
How to Toggle the Switch path 243

**Typical Applications** 244

Selecting a Laser Source 244
Selecting Measurement and Calibration Paths 244
Inserting or Bypassing an Optical Component 245
Selecting one of several DUTs in a parallel test setup 245
Selecting one of several instruments 246

## 10 Applications

**Working with Application Graphs** 249
- How to Set Markers 250
- How to Zoom In 250
- How to Zoom Out 251
- To Switch the Grid On/Off 251
- How to Use Legends 251
- How to Select the Samples Display 253
- How to Read Curve Values 256

**The Logging Application** 261
- How to Set Up a Logging Function 262
- Running a Logging Application 267
- Analysing a Logging Application 269
- On-Screen Messages 273

**The Stability Application** 274
- How to Set Up a Stability Function 275
- Analysing a Stability Application 282
- On-Screen Messages 286

**The PACT Application** 287
- What is the PACT ? 287
- How to Set Up PACT 287
- How to Measure the Reference 291
- How to Perform a Loss Measurement 294
- Analysing a PACT Measurement 299
- On-Screen Messages 301

**The Pmax Curve** 302
- What is the Pmax Curve ? 302
- How to View the Pmax Curve 302

**The Return Loss Application** 303

Starting the Application 303
Measuring Return Loss 303
Measuring Return Loss and Insertion Loss 303
On-Screen Messages 304
Configuration 304
User Interface 305

**Recording Measurement Results** 307

Printing Application Measurement Results 307
Saving Application Measurement Results to Diskette (not available on later units) 310

11 Installation and Maintenance

**Safety Considerations** 314

**Initial Inspection** 315

**AC Line Power Supply Requirements** 316

Line Power Requirements 316
Line Power Cable 316
Changing the Battery 320
Changing the Fuse 320

**Operating and Storage Environment** 321

Temperature 321
Humidity 321
Altitude 322
Pollution Protection 322
Storage and Shipment 322
Instrument Cooling 322
Storage Position 324
Carrying the Instrument 325

**Using Modules** 327
How to Fit and Remove Modules 327
Adding a Connector Interface 333
Protecting Empty Module Slots 333
**Input and Output Connectors** 335
The Remote Interlock (RIL) connector 337
**GPIB Interface** 338
Cables and Adapters 338
Connector 338
**GPIB Logic Levels** 340
**Serial Interface** 341
**Parallel Port, PCMCIA Slot, Keyboard connector and 24V DC Output** 342
**Claims and Repackaging** 343
Return Shipments to Keysight Technologies 343

12 Accessories

**Instrument and Options - Keysight 8163A/B** 346
**Instrument and Options - Keysight 8164A/B** 347
**Instrument and Options - Keysight 8166A/B** 348
Modules 349
Keysight 81645A Filler Module 353
**GPIB Cables and Adapters** 354

13 Specifications and Regulations Compliance

**8163A Specifications** 356
**Keysight 8163B Specifications** 357
**8164A Specifications** 358
**Keysight 8164B Specifications** 359

**8166A Specifications** 360

**Keysight 8166B Specifications** 361

**Declarations of Conformity** 362

Keysight 8163A Lightwave Multimeter 362
Keysight 8163B Lightwave Multimeter 363
Keysight 8164A Lightwave Measurement System 364
Keysight 8164B Lightwave Measurement System 365
Keysight 8166A Lightwave Multichannel System 366
Keysight 8166B Lightwave Multichannel System 367

**Regulations Information** 368

Safety Canada 368
EMC Canada 368
EMC Australia/New Zealand 368

14 Error Messages

**SYST:ERR?** 370

**Screen Status Messages** 372

**Mainframes** 373

8163A 373
8163B 373
8164A 374
8164B 374
8166A 375
8166B 376

**Errors appearing on pop-up menus** 377

Error on Module 377
Error 380

**Tunable Laser Sources** 382

Initialization Tests 382
Selftests 389

**Return Loss Meters** 395

**Power Meters & Interface Modules with Optical Head** 400

**Fixed Laser Sources (Fabry Perot)** 407

**DFB Laser Sources** 412

**Attenuator Modules** 415

**Optical Switch modules** 418

15 Cleaning Instructions

**Safety Precautions** 425

**Why is it important to clean optical devices ?** 426

**What do I need for proper cleaning?** 427

Standard Cleaning Equipment 427
Additional Cleaning Equipment 429

**Preserving Connectors** 432

Making Connections 432
Dust Caps and Shutter Caps 432
Immersion Oil and Other Index Matching Compounds 432

**Cleaning Instrument Housings** 433

**Which Cleaning Procedure should I use ?** 434

Light dirt 434
Heavy dirt 434

**How to clean connectors** 435

Preferred Procedure 436
Procedure for Stubborn Dirt 436
An Alternative Procedure 437

**How to clean connector adapters** 438

Preferred Procedure 438
Procedure for Stubborn Dirt 438

**How to clean connector interfaces** 439
Preferred Procedure 439
Procedure for Stubborn Dirt 439
How to clean bare fiber adapters 439
Preferred Procedure 440
Procedure for Stubborn Dirt 440
**How to clean lenses** 441
Preferred Procedure 441
Procedure for Stubborn Dirt 441
**How to clean instruments with a fixed connector interface** 442
**How to clean instruments with an optical glass plate** 443
**How to clean instruments with a physical contact interface** 444
Preferred Procedure 445
Procedure for Stubborn Dirt 445
**How to clean instruments with a recessed lens interface** 446
Preferred Procedure 446
Procedure for Stubborn Dirt 446
**How to clean optical devices which are sensitive to mechanical stress and pressure** 447
Preferred Procedure 447
Procedure for Stubborn Dirt 447
Alternative Procedure 447
**How to clean metal filters or attenuator gratings** 448
Preferred Procedure 448
Procedure for Stubborn Dirt 448
**Additional Cleaning Information** 449

**Other Cleaning Hints** 451

Making the connection 451
Lens cleaning papers 451
Immersion oil and other index matching compounds 451
Cleaning the housing and the mainframe 451

16 Firmware Upgrades

**Firmware Upgrade Process** 454

Index

# 1 Getting Started

Safety Considerations / 18
Laser Safety Information / 23
8163A/B Lightwave Multimeter / 34
8164A/B Lightwave Measurement System / 35
8166A/B Lightwave Multichannel System / 36
A Description of the User Interface / 37
How to Change the Value of a Parameter / 54
A Sample Session / 58

This chapter introduces the features of the Keysight 8163B Lightwave Multimeter, the Keysight 8164B Lightwave Measurement System, and the Keysight 8166B Lightwave Multichannel System. In general, if not specifically mentioned, the information in this User Guide also applies to the previous generation of 8163A, 8164A and 8166A. Here you will find a quick description of the instrument, how to use the user interface and how to perform a simple sample session.

The central element of the instrument is the Keysight 8163B Lightwave Multimeter, the Keysight 8164B Lightwave Measurement System, and the Keysight 8166B Lightwave Multichannel System mainframes. You customize the instrument using plug-in modules and changeable fiber-connector interfaces. You can use this instrument as a tunable laser source and also to take associated measurements.

## Safety Considerations

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

This product has been designed and tested in accordance with IEC Publication 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory. Use, and has been supplied in a safe condition. The instruction documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

### Safety Symbols

**CAUTION**

**The *caution* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.**

**WARNING**

**The *warning* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.**

### General

This is a Safety Class 1 instrument (provided with a protective earth terminal) and has been manufactured and tested according to international safety standards.

Before operation, you should review the instrument and manual for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

Some Keysight 8164B circuits and some Keysight 8166B circuits are powered whenever the instrument is connected to the AC power source. To disconnect from the line power, disconnect the power cord either at the rear power inlet or at the AC line power source (receptacle). One of these must always be accessible. If the instrument is in a cabinet, it must be disconnected from the line power by the system's line power switch.

**WARNING** To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, and so on).

## Operating Environment

**WARNING** The 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, and 8166A/B Lightwave Multichannel System are not designed for outdoor use. To prevent potential fire or shock hazard, do not expose the instrument to rain or other excessive moisture.

## Line Power Requirements

**CAUTION** The 8163A/B Lightwave Multimeter System complies with overvoltage category II and can operate from the single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range 50 to 60 Hz.The maximum power consumption is 120 VA with all options installed.

**CAUTION** The 8164A/B Lightwave Measurement System complies with overvoltage category II and can operate from any single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range from 50 to 60 Hz. The maximum power consumption is 270 VA with all options installed.

**CAUTION**

The 8166A/B Lightwave Multichannel System complies with overvoltage category II and can operate from any single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range from 50 to 60 Hz. The maximum power consumption is 450 VA with all options installed.

### Input/Output Signals

**CAUTION**

There are two input BNC connectors: the Remote Interlock Connector and the Trigger Input, see “Input and Output Connectors” on page 310. These are TTL inputs. A maximum of 5 V can be applied as an external voltage to either of these input connectors.

There is one output BNC connector: the Trigger Output, see “Input and Output Connectors” on page 310. This is a TTL output. Do not apply an external voltage to this connector.

### Line Power Connectors

In accordance with international safety standards, the instrument has a three-wire power cable. When connected to an appropriate AC power receptacle, this cable earths the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination.

**WARNING**

To avoid the possibility of injury or death, you must observe the following precautions before switching on the instrument.

- Insert the power cable plug only into a socket outlet provided with a protective earth contact. Do not negate this protective action by the using an extension cord without a protective conductor.
- Do not interrupt the protective earth connection intentionally.
- Do not remove protective covers. Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified service personnel.
- Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.
- Defective, damaged, or malfunctioning laser sources must be returned to a Keysight Technologies Service Center.
- Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

## Instrument Markings



The instruction manual symbol. The product is marked with this warning symbol when it is necessary for the user to refer to the instructions in the manual.



The laser radiation symbol. This warning symbol is marked on products which have a laser output.



The AC symbol is used to indicate the required nature of the line module input power.



The ON symbols are used to mark the positions of the instrument power line switch.



The OFF symbols are used to mark the positions of the instrument power line switch.



The CE mark is a registered trademark of the European Community.



The CSA mark is a registered trademark of the Canadian Standards Association.



The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.

ISM1-A This text denotes the instrument is an Industrial Scientific and Medical Group 1 Class A product.



Frame or chassis terminal.



Protective conductor Terminal



Caution, risk of electric shock.



Magnetic fields may interfere with a pacemaker



Caution, hot surface

# Laser Safety Information

The laser sources specified by this user guide are classified according to IEC 60825-1.

The laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated 2007-June-24.

**Table 1 Initial Safety Information for Laser Source Modules**

| | 81650A | 81651A | 81652A | 81654A |
|---|---|---|---|---|
| Laser type | FP-Laser InGaAsP | FP-Laser InGaAsP | FP-Laser InGaAsP | FP-Laser InGaAsP |
| *Wavelength (±15nm)* | 1310 nm | 1550 nm | 1550/1625 nm | 1310/1550 nm |
| Max. CW output power [1] | <1.8 mW | <1.8 mW | <1.8 mW | <1.8 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2007) | 1 | 1 | 1 | 1 |
| Max. permissible CW output power | 15.6 mW | 10 mW | 10 mW | 15.6 mW/10 mW |

[1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector.

**Table 2 High Power Laser Source Modules - Laser Safety Information**

| | Keysight 81655A | Keysight 81656A | Keysight 81657A |
|---|---|---|---|
| Laser Type | FP-Laser<br>InGaAsP | FP-Laser<br>InGaAsP | FP-Laser<br>InGaAsP |
| *Wavelength (±15nm)* | 1310 nm | 1550 nm | 1310/1550 nm |
| Max. CW output power [1] | <28 mW | <28 mW | <28 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to<br>IEC 60825-1 (2007) | 1M | 1M | 1M |
| Max. permissible CW output power | 52 mW | 163 mW | 52 mW/163 mW |
| [1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector. . | | | |

**Table 3 DFB Laser Source Modules - Laser Safety Information**

| | Keysight 81662A | Keysight 81663A |
|---|---|---|
| Laser Type | CW DFB Laser<br>with built-in isolator | CW DFB Laser<br>with built-in isolator |
| **Wavelength** range | 1500 - 1650 nm<br>see display | 1500 - 1650 nm<br>see display |
| Max. CW output power [1] | <15 mW | <28 mW |
| Beam waist diameter | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 |
| **Laser Class** according to<br>IEC 60825-1 (2007) | 1M | 1M |
| Max. permissible CW output power | 163 mW | 163 mW |
| [1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector. | | |

## Initial Safety Information for Tunable Laser Modules

**Table 4 Backloadable Tunable Laser Modules - Laser Safety Information**

| | 81606A #216<br>81608A #216<br>81609A #216 | 81606A #116<br>81607A #116<br>81608A #116<br>81609A #116 | 81602A #013 | 81606A #113<br>81608A #113<br>81609A #113 |
|---|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| **Wavelength** range | 1450 – 1650 nm | 1490 – 1640 nm | 1250 - 1370 nm | 1240 - 1380 nm |
| Max. CW output power [1] | < 25 mW | < 25 mW | < 80 mW | < 30 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2014) | 1M | 1M | 3B | 1M |
| Max. permissible CW output power | 163 mW | 163 mW | 500 mW | 55 - 500 mW |
| [1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector. | | | | |

**Table 5 Backloadable Tunable Laser Modules - Laser Source Specification**

| | 81600B #201 | 81600B #200 | 81600B #160 | 81600B #150 | 81600B #140 | 81600B #130 | 81600B #142 | 81600B #132 |
|---|---|---|---|---|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| Wavelength range | 1455 - 1640 nm | 1440 - 1640 nm | 1495 - 1640 nm | 1450 - 1590 nm | 1370 - 1495 nm | 1260 - 1375 nm | 1370 - 1495 nm | 1260 - 1375 nm |
| Max. CW output power | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Laser Class according to IEC 60825-1 (2007) | 1M | 1M | 1M | 1M | 1M | 1M | 1M | 1M |
| Max. permissible CW output power | 163 mW | 163 mW | 163 mW | 163 mW | 52 mW | 52 mW | 52 mW | 52 mW |
| * Max. CW output power is defined as the highest possible optical power that the laser source can produce at its output connector. | | | | | | | | |

**Table 6 Backloadable Tunable Laser Modules (discontinued) - Laser Safety Information**

| | 81480B | 81482B | 81680B | 81682B | 81640B | 81642B | 81672B |
|---|---|---|---|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| Wavelength range | 1370-1495 nm | 1370-1495 nm | 1460-1580 nm | 1460-1580 nm | 1495-1640 nm | 1495-1640 nm | 1260-1375 nm |
| Max. CW output power [1] | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW | <15 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2007) | 1M | 1M | 1M | 1M | 1M | 1M | 1M |
| Max. permissible CW output power | 52 mW/ 163 mW | 52 mW/ 163 mW | 163 mW | 163 mW | 163 mW | 163 mW | 52 mW |

[1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector.

**Table 7 Compact Tunable Laser Modules - Laser Safety Information**

| | 81980A | 81940A | 81944A | 81989A | 81949A |
|---|---|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| Wavelength range | 1465 nm-1575 nm | 1520 nm-1630 nm | 1520 nm-1630 nm | 1465 nm-1575 nm | 1520 nm-1630 nm |
| Max. CW output power [1] | 20 mW | 20 mW | 20 mW | 20 mW | 20 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2007) | 1M | 1M | 1M | 1M | 1M |
| Max. permissible CW output power | 163 mW | 163 mW | 163 mW | 163 mW | 163 mW |

[1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector.

**Table 8 Compact Tunable Laser Modules (discontinued)- Laser Safety Information**

| | 81689A | 81689B | 81649A |
|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| Wavelength range | 1525 - 1575 nm | 1525 - 1575 nm | 1570-1620 nm |
| Max. CW output power [1] | <15 mW | <15 mW | <15 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2007) | 1M | 1M | 1M |
| Max. permissible CW output power | 163 mW | 163 mW | 163 mW |

[1] *Max. CW output power* is defined as the highest possible optical power that the laser source can produce at its output connector.

**Table 9 Tunable Laser Modules - Laser Safety Information**

| | 81950A Option 210 | 81950A Option 201 | 81960A |
|---|---|---|---|
| Laser Type | EC-Laser InGaAsP | EC-Laser InGaAsP | EC-Laser InGaAsP |
| Wavelength range | 1527nm-1566nm | 1570nm-1609nm | 1505 nm-1630 nm |
| Max. CW output power [1] | 50 mW | 50 mW | 50 mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 |
| **Laser Class** according to IEC 60825-1 (2007) | 1M | 1M | 1M |
| Max. permissible CW output power[2] | 163 mW | 163 mW | 163 mW |
| [1] *Max. CW output power is defined as the highest possible optical power that the laser source can produce at its output connector.*<br>[2] *Max. permissible CW output power is the highest optical power that is permitted within the appropriate laser class.* | | | |

## Initial Safety Information for Return Loss Modules

**Table 10 Return Loss Modules - Laser Safety Information**

| | 81611A | 81612A | 81613A | 81614A |
|---|---|---|---|---|
| Laser type | FP-Laser InGaAsP | FP-Laser InGaAsP | FP-Laser InGaAsP | FP-Laser InGaAsP |
| Wavelength (±15nm) | 1310 nm | 1550 nm | 1550/1625 nm | 1310/1550 nm |
| Max. CW output power [1] | <1.8mW | <1.8mW | <1.8mW | <1.8mW |
| Beam waist diameter | 9 µm | 9 µm | 9 µm | 9 µm |
| Numerical aperture | 0.1 | 0.1 | 0.1 | 0.1 |
| Laser Class according to IEC 60825-1 (2007) | 1 | 1 | 1 | 1 |
| Max. permissible CW output power | 15.6 mW | 10 mW | 10 mW | 15.6 mW/10 mW |
| [1] Max. CW output power is defined as the highest possible optical power that the laser source can prodcue at its output connector | | | | |

## Laser Safety Labels

**Laser class 1 label**




Figure 1 Class 1 Safety Label - Keysight 81650A/51A/52A/54A/11A/12A/13A/14A

**Laser class 1M label**




Figure 2 Class 1M Safety Label - Keysight 81655A/6A/7A, 81662A/3A, 81600B family, (81480B/82B/ 81640B/42B/80B/82B/72B), 81980A/40A/89A/49A, (81649A/89A/89B), 81606A/7A/8A/9A.

**Laser class 3B label**




Figure 3 Class 3B Safety Label - Keysight 81602A

A sheet of laser safety labels is included with the laser module as required. In order to meet the requirements of IEC 60825-1 we recommend that you stick the laser safety labels, in your language, onto a suitable location on the outside of the instrument where they are clearly visible to anyone using the instrument

**WARNING**

Protect yourself and pay attention to the following laser safety warnings:

- Do not switch on the instrument when there is no termination to the optical output connector, to the optical fiber or to the attached device. The laser radiation can seriously damage your eyesight.
- The use of other optical instruments with this product will increase the hazard to your eyes.
- Refer servicing only to qualified and authorized personnel.

**For Class 3B lasers**

**WARNING** The built-in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye and skin safe conditions.

**CAUTION** Protect your extra-high power tunable laser from damage:

- Clean the instrument's output connector and all interfaces of attached fibers and termination devices to avoid burning-in dust and other residue!
- Do not leave plastic caps on the output connector or on the end of a connected fiber when you activate the laser – you risk damaging the connector surface with deposit from hot plastic!
- Make sure the optical path is terminated properly and confirm that the termination can cope with an optical power level of over +18.5 dBm or 70 mW!
- Use a metal cap to cover the laser outputs when open. Terminate open patchcord ends with a commercially available "fiber optic light trap".

# 8163A/B Lightwave Multimeter

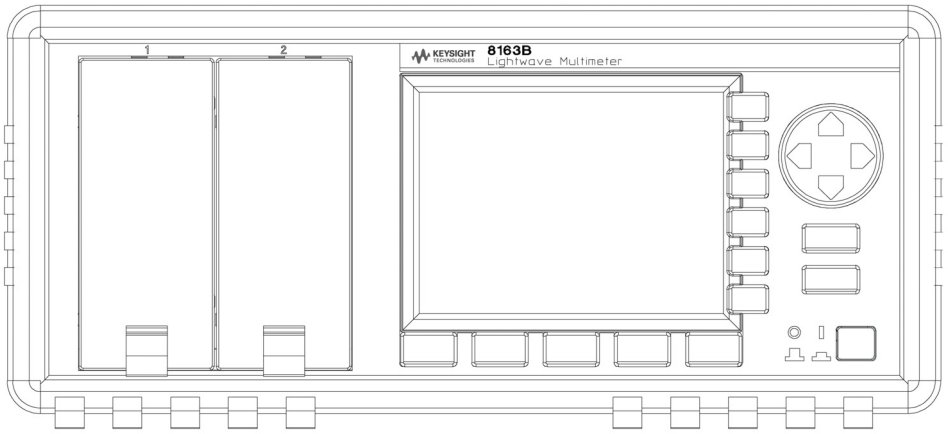



Figure 4 The Keysight 8163B Lightwave Multimeter Mainframe

The 8163A/B Lightwave Multimeter is a high-performance optical multimeter for the characterization and evaluation of optical components.

It's modular format makes it flexible enough to meet changing needs when measuring optical power, power loss, or return loss for single or multi-mode components.

The 8163A/B Lightwave Multimeter mainframe has two slim module slots. The system can host up to two front-loadable modules, of any combination of the following types:

- compact Tunable Laser modules, such as the the Keysight 81960A,
- fixed wavelength Laser Sources, such as the Keysight 81655A,
- DFB Source modules, such as the Keysight 81663A,
- Power Sensors, both dual and single, such as the Keysight 81635A,
- Fast Power Sensor Modules, such as the Keysight 81636B,
- Interface Modules for Optical Heads, such as the Keysight 81618A,
- Return Loss Modules, such as the Keysight 81610A
- Attenuator Modules, such as the Keysight 81570A
- Optical Switch Modules. such as the Keysight 81595B

The front-loadable module slots also support all modules designed for the 8153A Lightwave Multimeter.

# 8164A/B Lightwave Measurement System

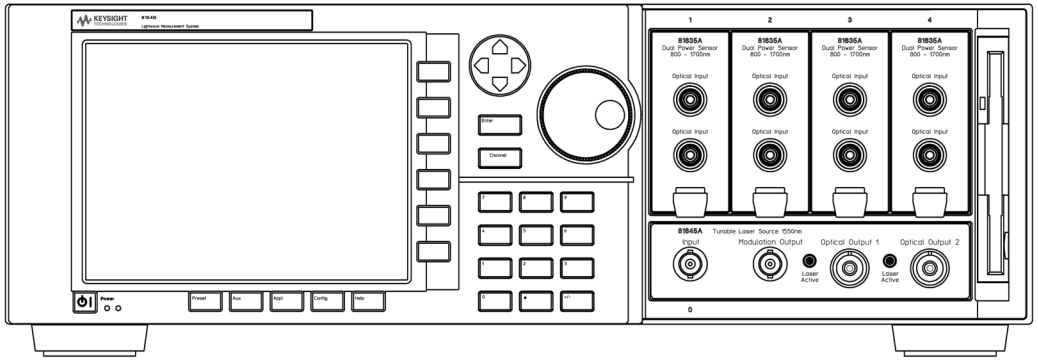



Figure 5 The Keysight 8164B Lightwave Measurement System Mainframe

The 8164A/B Lightwave Measurement System mainframe has one large and four slim module slots.

The system can host:

1 one back-loadable Tunable Laser module, such as the Keysight 81606A.

2 and up to four front-loadable modules, of any combination of the following types:

- compact Tunable Laser modules, such as the the Keysight 81960A,
- fixed wavelength Laser Sources, such as the Keysight 81655A,
- DFB Source modules, such as the Keysight 81633A,
- Power Sensors, both dual and single, such as the Keysight 81635A,
- Fast Power Sensor Modules, such as the Keysight 81636B,
- Interface Modules for Optical Heads, such as the Keysight 81618A,
- Return Loss Modules, such as the Keysight 81610A
- Attenuator Modules, such as the Keysight 81570A
- Optical Switch Modules. such as the Keysight 81595B

The front-loadable module slots also support all modules designed for the 8153A Lightwave Multimeter.

# 8166A/B Lightwave Multichannel System

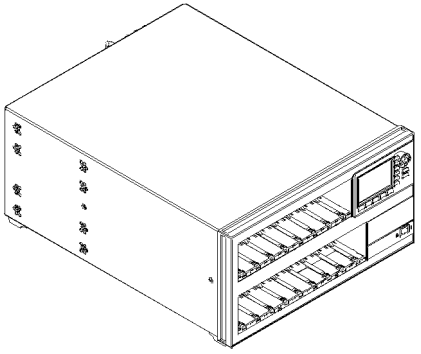


Figure 6 The 8166A/B Lightwave Multichannel System Mainframe

The 8166A/B Lightwave Multichannel System has 17 slim module slots.

The system can host up to seventeen front-loadable modules, of any combination of the following types:

- compact Tunable Laser modules, such as the the Keysight 81960A,
- fixed wavelength Laser Sources, such as the Keysight 81655A,
- DFB Source modules, such as the Keysight 81663A,
- Power Sensors, both dual and single, such as the Keysight 81635A,
- Fast Power Sensor Modules, such as the Keysight 81636B,
- Interface Modules for Optical Heads, such as the Keysight 81618A,
- Return Loss Modules, such as the Keysight 81610A
- Attenuator Modules, such as the Keysight 81570A
- Optical Switch Modules. such as the Keysight 81595B,

The front-loadable module slots do not support any modules designed for the 8153A Lightwave Multimeter.

## A Description of the User Interface

Figure 7 on page -37 and Figure 8 on page -38 show the user interface of the Keysight 8164A/B, the Keysight 8163A/B and Keysight 8166A/B, respectively, and the names used in this manual to describe the groups of keys.

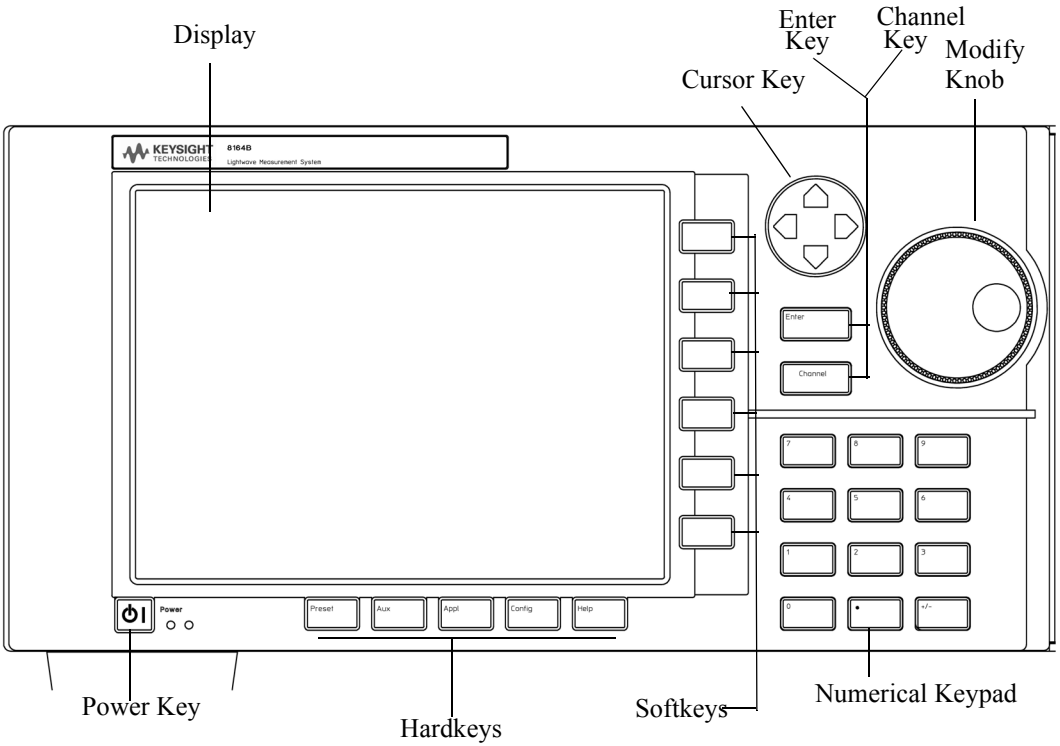



Figure 7 The 8164A/B Lightwave Measurement System User Interface

The 8163A/B and the 8166A/B do not provide the following two features of the 8164A/B's user interface:

- the Modify Knob, and
- the Numerical Keypad.

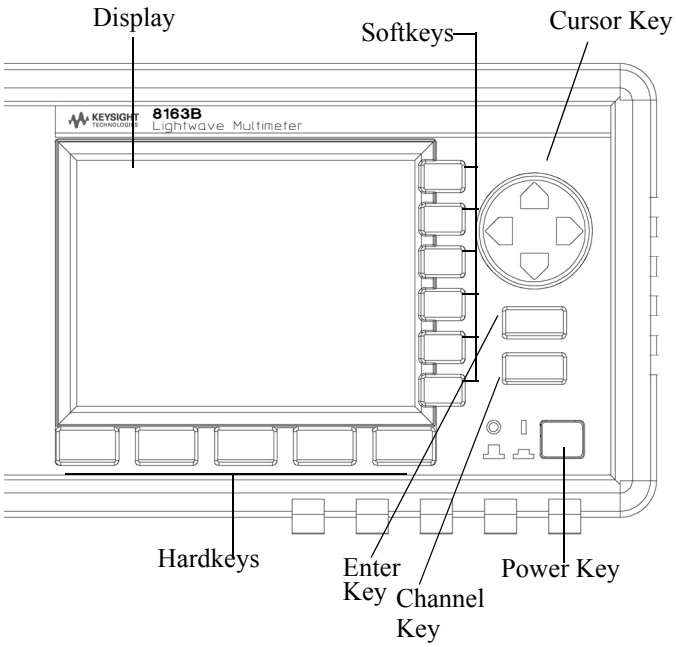



Figure 8 The 8163A/B Lightwave Multimeter User Interface

Password

When you use this instrument with high-power Laser Source modules or Tunable Laser modules, you must enter the password to unlock the instrument.

**NOTE** The default password is 1234.

**If You Forget Your Password**

If you forget your password, contact your nearest Keysight Technologies Sales/Service Office. Find contact details by accessing http://www.keysight.com/ on the Internet.

User Interface Features

### Introducing Softkeys

A softkey is a key whose function changes depending on the keys that you have pressed before. The function of the softkey is shown on the display to the left of the softkey.

### Introducing Hardkeys

A hardkey is a key that always has the same function.

### Special Module States

Besides parameter or measurement values, you may also see some texts instead.

- <empty> - The slot is empty.
- <unknown> - The installed module is not supported by the firmware revision.

### Slot and Channel Numbers

Each module is identified by a slot number and a channel number.

You can use slot and channel numbers:

- to identify each channel in the overview screen with a number at the side of the screen,
- to identify each channel in the Details screen with a tab at the top of the screen,
- to identify the channel when referencing the power measured by another channel, see How to Reference Another Power Measurement Channel on page -104,
- to identify the channel when using an application, see Applications on page -247, and
- to identify a channel when using a GPIB command, see the *8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, & 8166A/B Lightwave Multichannel System Programming Guide* for more information on GPIB commands.

The slot number represents the module's position in the mainframe. Front-loadable modules are numbered:

- from one to two from left to right for the 8163A/B,
- from one to four from left to right for the 8164A/B, and
- from one to seventeen from left to right for the 8166A/B.

These numbers are displayed on the front panel beside each module slot. The 8164A/B slot for back-loadable modules is numbered zero.

**NOTE**

Modules with two channels, for example, the Keysight 81635A Dual Power Sensor, use the channel number to distinguish between these channels.

The channel number of single channel modules is always one.

## How to Navigate/Modify the Display

### Overview Screen

Figure 9 on page -40 shows the overview screen for the 8163B Lightwave Multimeter, this screen is shown immediately after start-up. It shows the most important parameters of all installed modules.

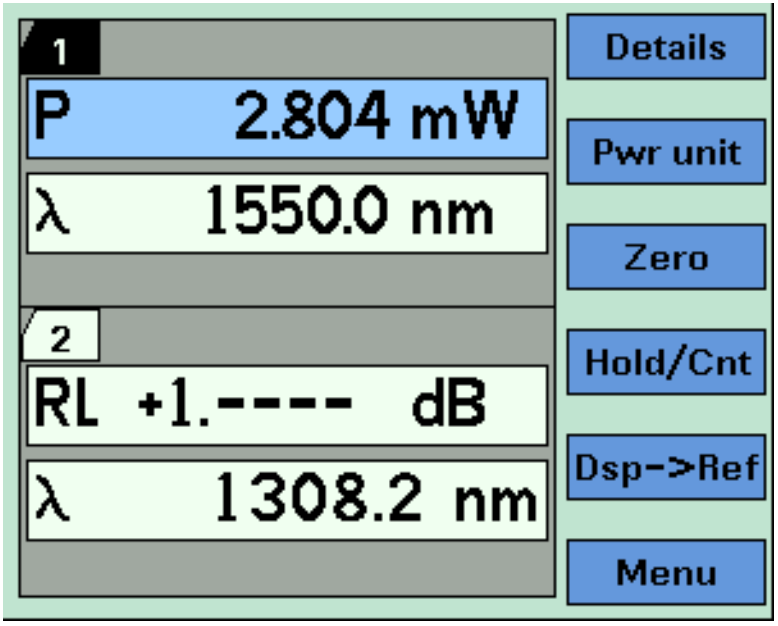



Figure 9 The 8163B's Overview Screen

**NOTE** The display of the Keysight 8163A and the Keysight 8166A is monochrome only.

Figure 9 on page -40 shows the overview screen for the 8164A/B Lightwave Measurement System, this screen is shown immediately after start-up. It shows the most important parameters of all installed modules

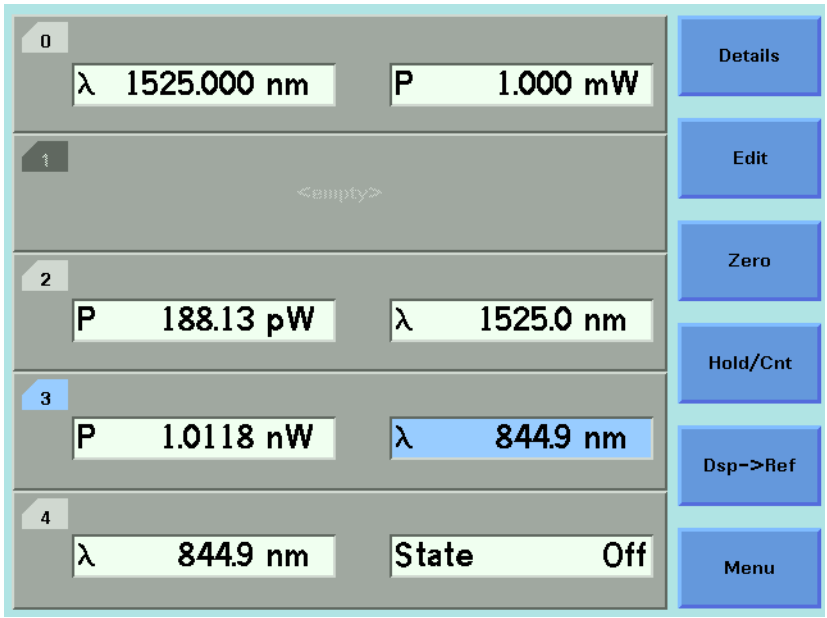



Figure 10 The 8164A/B's Overview Screen

Figure 11 on page -42 shows the overview screen for the 8166A/B Lightwave Multichannel System, this screen is shown immediately after start-up. It shows the module slots that are occupied.

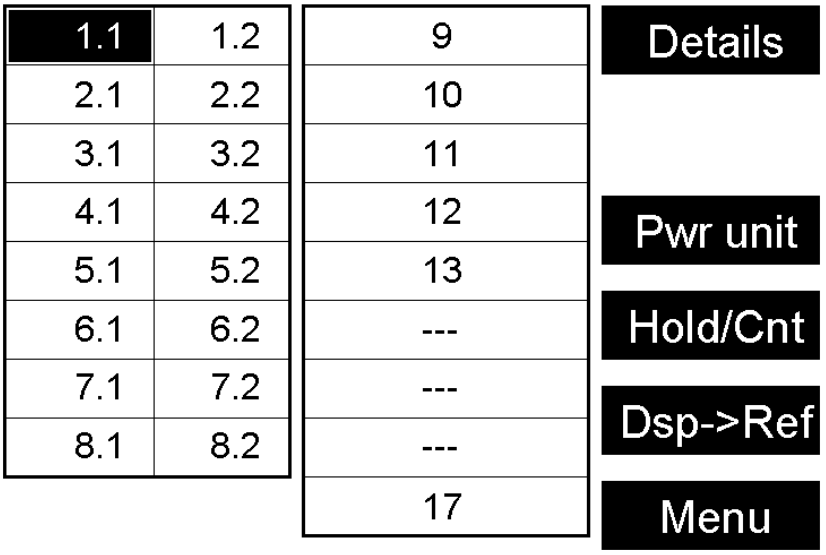



Figure 11 The 8166A/B Overview Screen

### How to Use the Cursor Key

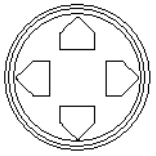


Figure 12 The Cursor Key

You can move the highlighted marker between parameters using the [Cursor] hardkey.

When editing a parameter, see How to Change the Value of a Parameter on page -54, the up and down cursor keys can be used to increment and decrement the value of a digit and the left and right cursor keys can be used to move the highlighted digit left and right.

### How to Use the Numerical Keypad

**NOTE** The Numerical Keypad is only available if you use the Keysight 8164A/B.

You can use the Numerical Keypad to change the value of a parameter. See How to Change the Value of a Parameter on page -54.

### How to Use the Modify Knob

**NOTE** The Modify Knob is only available if you use the Keysight 8164A/B.

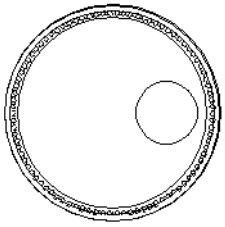


Figure 13 The Modify Knob

You can use the Modify Knob to navigate around the display. When you turn the Modify Knob through one click, one action is performed.

Turning the Modify Knob clockwise moves the highlighted marker right and then down. Turning the Modify Knob anti-clockwise moves the highlighted marker left and then up.

You can use the Modify Knob to change the value of a parameter. See How to Change the Value of a Parameter on page -54.

### How to Change Channel

You can navigate between module channels by pressing the *Channel* hardkey. You can use this key when either the overview screen or the details screen is displayed.

### How to Access the Details Screen

You can access the parameters of a module that are not shown on the overview screen by pressing *Channel* to select the channel and pressing the [Details] softkey. You should see the Details screen as shown in Figure 14 on page -44, Figure 15 on page -45, or Figure 16 on page -46.

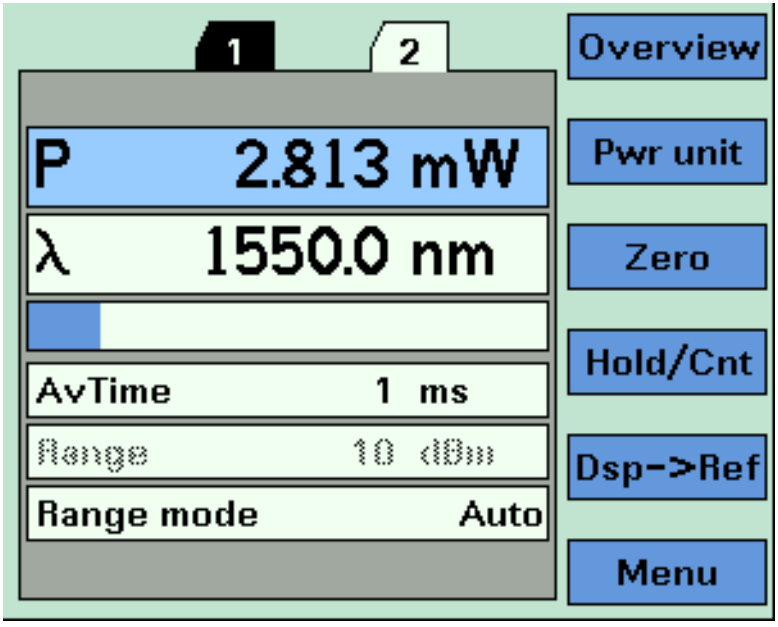



Figure 14 The 8163B's Details Screen for a Power Sensor Channel

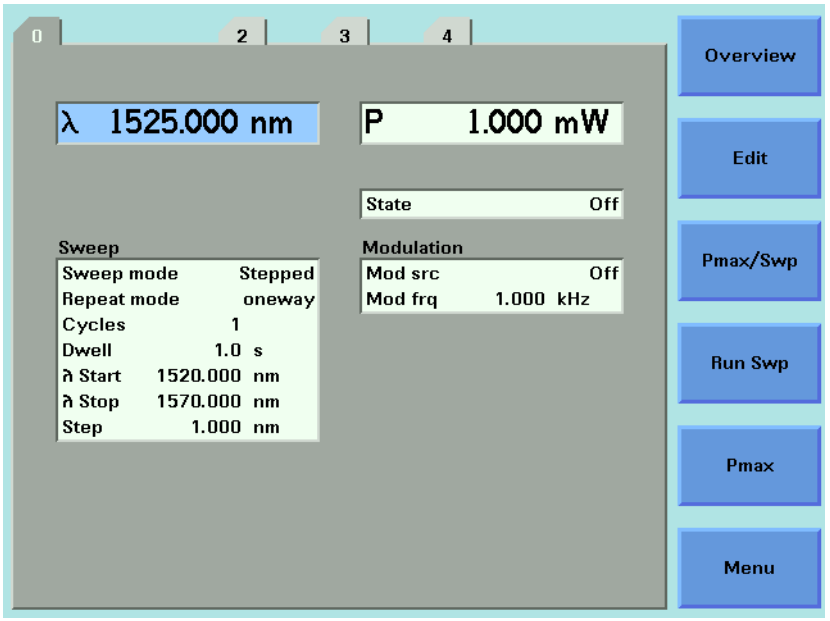



Figure 15 The 8164A/B's Details Screen for a Tunable Laser Channel

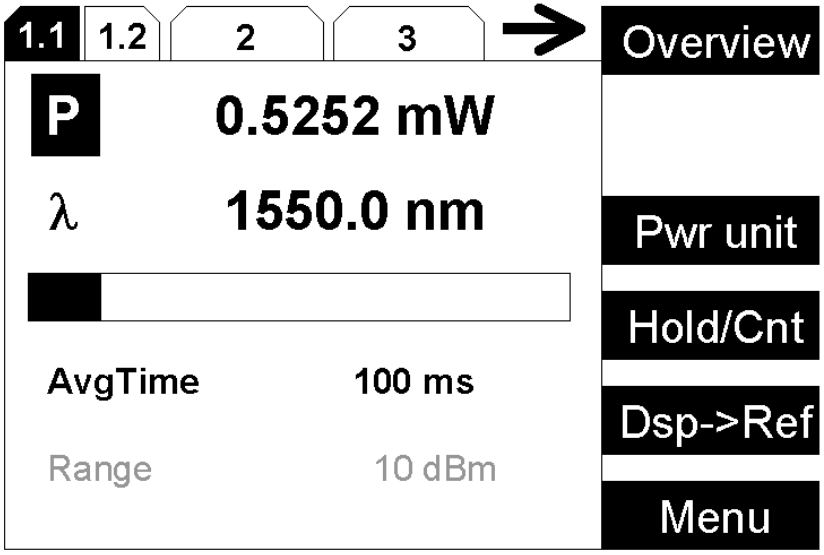



Figure 16 The 8166A/B Details Screen for a Power Sensor Channel

If more than 3 modules are inserted in the 8166A/B Lightwave Multichannel System, the user interface cannot display each channel number in the details screen. The arrow indicates that undisplayed channels can be accessed by pressing the *Channel* hardkey.

To return to the overview screen press the [Overview] softkey.

### How to Access the Menu

Press the [Menu] softkey to access all the parameters and functions that apply to a module. Figure 17 on page -47 and Figure 19 on page -49 show the type of menu you should see for a Power Sensor channel.

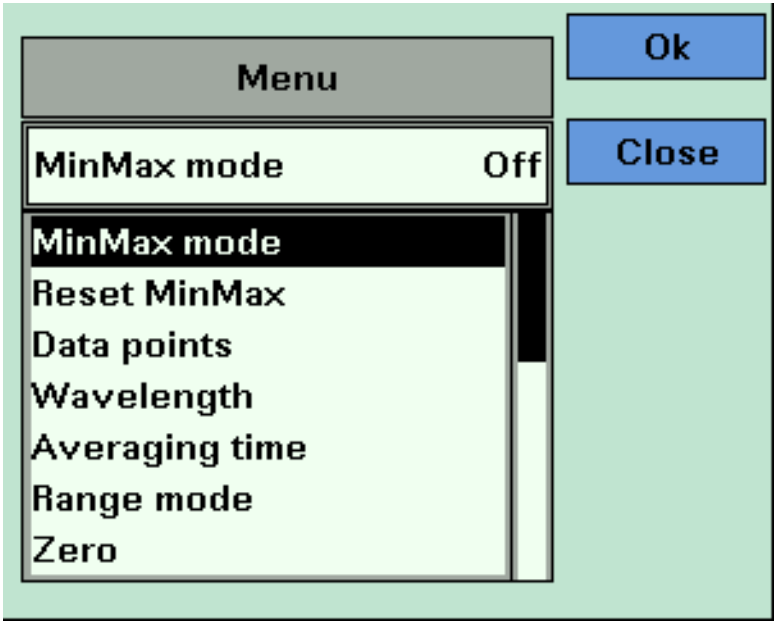



Figure 17 The 8163B/6B Menu for a Power Sensor Channel

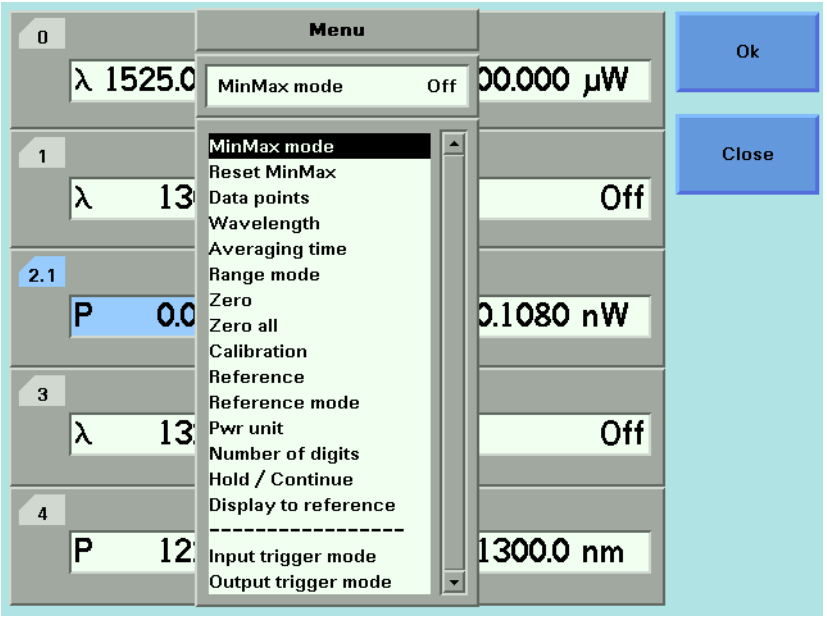



Figure 18 The 8164A/B Menu for Power Sensor Channel

## How to Change the System Configuration

Press the *Config* hardkey to access all the system configuration parameters that can be changed. Figure 19 on page -49 and Figure 20 on page -50 show the menu you should see. See Additional Information on page -61 for more details.

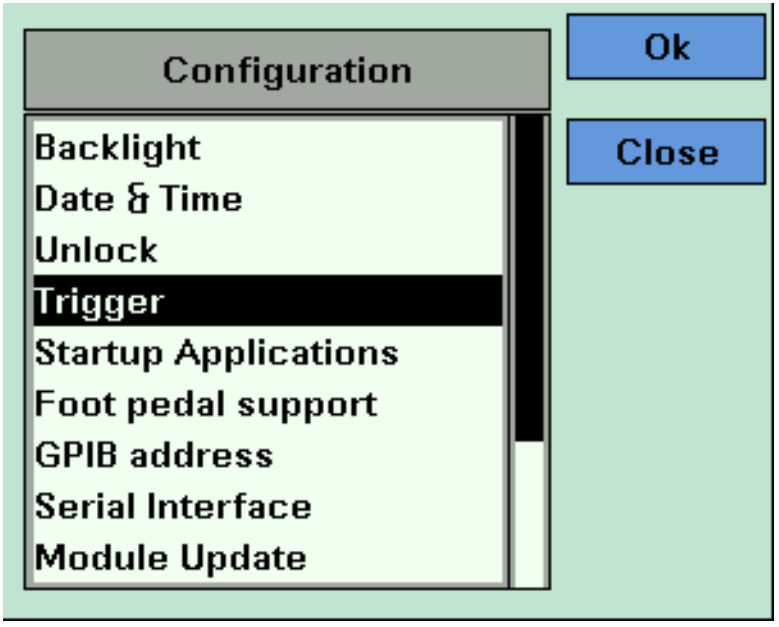



Figure 19 The 8163B System Configuration Menu

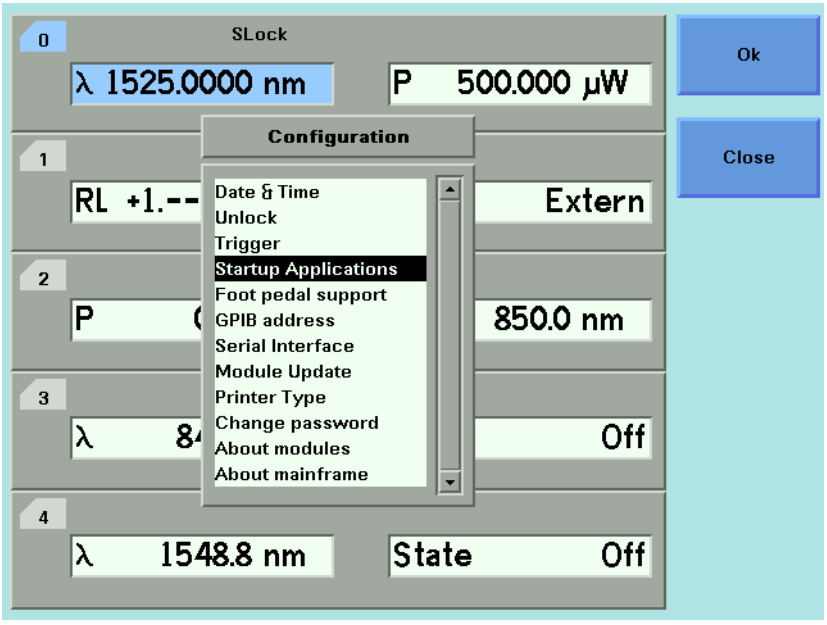



Figure 20 The 8164A/B System Configuration Menu

## How to Get Help

Press the *Help* hardkey any time you need more information. The instrument displays online documentation for the currently selected parameter.

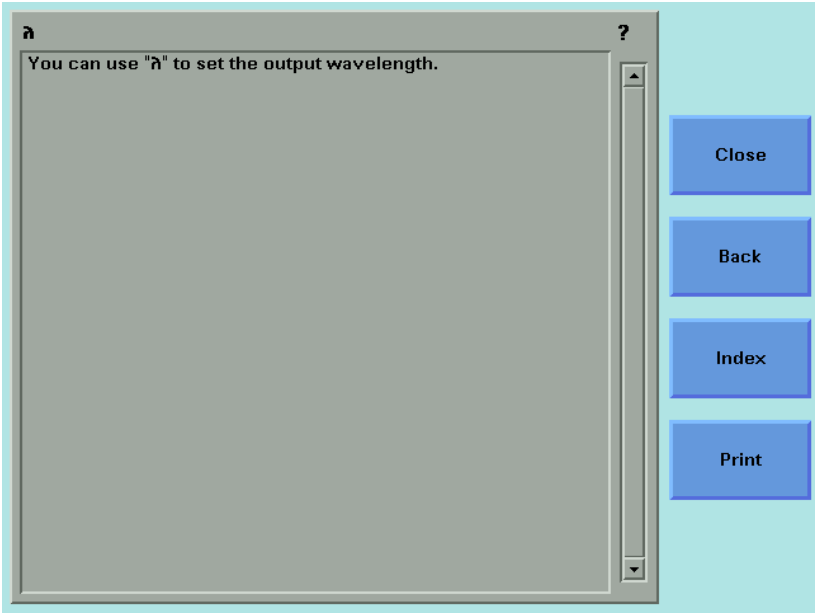



Figure 21 The 8164A/B Help Screen

Press the [Index] softkey to access the Index of help topics.

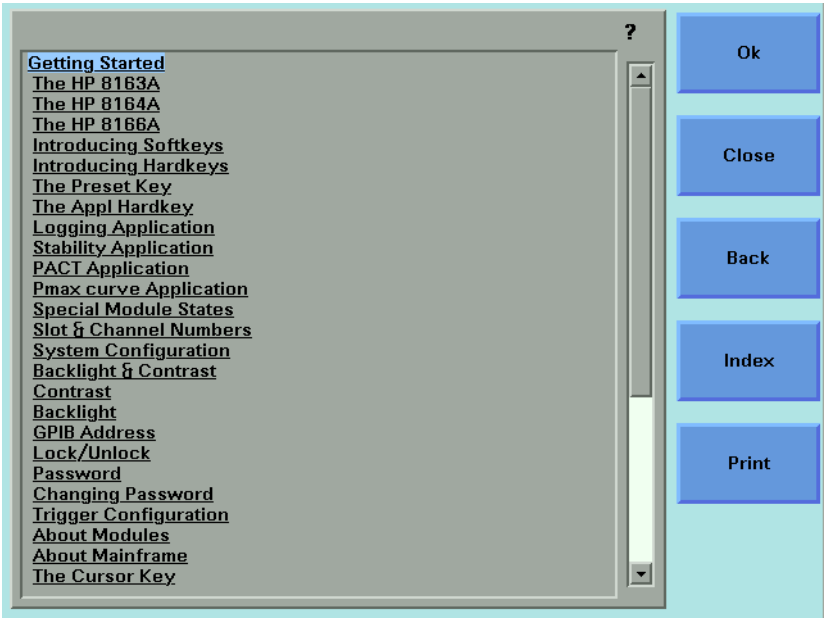



Figure 22 The 8164A/B Help Index

Press the [Back] softkey to return to the last Help topic you accessed.

You can scroll through the text using the up and down cursor keys. The scroll bar displays the current position in the text.

Cross-references within the text allow you to access relevant topics. Cross-references are underlined. If a cross-reference is highlighted, it is selected. Use the left or right cursor keys to move to another cross-reference. If you press the "Enter" hardkey or the [OK] softkey, you will jump to the chosen cross-reference.

Press the [Print] softkey to print the current help page. See How to Connect a Printer on page -97 for more information on printing.

Press the [Close] softkey to leave the online documentation and resume your task.

### How to Access Applications

You can access these applications for the Keysight 8163A/B Lightwave Multimeter or Keysight 8164A/B Lightwave Measurement System by pressing the *Appl* hardkey, the Applications Menu appears, as shown in Figure 23 on page -53. See Applications on page -247 for further details.

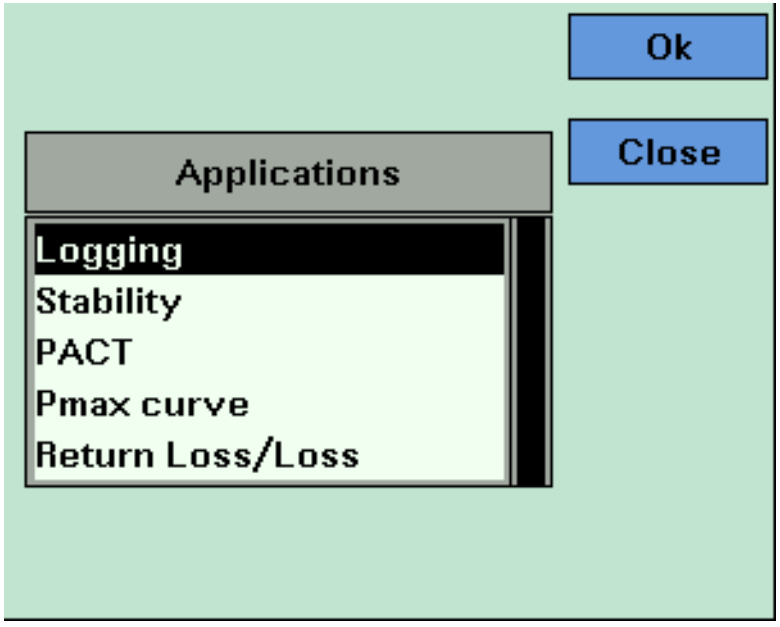



Figure 23 The Applications Menu

**NOTE**

These applications are not available for the 8166A/B Lightwave Multichannel System.

The Return Loss Application is only available for the 8163B Lightwave Multimeter.

## How to Change the Value of a Parameter

What follows is a description of the various ways of changing the value of parameters. Examples in which particular parameter values are changed are given with the parameter descriptions.

Parameters can be either:

- continuous, you may choose any value within a given range, or
- discrete, you may choose a value from a menu.

### How to Select a Parameter

You can select the parameter from the following screens:

- from the Details screen, after pressing the [Details] softkey,
- from the Menu screen, after pressing the [Menu] softkey, or,
- for the 8163A/B and 8164A/B, from the Overview screen.

To start editing a parameter, you move to it and:

- press the *Enter* hardkey,
- press the [Edit] softkey,
- press the Modify Knob (if you are using the 8164A/B), or,
- for numerical parameters only, type a digit on the numerical keypad (if you are using the 8164A/B).

### How to Accept the New Value of a Parameter

When you have changed the value of a parameter, to accept this change:

- press the *Enter* hardkey,
- press the [OK] softkey,
- or, press the Modify Knob (if you are using the 8164A/B).

These keys all perform the same purpose. All references to pressing *Enter* throughout this User's Guide, refer to one of these three actions.

### How to Make a Big Change to a Continuous Parameter

If you are changing the value of a parameter completely, type in the value on the numerical keypad (if you are using the 8164A/B), and press *Enter*.

To change the output power from 100 μW to 755 μW:

1 Press the [Menu] softkey.

2 Move to Power, using the cursor key, and press *Enter*.

3 Type 755.000 on the numerical keypad and press *Enter*.

### How to Make a Small Change to a Continuous Parameter

For small changes to a parameter use the up and down cursor keys, the numerical keypad (if you are using the 8164A/B), or the modify knob (if you are using the 8164A/B).

Move to the parameter and then:

1 Press [Edit]. The first digit before the decimal point will be highlighted first, as shown in Figure 24.

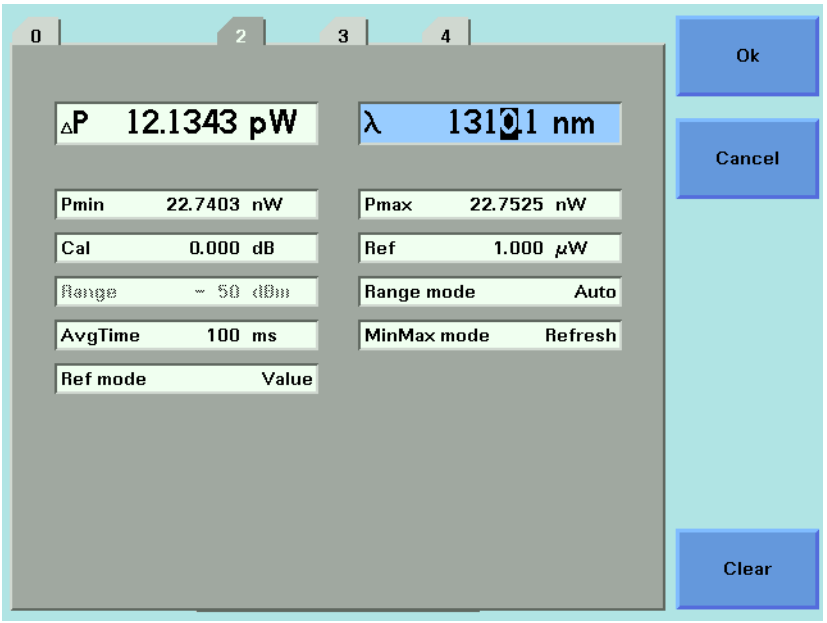



Figure 24 The First Digit Before the Decimal Point is Highlighted First

4 If you want to select another digit to edit, use the left or right cursor key.

5 Enter the new value for the digit by using the numerical keypad, the up and down cursors or turning the modify knob.

6 Repeat steps 2 and 3 to continue editing the value.

7 When you have finished editing the value, press *Enter*. The edited value becomes the new value of the parameter.

To change the wavelength from 1540.000 nm to 1525.000 nm:

1 Move to the wavelength parameter for a Tunable Laser module and press [Edit]. The most significant digit is highlighted.
2 Press the left cursor once to highlight the digit four.
3 Press the down cursor twice to change the value of the digit to two.
4 Press the right cursor once to move the cursor one digit right.
5 Press the up cursor five times to change the value of the digit to five. Press *Enter* to end the editing.

### How to Change a Discrete Parameter

For discrete parameters, you may choose a particular values within a given range.

1 For a Power Sensor module:
2 Move to the Power Sensor channel and press the [Details] softkey.
3 Move to the [*AvgTime*] parameter and press *Enter*.

Move to 1 s, by using the cursor key, and press *Enter*.

or

1 Move to the Power Sensor channel and press the [Menu] softkey.
2 Move to the <*Averaging Time*> parameter and press *Enter*. You see the screen in Figure 25 on page -57.
3 Move to <1 s>, by using the cursor key, and press *Enter*.

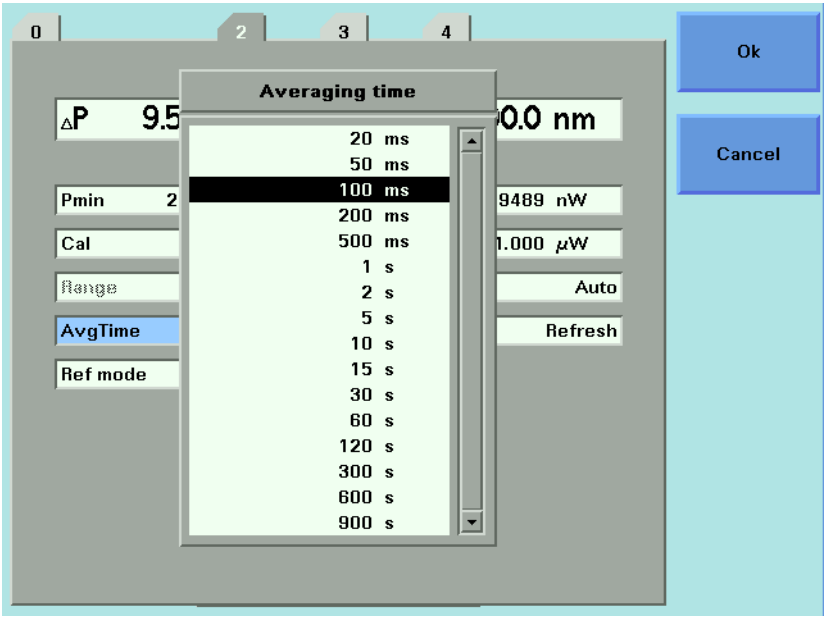



Figure 25 Averaging Time Menu

### How to Set All Parameters to Their Default Values

Press *Preset* to set all parameters to their default values.

### If You Make a Mistake

If you make a mistake while you are editing a parameter, you can cancel the editing, and retain the previous value for the parameter by pressing the [Cancel] softkey.

### If the Parameter Changes to Different Value

If you press *Enter* or the [OK] softkey and the parameter changes to a different value, then you tried to enter a value outside the calibrated range. The new value is the nearest valid value to the value you entered.

# A Sample Session

This sample session shows you how to measure the power of a modulated signal at a single wavelength.

The sample session is written for the 8163A/B Lightwave Multimeter or 8164A/B Lightwave Measurement System, the Keysight 81960A Tunable Laser module, and the Keysight 81634B Power Sensor. To perform the sample session as described here, you also need a patchcord (if you are using the 81000AI Connector interface, then a Diamond HMS-10/HRL to Diamond HMS-10/patchcord, 81109AC).

## How to Measure the Power of a Modulated Signal

We want to measure the power of a 1540 nm signal, modulated by a 100 kHz square wave, at 500 mW.

1 1 Make sure that all your connectors, and connector interfaces are clean.

2 Make sure that the Optical Output of the Laser Source is not active.

3 Connect the output of the Laser Source to the input of the Power Sensor module, as shown in Figure 26 on page -59. You must connect the correct fiber end connector for your Tunable Laser module:

*a* For straight contact connectors, use a straight contact fiber end connector with a black sleeve.

*b* For angled contact connectors with a green sign beside the Tunable Laser module's optical output connector, use an angled contact fiber end connector with a green sleeve.

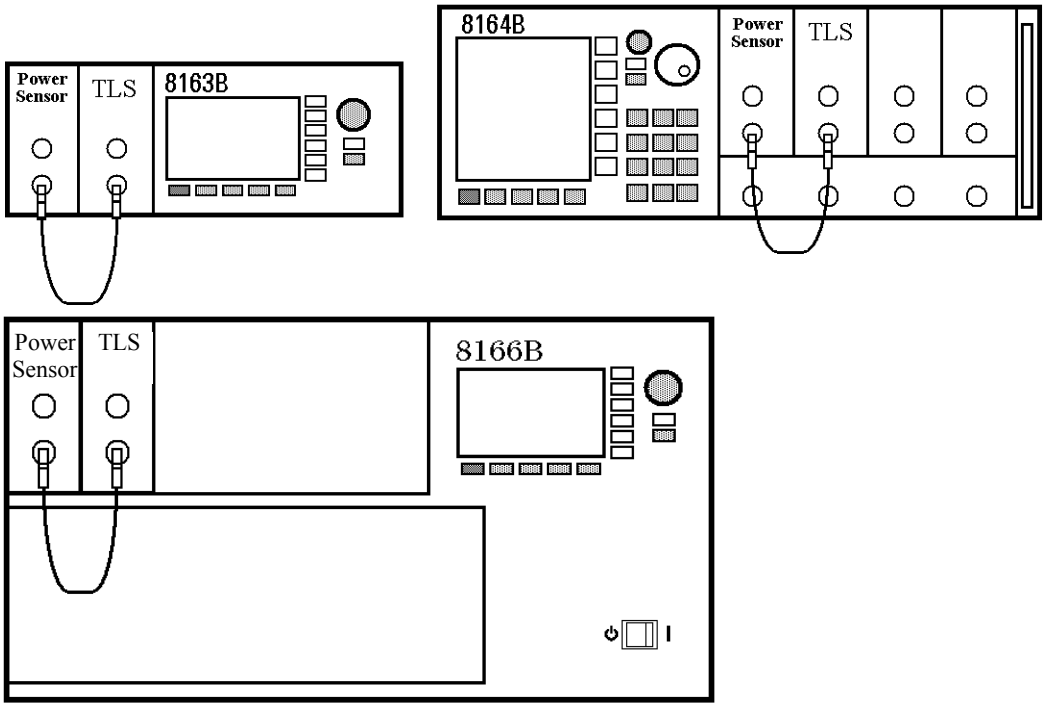



Figure 26 Connecting the Instrument for the Sample Session

4 Make sure the instrument is powered up.

5 How to set the wavelength for the Power Sensor module:

*a* Move to the wavelength parameter, [λ], for the Power Sensor module and press *Enter*.

*b* Enter 1540.000 and press *Enter*.

6 How to set the averaging time for the Power Sensor module:

*a* Move to the measurement averaging time, [*Tavg*], and press *Enter*.

*b* Move to <*1 s*>, using the cursor key, and press *Enter*.

7 For the Power Sensor module, make sure that Watts are the selected Power Unit and that the instrument is in automatic ranging mode. To change these settings:
   *a* Move to the power parameter, [*P*], and press the [Power Unit] softkey.
   *b* Move to <*W*>, using the cursor key, and press *Enter*.
   *c* Move to the [*Range Mode*] parameter and press *Enter*.
   *d* Move to <*Auto*>, using the cursor key, and press *Enter*.
8 How to set the wavelength for the Tunable Laser module:
   *a* Move to the wavelength parameter, [λ], for the Tunable Laser module and press *Enter*.
   *b* Enter 1540.000 and press *Enter*.
9 How to set the modulated power for the Tunable Laser module:
   *a* If power is not displayed in Watts, move to the [*P*] parameter and press the [Power Unit] softkey.
   *b* Move to <*W*>, using the cursor key, and press *Enter*.
   *c* Move to the [*P*] parameter and press *Enter*.
   *d* Enter 5.
   *e* Change units to μW, if necessary, using the [Unit+] or [Unit-] softkey.
   *f* Press *Enter*.
10 How to set the modulation frequency for the Tunable Laser module:
   *a* Select the [*Frequency*] parameter and press *Enter*.
   *b* Enter 100.000 and press *Enter*.
11 For the Tunable Laser module, press the button beside the Optical Output. The green LED should switch on to indicate that the laser is now active.

You should notice that the power reading is approximately half the value set on the Tunable Laser module. This is because the output is modulated by a square wave with a 50% duty cycle.

# 2 Additional Information

Using the System Utilities / 62
How to Connect an External Monitor / 95
How to Connect a Printer / 97

This chapter describes the system functions of the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System. Here you will find out how to set the configuration settings and how to connect an external monitor.

# Using the System Utilities

Press the *Config* hardkey to access configuration information for your mainframe. You see the screens in Figure 27 on page 62 and Figure 28 on page 63.

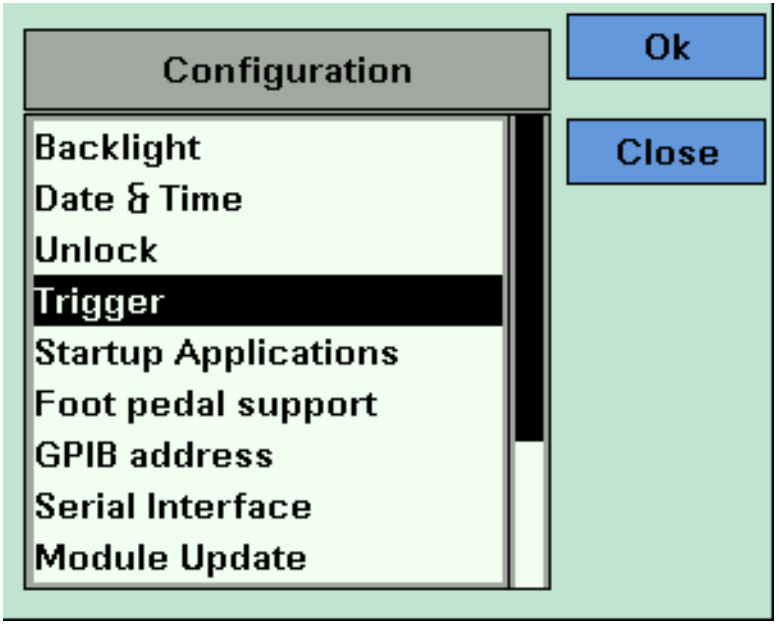



Figure 27 The 8163B/6B Configuration Menu

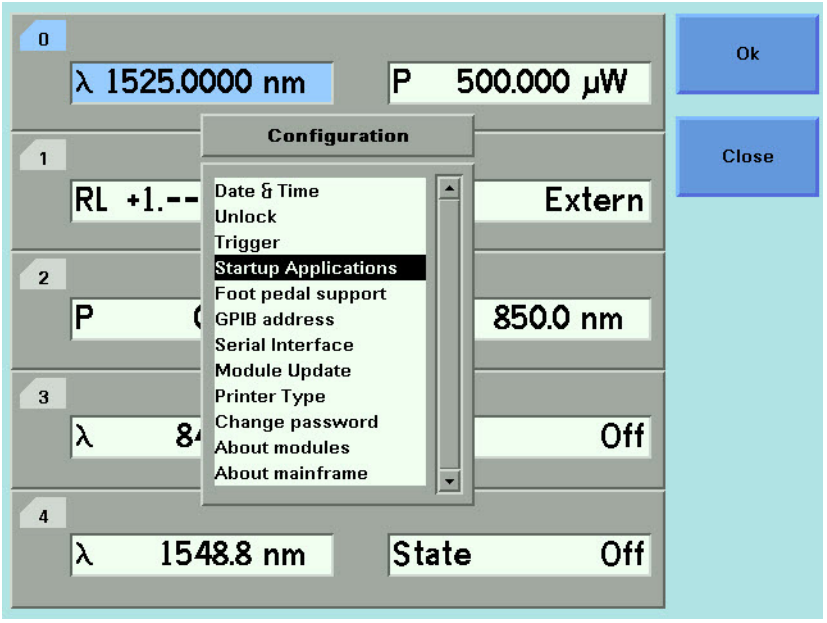



Figure 28 The 8164A/B System Configuration Menu

You can move to any of the menu items by using the cursor key or the Modify knob. Select an item by pressing *Enter* or the [OK] softkey.

## How to Set the Backlight

The Backlight and menu option allows you to change the appearance of the screen.

**NOTE** **The Backlight menu option is supported by the 8163A/B and 8166A/B but not by the 8164A/B.**

## To Set the Backlight

To change the backlight level of the 8163A/B/6A/B's screen:

1 Press the *Config* hardkey.

2 Move to the <*Backlight*> menu option and press *Enter*. You see a box displaying the current setting.

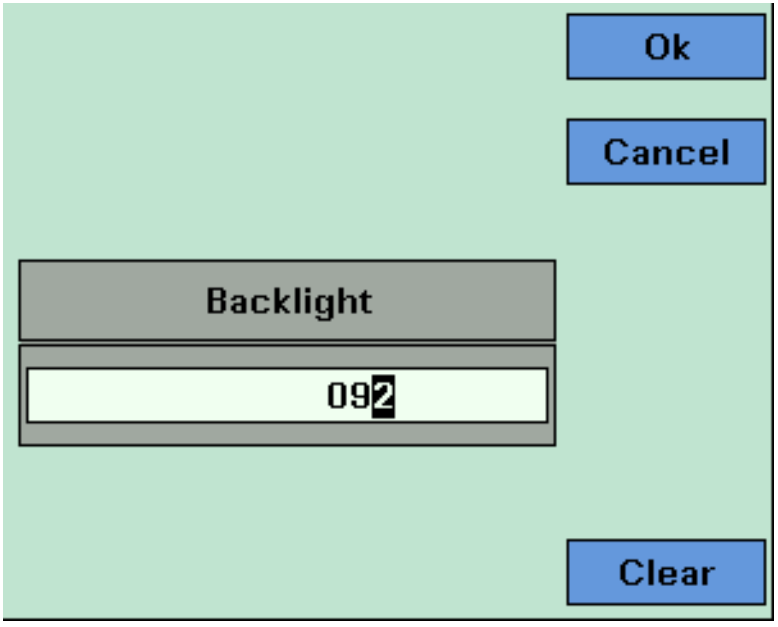



Figure 29 Entering a Backlight Value

3 Enter an integer value between zero and one hundred in this box and press *Enter*.

**NOTE** **The Contrast can also be set for the 8163A and the 8166A models, but only these models, as follows:**

1 Press the *Config* hardkey.

2 Move to the <*Contrast*> menu option and press *Enter*. You see a box displaying the current setting

3 Enter an integer value between zero and one hundred in this box and press *Enter*.

## How to Set the Date & Time

The instrument uses the date and time when:

- you print out data from an application,
- you save data to diskette from an application, and
- you send the **:SYSTem:DATE?** or :**SYSTem:TIME? GPIB** commands, see your instrument's Programming Guide for more details.

To set the date and time:

1 Press the *Config* hardkey.

2 Move to the <*Date & Time*> menu option and press *Enter*. You see a box, similar to Figure 30 on page 66, displaying the current date and time settings.

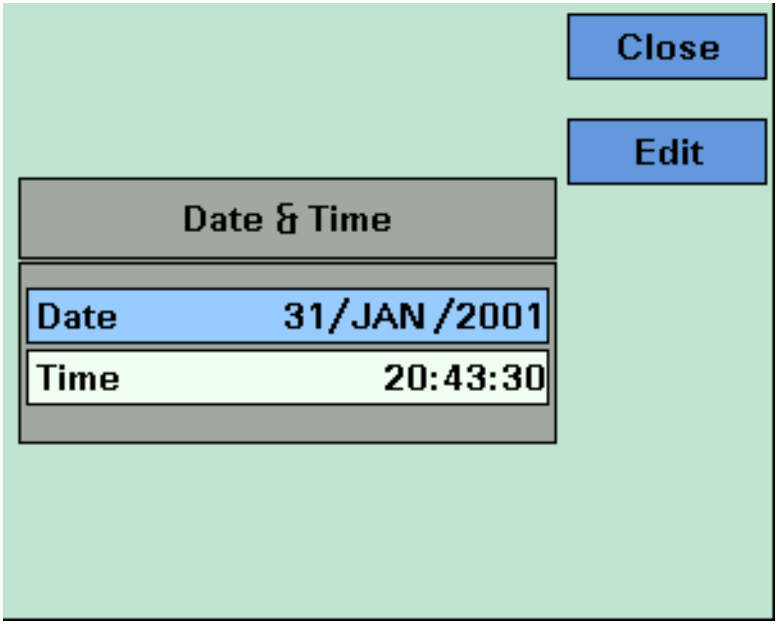



Figure 30 Editing the Date and the Time

3 Use the cursor key to move to the Date field. Press the [Edit] softkey. The day of the month is highlighted.

4 Use the left and right cursor keys to move to the day, month or year. Edit the day, month or year using the cursor key. Press *Enter*.

5 Perform steps step 3 to step 4 again if the date is not fully correct.

6 Use the cursor key to move to the Time field. Press the [Edit] softkey. The hour of the day is highlighted. The 24-hour clock is used.

7 Use the left and right cursor keys to move to the hour, minute, or second. Edit the hour, minute, or second using the cursor key. Press [OK].

8 Perform steps step 6 to step 7 again if the date is not fully correct.

9 When the time and date are both correct, press [Close] to return to the configuration menu.

## How to Lock/Unlock the High-Power Laser Sources

To unlock high-power laser sources (including Tunable Laser modules):

1 Press the *Config* hardkey.

2 Move to the <*Unlock*> menu option and press *Enter*. You see a box requesting you to enter the password.

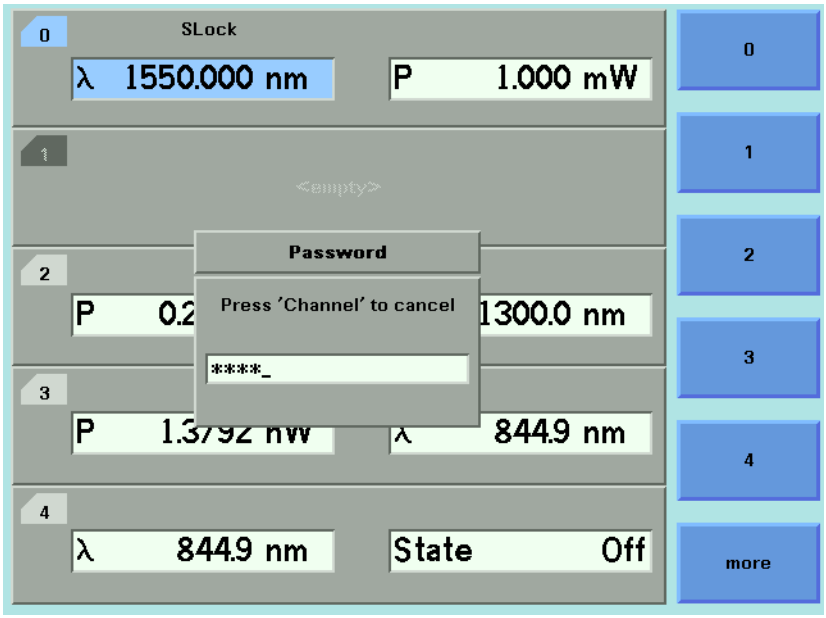



Figure 31 Unlocking the Instument

3 Enter the password, using the softkeys or the numerical keypad. Press *Enter* and the instrument unlocks.

**NOTE** The default password is 1234.

To lock the instrument, perform the steps above, but in step 2 move to the <*Lock*> menu option in place of the <*Unlock*> menu option.

## How to Set the Trigger Configuration

The trigger level at the external trigger connectors is by default active high, this means when a trigger rises above the high TTL level (rising edge), a trigger is accepted.

You can select three modes of triggering from the trigger configuration menu:

- <*None*>, which you should choose if you do not want to use triggering.
- <*Default*>, which you should choose if you want to enable the trigger connectors.
- <*Pass Through*>, which you should choose if you want an input trigger to automatically generate an output trigger. This allows you to trigger another instrument almost simultaneously.
- <*Feedback*>, which you should choose if you want an output trigger to automatically generate an input trigger. For example, using this mode, you could trigger each step of a wavelength sweep with just one externally generated input trigger.

To change the triggering mode:

1 Press the *Config* hardkey.

2 Move to the <*Trigger*> menu option and press *Enter*. You see a box displaying the available triggering modes.

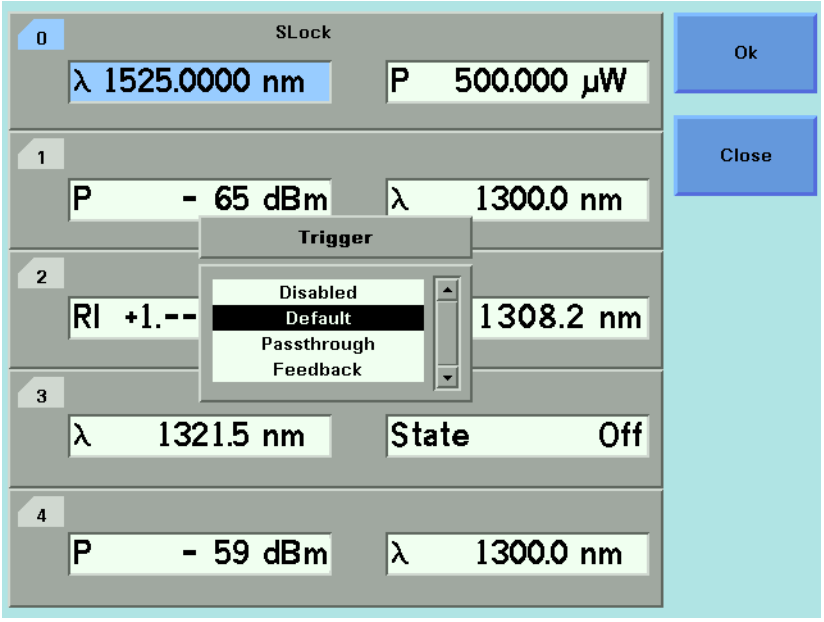



Figure 32 Changing the Triggering Mode

3 Move to your chosen triggering mode and press *Enter*.

## How to Configure Startup Applications

**NOTE** **Only valid for the 8163B and 8164B.**

Several Applications on the 8163B and 8164B can be configured to start upwhen the system is switched on.

To configure startup applications:

1 Press the *Config* hardkey.

2 Move to the <*Startup Applications*> menu option and press *Enter*.

3 Select the application you want to start up when the system is switched on.

## How to Configure your Foot Pedal

This accessory is not available from Keysight, but can be acquired from electronic warehouses, see e.g. http://www.herga.com. It is a pedal switch that temporarily closes an electrical contact, and has a BNC type plug.

This accessory is similar to a mouse, you press the Foot Pedal and a trigger is generated. You can attach the Foot Pedal to the Input Trigger BNC Connector, see Input and Output Connectors on page 335.

To configure your Foot Pedal:

1 Press the *Config* hardkey.

2 Move to the <*Foot pedal support*> menu option and press *Enter*. You see a box displaying <*On*> and <*Off*>.

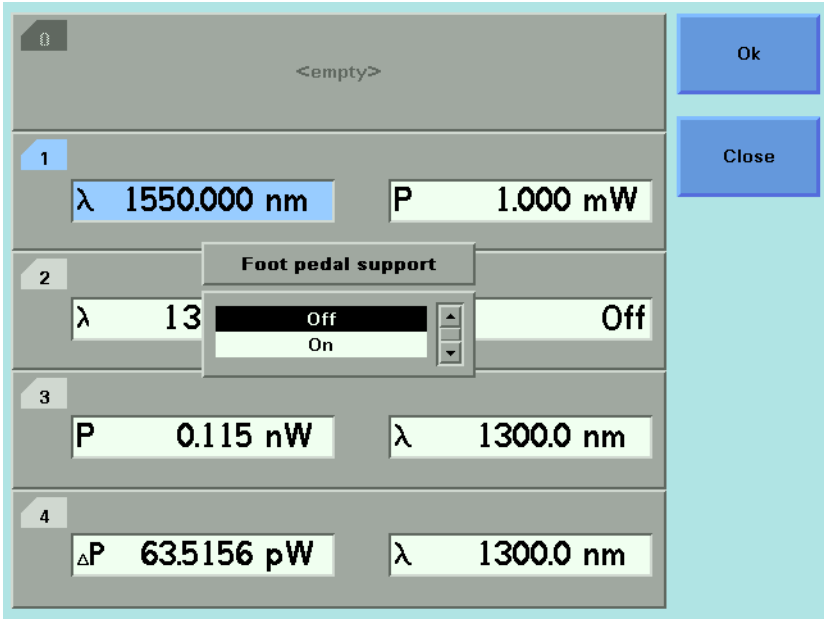



Figure 33 Enabling/Disabling the Foot Panel

3 Move to <*On*> to enable the Foot Pedal or move to <*Off*> to disable the Foot Pedal.

**NOTE** The 8163A, 8164A, and 8166A require FPGA version 1.5 or higher. The FPGA version number and date is displayed after you boot up the instrument.

**NOTE** The Trigger configuration must not be set to “disabled”.

4 Press *Enter*.

## How to Set the GPIB Address

**NOTE** The default GPIB address is 20.

To set the GPIB address:

1 Press the *Config* hardkey.

2 Move to the <*GPIB Address*> menu option and press *Enter*. You see a box displaying the current GPIB address.

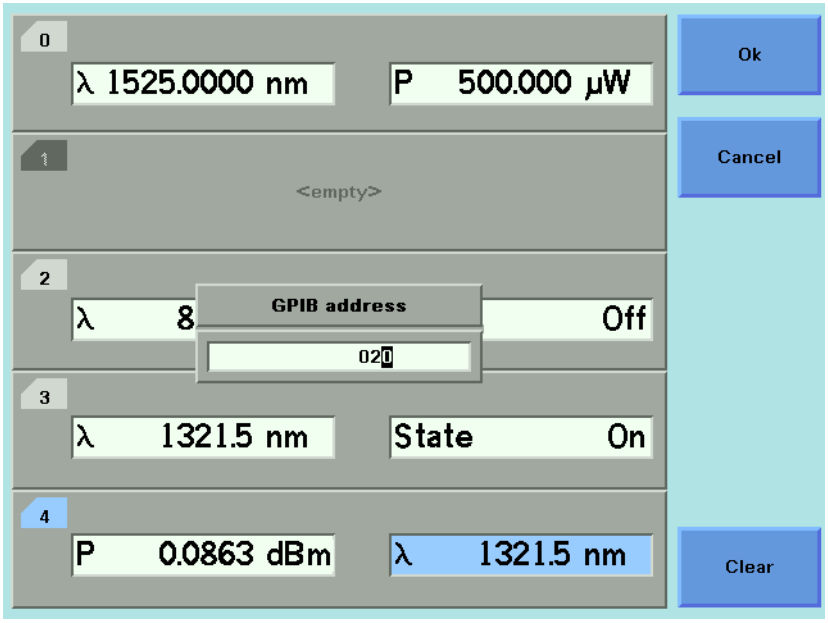



Figure 34 Entering a GPIB Address

3 Enter an integer value between 0 and 30 into this box and press *Enter*. The address is set to this value.

**NOTE** Avoid using 21 as the GPIB address because this number is often the controller's default GPIB address.

# How to Configure LAN

## User Interface

Some new entries have been added to the Configuration menu, which can be opened with the [Config] hard key:

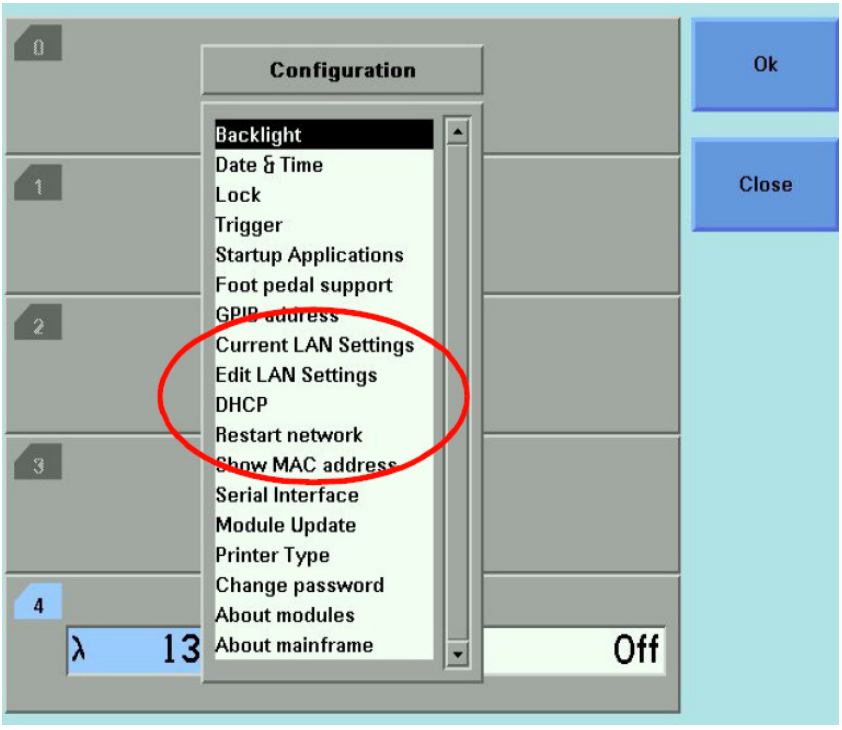



Figure 35 Configuration Menu

## Show the Current LAN Settings

Use the cursor keys (or the modify knob on the 8164B) to select “Current LAN Settings” in the “Configuration Menu” and press the [OK] soft key to open a box displaying the currently used LAN settings.




Figure 36 Configuration - Current LAN Settings

This box displays the networking parameters currently in use. Depending on the DHCP setting these values may be supplied by the DHCP server and differ from the values entered in the “Edit LAN Settings” dialog. The message box does not update automatically. To update the values, press the [Close] soft key then select “Current LAN Settings” again.

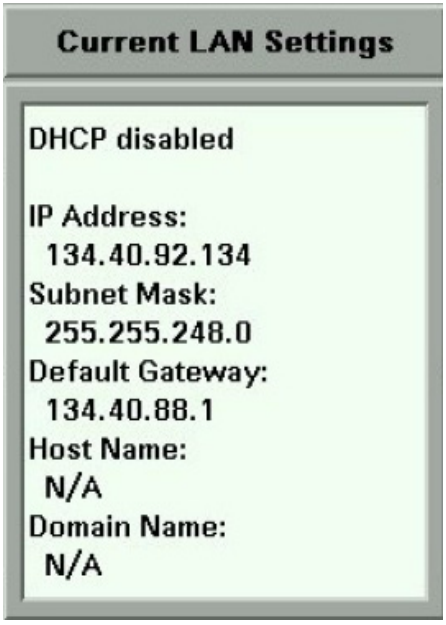



Figure 37 Current LAN Settings

## Edit LAN Settings

Use the cursor keys (or the modify knob on the 8164B) to select “Edit LAN Settings” in the “Configuration Menu”, then press the [OK] soft key.




Figure 38 Configuration - Edit LAN Settings

### Edit the IP Address

Use the cursor keys (or the modify knob and the numeric keypad on the 8164B) to edit the IP address.




Figure 39 LAN Settings - IP Address

### Edit the Subnet Mask

You can edit the subnet mask with the cursor keys:

- [up] – set one more bit
- [down] – clear one more bit
- [left] – clear the actual byte and jump one byte left
- [right] set all bits in the actual byte, jump one byte right, and set the first byte in it

The modify knob on the 8164B works like the [up] and [down] buttons.

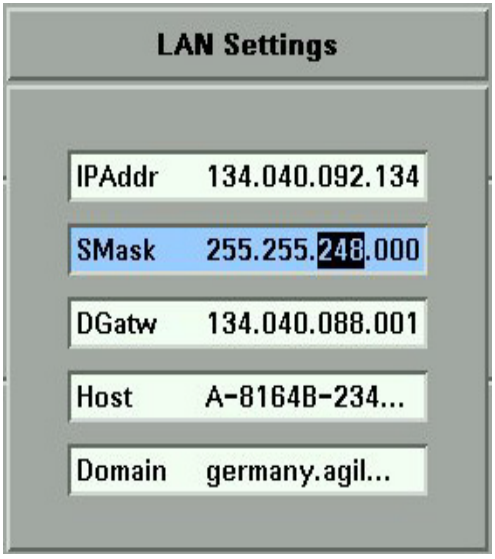



Figure 40 LAN Settings - Subnet Mask

### Edit the Default Gateway

Use the cursor keys (or the modify knob and the numeric keypad on the 8164B) to s edit the IP address.

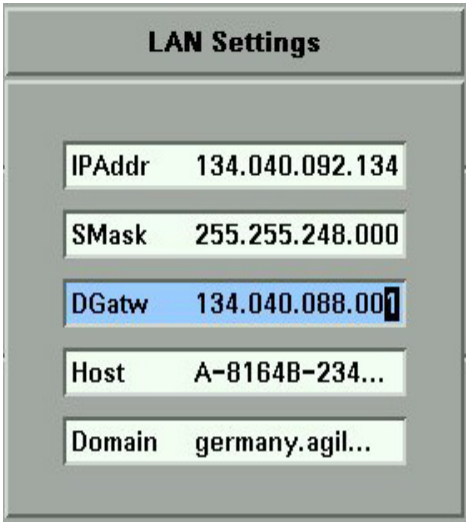



Figure 41 LAN Settings - DGatw

### Edit the Host Name

You can enter the host name in a special dialog for text input.

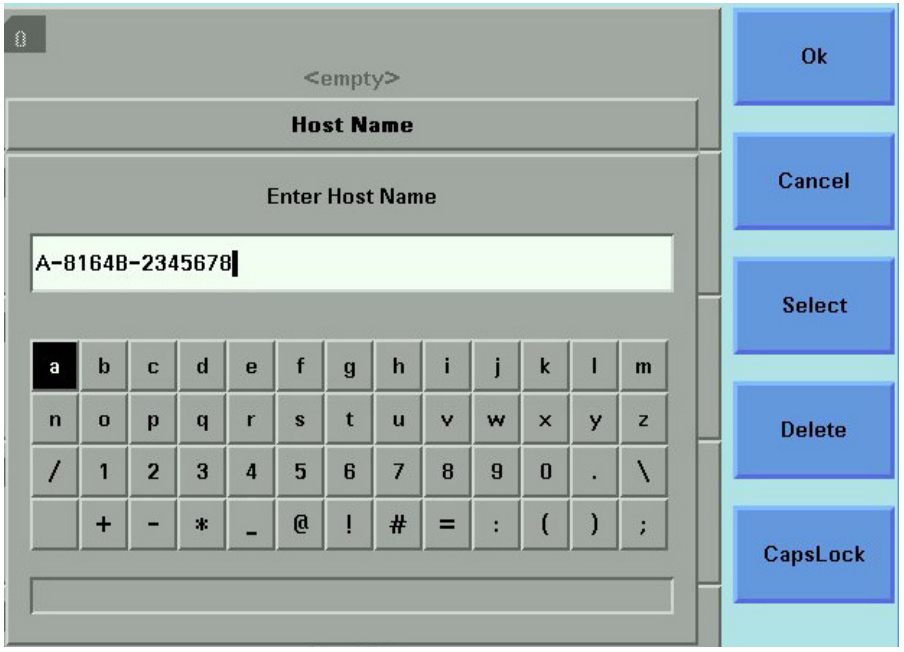



Figure 42 Edit Host Name

- Select a character by moving the high light with the cursor keys, (or the modify knob on an 8164B/LAN), then press the [Select] soft key.
- Delete the last character using the [Delete] soft key.
- The [OK] soft key is disabled until the value in the editor is valid.
- If you try to enter a character which would create an invalid host name, the instrument beeps.
- If enter an empty host name, the host name is reset to its default value.

### Edit the Domain Name

You can enter the domain name in a special dialog for text input.




Figure 43 Edit Domain Name

- Select a character by moving the high light with the cursor keys, (or the modify knob on an 8164B/LAN), then press the [Select] soft key.
- Delete the last character using the [Delete] soft key.
- The [OK] soft key is disabled until the value in the editor is valid.
- If you try to enter a character which would create an invalid domain name, the instrument beeps.

## Enable or Disable DHCP

1 Use the cursor keys (or the modify knob on the 8164B) to select “DHCP” in the “Configuration Menu” and press the [OK] soft key to open a box that lets you enable or disable DHCP.

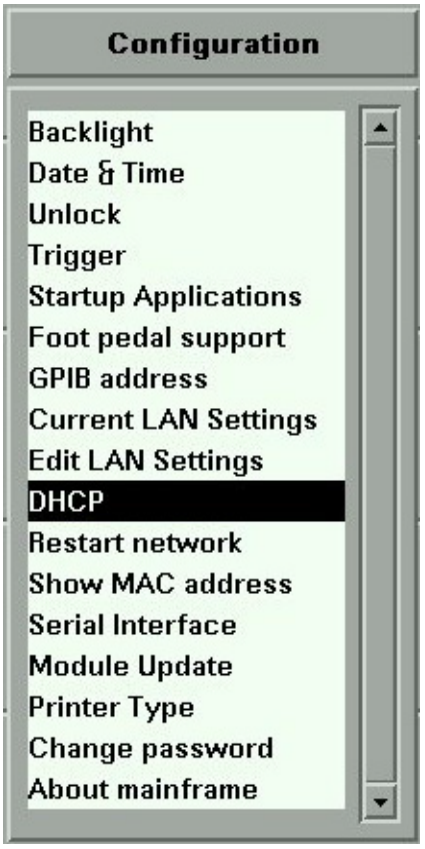



Figure 44 Configuration - DHCP

2 Use the cursor keys (or the modify knob on the 8164B) to select
- “Off” if you want to disable DHCP, or
- “On” if you want to enable DHCP.

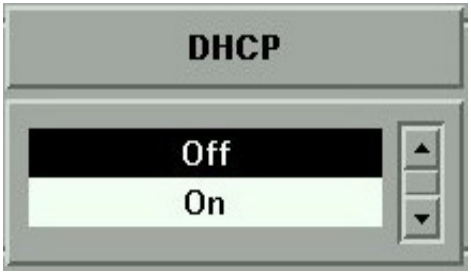



Figure 45 Enable/Disable - DHCP

3 Press the [OK] soft key.

## Show the MAC Address

Use the cursor keys (or the modify knob on the 8164B) to select “Show MAC Address” in the “Configuration Menu” and press the [OK] soft key to open a box displaying the network adapters MAC address.

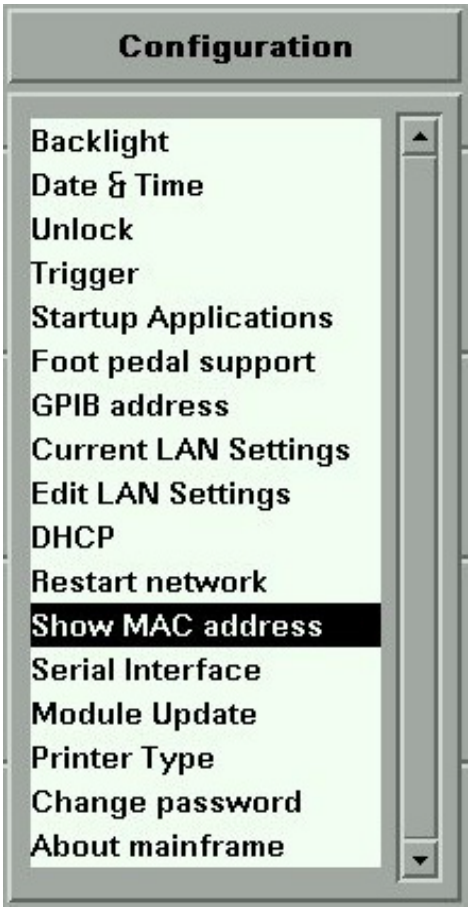



Figure 46 Configure - Show MAC Address

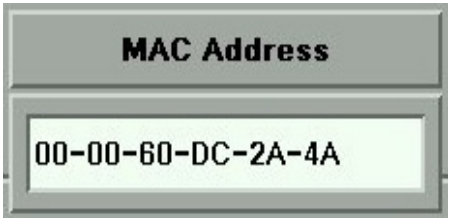



Figure 47 MAC Address

## Restart the Networking

If you have changed network parameters and want to apply them, use the cursor keys (or the modify knob on the 8164B) to select “Restart network” in the “Configuration Menu”, then press the [OK] soft key.




Figure 48 Configuration - Restart Network

# How to Set the Speed of the Serial Interface

**NOTE** The default Baudrate of the serial interface is *38400* bps.

To set the Baudrate of the instrument's serial interface:

1 Press the *Config* hardkey.

2 Move to the <*Serial Interface*> menu option and press *Enter*. You see a box displaying all the available line speeds in bps.

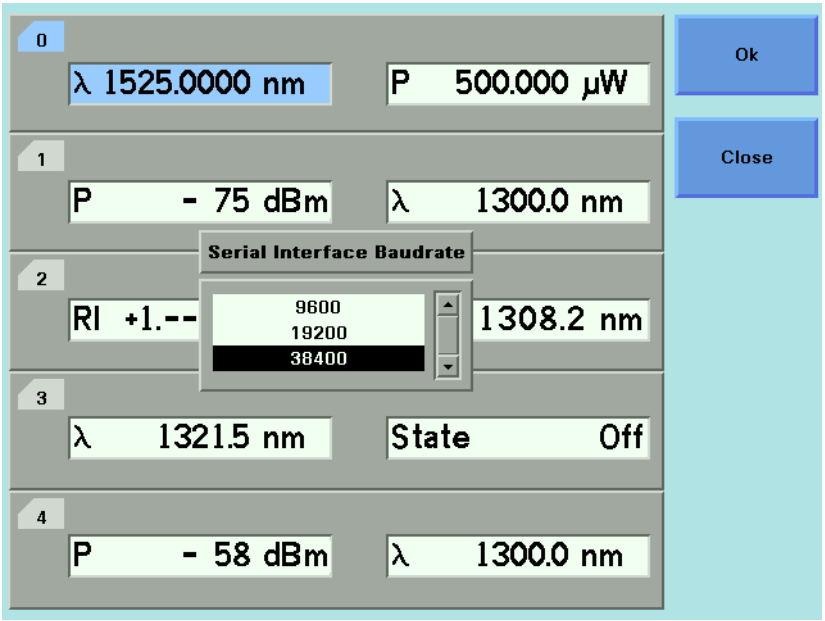



Figure 49 Selecting a Baudrate for the Serial Interface

3 Move to the Baudrate required and press *Enter*.

**NOTE**

**The Baudrate set for the serial interface of the instrument should match that set for the PC serial interface connected to it.**

**The PC serial interface should be configured to match the instrument's fixed parameters. Refer to Serial Interface on page 341.**

## How to Update a Module

For information about instrument and module firmware upgrade procedures refer to Firmware Upgrades on page 453

To set the mainframe in *Module Update* mode:

**NOTE**

**Module Update mode is necessary only when updating a module via the serial interface.**

1 Press the *Config* hardkey.

2 Move to the <*Module Update*> menu option and press *Enter*. You see a box that displays *Module Update* mode as *on*.

3 Press [OK] to start the *Module Firmware Download* process.

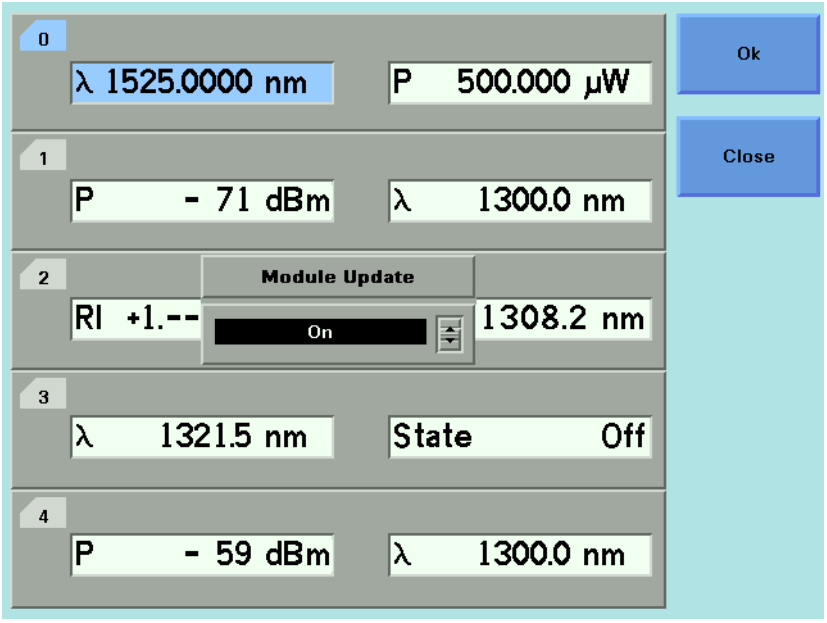



Figure 50 Module Update mode

**NOTE** Reboot the mainframe to restore normal operation.

## How to Select the Printer Type

You can use a printer connected to the parallel port on the rear panel of your mainframe, see Input and Output Connectors on page 335 for a diagram of your mainframe's rear panel.

You can print out any of the following information:

- a help screen, see How to Get Help on page 50,
- data from an application, see Printing Application Measurement Results on page 307.

To select a printer type:

1 Press the *Config* hardkey.

2 Move to the <*Printer Type*> menu option and press *Enter*. You see a box, as shown in Figure 51 on page 90, displaying the following printer types:

- <*HP PCL*>, you can use any printer that uses the Hewlett-Packard Printer Control Language Level 3 or higher, and
- <*EPSON 8 pin*>, you can use any printer that is compliant with Epson 8 pin printers.

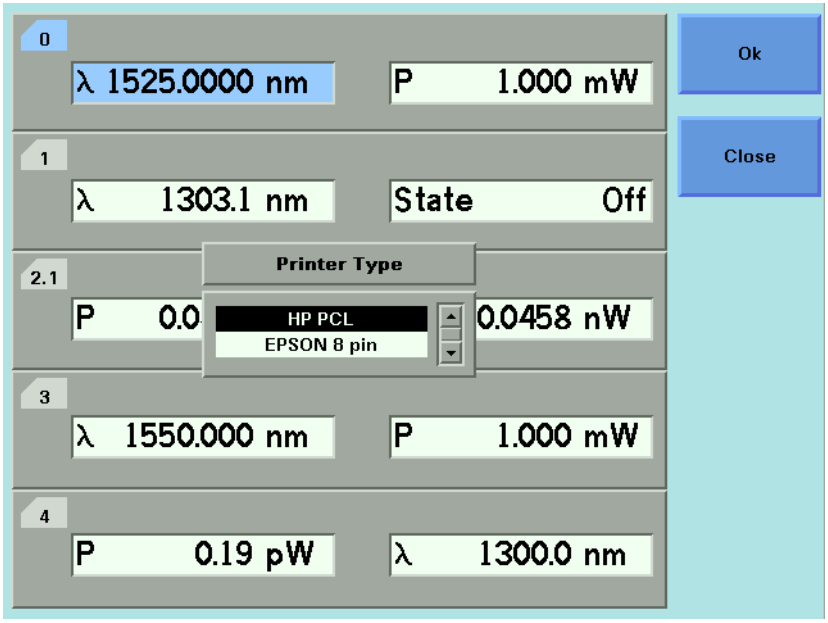



Figure 51 Selecting a Printer Type

3 Move to your printer type and press *Enter*. You return to the configuration menu.

## How to Change the Password

The password is used for unlocking the instrument. To change the password:

1 Press the *Config* hardkey.

2 Move to the <*Change Password*> menu option and press *Enter*. You see a box requesting you to enter the password.

3 Enter the current password, using the softkeys or the numerical keypad and press *Enter*. You see a box requesting you to enter the new password.

4 Enter your new password. It should be 4 digits long. Press *Enter*.

## If You Forget Your Password

If you forget your password, contact your nearest Keysight Technologies Sales/Service Office. Find contact details by accessing http://www.keysight.com/ on the Internet.

## How to Get Information About Modules

To get information about modules:

1 Press the *Config* hardkey.

2 Move to the <*About Modules*> menu option and press *Enter*. You see a box displaying the slots which have installed modules, see Figure 52.

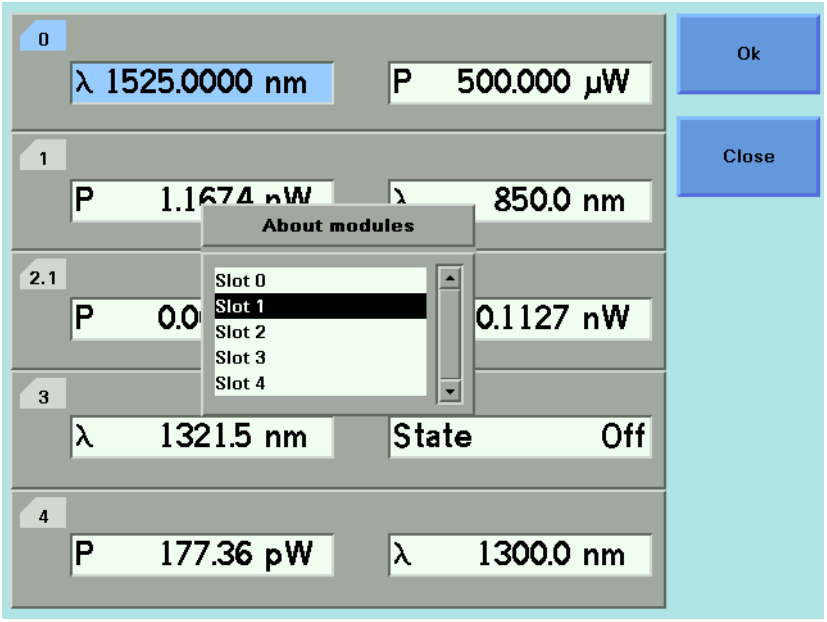



Figure 52 Slots with Installed Modules

3 Move to the module using the cursor key for which you require information. Press *Enter*.

4 The part number, serial number, and firmware revision of the chosen module are displayed, as shown in Figure 53 on page 93.

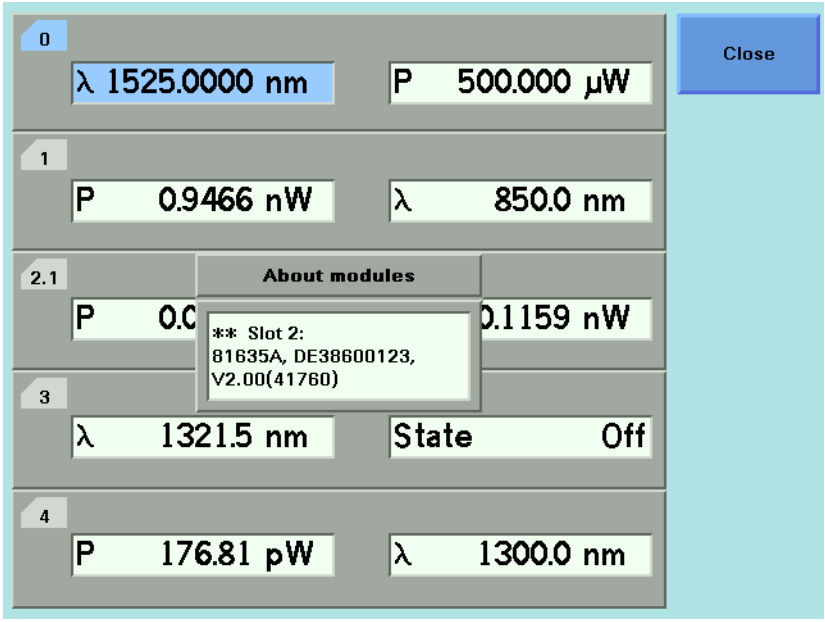



Figure 53 Viewing Information About a Module

5 Press [Close] to return to the menu in Figure 52 on page 92.

6 Perform steps step 3 to step 5 to view information about other module slots or press [Close] to return to the configuration menu.

**NOTE** Depending on the date of production, manufacturer will be returned as Keysight Technologies, Agilent Technologies or HEWLETT-PACKARD.

See How to Get Information About the Mainframe on page 94 for information on mainframe identity strings.

## How to Get Information About the Mainframe

To get information about the mainframe:

1 Press the *Config* hardkey.

2 Move to the <*About Mainframe*> menu option and press *Enter*. You see a box displaying information about your mainframe, see Figure 54 on page 94. The manufacturer, part number, serial number, and firmware revision of the mainframe are listed.

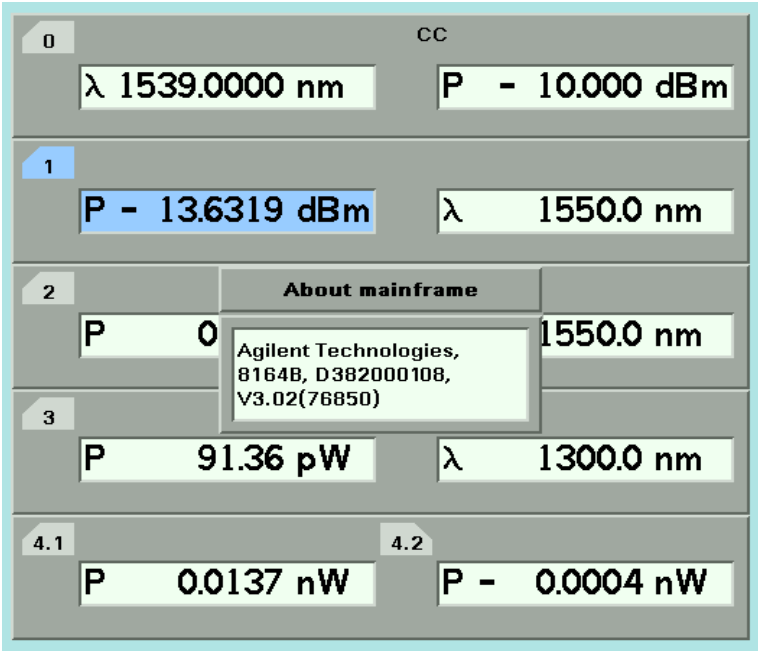



Figure 54 Viewing Information About the Mainframe

3 Press [Close] to return to the configuration menu.

**NOTE** Depending on the date of production, manufacturer will be returned as Keysight Technologies, Agilent Technologies or HEWLETT-PACKARD.

See How to Get Information About Modules on page 91 for information on module identity strings.

# How to Connect an External Monitor

You can connect a standard VGA monitor to the 8164A/B Lightwave Measurement System and the 8166B Lightwave Multichannel System. This is a useful feature for making presentations or for training courses.

**NOTE** **You cannot connect a monitor to the 8163A/B Lightwave Multimeter or 8166A Lightwave Multichannel system.**

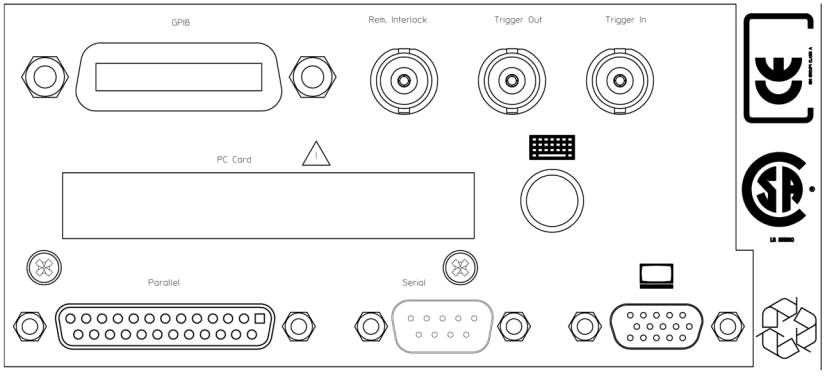



Figure 55 Rear Panel of the 8163A Lightwave Measurement System

- Place your monitor on a flat sturdy surface.
- Before you make any connections make sure the Lightwave Measurement System and monitor are turned off.
- Connect the power cable to the video input on the back of your monitor. Tighten the thumbscrews on the plug.
- Connect the video cable (it has a 15-pin plug) to the video outlet on the back of the Lightwave Measurement System. Tighten the thumbscrews on the plug.
- Connect the power cord to the display.
- Plug the power cord into the power outlet.

**NOTE** Refer to the user's guide that came with your monitor, if necessary, to locate your monitor's output and input ports.

# How to Connect a Printer

You can use a printer connected to the parallel port on the rear panel of your mainframe, see Input and Output Connectors on page 335 for a diagram of your mainframe's rear panel.

You can use either of the following printer types:

- <*HP PCL*>, a printer that uses the Hewlett-Packard Printer Control Language, or
- <*EPSON 8 pin*>, a printer that is compliant with Epson 8 pin printers.

To set up the printer, perform the following steps:

1 Set up your printer as described in your printer's User's Guide.

2 Connect a parallel cable between your printer's parallel connector to the parallel port on the rear panel of your mainframe, see Input and Output Connectors on page 335 for a diagram of your mainframe's rear panel.

3 To select a printer type, see How to Select the Printer Type on page 89.

You can then print out any of the following information:

- a help screen, see How to Get Help on page 50,
- data from an application, see Printing Application Measurement Results on page 307.

# 3 Power Measurement

How to Measure Power / 100

This chapter describes how to use the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System to measure optical power using a Power Meter, that is:

- a Power Sensor module or
- an Optical Head in conjunction with an Optical Head Interface module.

# How to Measure Power

## The Power Value

The <*P*> parameter displays the power measurement value. In MinMax mode, this parameter changes to <Δ*P*>, the difference between minimum and maximum power, see How to Choose the MinMax Mode on page 116.

### How to Set the Number of Digits

You can set the maximum number of digits that are used in power measurement. This is the maximum number of digits after the decimal point.

To change the number of digits to two:

1 Move to the Power Meter channel and press the [Menu] softkey.

2 Move to <*Number of Digits*> option and press *Enter*. You will see the screen in Figure 56 on page -100.

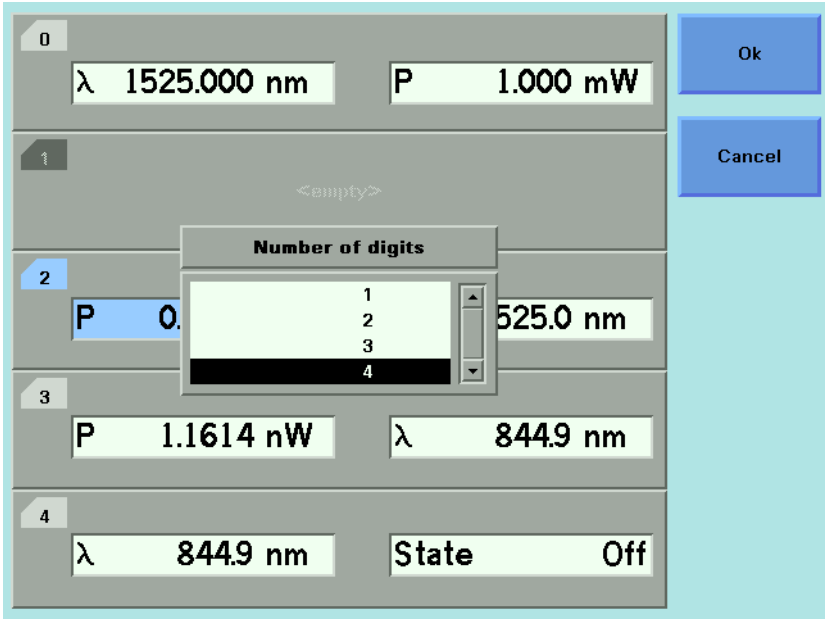



Figure 56 The Number of Digits Menu

3 Move to 2 and press *Enter*.

4 Press the [Close] softkey to exit the menu.

## How to Set the Power Unit

Pressing the Power Unit softkey allows you to select either W, dB, or dBm as the units in which power is displayed. The Power Unit softkey is visible when you move to the [*P*] or [*Ref* ] parameters. Alternatively the Power Unit can be changed by using the Power Meter menu.

### What are the Power Units ?

Watts (W) are the SI unit for power measurement.

You can also measure power in dB or dBm. Values displayed in these units are derived from measurement in Watts.

By selecting dBm, the following calculation is made:

$$P_{dBm} = 10\log\frac{P_{input}(W)}{1\times10^{-3}(W)}$$

Where,

$P_{dBm}$is the power value displayed in dBm, and

$P_{input}$is the input signal level in Watts.

Power, in units of dBm, is measured relative to 1 mW, it is an absolute power measurement.

By selecting dB, the following calculation is made:

$$P_{dB} = 10\log\frac{P_{input}(W)}{P_{ref}(W)}$$

Where,

$P_{dB}$is the power value displayed in dB,

$P_{input}$is the input signal level in Watts, and

$P_{ref}$is the chosen reference power value in Watts.

Power, in units of dB, is measured relative to a particular reference power value. For information on selecting this reference value, see How to Input a Reference Level on page 103.

To set the power unit to dBm:

1 Move to the [*P*] parameter and press the [Power Unit] softkey. You will see the menu in Figure 57 on page -102.

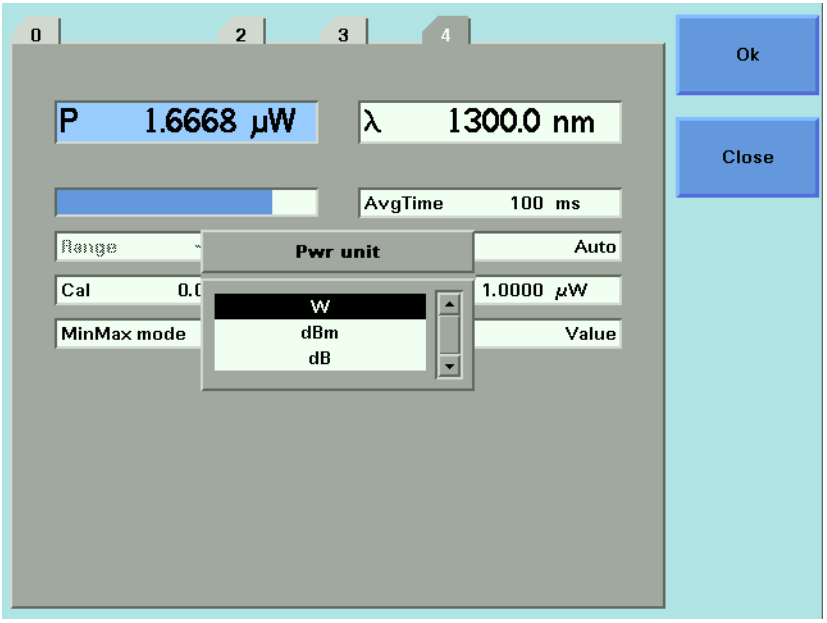



Figure 57 Selecting the Power Unit

2 Move to <*dBm*>, by using the cursor key, and press *Enter*.

## How to Set the Calibration Offset

This is a calibration offset that you can enter to compensate for external optical circuitry, for example, the 81022FF Integrating Sphere or a 3 dB coupler. The calibration offset, [*Cal*], is automatically subtracted from the input signal.

$P_{measured}(dBm) = P_{input}(dBm) - CAL(dB)$

Where,

$P_{measured}$ is the adjusted value of the signal read in dBm,

$P_{input}$ is the input signal level in dBm, and

*CAL* is the calibration offset in decibels (dB).

To set the calibration offset to 40.000 dB:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [*Cal*] parameter and press *Enter*.
3 Enter 40.000 and press *Enter*.

## How to Set the Reference Level

### How to Input a Reference Level

dB results are shown relative to a reference level. The [*Ref*] parameter sets the reference level. Setting, or changing, the reference only affects results that are displayed in dB.

The reference level is displayed in units of dBm or Watts. Depending on which is selected the following equations are used to calculate the power level in dB:

$P_{display}(dB) = P_{measured}\ (dBm) - REF(dBm)$

or

$$P_{display}(dB) = 10\log\frac{P_{measured}(W)}{REF(W)}$$

Where,

$P_{display}$ is the displayed relative power,

$P_{measured}$ is the absolute power level (see How to Set the Calibration Offset on page 102), and

*REF* is the reference level.

You can choose the units for the reference using the Power Unit softkey. If you choose dB, the power value changes to dB and the displayed reference level changes to dBm.

To set the reference level to 10 mW:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [*Ref*] parameter and press the [Power Unit] softkey.
3 Move to <*W*> and press *Enter* twice.
4 Change the units to mW using the [Unit+] and [Unit-] softkeys.
5 Enter 10.000 and press *Enter*.

### How to Set the Reference Value to the Current Power Value

In addition to entering a new reference value, you can change the reference value to the currently displayed power value by pressing the [Dsp->Ref] softkey.

Pressing the [Dsp->Ref] softkey takes the input power level and stores it as the reference. Setting the reference only affects results displayed in dB.

When you press the [Dsp->Ref] softkey, the absolute power level, the power value in dBm or Watts, is stored as the reference, that is:

$REF = P_{measured}$

Where,

REF is the reference, and

$P_{measured}$ is the absolute power level (see How to Set the Calibration Offset on page 102).

The [Dsp->Ref] softkey is displayed if you move to a power measurement channel.

### How to Reference Another Power Measurement Channel

You can use the reference mode, [*Ref Mode*], to reference another Power Meter's current power level. If you choose this mode, the reference of the channel continuously updates to the current power value measured by the other channel.

The following equations describe how the power in dB is calculated if you reference another channel:

$P_{display}(dB) = P_{measuredA}\ (dBm) - P_{measuredB}\ (dBm) - REF(dB)$

or

$$P_{display}(dB) = 10\log\frac{P_{measuredA}(W)}{P_{measuredB}(W)} - REF(dB)$$

Where:

$P_{display}$ is the displayed relative power,

$P_{measuredA}$ is the absolute power level (see How to Set the Calibration Offset on page 102) measured by the current Power Meter, and

$P_{measuredB}$ is the absolute power level (see How to Set the Calibration Offset on page 102) measured by the Power Meter you choose to reference, and

*REF* is the reference level in decibels (dB).

**NOTE** **You can only set the reference level, REF, in decibels (dB) when you reference Power Meter's current power level. This reference level is stored in separate memory than the absolute reference level.**

To reference another channel:

1 Move to the Power Meter channel and press the [Details] softkey.

2 Move to the [*Ref Mode*] parameter and press *Enter*.

3 Move to the channel number you want to reference, using the cursor key, and press Enter. For example, in Figure 58 on page -105, you could choose 3.1 (for channel 3.1). Refer to Slot and Channel Numbers on page 39 for information on channel numbers.

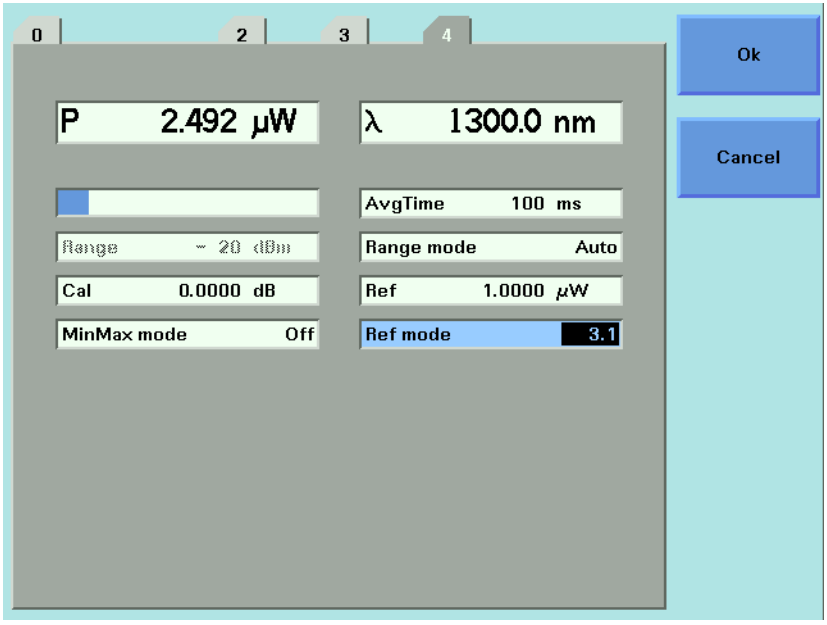



Figure 58 Referencing Another Channel

To return to setting a constant reference level:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [*Ref Mode*] parameter and press *Enter*.
3 Move to the <*Value*> menu option and press *Enter*.

### How to Set the Wavelength

This is the wavelength value. The responsivity of the Power Meter varies with wavelength. For accurate power measurement, you need to input the wavelength of the optical input. To set the wavelength to 1545.000 nm:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [λ] parameter and press *Enter*.
3 Enter 1545.000 and press Enter.

### How to Remove Electrical Offsets

Optical Power Meters measure optical power by converting optical power to electrical power, and then measuring electrical power. An electrical offset is electrical power that is always present, even if there no optical power is input. If electrical offsets are not removed, they affect the accuracy of power measurement.

Performing a zero sets the zero power level to the average electrical offset level for the current environmental conditions.

**NOTE** **The environmental conditions and the temperature of the instrument affect electrical offset. For the best results you must:**

- Allow the instrument time to acclimatize (around 24 hours).
- Allow the instrument time to warm up (around 20 minutes).
- Make sure that the optical input is not receiving any light. If you are using multi-mode fiber-optic cable, you must disconnect the cable and cover the input to the Power Meter to perform a zero.

It is good practice to perform a zero before making any important measurements.

To remove electrical offsets:

1 Make sure the optical input is not receiving any light. If the instrument has just been switched on, wait until SETTLING is not displayed for the module channel.

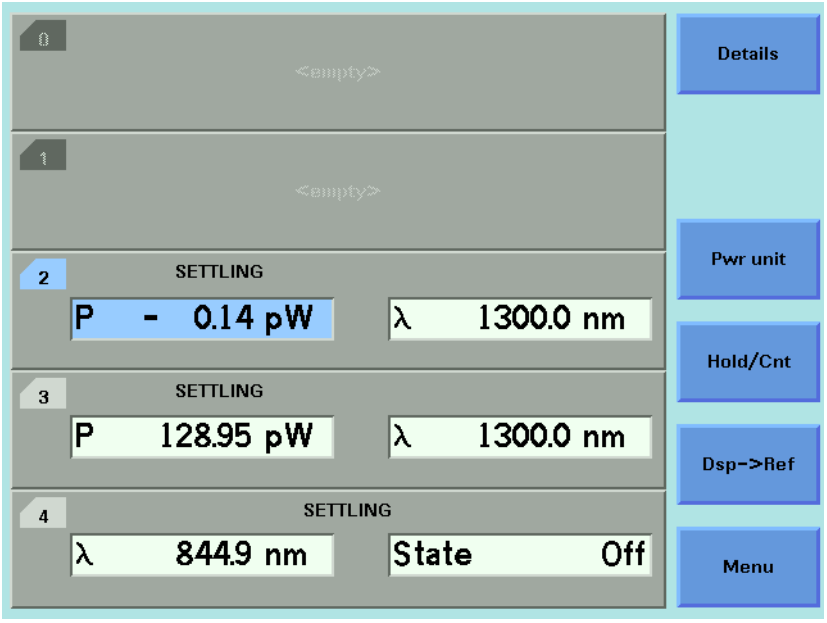



Figure 59 Module Channels that are Setting

2 Move to the Power Meter channel and press the [Menu] softkey.

3 Move to the <*Zero*> option to zero the current power measurement channel or the <*Zero All*> option to zero all power measurement channels. You will see the screen shown in Figure 60 on page -108, this appears for around 30 seconds while zeroing is performed.

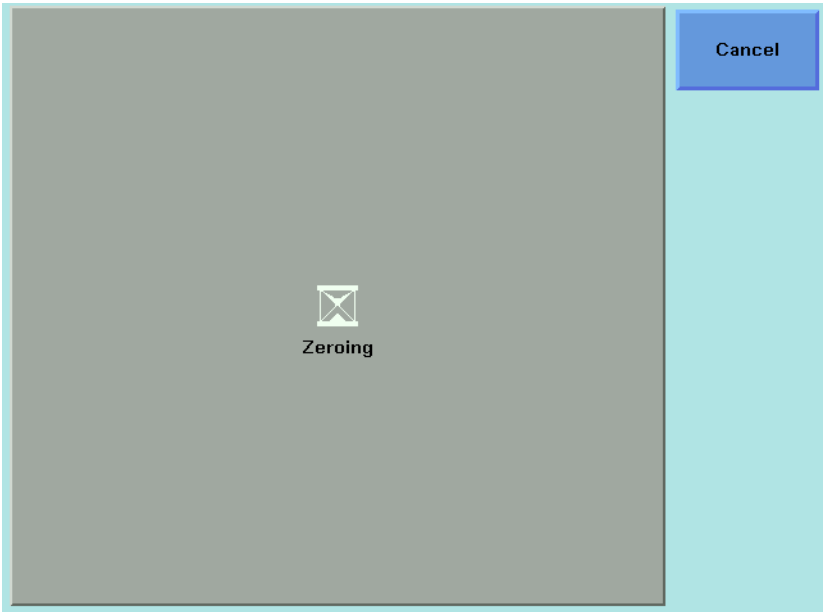



Figure 60 Zeroing Sreen

**NOTE** **If you see the screen shown in Figure 61 on page -109, the zeroing operation has failed because the Power Meter received light. The most common reason for zeroing to fail is if:**

- a source is connected to the Power Meter's input connector,
- the fiber connected to the Power Meter's input connector is collecting light, or
- the Power Meter receives ambient light because the input connector is uncovered.

Press *Enter* and start again at step 1.

4 When the zeroing operation finishes, press the [Close] softkey to close the menu.

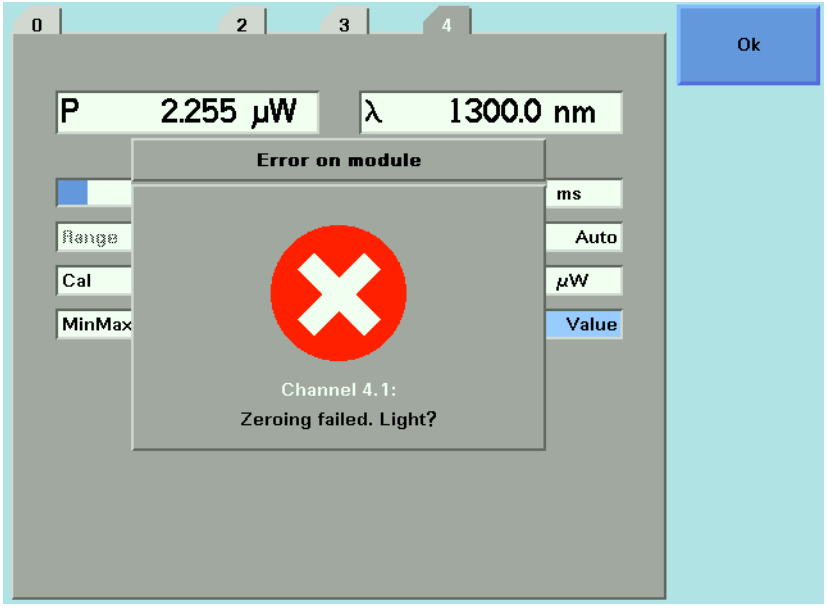



Figure 61 Zeroing Fails, if the Power Meter Receives Input Light.

### How to Choose the Range Mode

**NOTE** For a Dual Power Sensor, you cannot set the range mode of the slave channel, channel 2, directly. By default, the range mode of the slave channel, channel 2, is the same as that for the master channel, channel 1. See Table 12 on page -122 for more details.

You can choose either of two ranging modes from the Range mode menu:

- <*Auto*>, the auto-ranging mode, ensures that the result has a displayed value between 9% and 100% of full scale. The default state is for automatic ranging to be enabled.
- <*Manual*>, which allows you to set a user-defined range.

How to Set the Range

If you choose <*Auto*> from the Range mode menu, this parameter can not be set. The Range parameter, [*Range*], is displayed in light grey text, see Figure 62 on page -110, in automatic ranging mode and displays the automatically-determined range.

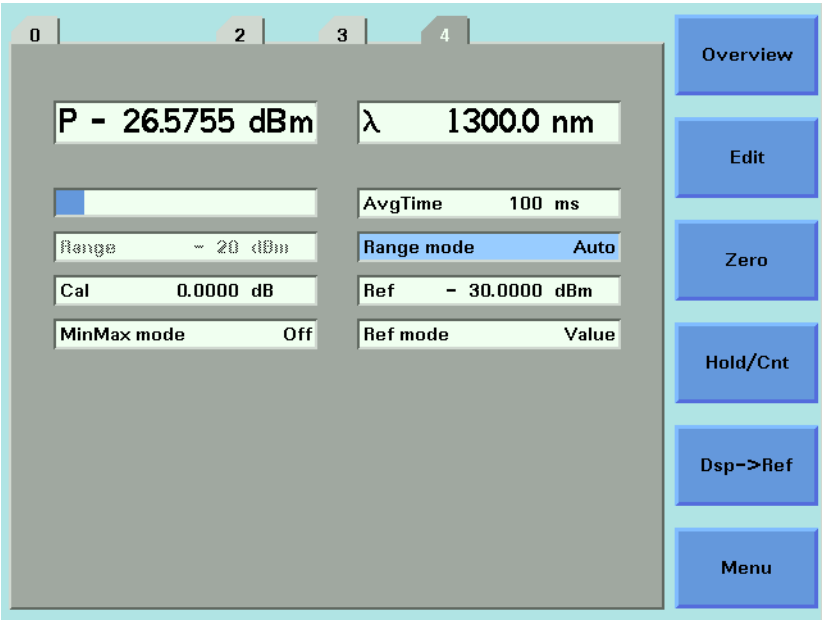



Figure 62 Auto-Range Mode

If you choose <*Manual*> from the Range mode menu, you must choose a range setting from the Range menu.

To choose a range setting, follow the following steps:

1 Setup the instrument.
2 Move to the Power Meter channel and press the [Details] softkey.
3 Move to the [*P*] parameter and press the [Power Unit] softkey. You will see the menu in Figure 57.
4 Move to <*dBm*>, by using the cursor key, and press *Enter*.
5 Move to the [*Range Mode*] parameter and press *Enter*.
6 Move to <*Auto*>, by using the cursor key, and press *Enter*.
7 Perform a set of measurements.

8 Note the highest [*Range*] that the instrument automatically set during this set of measurements.

9 Move to the Power Meter channel and press the [Details] softkey.

10 Move to the [*Range Mode*] parameter and press *Enter*.

11 Move to <*Manual*>, by using the cursor key, and press *Enter*.

12 Move to the [*Range*] parameter and press *Enter*.

13 Enter the range value determined in step 8, by using the cursor key, and press *Enter*.

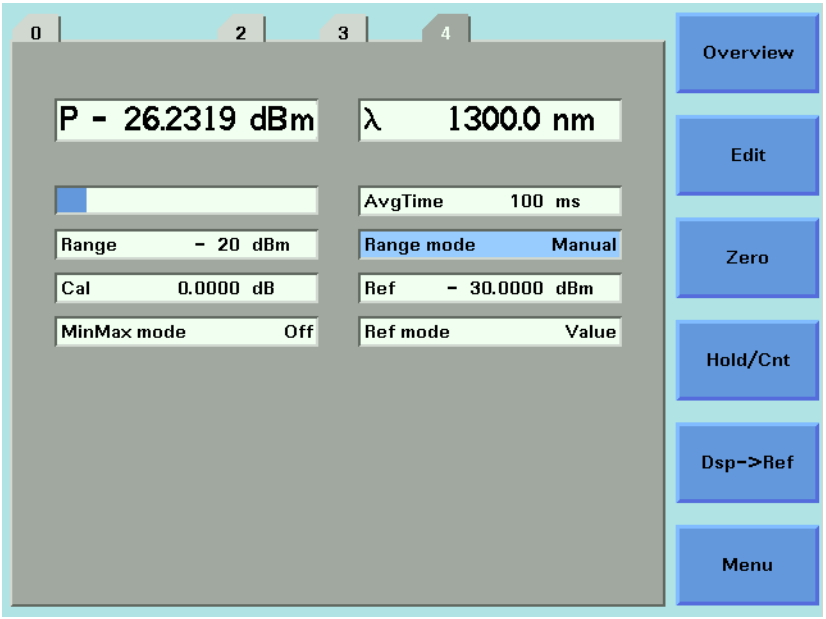



Figure 63 Manual Range Mode - Within Range

If the measured power is more than 3dBm greater than the range setting, it is impossible for power to be displayed. The power value, +1.--- dBm, as shown in Figure 64 on page -112, is shown. This means that the measured power is greater than the Upper Power Limit. You must decrease the [*Range*] value.

See Table 11 on page -114 for more details.

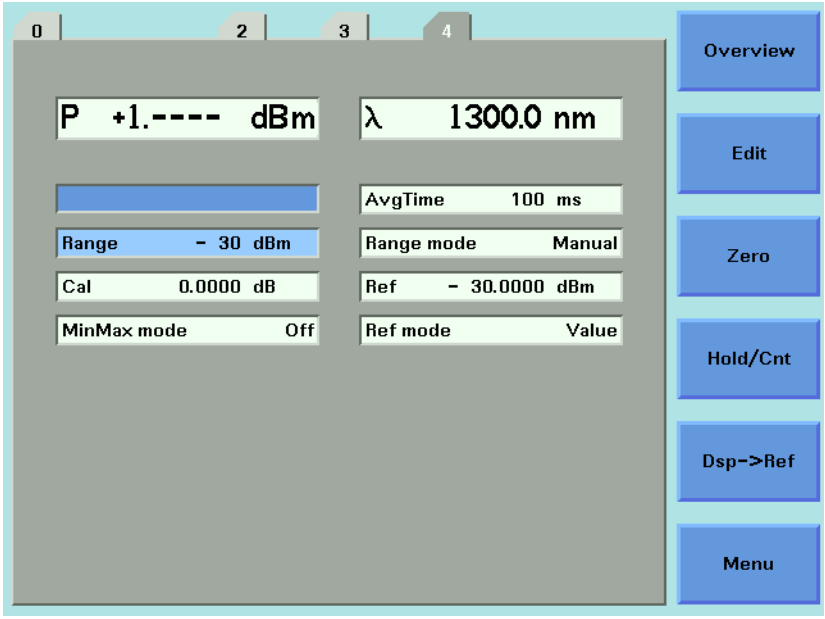



Figure 64 Out of Range - Power Greater Than Upper Power Limit

If the measured power is more than 40 dBm less than the range setting, it is impossible for power to be displayed. The power value, -1.--- dBm, as shown in Figure 65 on page -113, is shown. This means that the measured power is greater than the resolution at this [*Range*] value. You must increase the [*Range*] value.

See Table 11 on page -114 for more details.

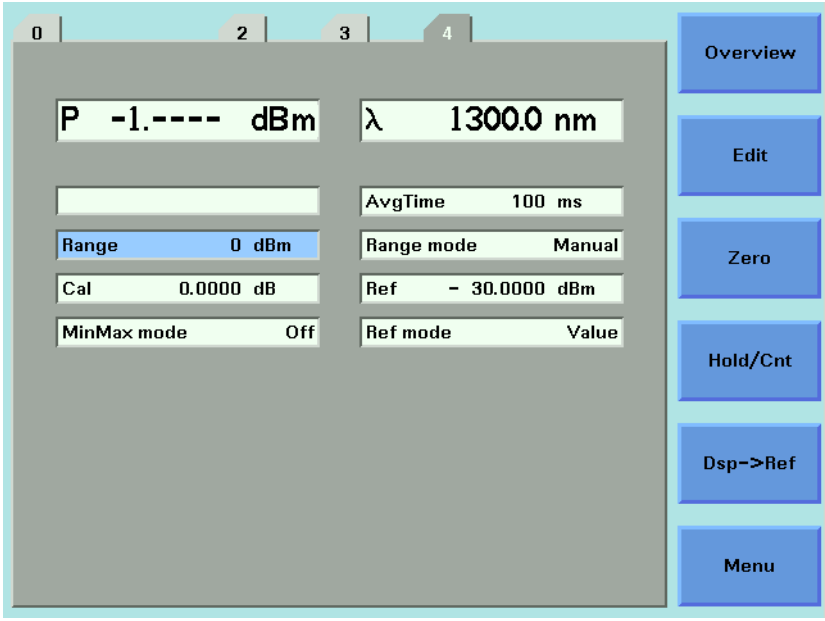



Figure 65 Out of Range - Power Less Than Resolution

Figure 66 on page -114 shows an example of the range values you can choose for the Keysight 81634B. Inn this case the values range from 10 dBm (upper power limit of 13 dBm) to -70 dBm (upper power limit of -67 dBm) in 10 dBm increments.

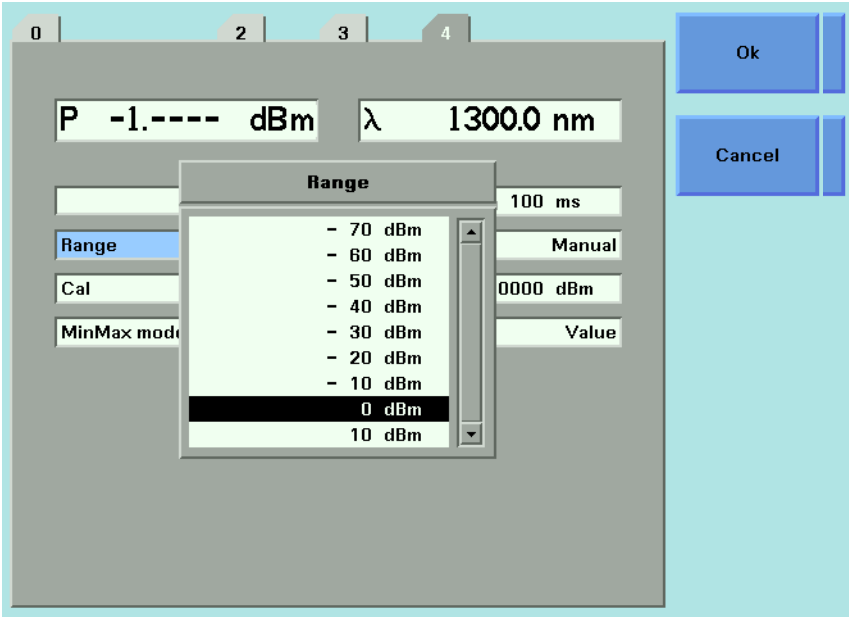



Figure 66 Range Value Menu

## Upper Power Limit and Resolution

Table 11 on page -114 shows the upper power limit and measurement resolution at various power ranges. As can be seen the resolution decreases as the chosen [*Range*] decreases. The resolution is always 40 dBm less than the chosen [*Range*] value. The Upper Power Limit is always 3 dBm greater than the chosen [*Range*] value.

**Table 11 Upper Power Limits and Resolution for Various Power Ranges**

| [Range] | Upper Power Limit | | Resolution | |
|---|---|---|---|---|
| 40 dBm | 19.999 W | 43.000 dBm | 0.001 W | -0.000 dBm |
| 30 dBm | 1.9999 W | 33.000 dBm | 0.1 mW | -10.000 dBm |
| 20 dBm | 199.99 mW | 23.000 dBm | 0.01 mW | -20.000 dBm |
| 10 dBm | 19.999 mW | 13.000 dBm | 0.001 mW | -30.000 dBm |

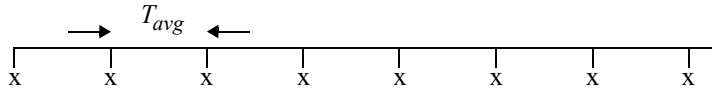
| [RANGE] | Upper Power Limit | | Resolution | |
|---|---|---|---|---|
| 0 dBm | 1.9999 mW | 3.000 dBm | 0.1 mW | -40.000 dBm |
| -10 dBm | 199.99 mW | -7.000 dBm | 0.01 mW | -50.000 dBm |
| -20 dBm | 19.999 mW | -17.000 dBm | 0.001 mW | -60.000 dBm |
| -30 dBm | 1.9999 mW | -27.000 dBm | 0.1 nw | -70.000 dBm |
| -40 dBm | 199.99 nW | -37.000 dBm | 0.01 nw | -80.000 dBm |
| -50 dBm | 19.999 nW | -47.000 dBm | 0.001 nw | -90.000 dBm |
| -60 dBm | 1.9999 nW | -57.000 dBm | 0.1 pW | -100.000 dBm |
| -70 dBm | 199.99 pW | -67.000 dBm | 0.01 pW | -110.000 dBm |

## How to Set the Averaging Time

**NOTE** For a Dual Power Sensor, you cannot set the averaging time of the slave channel, channel 2, directly. By default, the averaging time of the slave channel, channel 2, is the same value as that for the master channel, channel 1. See Table 12 on page -122 for more details.

This is the length of time over which a signal is averaged. Longer averaging times increase the accuracy and improve the noise rejection. Longer averaging times also decrease sensitivity.

For averaging times of 1 second or less, a new measurement is shown at the end of each averaging time. This is drawn in Figure . A new measurement is shown on the display at each x.




Measurement with Tavg ~1 second

With modules designed for the 8153A Lightwave Multimeter, for averaging times of more than 1 second, the displayed power is given by the formula:

$$P_{new} = P_{old}\left(1 - \frac{T_{sample}}{T_{avg}}\right) + Sample\left(\frac{T_{sample}}{T_{avg}}\right)$$

Where,

$P_{new}$is the new displayed result,

$P_{old}$is the previously displayed result,

*ample*is the value read by the hardware,

$T_{avg}$is the averaging time, as set by the user, and

$T_{sample}$is the time the hardware takes to make a reading.

If the measurement condition change (for example, a range change in automatic ranging), $P_{old}$ is reset and the averaging starts again. This is why the display update seems faster in automatic ranging.

To set the averaging time to 1 second:

1 Move to the Power Meter channel and press the [Details] softkey.

2 Move to the [*AvgTime*] parameter and press *Enter*.

3 Move to <*1 s*>, by using the cursor key, and press *Enter*.

How to Choose the MinMax Mode

**NOTE** **For a Dual Power Sensor, you cannot set the averaging time of the slave channel, channel 2, directly. By default, the averaging time of the slave channel, channel 2, is the same value as that for the master channel, channel 1. See Table 12 on page -122 for more details.**

MinMax mode measures the incoming power and displays the minimum value measured, [*Pmin*], and the maximum value measured, [*Pmax*]. The difference between these values, DP, is displayed in place of P, the power value. This mode is intended principally for polarization dependent measurements, but can be used for other types of measurement.

You can choose three modes of operation from the MinMax mode menu:

- <*Continuous*> mode, which compares each new measured value with the maximum and minimum values so far, and replaces them as necessary.
  This mode is useful for measuring the Polarization Dependent Loss (PDL) of a component. Run the application while sweeping the polarization of the source applied to the component.
- <*Window*> mode, which compares each new measured value with the maximum and minimum values of each of the previous N samples. When a new measurement is taken it is added to a buffer containing the previous N samples and the oldest measurement is deleted.
- <*Refresh*> mode, which adds each new measurement to a buffer. The minimum and maximum values, in this buffer, are displayed. After N samples are added to the buffer, the buffer resets and a new buffer is created.
  You can use Window and Refresh modes, for example, when you are searching for or setting the position of minimum PDL.

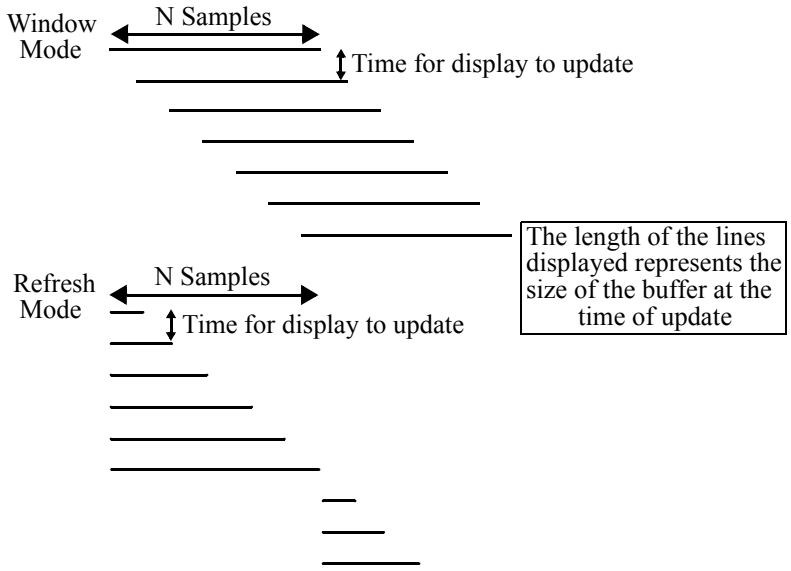



Figure 67 The Window and Refresh Modes

To choose the <*Refresh*> MinMax mode:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [*MinMax Mode*] parameter and press *Enter*.
3 Move to <*Refresh*>, by using the cursor key, and press *Enter*. The screen in Figure 68 on page -118 appears.

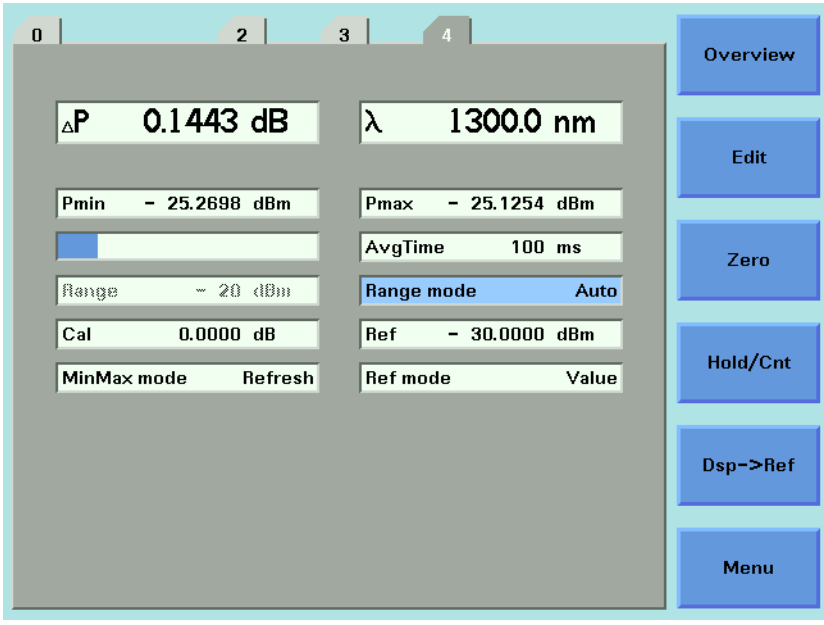



Figure 68 MinMax Mode Screen

4 Press *Menu*, move to <*Data Points*> and press *Enter*.
5 Enter 100 and press *Enter*.

## How to Turn Off MinMax Mode

To turn off MinMax mode, and return to continuous power measurement:

1 Move to the Power Meter channel and press the [Details] softkey.
2 Move to the [*MinMax Mode*] parameter and press *Enter*.
3 Move to <*Off*>, by using the cursor key, and press *Enter*.

### How to Hold the Screen

Pressing the [Hold/Cnt] softkey allows you to hold the screen so that no new measurements are displayed. Hold is displayed as shown in Figure 69 on page -119.

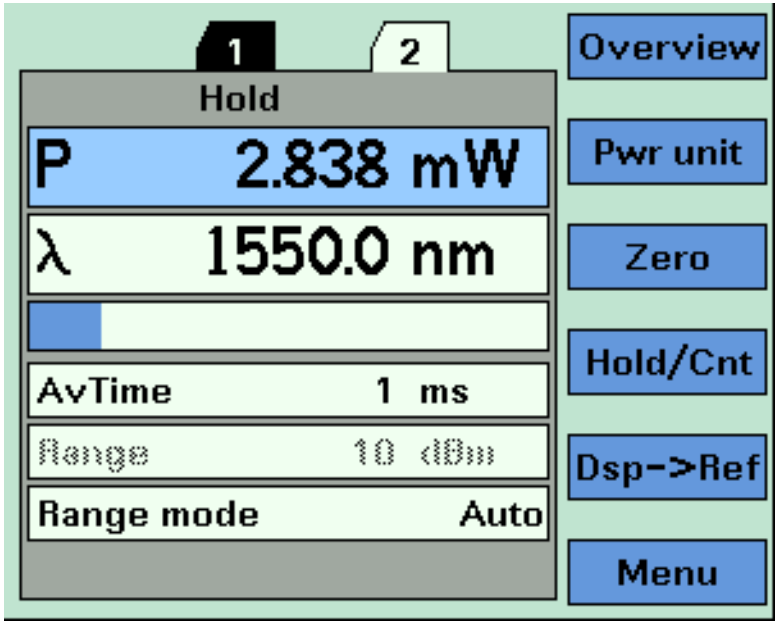



Figure 69 Power Module Channel is Held - Overview Screen

By pressing the [Hold/Cnt] softkey a second time the screen will display new measurements continuously.

### How to Use Triggers

Keysight 8163A/B Series Power Meter modules allow you trigger the instrument to perform tasks and to output trigger signals to external measurement instruments.

**NOTE**

**For a Dual Power Sensor, you cannot set the averaging time of the slave channel, channel 2, directly. By default, the averaging time of the slave channel, channel 2, is the same value as that for the master channel, channel 1. See Table 12 on page -122 for more details.**

## How to Trigger Power Measurements

You can configure 8163A/B Series Power Meter modules to perform certain tasks when you apply a trigger to the Input Trigger Connector.

You must prearm a measurement function before an action can be triggered:

1 See How to Set the Trigger Configuration on page 68 for how to configure the trigger connectors.

2 Move to the Power Meter channel and press the [Menu] softkey.

3 Move to <*Input Trigger Mode*>, by using the cursor key, and press *Enter*. You will see the screen in Figure 70 on page -120.

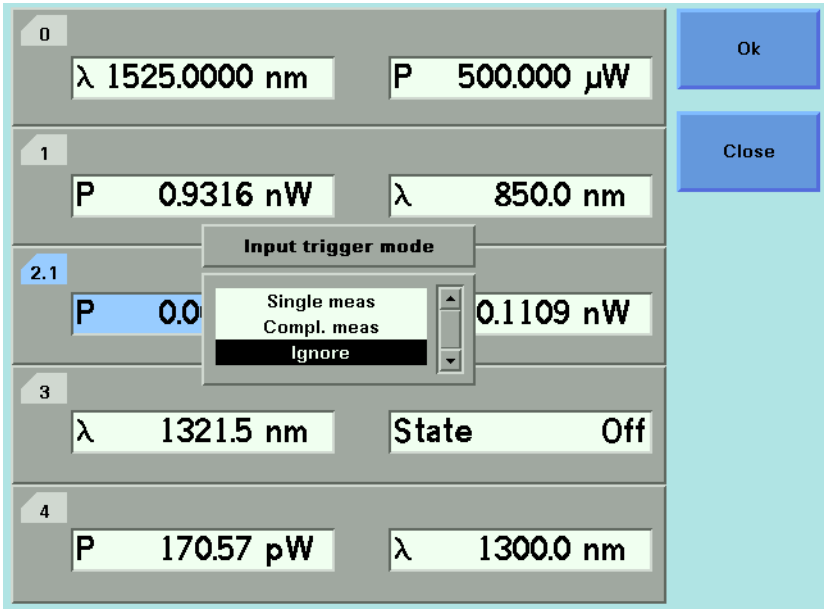



Figure 70 Input Trigger Mode

4 Move to one of the following, by using the cursor key:

- <*Single meas*>, an input trigger will trigger one sample of a measurement function to be performed and to store the result in a data array.
- <*Compl. meas*>, an input trigger will trigger a complete measurement function to be performed.
- <*Ignore*>, input triggers are ignored.

5 Press *Enter*.

You can generate input triggers in any of the following ways:

- trigger the Input Trigger Connector on the rear panel of your instrument,
- set <*Trigger Configuration*> to <*Loopback*> so that an output trigger automatically generates an input trigger, or
- use the :TRIGger GPIB command, see your mainframe's Programming Guide.

### How to Use Output Triggering

You can configure 8163A/B Series Power Meter modules to output a trigger when the instrument performs certain tasks.

To set your module's Output Trigger Configuration:

1 See How to Set the Trigger Configuration on page 68 for how to configure the trigger connectors.

2 Move to the Power Meter channel and press the [Menu] softkey.

3 Move to <*Output Trigger Mode*>, by using the cursor key, and press *Enter*. You will see the screen in Figure 71.

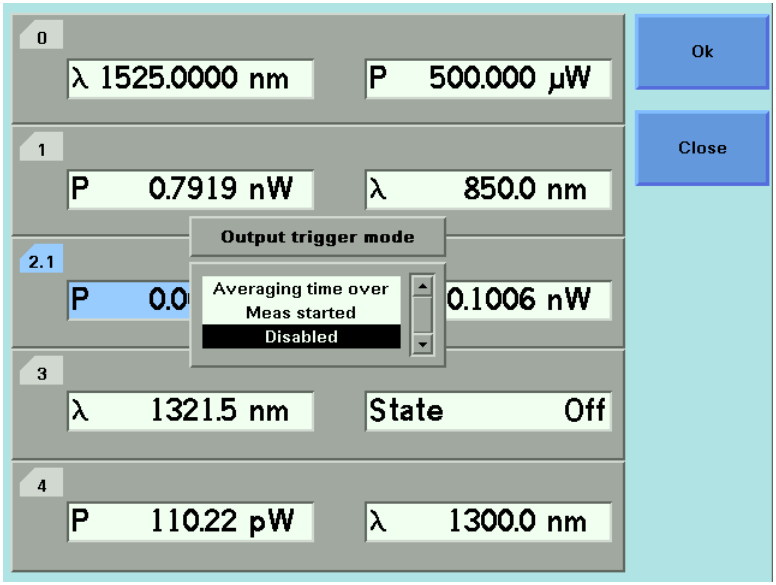



Figure 71 Output Trigger Mode

4 Move to one of the following, by using the cursor key:

- <*Averaging Time Over*>, a trigger is output when the averaging time period of a measurement finishes.
- <*Meas Started*>, a trigger is output when the averaging time period of a measurement begins.
- <*Disabled*>, the output trigger mode is disabled.

5 Press *Enter*.

### Dual Power Meters – Master and Slave Channels

For the Keysight 81635A Dual Power Sensor and the Keysight 81619A Dual Optical Head Interface module, channel 1 is the master channel and channel 2 is the slave channel. The master and slave channels share the same software and hardware triggering system. For some commands, setting parameters for the master channel sets the parameters for the slave channel. In these cases, you may only set parameters for the slave channel by setting master channel parameters.

The parameters listed in Table 12 on page -122 can only be set or viewed using the master channel.

**Table 12 Parameters that can only be set using the master channel**

| Parameter |
|---|
| <*Zero*> |
| <*MinMax mode*> |
| <*Reset MinMax*> |
| <*Data points*> |
| <*Averaging time*> |
| <*Range mode*> |
| <*Input trigger mode*> |
| <*Output trigger mode*> |

# 4 Laser Sources

How to Use Laser Source Modules / 124

This chapter describes how to use the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System to control fixed wavelength laser source modules.

# How to Use Laser Source Modules

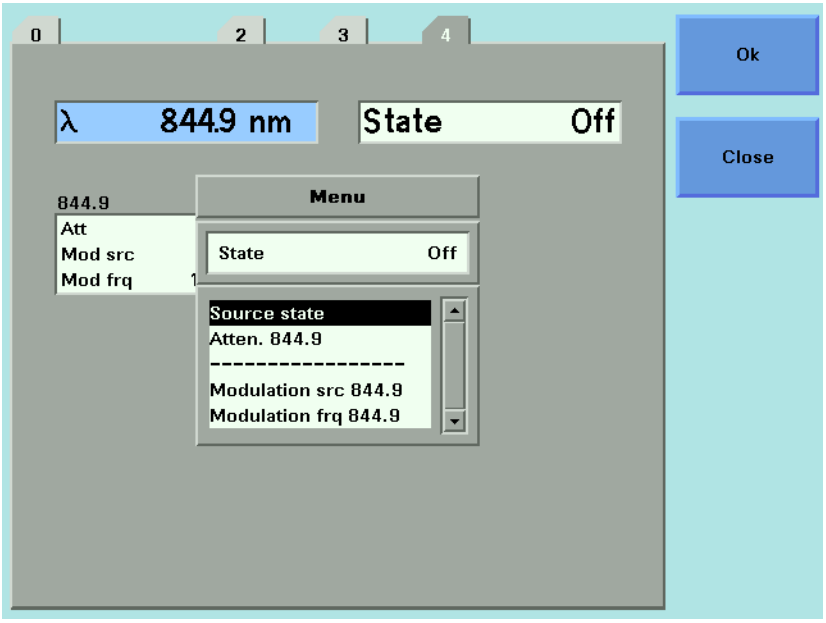



Figure 72 Menu of Parameters for a Fixed Wavelength Laser Source

## The Laser Wavelength Value

The laser wavelength value [λ] for a fixed-wavelength laser source module is the calibrated optical wavelength value for the laser source. This is a fixed value, you can display the value but you cannot edit it.

### Dual-Wavelength Laser Source Modules

Dual-wavelength laser source modules have optical outputs at two wavelengths. You can choose to output an optical signal at either a single wavelength or at both wavelengths simultaneously.

To choose both output wavelengths for a dual-wavelength laser source module:

1 Move to [λ] parameter and press *Enter*.

2 Select <*1309.6+1551.6*>, using the cursor key, and press *Enter*. You will see the screen in Figure 73 on page -125.

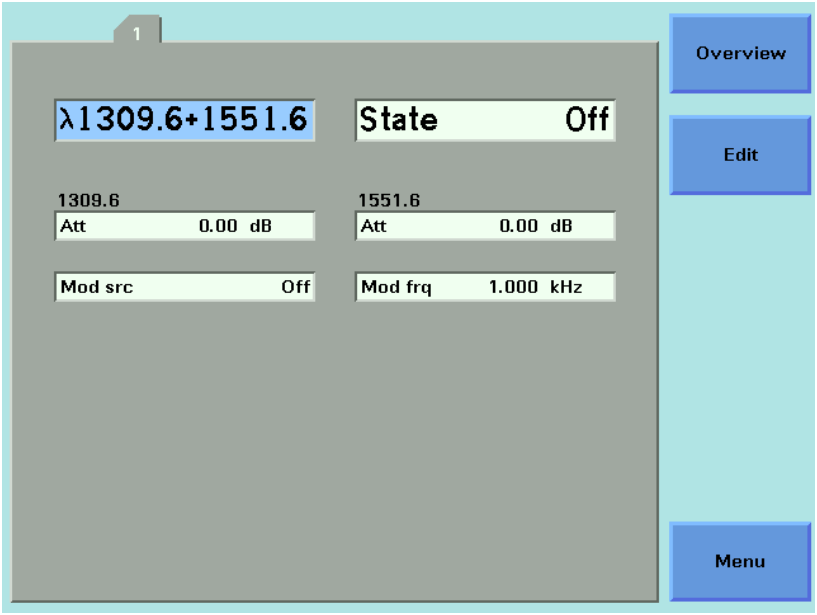



Figure 73 Dual-Wavelength Laser Source Outputs Both Wavelength

**NOTE**

For further information on modulating the optical output of a dual-wavelength laser source module, see How to Modulate Dual-Wavelength Laser Source Modules on page 128.

### How to Enable/Disable Laser Output

To enable laser output using the user interface:

1 Move to [*State*] parameter and press *Enter*.

2 Move to [*On*], by using the cursor key, and press *Enter*. The green LED on the module front panel switches on.

To disable laser output using the user interface:

1 Move to [*State*] parameter and press *Enter*.

2 Move to [*Off*], by using the cursor key, and press *Enter*. The green LED on the module front panel switches off.

## How to Set Attenuation

The amount of power that is output from a source can be controlled. You can use the attenuation parameter to reduce the optical power of the laser output.

$P_{output} = P_{source}$ - ATT (dB)

Where,

$P_{output}$ is the power level at the output of the module,
$P_{source}$ is the power level at the output of the source, and
ATT is the attenuation parameter.

To set the attenuation value to 2 dB:

1 Move to the laser source channel and press the [Details] softkey. You see the screen in Figure 74 on page -126.

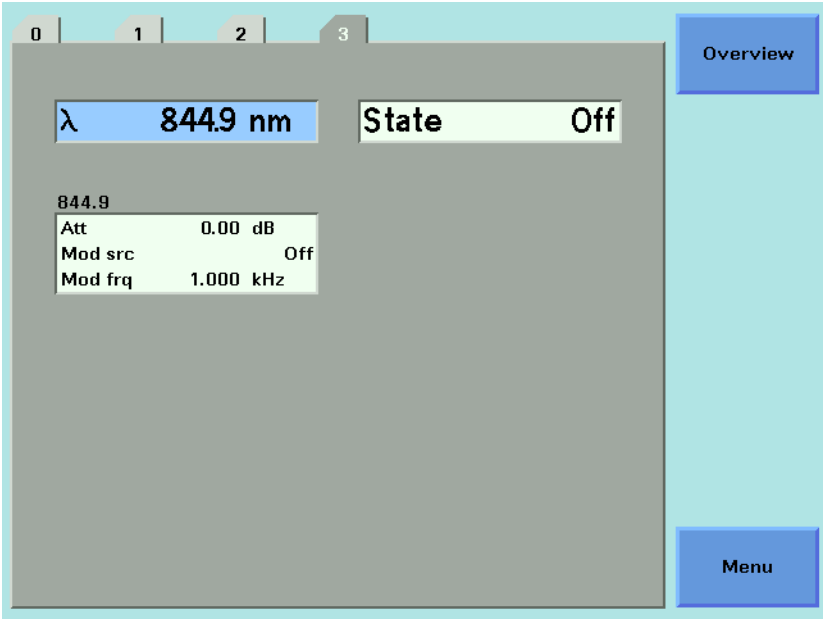



Figure 74 The Power Sensor Details Screen

2 Move to the [*Attenuation*] parameter and press *Enter*.

3 Enter 2.00 and press *Enter*.

## How to Modulate the Optical Output

### How to Change Modulation Source

The Modulation Source parameter, [*Mod Src*], allows you to modulate the output signal. This parameter can be set to Off, Internal, Coherence Control, or Backplane.

For details of the Off setting How to Disable Modulation on page 127.

For details of the Internal setting How to Use the Internal Modulation on page 127.

For details of the Coherence Control setting How to Increase Linewidth on page 128.

For details of the Backplane setting see External Digital Modulation using Input Trigger Connector on page 159.

### How to Disable Modulation

If <*Off*> is displayed as the Modulation Source parameter, [*Mod Src*], the laser source outputs an unmodulated continuous-wave signal.

To disable modulation:

1 Move to the Laser Source channel and press [Details] softkey.

2 Move to the modulation source parameter, [*Mod Src*], and press *Enter*.

3 Move to <*Off*>, by using the cursor key, and press *Enter*.

## How to Use the Internal Modulation

The internal modulation is a square wave with a 50% duty cycle. You can set both the amplitude and the frequency of this signal. The amplitude is set by the power parameter. This is the maximum output power of the output signal; at the minimum output power, no power is output.

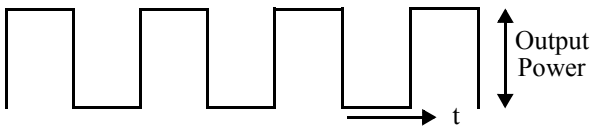



Figure 75 The Modulated Signal

### How to Set the Frequency of a Modulated Signal

To set the frequency of the modulation to 6.500 kHz:

1 Move to the frequency parameter, [*Mod Frq*], press *Enter*.

2 Enter 6.500 press *Enter*.

### How to Set the Modulation Mode

3 Move to the modulation source parameter, [*Mod Src*], and press *Enter*.

4 Move to <*Internal*>, by using the cursor key, and press *Enter*. The text **Int** appears in the Laser Source channel.

### How to Increase Linewidth

You can use coherence control to increase the linewidth of the optical signal output from your 8163A/B Series Laser Source module.

Enabling the coherence control increases the linewidth of the optical output signal to between 50 and 500 MHz (typically). Coherence control greatly reduces interference effects and therefore improves the power stability in sensitive test setups.

To enable coherence control:

1 Move to the Laser Source channel and press [Details].

2 Move to [*Mod Src*] and press *Enter*.

3 Move to <*Coherence Ctrl.*>, Coherence Control, to increase linewidth.

For typical values, refer to User's Guide for your laser source module, among the Supplementary Performance Characteristics provided with the module's Specifications.

4 Press *Enter*. The text **CC** appears in the Laser Source channel.

### How to Modulate Dual-Wavelength Laser Source Modules

**NOTE** You cannot modulate both wavelengths of the 81554SM Dual-Wavelength Laser Source module independently. If you select both wavelength outputs using the [λ] parameter, you can choose to modulate both outputs at the same frequency or to output both outputs as CW signals.

**NOTE**

If you choose to output both wavelengths of the 81554SM Dual-Wavelength Laser Source and to modulate the optical output signal, the two signals may be 180° out of phase with each other.

For 8165x Series Dual-Wavelength Laser Source modules, you can choose independent modulation sources and independent modulation frequencies for both wavelengths.

**NOTE**

If you choose independent modulation sources for a Dual-Wavelength Laser Source module, the text Mod will be displayed in the Laser Source channel.

If you choose the same modulation sources for both wavelengths of a Dual-Wavelength Laser Source module, the relevant text will be displayed in the Laser Source channel, for example, Int if both wavelengths use internal modulation.

To modulate the lower wavelength source at 100 kHz using internal modulation and the upper wavelength source using coherence control for a Dual-Wavelength Laser Source module:

1 Move to the laser source channel and press the [Details] softkey.

2 Move to [λ] parameter and press *Enter*.

3 Select the lower wavelength source, for example, <*1309.6*>, using the cursor key, and press *Enter*.

4 Move to the [*Mod Frq*] parameter for the lower wavelength source and press *Enter*.

5 Enter 100.000 and press *Enter*.

6 Move to the [*Mod Src*] parameter for the lower wavelength source and press *Enter*.

7 Move to <*Internal*>, by using the cursor key, and press *Enter*. The text **Mod** appears in the Laser Source channel.

8 Move to the [*Mod Src*] parameter for the upper wavelength source and press *Enter*.

9 Move to <*Coherence Ctrl.*>, by using the cursor key, and press *Enter*. The text **Mod** is still displayed in the Laser Source channel.

10 Enable the laser output, by pressing the *Active* hardkey on the module's front panel.

How to Use Triggers

Some Laser Source modules allow you to output trigger signals to external measurement instruments.

### How to Use Output Triggering

You can configure the output trigger connector to output a TTL signal at the frequency of the internal modulation of a Keysight 8163A/B Series Laser Source module.

To set your module's Output Trigger Configuration:

1 See How to Set the Trigger Configuration on page 68 for how to configure the trigger connectors.

2 Move to the Laser Source channel and press [Menu].

3 Move to <*Output Trigger Mode*>, by using the cursor key, and press *Enter*. You will see the screen in Figure 76 on page -130.

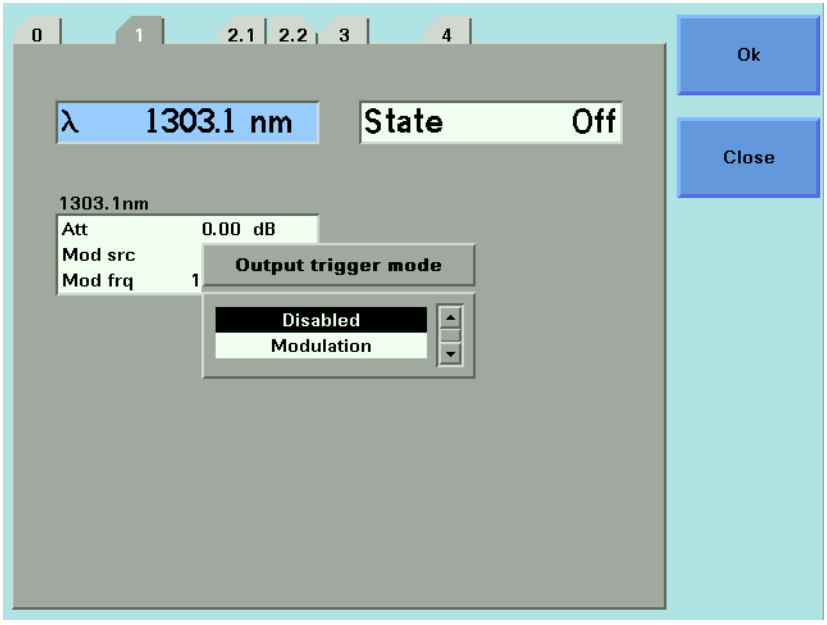



Figure 76 Output Trigger Mode

4 Move to one of the following, by using the cursor key:
   - <*Disabled*>, the output trigger mode is disabled.
   - <*Modulation*>, the output trigger connector outputs a TTL signal at the frequency of the internal modulation. This signal is output whether the laser is switched on or off.
5 Press *Enter*.

# 5 Tunable Lasers

What is a Tunable Laser? / 134
How to Set the Wavelength / 143
How to Perform a Wavelength Sweep / 147
How to Modulate a Signal / 155
How to Use Triggers / 163
How to Use Auxiliary Functions / 167

This chapter explains how to control Tunable Laser modules from the user interface of the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System.

# What is a Tunable Laser?

A tunable laser is a laser source for which the wavelength can be varied through a specified range. The Keysight Technologies Tunable Laser modules also allow you to set the output power, and to choose between continuous wave or modulated power.

## How to Set the Power

The laser output can be either:

- a continuous wave (CW) signal, fixed amplitude signal, see How to Set the Output Power of a CW Signal on page 134,
- a modulated signal, see How to Modulate a Signal on page 155, or
- a signal with increased linewidth (coherence control), see How to Increase Linewidth on page 161.

If [*Mod Src*] is <*Off*>, a continuous wave signal is the chosen optical output. A continuous wave signal is the default.

If any other [*Mod Src*] source is chosen, the chosen source modulates the signal. For possible modulation sources, see How to Modulate a Signal on page 155.

### Attenuator

If your tunable laser has an built-in optical attenuator, you can choose one of the two following power modes:

- <Automatic> Attenuation Mode, you specify the output power and the instrument automatically sets the optical output power by using the optimum combination of laser diode current and optical attenuation, or
- <Manual Att.> Mode, you specify the output power and the attenuation.

The two modes are separate, the values set in one mode do not affect values set in the other.

## How to Set the Output Power of a CW Signal

### How to Set Output Power

To set the output power to 555.000 μW:

### Attenuator

If your tunable laser has an built-in optical attenuator, move to [Power Mode], press Enter, move to <Automatic>, and press Enter.

1 Move to the power parameter, [*P*], and press [Pwr unit].
2 Move to <W> and press *Enter*.
3 Press *Enter* to start editing the output power value.
4 Enter 555.000, press [Unit+] or [Unit-], as required, to select μW as the power units, and press *Enter*.

### How to Set the Optical Output

To set the Optical Output of a Tunable Laser module with two optical outputs:

1 Press [Details].
2 Move to [*Optical Output*] and press *Enter*.
3 Use the Modify Knob to move to one of the following:
   - <*High Power (2)*>, a high power optical output, for example, for use in tesing Erbium Doped Fiber Amplifiers (EDFAs), you see a screen similar to Figure 77,
   - <*Low SSE (1)*>, a lower power optical output with low Source Spontaneous Emission (SSE), for example, for use in passive component test, you see a screen similar to Figure 78 on page -137,
   - <*Both (master:2)*>, where both optical outputs can be enabled but only the output of the high power optical output can be regulated, and
   - <*Both (master:1)*>, where both optical outputs can be enabled but only the output of the low SSE optical output can be regulated.

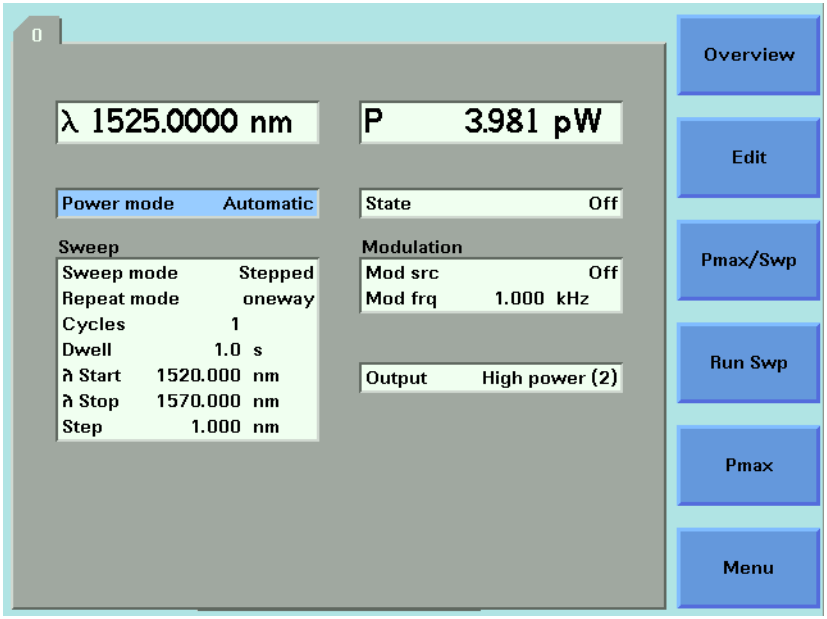



Figure 77 Setting High Power parameters

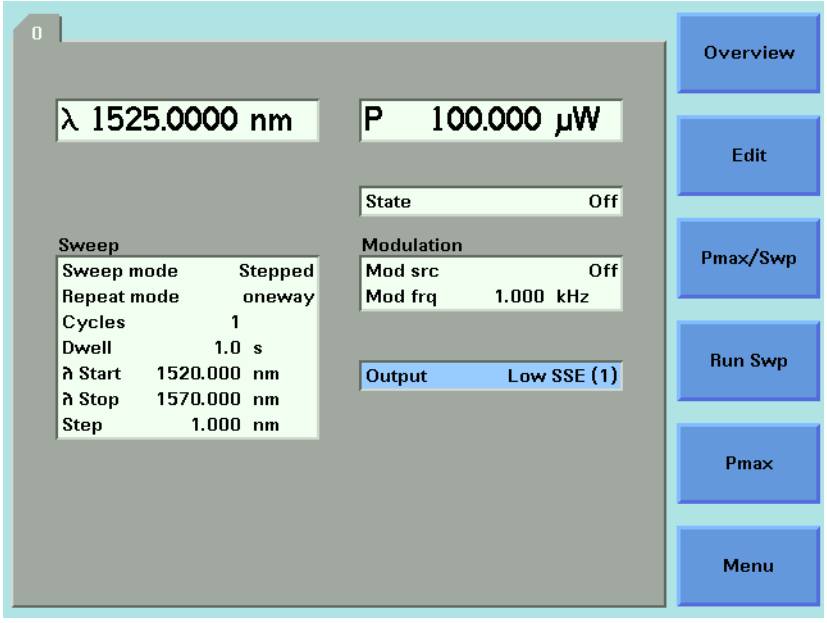



Figure 78 Setting Low SSE parameter

**NOTE**

If you select <Both (master:2)> or <Both (master:1)> as the regulated path, both channels output optical power. You can only view or set the parameters for the primary optical output, for example, the high power output for <Both (master:2)>.

The LED beside the primary optical output is lit constantly, while the LED beside the secondary optical output flashes. For example, if you select *<Both (master:2)>* as the regulated path, the LED beside Output 2, the High Power Output, is lit constantly and the LED beside Output 1, the Low SSE optical output, flashes.

**How to Set the Optical Output**

1 Move to [*Output*] and press *Enter*.

2 Move to your chosen optical output and press *Enter*.

**How to Enable the Optical Output**

3 Move to [*State*] and press *Enter*.

4 Move to <*On*>, by using the cursor key, and press *Enter* to enable the output. The LED beside the optical output is lit constantly.

**NOTE**

If you enable the laser output for a module with two optical outputs by pressing the Active hardkey on the module's front panel, you automatically choose the optical output for that module. For example, if you press the Active hardkey beside Output 1, the Low SSE optical output, you choose <Low SSE> as the optical output, the LED beside the Output 1 lights constantly.

Furthermore, if you then proceed to press the Active hardkey beside Output 2, the High Power Output, you choose <Both (master:1)> as the optical output, the LED beside the Output 2 flashes.

If you press the Active hardkey beside a flashing LED, you disable the unregulated optical output. If you press the Active hardkey beside a constantly lit LED, you disable both optical outputs.

### How to Set Power and Attenuation

#### Attenuator

If your tunable laser has an built-in optical attenuator, you can set the laser output power and then set the attenuation.

1 Move to the Tunable Laser channel and press [Details].

2 Choose the Output 2, the high power output, for a Tunable Laser module with two optical outputs, as described in How to Set the Optical Output on page 135. For modules with one optical output this is not necessary.

3 Move to the power parameter, [P], and press [Pwr unit].

4 Move to <dBm> and press Enter.

5 Type 5.000, using the numerical keypad and press Enter.

6 If [Power Mode] is not set to <Manual Att.> (see Figure 77), that is, it is set <Automatic>, perform the following steps:

   *a* Move to [Power Mode] and press Enter.

   *b* Move to <Manual Att.> and press Enter. The attenuation parameter, [Atten.], appears, see Figure 79 on page -139.

7 Move to [Atten.], type 3.000, using the numerical keypad, and press Enter.

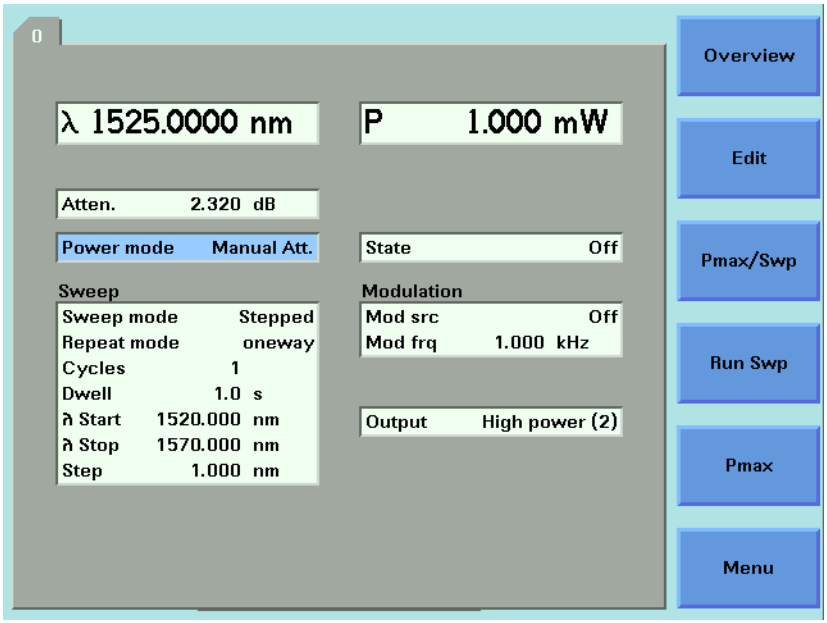



Figure 79 Setting Attenuation

## What is Excessive Power ?

If the text ExP is displayed in a Tunable Laser channel, see Figure 80 on page -140, you have set an output power level that is larger than the laser diode can produce at the selected wavelength.

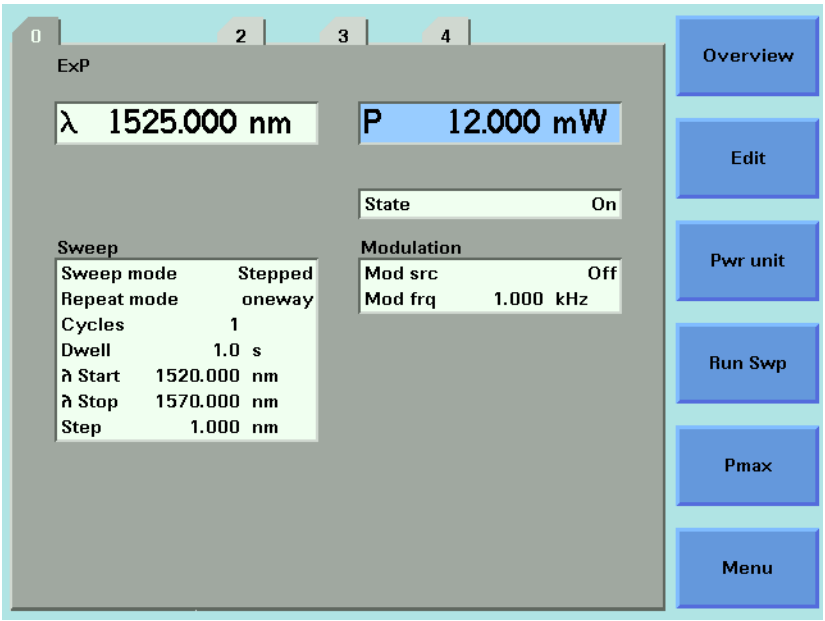



Figure 80 Excessive Power

To avoid this you can:

- reduce the optical output power,
- press [Pmax] to select the highest permissible power for the selected wavelength value, or
- press [Pmax/Swp] to select the highest permissible power for the selected wavelength sweep.

## How to Set the Laser to the Dark Position

### Attenuator

If your tunable laser has an built-in optical attenuator, you can use <Dark position> to block all laser light from the output. You can use this as an alternative to disabling the laser. To enable/disable the dark position:

1 Move to the Tunable Laser channel and press the [Menu] softkey.

2 Move to the <Dark position> and press Enter. The Dark Position box appears.

3 Move to one of the following menu items:

- <On>, to enable the dark position, or
- <Off>, to disable the dark position

4 Press Enter to return to the Menu screen.

5 Press [Close] to exit from the Menu screen.

## The Analog Output

If there is an output BNC connector on the front panel of your Tunable Laser module, you can output a DC voltage level that is proportional to the laser output power. The relationship between this voltage level and the output power is not calibrated.

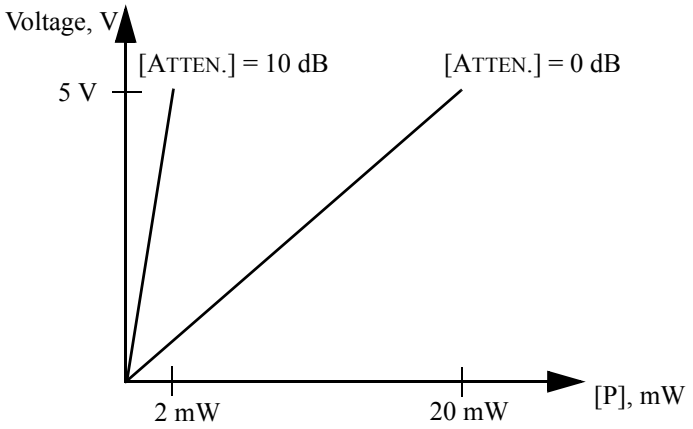



Figure 81 Output Power and the Analog Output in <Manual ATT.> Mode

### Attenuator

If your Tunable Laser module has an attenuator installed, the Analog Output signal depends on the power mode you have chosen. The voltage level is proportional to the optical power produced by the laser diode (not the optical output power).

In <Manual Att.> Mode, the relationship between the power value, [P], and the voltage level is only proportional to the output power if the attenuation remains constant. The attenuator adds a constant offset to the voltage level.

In <Automatic> Attenuation Mode, the laser output power, and therefore the Analog Output signal, is not linearly proportional to the output power. This is because the actual output optical power is derived by the optimum combination of the laser output power and the attenuation.

To set the power to -10 dBm:

1 Move to power parameter, [P], and press [Pwr unit]. You should see the power unit menu.
2 Move to <dBm> and press *Enter*.
3 Press *Enter* to edit the power value.
4 Enter -10.000 and press *Enter*.

**How to Set the BNC Output Line Mode as an Analog Output**

1 Press [Menu], move to <*BNC Output*> and press [OK].
2 Move to <*V~P*>, to choose an analog output signal, press *Enter*, and press [Close].

### Attenuator

If you want to you use the analog output signal and your Tunable Laser module has an attenuator installed, it is advisable to use <Manual Att.> Mode and choose a constant attenuation value.

# How to Set the Wavelength

There are three ways to set the wavelength of the Tunable Laser.

- You can set the wavelength (λ) directly,
- You can set the wavelength from a base wavelength and an offset in the frequency domain, or
- You can set a wavelength range for the instrument to “sweep”.

## Wavelength Range

Every Tunable Laser module has a specified wavelength range. This range is available for all Tunable Laser modules. See the "Specifications" chapter of your Tunable Laser User’s Guide to find your module’s specified range.

Every Tunable Laser module has a permitted wavelength range. This range is greater than the specified range. The permitted wavelength range varies for each Tunable Laser module. You can set the wavelength to any value within the permitted wavelength range.

Figure 82 on page -143 shows an example of specified and permitted wavelength range.

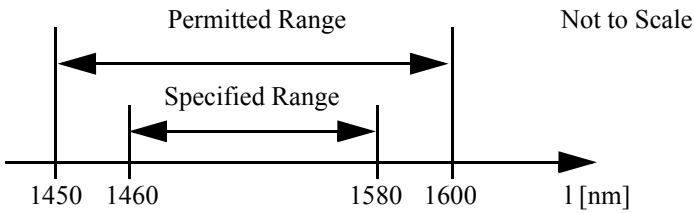



Figure 82 Specified and Permitted Wavelength Range

## How to Set the Wavelength Directly

You can set a constant wavelength.

To set the wavelength to 1545.500 nm:

1 Move to the Tunable Laser channel.
2 Move to the wavelength parameter, [λ], and press *Enter*.
3 Enter 1545.500 and press *Enter*.

### How to Set a Relative Wavelength

You use a relative wavelength for heterodyning, for example, when you are measuring the linewidth of DFB (distributed feedback) lasers.

The output wavelength, $\lambda$, is set from the base wavelength, $\lambda_0$, and the frequency offset, *df*. The formula for calculating the output wavelength is:

$$\lambda = \frac{c\lambda_0}{\lambda_0 df + c}$$

where c is the speed of light in a vacuum ($2.998 \times 10^8$ $ms^{-1}$).

To set a frequency offset of 1.000 THz from a base wavelength of 1545 nm:

1 Move to the Tunable Laser channel and press [Details].
2 Press [Menu]. The menu appears.
3 Move to <*Wavelength Mode*> in the menu and press *Enter*. A menu appears.
4 Move to <*Offset*>, by using the cursor key, press *Enter*, and press *Close*. You see the screen in Figure 83 on page -145.

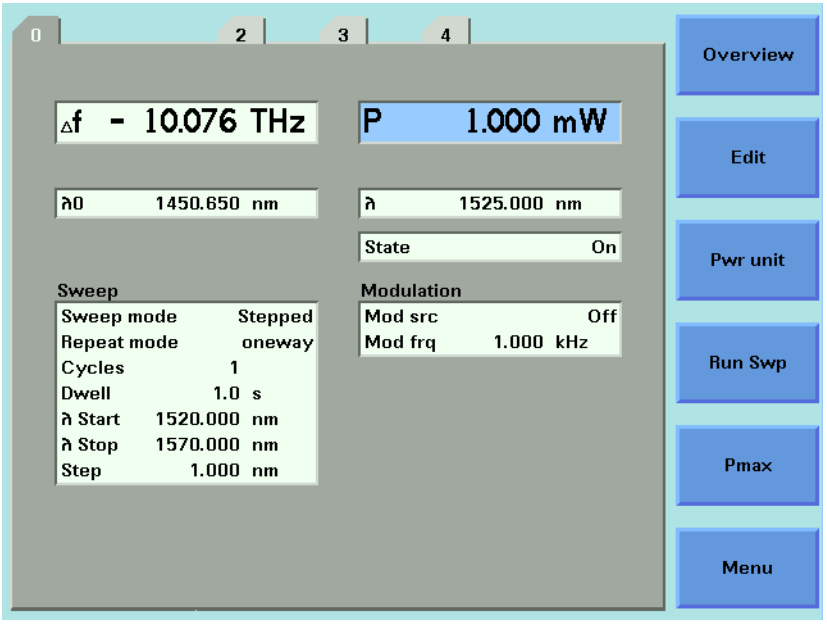



Figure 83 Setting a Relative Wavelength

**How to Change the Output Wavelength**

1 Move to [λ] and press *Enter*. [λ] is the output wavelength, λ, in the equation above.

2 Enter 1570 and press *Enter*.

**NOTE** Note how the frequency offset, [Δf], changes as you change the value of [λ].

**How to Set the Base Wavelength**

**NOTE** You cannot set <λ0>, the base wavelength directly.

3 Press [λ->λ0] to set <λ0> to 1570 nm. <λ0> represents the base wavelength, $\lambda_0$, in the equation above.

**NOTE** Note how the frequency offset, [Δf], changes to zero when you press [λ->λ0].

**How to Change the Frequency Offset**

4 Move to [Δf] and press *Enter*. [Δf] represents the frequency offset, *df*, in the equation above.

5 Enter 1.000 and press *Enter*. The frequency offset, [Δf], changes to 1.000 THz.

**NOTE** Note how the output wavelength, [λ], changes as you change the value of [Δf].

# How to Perform a Wavelength Sweep

## What is a Wavelength Sweep ?

A wavelength sweep is performed when the instrument changes the optical wavelength of the optical output across a user-defined wavelength range. You can use a wavelength sweep to measure the wavelength-dependent loss of an optical component.

## How to Set the Wavelength Sweep

**The Sweep Parameters**

These are the parameters for the wavelength sweep:

- [λ *Start*], the wavelength at which the sweep begins,
- [λ *Stop*], the wavelength at which the sweep ends,
- [*Step*], the size of the change in the wavelength for each step of a stepped sweep,
- [*Cycles*], the number of times the sweep is repeated,
- [*Dwell*], the amount of time spent at the wavelength during each step, for a stepped sweep
- [*Vsweep*], the speed of a continuous sweep,
- [*Sweep mode*], see How to Perform a Sweep on page 149,
- [*Repeat mode*], see How to Set the Repeat Mode on page 148.

**NOTE**

**For a <Continuous> sweep, [Step] sets the wavelength interval between output triggers, if you have set <Output Trigger Mode> to <Step Finished>, see How to Use Output Triggering on page 165.**

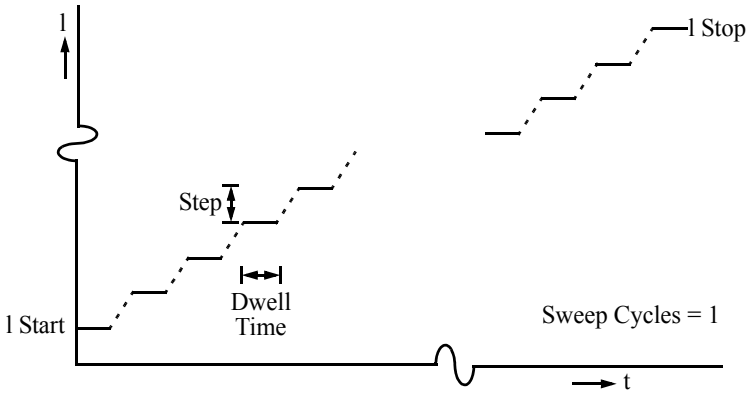



Figure 84 The Parameters for a Stepped Wavelength Sweep

### How to Set the Repeat Mode

The [*Repeat Mode*] determines how the instrument performs a multi-cycle sweep.

- Select <*Twoway*>, if you want to start every odd sweep cycle at [λ *Start*] and to start each even sweep cycle at [λ *Stop*].
- Select <*Oneway*>, if you want to start every sweep cycle at [λ *Start*] and to end every sweep cycle at [λ *Stop*].

Figure 85 on page -148 illustrates how these modes work for a three-cycle wavelength sweep.

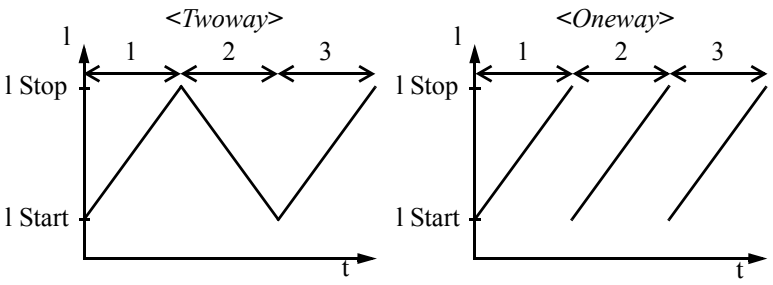



Figure 85 Repeat Modes

### How to Set the Maximum Power for the Sweep Range

Pressing [Pmax/Swp] sets the power to the maximum for the selected sweep range. Alternatively, you can set a power level in the way described in How to Set the Output Power of a CW Signal on page 134. Pressing [Pmax/Swp] ensures the power will be constant for the whole sweep.

## How to Perform a Sweep

There are three sweep modes:

- <*Stepped*>, which dwells at wavelengths that are separated by a certain step size,
- <*Continuous*>, which sweeps continually at the speed you set, and
- <*Manual*>, which you can run each step manually.

**NOTE**

**You cannot turn the laser off by pressing the *Active* hardkey on the Tunable Laser front panel, while a wavelength sweep is running.**

**You can press [Stop] and, then, press the *Active* hardkey on the Tunable Laser front panel, to turn off the laser.**

### How to Execute a Stepped Sweep

To execute a stepped wavelength sweep over the range 1510 nm to 1570 nm, three times, sweeping two ways, in 1 nm steps, stopping for half a second at each wavelength step:

1 Move to the Tunable Laser channel and press [Details].
2 Move to [*Sweep Mode*] and press *Enter*.
3 Move to the <*Stepped*> sweep mode and press *Enter*.
4 Move to [λ *Start*] and press *Enter*.
5 Enter 1510.000 and press *Enter*.
6 Move to [λ *Stop*] and press *Enter*.
7 Enter 1570.000, press *Enter*.
8 Move to [*Cycles*] and press *Enter*.
9 Enter 3 and press *Enter*.
10 Move to [*Repeat Mode*] and press *Enter*.
11 Move to <*Twoway*>, by using the cursor key, and press *Enter*.
12 Move to [*Step*] and press *Enter*.
13 Enter 1.000 and press *Enter*.

14 Move to [*Dwell*] and press *Enter*.

15 Enter 0.5000 and press *Enter*.

16 Press the [Active] hardkey on the front panel of your Tunable Laser module to enable the optical output.

17 Press [Run Swp] to start the sweep. The screen in Figure 86 on page -150 appears.

18 The wavelength is swept automatically but you can:

*a* press [Stop] to end the sweep, or

*b* press [Pause] to pause the sweep. The screen in Figure 87 on page -151 appears. You can:

- Press [Continue] to continue sweeping automatically.
- Press [Prev] or [Next] to sweep manually.
- Press [Stop] to end the sweep.

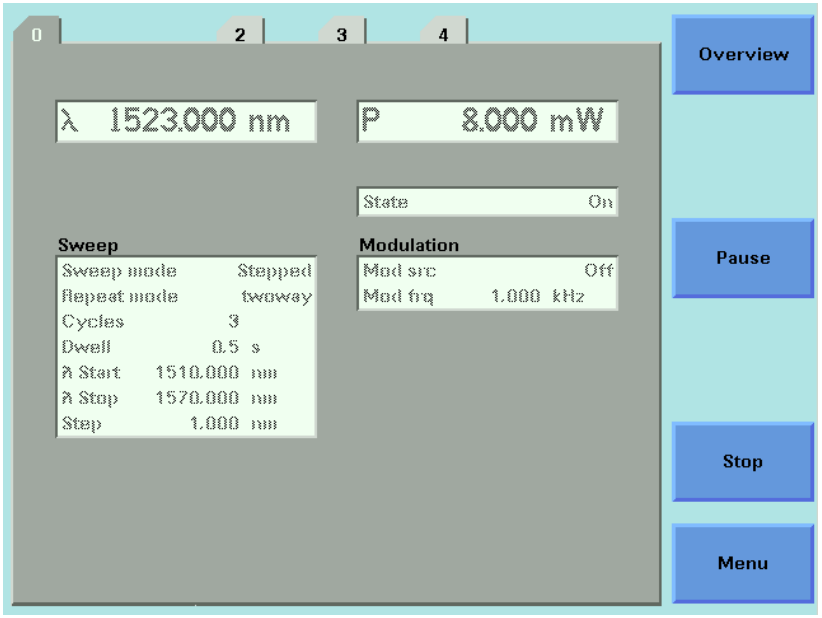



Figure 86 Executing a Stepped Sweep

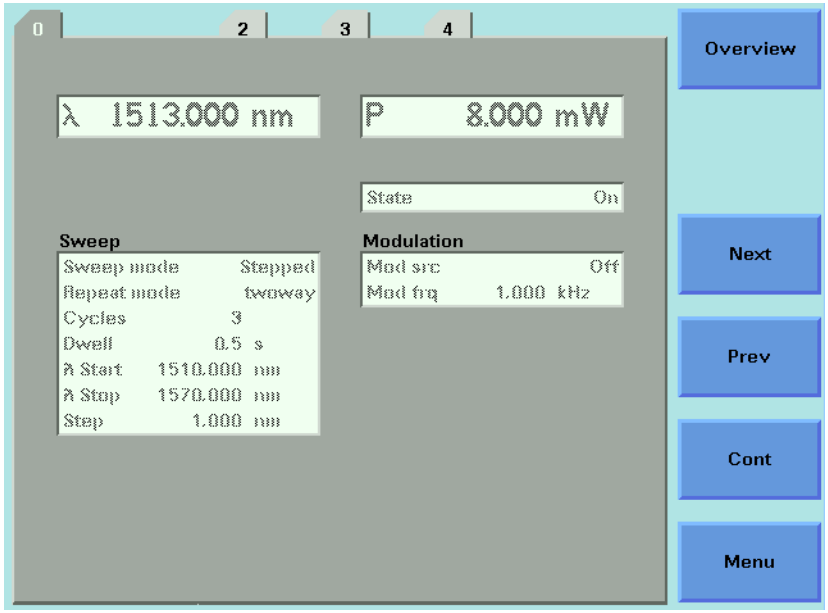



Figure 87 Pausing a Stepped Sweep

**How to Execute a Continuous Sweep**

**NOTE**

Continuous sweep mode is not available for all tunable laser models.

Only the 81602A, 81606A, 81607A, 81608A and 81960A allow choosing a repeat mode for a continuous sweep. To manually select two way continuous sweeps for these models, first select Stepped Sweep mode, then select two way Repeat mode, and then return to Continuous Sweep mode.

To execute a continuous wavelength sweep over the range 1520 nm to 1560 nm, three times, at a speed of 5 nm/s:

1 Move to the Tunable Laser channel and press [Details].
2 Move to [*Sweep Mode*] and press *Enter.*
3 Move to the <*Continuous*> sweep mode and press ENTER.
4 Move to [λ *Start*] and press *Enter.*
5 Enter 1520.000 and press *Enter*.

6 Move to [λ *Stop*] and press *Enter.*
7 Enter 1560.000, press *Enter*.
8 Move to [*Sweep Cycles*] and press *Enter.*
9 Enter 0003 and press *Enter*.
10 Move to [*Vsweep*] and press *Enter*.
11 Move to 5 nm/s, by using the cursor key, and press *Enter*.
12 Move to [*Step*] and press *Enter*.
13 Enter 1.000 and press *Enter*.

**NOTE** For a <Continuous> sweep, [Step] sets the wavelength interval between output triggers, if you have set <Output Trigger Mode> to <Step Finished>, see How to Use Output Triggering on page 165.

14 Press the [Active] hardkey on the front panel of your Tunable Laser module to enable the optical output.
15 Press [Run Swp] to start the sweep.

**NOTE** The following table explains all possible configuration problems:

| | |
|---|---|
| **368,LambdaStop <=LambdaStart** | start wavelength must be smaller than stop wavelength |
| **369,sweepTime < min** | the total time of the sweep is too small |
| **370,sweepTime > max** | the total time of the sweep is too large |
| **371,triggerFreq > max** | the trigger frequency (calculated from sweep speed divided by sweep step) is too large |
| **372,step < min** | step size too small |
| **373,triggerNum > max** | the number of triggers exceeds the allowed limit |
| **374,LambdaLogging = On AND Modulation = On AND ModulationSource! = CoherenceControl** | The only allowed modulation source with the lambda logging function is coherence control. |
| **375,LambdaLogging = On AND TriggerOut! = StepFinished** | lambda logging only works "Step Finished" output trigger configuration |

| | |
|---|---|
| **376,Lambda logging in stepped mode** | lambda logging can only be done in continuous sweep mode |
| **377,step not multiple of <x>** | the step size must be a multiple of the smallest possible step size |

16 A continuous sweep can end in two ways:

*a* when the sweep is completed, or

*b* when you press [Stop].

### How to Perform a Manual Sweep

You can perform a manual sweep if you choose the <*Manual*> sweep mode or if you press [Pause] during an automatic sweep. In a manual sweep you choose when you want to perform each step of a stepped sweep. You can choose to move forward or backward a wavelength or to end the sweep.

To perform a manual wavelength sweep over the range 1510 nm to 1570 nm, three times, sweeping two ways, in 1 nm steps:

1 Move to the Tunable Laser channel and press [Details].

2 Move to [*Sweep Mode*] and press *Enter*.

3 Move to the <*Manual*>, by using the cursor key, and press *Enter*.

4 Perform step 4 to step 13 on page 149 to set the sweep parameters.

5 Press the [Active] hardkey on the front panel of your Tunable Laser module to enable the optical output.

6 Press [Run Swp] to start the sweep. The screen in Figure 88 on page -154 then appears.

7 You can:

- press [Next] to move on to the next wavelength step,
- press [Prev] to move on to the previous wavelength step, or
- press [Stop] to end the sweep.

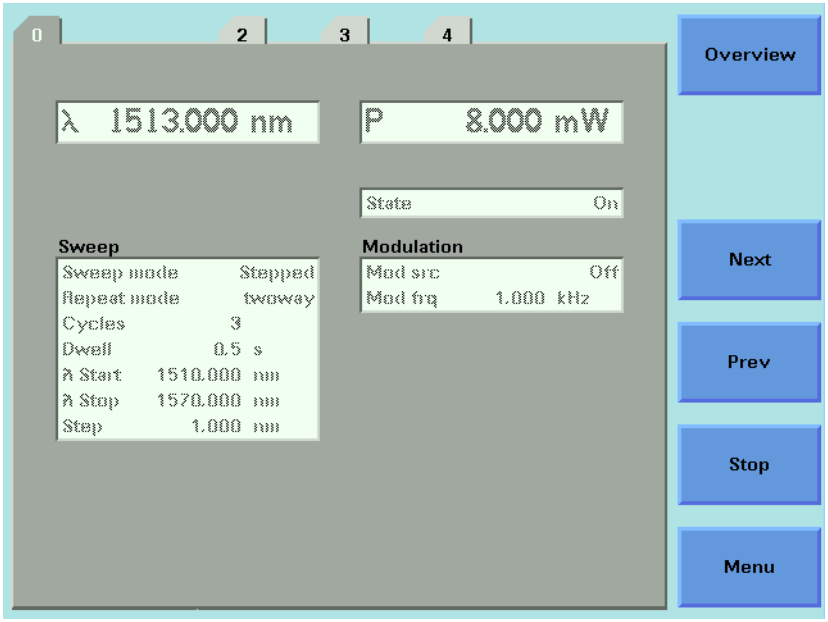



Figure 88 Performing a Manual Sweep

8 Perform step 6 until you choose to press [Stop].

## How to Modulate a Signal

**NOTE** The signal modulation feature is not available when Auto Cal Off is selected.

There are two ways of modulating the amplitude of the optical output.

- Using the internal modulation, and
- using external modulation.

### How to Use the Internal Modulation

The internal modulation is a square wave with a 50% duty cycle. You can set both the amplitude and the frequency of this signal. The amplitude is set by the power parameter. This is the maximum output power of the output signal; at the minimum output power, no power is output.

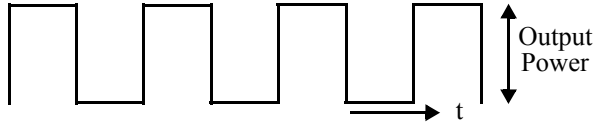



Figure 89 The Modulated Signal

**How to Set the Output Power of a Modulated Signal**

To set the output power to 555.000 μW:

1 Move to the Tunable Laser channel and press [Details] softkey.
2 Move to the power parameter, [*P],* and press [Pwr unit].
3 Move to <*W*>, by using the cursor key, and press *Enter*.
4 Press *Enter* to start editing the output power value.
5 Enter 555.000, press [Unit+] or [Unit-], as required, to select <μW> as the power units, and press *Enter*.

**How to Set the Frequency of a Modulated Signal**

To set the frequency of the modulation to 6.500 kHz:

6 Move to the frequency parameter, [*Mod Frq*], press *Enter*.
7 Enter 6.500 press *Enter*.

**How to Set the Modulation Mode**

8 Move to the modulation source parameter, [*Mod Src*], and press *Enter*.

9 Move to <*Internal*>, by using the cursor key, and press *Enter*. The text *Int* appears in the Tunable Laser channel.

## How to Use External Modulation

The following external modulation modes are available:

- <*External Digital*> - External Digital Modulation
- <*External Analog*> - External Analog Modulation
- <*Wavel. Locking*> - Wavelength Locking
- <*Backplane*> - External Digital Modulation using Input Trigger connector or Trigger Feedback from another module in the same mainframe.
- <*Coherence Ctrl.*> - Coherence Control

**External Digital Modulation**

External digital modulation uses a TTL-level signal. Apply this signal to the input BNC connector on the front panel of your Tunable Laser module.

**CAUTION**

There are two BNC connectors on the front panel of the 814xxB, 816xxB and 8160xA tunable laser modules, a BNC input connector and a BNC output connector.

There is one BNC connector on the front panel of the 81689A and 819xxA compact tunable laser modules, a BNC input connector.

An absolute maximum of ±6 V can be applied as an external voltage to any BNC connector.

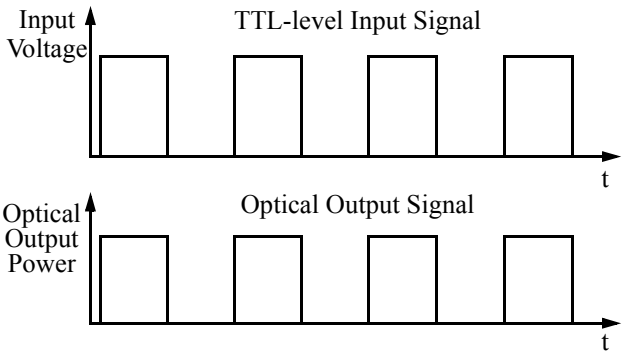



Figure 90 External Digital Modulation

Figure 90 on page -157 shows how a TTL-level input signal modulates the optical output. Digital modulation sets the frequency of the output signal.

To set the amplitude of the output signal, set the power parameter. This is the maximum output power of the output signal; at the minimum output power, no power is output.

To enable external digital modulation:

1 Move to the Tunable Laser channel and press [Details].

2 Move to [*Mod Src*] and press *Enter*.

3 Move to <*External Digital*> by using the cursor key, and press *Enter*. The text *ExtD* appears in the Tunable Laser channel.

**External Analog Modulation**

External analog modulation uses a signal of up to 5 $V_{pp}$. A 5 $V_{pp}$ signal causes 15% modulation of the power of the optical signal. Apply this signal to the input BNC connector on the front panel of your Tunable Laser module.

**CAUTION**

There are two BNC connectors on the front panel of the 814xxB, 816xxB and 8160xA tunable laser modules, a BNC input connector and a BNC output connector.

There is one BNC connector on the front panel of the 81689A and 819xxA compact tunable laser modules, a BNC input connector.

An absolute maximum of ±6 V can be applied as an external voltage to any BNC connector.

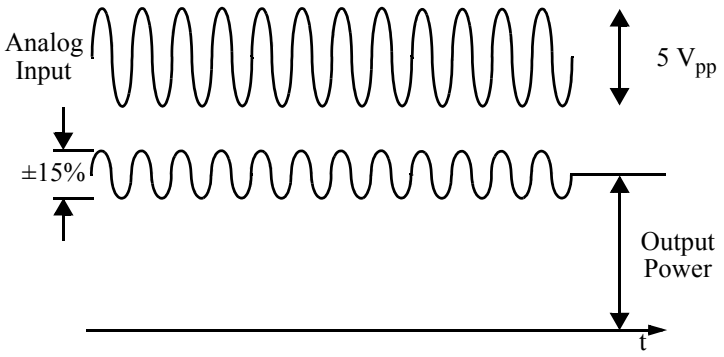



Figure 91 External Analog Modulation and Output Powr

To enable external analog modulation:

1 Move to the Tunable Laser channel and press [Details].

2 Move to [*Mod Src*] and press *Enter*.

3 Move to <*External Analog*>, by using the cursor key, and press *Enter*. The text ExtA appears in the Tunable Laser channel.

**Wavelength Locking**

You can choose wavelength locking as the modulation source, so the the change in output wavelength is roughly proportional to the voltage you apply to the input BNC connector on the front panel of your Tunable Laser module as shown in Figure 92 on page -159. This enables you to fine tune the output wavelength within a limited wavelength range.

Wavelength locking may exhibit some hysteresis effects. The wavelength change may differ slightly when you increase voltage from when you decrease voltage.

If you modulate the input signal, the amplitude of the wavelength change of the modulated optical output reduces with increasing modulation frequency. See Appendix C of the Tunable Laser Modules User's Guide for more details.

**CAUTION**

**There are two BNC connectors on the front panel of the 814xxB, 816xxB and 8160xA tunable laser modules, a BNC input connector and a BNC output connector.**

**An absolute maximum of ± 6 V can be applied as an external voltage to any BNC connector.**

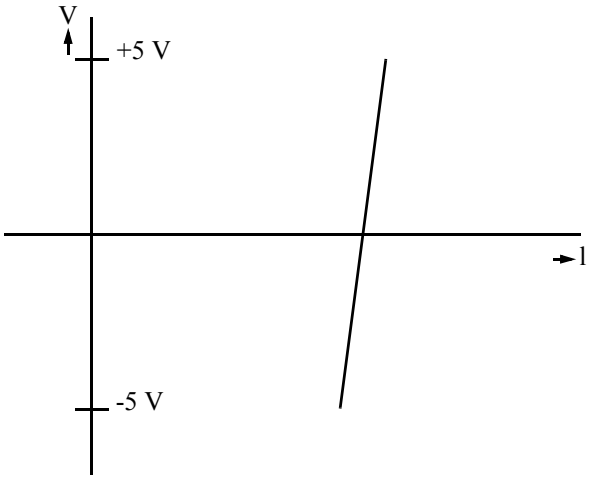



Figure 92 Wavelength Locking

To enable wavelength locking:

1 Move to the Tunable Laser channel and press [Details].

2 Move to <*Mod Src*> and press *Enter*.

3 Move to <*Wavel. Locking*>, by using the cursor key, and press *Enter*. The text λLock appears in the Tunable Laser channel.

**External Digital Modulation using Input Trigger Connector**

External digital modulation uses a TTL-level signal. Apply this signal to the Input Trigger connector on the rear panel of your mainframe. For information on external digital modulation, see External Digital Modulation on page 156.

**CAUTION**

A maximum of 5 V can be applied as an external voltage to the Input Trigger connector.

Take care not to use the Trigger Output connector or the Remote Interlock connector for modulation. Do not apply an external voltage to these connectors.

**NOTE**

If external digital modulation, <backplane>, is chosen for the DFB or Fabry-Perot Laser modules, the applied triggering should have a 50% duty cycle and a frequency of 200 Hz - 100 kHz.

- the average power of the output signal of the Keysight 81689A Tunable Laser module varies in proportion with the change in duty cycle, while,
- the power of the output signal of all other modules adjusts so that the average power of the output signal is always 50% of the set power.

**NOTE**

If external digital modulation using the Input Trigger Connector, <Backplane>, is chosen as the modulation source, [Mod Src], the 81689A and 819xxA compact tunable laser modules behaves differently from all other modules.

To enable external digital modulation using the Input Trigger Connector:

1 Move to the Tunable Laser channel and press [Details].

2 Move to [*Mod Src*] and press *Enter*.

3 Move to <*Backplane*>, by using the cursor key, and press *Enter*. The text **Back** appears in the Tunable Laser channel.

**External Digital Modulation Using Trigger Feedback**

The trigger for External Digital Modulation can be provided by another module in the same mainframe by using the Trigger Feedback configuration as described on External Digital Modulation using Input Trigger Connector on page 159. This can be used to synchronize the modulation of several sources. To use synchronized modulation:

1 Choose a “master” source module. Set as folows:

Menu -> Modulation Source -> internal

Menu -> Modulation Frequency -> desired value

Menu -> Output trigger mode -> Modulation

2 Set all “slave” modules:

Menu -> Modulation Source -> Backplane (new for DFB modules)

Menu -> Output trigger mode -> disabled (important)

3 To pass the master trigger to the slaves, set up the mainframe through the “Config” button under the screen:

Config -> Trigger -> Feedback

Note that the master laser must always be turned on, if one or more slaves are on.

**How to Increase Linewidth**

You can use coherence control to increase the linewidth of the optical signal output from your Tunable Laser module.

Enabling the coherence control increases the linewidth of the optical output signal to between 50 and 500 MHz (typically). Coherence control greatly reduces interference effects and therefore improves the power stability in sensitive test setups.

Some models also allow adjustment of the linewidth broadening with the "Coherence level" setting. A level of 100% corresponds to minimal broadening. The default level is usually a good setting.

To enable coherence control:

1 Move to the Tunable Laser channel and press [Details].

2 Move to [*Mod Src*] and press ENTER.

3 Move to <*Coherence Ctrl.*>, Coherence Control, to increase linewidth to approximately 500 MHz.

4 Press *Enter*. The text **CC** appears in the Tunable Laser channel.

**How to Set the Output Power of a Modulated Signal**

All external modulation modes require you to set the output power. To set the output power, see How to Set the Output Power of a Modulated Signal on page 155.

## How to Configure the Modulation Output

If your Tunable Laser module has a BNC output connector on its front panel, to synchronize your external measuring equipment to the modulation of the module:

1 Move to the Tunable Laser channel and press *Menu*.

**How to Set the BNC Output Line Mode as a Modulation Output**

2 Move to <*BNC Output*> and press [OK].

3 Move to <*Modulation*>, by using the cursor key. A TTL-level signal is output, if the optical output is digitally modulated, that is, if you choose <*Internal*>, <*External Digital*>, or <*Backplane*> as the chosen

modulation source. The output signal has the same frequency as the optical output.

4 Press [OK].

**How to Set the Modulation Output Mode**

5 Move to <*Modout*> and press [OK].

6 Move to either of the following two menu items, by using the cursor key:

- <*FRQ&RDY*>, where the modulation signal is combined with the laser-ready signal, so that the output is kept low when there is no optical signal being output, for example, when the laser is turned off or when you set the attenuator to the dark position, or
- <*FRQ*>, where the modulation signal is output all the time regardless of laser state.

7 Press [OK].

8 Press [Close] to return to the overview or detail screen.

# How to Use Triggers

Some Tunable Laser modules allow you to trigger the instrument to perform tasks and to output trigger signals to external measurement instruments.

## How to Use Input Triggering

You can configure your Tunable Laser module to perform certain tasks when you apply a trigger to the Input Trigger Connector.

**CAUTION**

**A maximum of 5 V can be applied as an external voltage to the Input Trigger connector.**

**Take care not to use the Trigger Output connector or the Remote Interlock connector for modulation. Do not apply an external voltage to these connectors.**

To set your module's Input Trigger Configuration:

1. See How to Set the Trigger Configuration on page 68 for how to configure the trigger connectors.
2. Move to the Tunable Laser channel and press [Menu].
3. Move to <*Input Trigger Mode*>, by using the cursor key, and press ENTER. You will see the screen in Figure 93 on page -164.

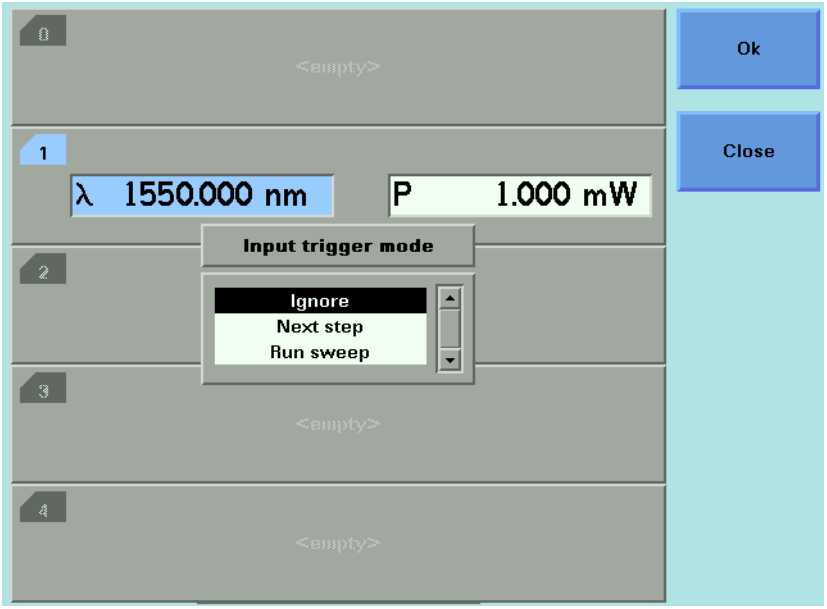



Figure 93 Input Trigger Mode

4 Move to one of the following, by using the cursor key:
   - <*Ignore*>, input triggers are ignored.
   - <*Next Step*>, an input trigger will cause the next step of a stepped sweep to be performed.
   - <*Run Sweep*>, an input trigger will start a single sweep cycle.

5 Press *Enter*.

You can generate input triggers in any of the following ways:
- applying a trigger to the Input Trigger Connector on the rear panel of your instrument,
- setting <*Trigger Configuration*> to <*Loopback*> so that an output trigger automatically generates an input trigger, or
- using the **:TRIGger** GPIB command, see your mainframe's Programming Guide.

## How to Use Output Triggering

You can configure your Tunable Laser module to output a trigger when the instrument performs certain tasks.

To set your module's Output Trigger Configuration:

1 See How to Set the Trigger Configuration on page 68 for how to configure the trigger connectors.

2 Move to the Tunable Laser channel and press [Menu].

3 Move to <*Output Trigger Mode*>, by using the cursor key, and press *Enter*. You will see the screen in Figure 94 on page -165.

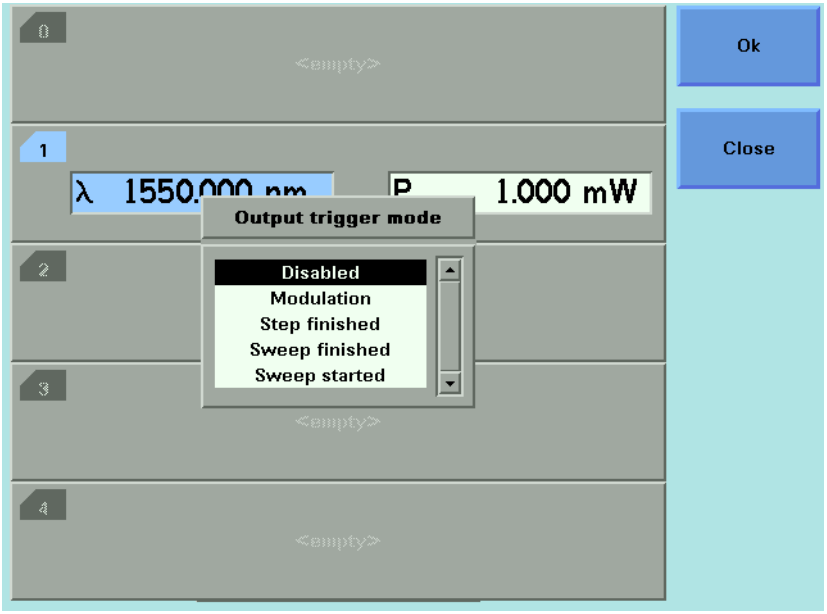



Figure 94 Output Trigger Mode

4 Move to one of the following, by using the cursor key:

<*Disabled*>, the output trigger mode is disabled.

<*Modulation*>, the output trigger connector outputs a TTL signal at the frequency of the internal modulation. This signal is output whether the laser is switched on or off.

<*Step Finished*>, a trigger is output after every step of a sweep finishes.

<*Sweep Finished*>, a trigger is output after a sweep cycle finishes.

<*Sweep Started*>, a trigger is output after a sweep cycle starts.

5 Press *Enter*.

**NOTE** If you choose <Step Finished> and a <Continuous> sweep, the wavelength interval between hardware triggers is set by the [Step] parameter, although, the sweep is not stepped.

# How to Use Auxiliary Functions

## Automatic Realignment

Automatic Realignment realigns the laser cavity after the Laser Safety error has occurred. You should use Automatic Realignment if you have already tried to reactivate the laser and to reduce power, and this has been unsuccessful.

**NOTE** **To get the specified performance, ensure that the warm-up time has passed before starting realignment.**

To realign the laser cavity:

1 Move to the Tunable Laser channel and press *Menu*.

2 Move to <*Realign*> and press [*OK*]. You will see the screen in Figure 95 on page -168.

3 Wait approximately 30 minutes. This time depends on how much the alignment of the instrument has drifted since the last Automatic Realignment was performed.

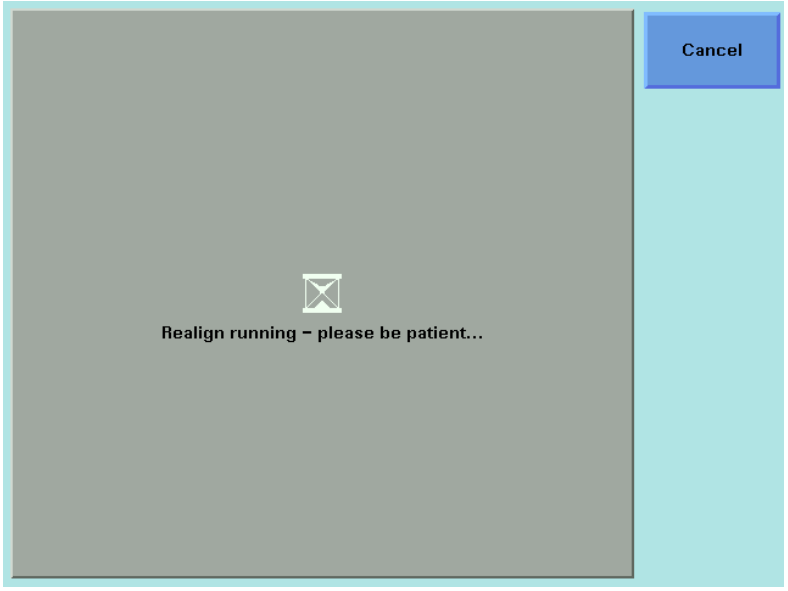



Figure 95 Realign Screen

**NOTE**

If the TLS recommends Realign (after boot or during a manual lambda zero), then “UNCAL” is shown on the user interface in both Autocal modes. No Accuracy class is shown in the Autocal Off mode.

The bit 6 “ARA recommended” is set in the “questionable condition register” (See the *8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, 8166A/B Lightwave Multichannel System Programming Guide*)

Please execute Realign in this case.

## How to Perform a Lambda Zero

Performing a Lambda Zero recalibrates the optical wavelength. This wavelength may drift due to a change in temperature and other environmental conditions.The regulated wavelength and wavelength logging data remain accurate, but the sweep may be offset from the intended range.

A Lambda Zero is automatically performed when the instrument boots or when an Automatic Realignment is performed.

The 81600B and earlier tunable laser instruments automatically perform a wavelength zero from time to time. To avoid interruption of your measurements, you should perform a wavelength zero at a time of your choice.

The 81602A, 81606A, 81607A, 81608A, 81609A and 819xxA lasers regulate this more dynamically after warm-up and do not automatically run wavelength zeroing. It is advisable to run this after warm-up. Also periodic use, perhaps daily, during continuous operation or if sweeps are missing points at the ends is recommended.

To perform a wavelength zero:

1 Move to the Tunable Laser channel and press *Menu*.

2 Move to <λ *Zeroing*› and press [OK]. You will see the screen in Figure 96 on page -170.

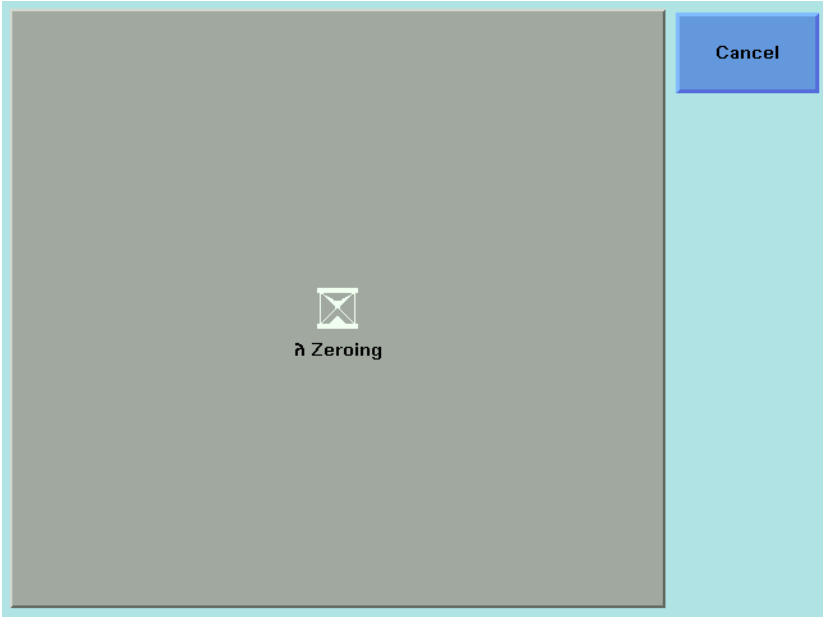



Figure 96 λ Zeroing Screen

3 Wait several minutes. This time depends on how much the wavelength of the instrument has drifted since the last Lambda Zero was performed.

**NOTE** **The 81600B and earlier instruments automatically perform a Lambda Zero if there is a ± 4.4 K temperature change since the last Lambda Zero was performed.**

Auto Cal Off

The disabling of the Auto Calibration feature enables the TLS to operate for a long period without interrupting the operation for “Auto Lambda Zeroing (setting)”. When Auto Calibration is disabled, it is possible to operate the TLS at a temperature that differs more than 4.4 K from the last Lambda Zeroing temperature. In this case, the accuracy and wavelength performance of the TLS can become less optimal due to temperature variation. The relevant accuracy class is indicated on the user interface when Auto Calibration is off.

**NOTE** The Auto Calibration mode is NOT stored in the Instrument Settings. After reboot or preset the Auto Calibration is always on.

**NOTE** When Auto Cal Off is selected the digital signal modulation feature is not available.

**NOTE** See the table below for the wavelength accuracies of ACC1, ACC2, and ACC3.

| | Wavelength accuracy (typ.) | | |
|---|---|---|---|
| **Class** | **Max Temperature Deviation** | **Absolute** | **Relative** |
| ACC1 | ± 4.4K | refer to specification | |
| ACC2 | ± 10K | ± 8 pm | ± 3 pm |
| ACC3 | ± 25K | ± 10 pm | ± 5 pm |

**NOTE** To get the specified performance ensure the warm-up time has passed and execute then a Lambda Zero before switching Auto Cal off.

**NOTE** If Lambda Zero is recommended (Accuracy Class is not ACC1) the 10th bit of the “questionable condition register” is set (See the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, 8166A/B Lightwave Multichannel System Programming Guide). This is done in both Auto Cal On and Off.

**NOTE**

When Auto Cal is on, during sweeps, there is no interruption to the measurement due to settling. Also no settling will occur during operation at a fixed wavelength when at least one output is switched on. By periodically checking the “questionable condition register” bit 10 you can detect when Lambda Zero is recommended.

# 6 Compact Tunable Lasers

Compact Tunable Laser modules / 174
How to Use a compact Tunable Laser / 175

This chapter explains how to use the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, or 8166A/B Lightwave Multichannel System together with the modular Keysight compact Tunable Laser family.

Here you will find:

- A brief description of the compact Tunable Laser family,
- A description of how to use these modules, including the SBS Suppression feature.

# Compact Tunable Laser modules

The Keysight compact Tunable Laser Source (TLS) family includes:

**Table 13 The Keysight compact TLS family**

| Module | Description |
|---|---|
| 81980A | S and C band compact TLS with SBS suppression for swept applications |
| 81940A, 81960A | C and L band compact TLS with SBS suppression for swept applications |
| 81944A | C and L band compact TLS with SBS suppression for swept applications used with PMD test system N3909A |
| 81989A | S and C band compact TLS with SBS suppression |
| 81949A | C and L band compact TLS with SBS suppression |

The Keysight 81980A, 81960A, 81940A, 81989A, 81949A Compact TLS modules provide high output power up to +13 dBm.

- The 81980A and 81989A cover the S and C bands, with high power in the C band.
- The 81960A, 81940A and 81949A cover the C and L bands, with high power in the L band.

Each module covers a total wavelength range of 110 nm. The 81960A covers a range of 125 nm.

# How to Use a compact Tunable Laser

## The User Interface

Compact TLS modules utilize the User Interface described in the Tunable Lasers on page 133. A description of how to use their modulation features given following How to Modulate a Signal on page 155.

### SBS Suppression

SBS Suppression is a frequency modulation that allows you to launch high optical output power into longer fibers without the impairment to time-domain measurements that can be associated with intensity (amplitude) modulation.

### To use the SBS Suppression control (SBS-C) feature:

Refer to Figure 97 on page -176.

1 Move to the Tunable Laser channel and press the [Details] softkey.

2 Set appropriate values in the Freq. Modulation box:

- The Frq Mod scr > SBS-Ctrl field is fixed, since SBS-Ctrl is the only frequency modulation source currently available.
- Set a value for the SBS suppression control frequency, SBSC frq, appropriate to your application.
- Set a value for the SBS suppression control level, SBSC lvl, appropriate to your application.

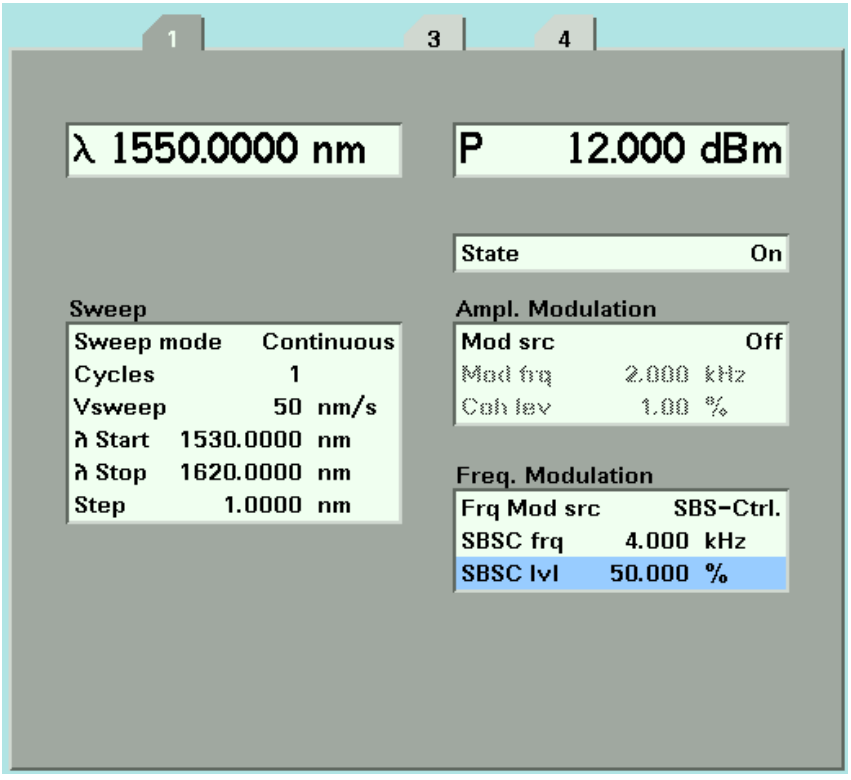



Figure 97 Updated Tunable Laser channel Details including SBS Suppression

# 7 Return Loss Measurement

Getting Started With Return Loss / 178
Calibration Measurements / 183
Return Loss Measurement / 184
A Background to Return Loss Measurement / 203

This chapter explains how to use the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, or 8166A/B Lightwave Multichannel System to measure Return Loss.

Here you will find:

- a quick explanation of the terms Return Loss and Insertion Loss,
- a description of how to measure Return Loss and Insertion Loss using 8161x series Return Loss modules,
- a brief discussion of the theoretical background to Return Loss measurements using 8161x series Return Loss modules.

**NOTE** For information about 81534A Return Loss Modules, refer to the "Operating and Programming Manual for the 81534A Return Loss Module." 81534-90012.

KEYSIGHT TECHNOLOGIES

# Getting Started With Return Loss

## What is Return Loss?

When light passes through an optical component most of it travels in the intended direction, but some light is reflected or scattered. In many applications these reflections are unwanted, because they can affect the emission characteristics of any laser in the system. In such applications, it is important to measure the reflections for the components of the system.

The reflection factor for a component is a measure of how much light the component reflects. It is a ratio of the power reflected by the device to the power incident on the device. More normally we talk about the return loss of a component. The return loss has units of dB. Return loss is given by:

$$Return\ Loss(dB) = -10\log(Reflection\ Factor)(dB)$$

or

$$Return\ Loss(dB) = -10\log\left(\frac{Reflected\ Power}{Incident\ Power}\right)(dB)$$

## What is Insertion Loss?

Light that is absorbed, scattered, or reflected by a component also affects how much light a component transmits.

The transmission factor for a component is a measure of how much light the component transmits. It is a ratio of the power transmitted by the device to the power incident on the device. More normally we talk about the Insertion Loss of a component. The insertion loss has units of dB. Insertion Loss is given by:

$$Insertion\ Loss(dB) = -10\log(Transmission\ Factor)(dB)$$

or

$$Insertion\ Loss(dB) = -10\log\left(\frac{Transmitted\ Power}{Incident\ Power}\right)(dB)$$

Equipment required

Return Loss and Insertion Loss can be measured in several ways. The method used by the 8161x series Return Loss modules requires the following equipment:

- A Keysight 81610A Return Loss module (where an internal source is not present), or a 81611A, 81612A or 81613A Return Loss module (where an internal source is present).
- If the Return Loss module does not include an internal source, or you choose to use an external source, a Laser Source module.

**NOTE** **If you are using an 81534A Return Loss Module, it is important that the Laser Source has a stable output. 8161x Return Loss modules include a monitor diode to compensate for power variation in the Laser Source.**

- A Power Meter.

A typical setup, using a Keysight 81610A Return Loss module, where the DUT is a connector pair, is described in Figure 98 on page -179.

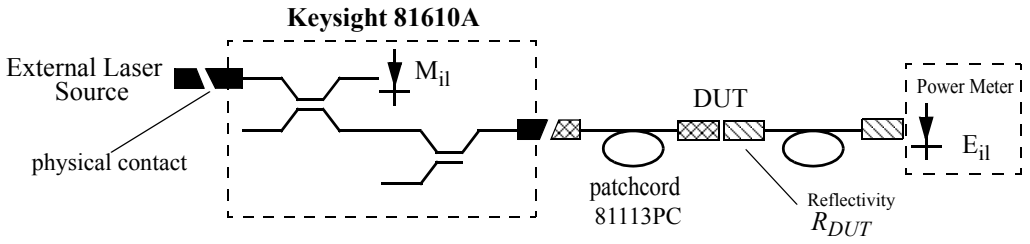



Figure 98 Measuring Return Loss and Insertion Loss

To measure insertion loss you measure the power transmitted through the DUT, see How to Measure Return Loss on page 198.

### How to Choose a Light Source

Highly accurate return loss measurement requires that you use a light source with a subset of the following properties:

- low coherence length
- high power
- [and, for the 81534A, power stability.]

If a return loss module with at least one internal source (such as the 81611A, 81612A or 81613A) is not available, we recommend that you use any of the following as part of your return loss measurement setup:

- *Erbium ASE Source.*
  This source offers a high-power low-coherence output that is very stable over time.
- *Laser Source modules.*
  See Accessories on page 345 for a list of modules that can be installed in your mainframe. Refer to the note below that explains the use of highly coherent light sources.
- *Tunable Lasers,* when you want to measure Return Loss over a wavelength range.
  See Accessories on page 345 for a list of modules that can be installed in your mainframe. Refer to the note below that explains the use of highly coherent light sources.
- *LED sources.*
  The intensity of the output of LED sources is very stable over time, although the low power output of LEDs restricts the dynamic range of return loss measurement.

**NOTE**

**If you use high-coherence light sources, you can improve performance by:**

- **modulating the output signal at 2 kHz or higher, or**
- **using coherence control to reduce the coherence length of the signal.**

## Return Loss Modules

The applicability of the available Return Loss modules is outlined below:

### 81610A Return Loss module

The 81610A Return Loss Module includes a power sensor, monitor diode and two couplers in one module. It is for use in the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System for making return loss measurements.

The Keysight 81610A Return Loss module does not include an internal source, and must be used in conjunction with a suitable external source.

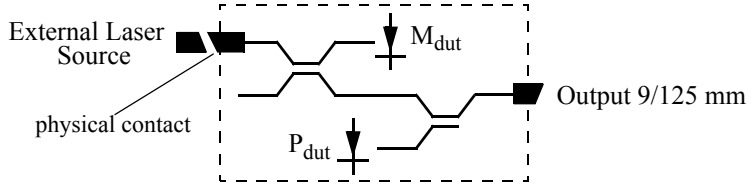



Figure 99 The Contents of the 81610A Return Loss module

### 81611A and 81612A Return Loss modules

81611A and 81612A Return Loss modules include a power sensor, monitor diode, two couplers, and an internal laser source in one module. It is for use in the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System for making return loss measurements.

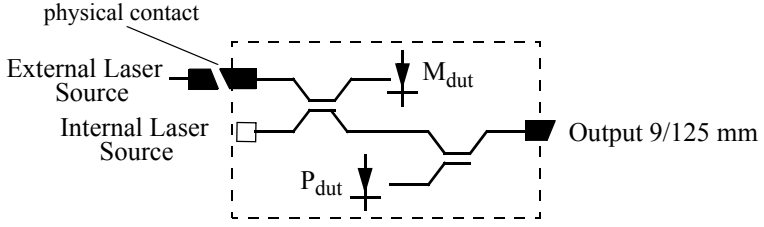



Figure 100 The Contents of the 81611A and 81612A Return Loss modules

### 81613A Return Loss modules

81613A Return Loss modules include a power sensor, monitor diode, three couplers, and two internal laser source in one module. They are for use in the 8163B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System for making return loss measurements.

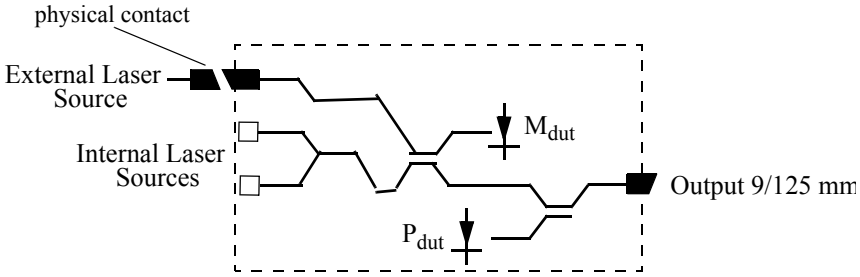



Figure 101 The Contents of the 81613A Return Loss modules

All 8161x series Return Loss modules include an input for an external laser source.

## Calibration Measurements

Before measuring the reflection factor of a device under test (DUT), it is important to take calibration measurements as described in Calibrating the Return Loss Module on page 188. These calibrations eliminate wavelength dependencies, coupler directivity, insertion losses, backscattering and other non-ideal characteristics of the system.

The Return Loss Application described later in the manual, available on the 8163B and 8163A, provides a convenient guide through the calibration and measurement process.

# Return Loss Measurement

## Patchcord on RL module Output

The front panel connector is angle-polished to minimize reflections. Only patchcords with angled connectors should used here and care should be taken to avoid contamination and scratches. A high-quality measurement patchcord should be used for connection to the device under test to avoid overly frequent reconnection at the instrument.

## Setup

### External and Internal Sources

The Return Loss measurement setup described uses:

- A Fabry-Perot laser source module, inserted as a second module in the same mainframe as the Return Loss module, or
- An internal source.

Making sure all the connectors are clean, set up the instrument as shown in Figure 102 on page -184 if you are using an External Source.

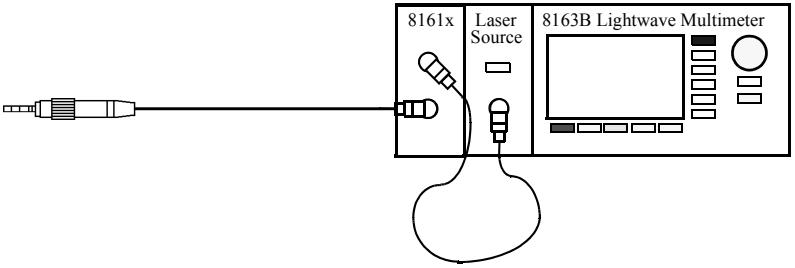



Figure 102 Return Loss Measurement Setup - External Source used

or Figure 103 on page -185 if you are using an internal source.

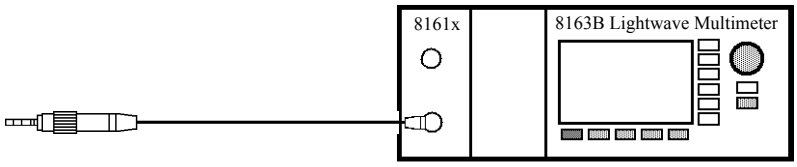



Figure 103 Return Loss Measurement Setup - Internal Source used

- If an external source is used, connect it to the Return Loss module Input.

**NOTE** **If you are using an external source, you must fix its output cable to ensure stability.**

- The measurement patchcord will have an angled connector at the return loss module. The other end should be straight-polished or angle-polished to match the input of the devices to be measured.

### Remove electrical offsets

1 Make sure that the source is not active and that you have covered the end of the patchcord to prevent light being coupled into the end. Move to the Return Loss module channel and press [Zero] to remove electrical offsets in the instrument.

### Set Averaging Time

2 Move to the [*AvgTime*] parameter (the measurement averaging time). Make sure that the selected averaging time is suitable for your measurements.

Use an averaging time of at least 200 ms, but increase this to at least 1 s for return losses greater than 50 dB. Longer averaging times give more accurate results, but reduce the speed at which the instrument can complete a measurement.

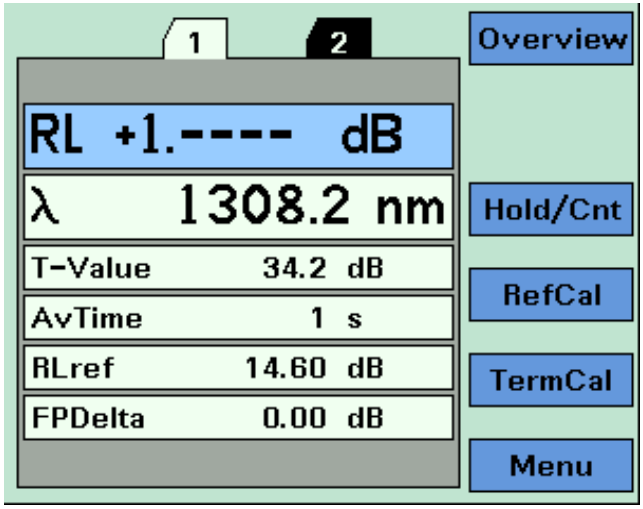



Figure 104 Keysight 8161x Details Screen

### Set Wavelength

1 Move to [λ] and either:
   - set this parameter to *Extern*.
   - choose an internal source by selecting its wavelength.
2 Enable the source.

### T-Value

The T-value can be described as the effective return loss of a system, with all internal parasitic reflections taken into account, in one parameter. The system's internal parasitic reflections include backscattering in the measurement patchcord, reflections due to imperfect directivity of the internal couplers, reflections at internal terminations, reflections at connector ends and diodes. Intuitively, one could call the T-value the "noise" of the system (set up). The T-value is used to evaluate how well the calibration was done, and thereby provide information on how high return losses (low reflectances) can be measured. The correlation between the T-value and the displayed return loss is that the power that corresponds to the T-value (system "noise") is subtracted from the power that corresponds to the measured return loss at the return loss diode, yielding the actual return loss. When the actual return loss is high, then this

subtraction becomes inaccurate when the T-value is not sufficiently high. Therefore, it is imperative for measurements of high return losses that the T-value is as high and as stable as possible. A "rule of thumb" is that one can only measure 5-10 dB higher return losses (lower reflections) than the T-value, meaning if a T-value of 65 dB is achieved after calibration it is possible to measure accurate return losses up to 70 or 75 dB. The equation for the T-value is as follows:

$$T-value = 10\log\left[\left(P_{ref}/P_{para}\right)\left(M_{para}/M_{ref}\right)\right] + RL_{ref} \approx 10\log\left[P_{ref}/P_{para}\right] + RL_{ref}$$

Where:

$P_{ref}$ is the reflected power from the measurement path at the return loss diode when making a reference calibration.

$P_{para}$ is the backward-flowing power from the measurement path at the return loss diode when making a terminated/parasitic calibration.

$M_{ref}$ is the power at the source monitor diode when making a reference calibration.

$M_{para}$ is power at the source monitor diode when making a terminated/parasitic calibration.

$RL_{ref}$ is the return loss reference value set by the user for the reference calibration.

These parameters are made available using the "Show Calibration " menu item, or using the GPIB query:

SENSe [n ]:[CHANnel [m ]]:RETurnloss:CALibration:VALUES?

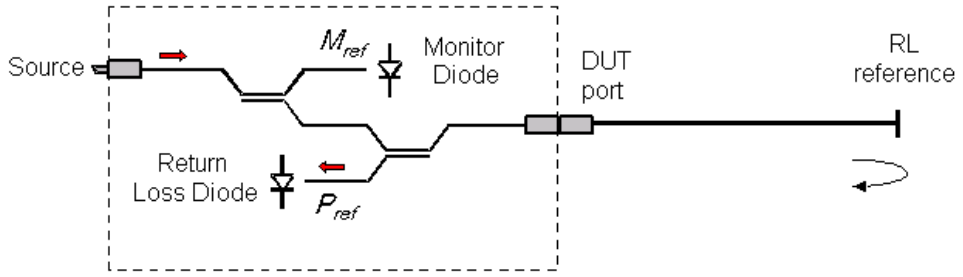



Figure 105 Reflectance Calibration using RL Reference

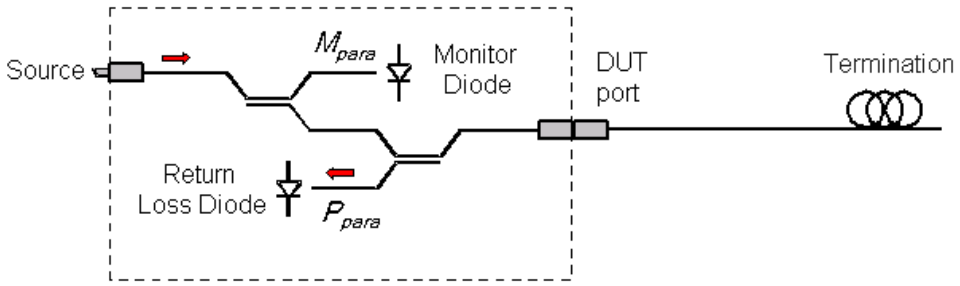



Figure 106 Termination Calibration

## Calibrating the Return Loss Module

Whenever a Return Loss module is in the mainframe, a return loss value is displayed. The calibration values used are either the most recently measured, where these are available, or factory default values.

If you are unsure of any of the calibration values that you are using, or if you have changed the measurement setup, take the appropriate calibration measurements again.

- First, calibrate the return loss module against a component of known reflectance.
  - The Keysight 81000BR Reference Reflector allows you to make a Reflectance Calibration and a Termination Calibration.
  - These procedures are described in Calibration using the Keysight 81000BR Reference Reflector on page 189.
  - The Keysight 81610CC Reference Cable also allows you to make a Reflectance Calibration. Use the measurement patchcord to make a Termination Calibration.
  - To measure insertion loss and the front panel delta of the system (see Calculating the Front Panel Delta on page 209), you must also measure the insertion loss of the Reference Cable and mesurement patchcord. This is usually the preferred procedure for this reason.
  - These procedures are decribed in Calibration using the Keysight 81610CC Reference Cable on page 192.

## Calibration using the Keysight 81000BR Reference Reflector

You can use the Keysight 81000BR Reference Reflector to make a Reflectance Calibration, and a Termination Calibration.

### Reflectance Calibration

Use this procedure to calibrate the Return Loss module against a component of known return loss.

1 Making sure all the connectors are clean, set up the instrument as shown in Figure 107 on page -189 if you are using an External Source.

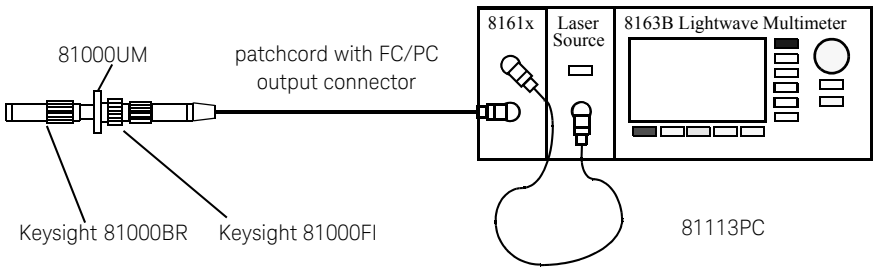



Figure 107 Reflectance Calibration - External Source

or Figure 108 on page -189 if you are using an internal source.

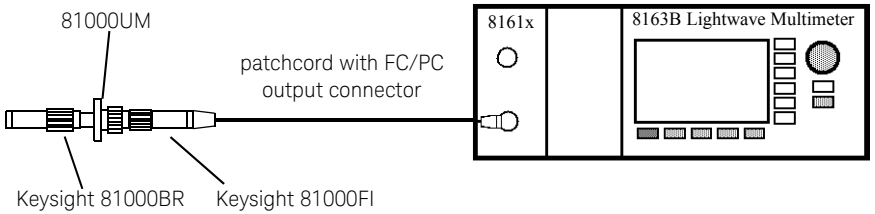



Figure 108 Reflection Calibration - Internal Source

**Tip:** For best results and higher repeatability, fix the cable.

2 Attach a component with a known return loss to the end of the patchcord.

**Tip:** The Keysight 81000BR Back Reflector is such a component, offering a return loss of 0.18 ± 0.1 dB.

3 Move to the Return Loss channel, then press [Details]

4 Move to [*FPDelta*], press [Edit], set the value to 0.000, then press [OK].

5 Move to [*RLref*] and make sure that the displayed value is correct. Set [*RLref*] to the value of the return loss of the reference reflection you are using. For example, if you are using the Keysight 81000BR reference reflector, set [*RLref*] to 0.18 dB.

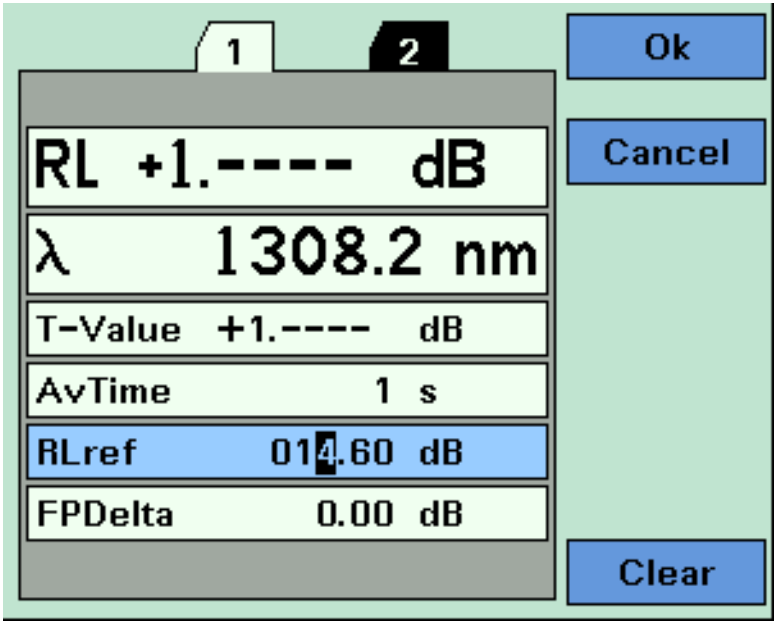



Figure 109 Measuring the Reflection Reference

6 Switch on the Laser.

7 Press [Menu]. Move to <*Reflectance calibration*> and press *Enter*. The instrument measures the power reflected by the back reflector. The [*RL*] value changes to the same value as entered for [*RLref*].

**Tip:** An alternative step step 7 is to select the Return Loss module's [Detail] screen, then press [RefCal]

### Termination Calibration

Use this procedure to calibrate the Return Loss module against a terminated cable, that is when there are no reflections returning from its end.

1 Making sure all the connectors are clean, set up the instrument as shown in Figure 110 on page -191 if you are using an External Source,

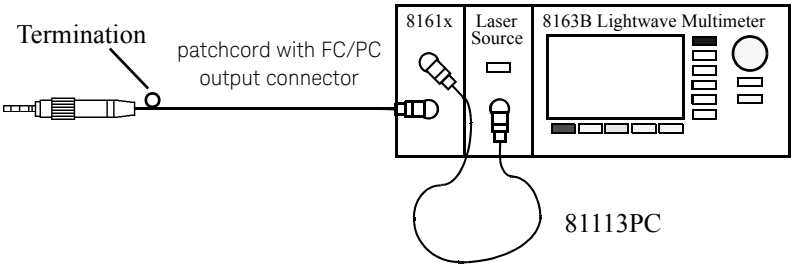



Figure 110 Termination Calibration - External source

or Figure 111 on page -191 if you are using an internal source.

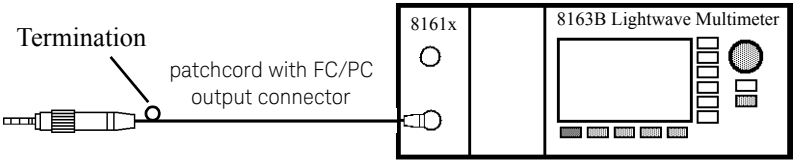



Figure 111 Termination Calibration - Internal Source

**NOTE** **If you are using an external source, you must fix its output cable to ensure minimum cable movement.**

2 Terminate the cable so that there are no reflections coming from the end.

**Tip**: You can do this by wrapping the fiber five times around the shaft of a screwdriver *(or some similar object with a diameter of between 5mm and 7mm)*.

3 Press [Menu] to access the menu.

4 Move to <*Terminated calibration*> and press *Enter*. The instrument measures the power reflected by the cable, and sets the [*Para*] values used by the Return Loss monitor's power sensor and monitor diode.

**Tip**: An alternative steps 3 and 4 is to select the Return Loss module's [Details] screen, then press [TermCal].

### Calibration using the Keysight 81610CC Reference Cable

Use the Keysight 816100CC Reference Cable to make a Reflectance Calibration, and the measurement patchcord to make a Termination Calibration. The 81610CC has an FC/PC connector as reflector, that has been measured and labeled at the factory. The connector face should be protected and not be contacted.

To measure insertion loss and the front panel delta of the system (see Calculating the Front Panel Delta on page 209), you must also measure the insertion loss of the Reference Cable and measurement patchcord.

**Reflectance Calibration**

Use this procedure to calibrate the Return Loss module against a component of known return loss.

1 Making sure all the connectors are clean, set up the instrument as shown in Figure 112 on page -192 if you are using an External Source,

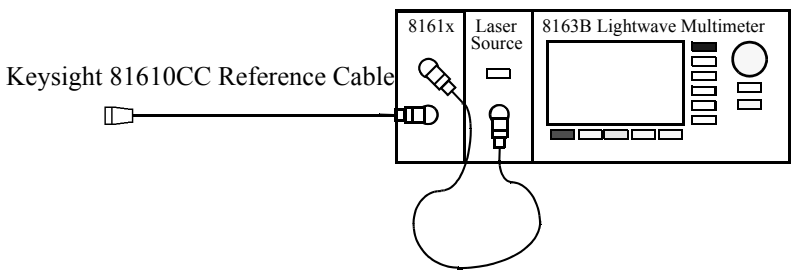



Figure 112 Measuring the Return Loss of the Reference Cable - External Source

or Figure 113 on page -193 if you are using an internal source.

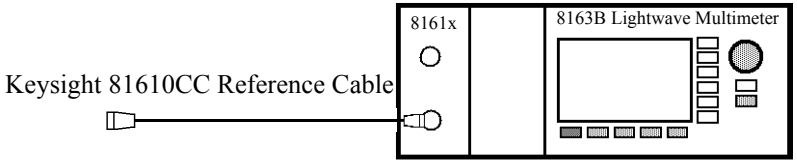



Figure 113 Measuring the Return Loss of the Reference Cable - Internal Source

Attach the angled connector of the Reference cable to the front panel. The 81610CC Cable needs an 81000SI connector interface at this port.

**Tip:** For best results and improved repeatability, fix the cable.

2 Move to [*FPDelta*], press [Edit], set the value to 0.000, then press [OK].

3 Move to [*RLref*], press [Edit]. Make sure that the displayed value of [*RLref*] is correct. If it is not, move to [*RLref*], press [Edit], set the value the return loss value of the reference cable you are using, then press [OK].

4 Switch on the Laser.

5 Press [Menu]. Move to <*Reflectance calibration*> and press *Enter*. The instrument measures the power reflected by the reference cable. The [*RL*] value changes to the same value as entered for [*RLref*].

**Front Panel Delta Calibration**

For higher accuracy we recommend that you also calibrate for *Front Panel Delta*. This is the difference between the insertion loss of the reference cable, and the insertion loss of the patchcord used for return loss measurement. The difference is normally the difference in the front panel connection, which can change with each reconnection.

### Measuring the Power Transmitted Through the Reference Cable

First, measure the power transmitted through the reference cable. Making sure all the connectors are clean, set up the instrument as shown in Figure 114 on page -194 if you are using an External Source. The reference connector can be attached to a power meter because this is a non-contact connection.

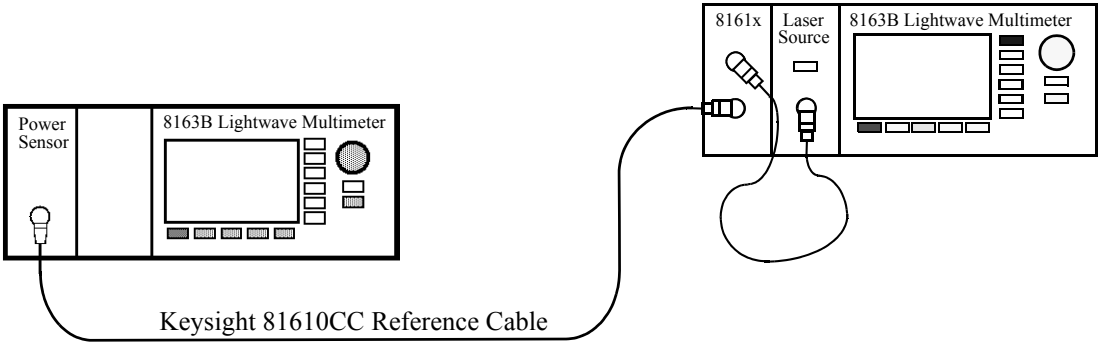



Figure 114 Power Transmitted through the Reference Cable - External Source

or Figure 115 on page -194 if you are using an internal source.

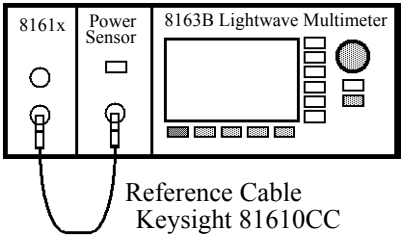



Figure 115 Power Transmitted through the Reference Cable - Internal Source

6 Move to the Power Sensor channel:
- Press [Menu].
- Move to <*Pwr unit*>, move to <*dB*> and press *Enter*.
- Move to <*Display to Reference*> and press *Enter*. This sets the power transmitted through the reference cable, $E_{Meas}$, as the reference value <*Ref*>.

7 Press [Close] to exit from the menu.

### Measuring the Power Transmitted through the Measurement Patchcord

Next, measure the power transmitted through the measurement patch cord.

1 Making sure all the connectors are clean, set up the instrument as shown in Figure 116 on page -195 if you are using an External Source,

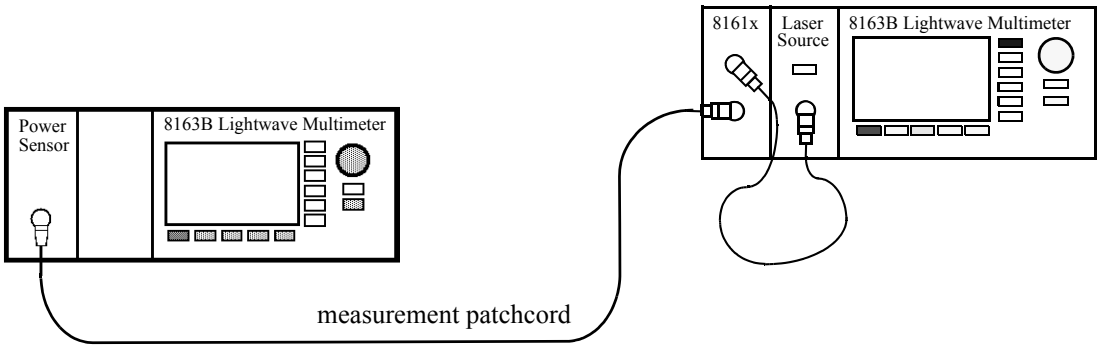



Figure 116 Power Transmitted through the Measurement Patchcord - External Source

or Figure 117 on page -195 if you are using an internal source.

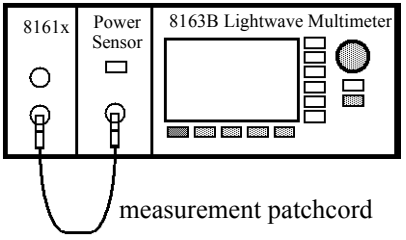



Figure 117 Power Transmitted through the Measurement Patchcord - Internal Source

2 .Move to the Power Sensor channel:

- Press [Menu].
- If necessary, move to <*Pwr unit*>, move to <*dB*> and press *Enter*.
- The Power Sensor channel displays a power value in dB that is equal to the front panel delta of the measurement system.

- Press [Close] to exit from the menu.

3 Move to the Return Loss module channel:
   - Press [Menu], move to <*FPDelta*>, press [OK]
   - Enter the power value in dB, [*P*], displayed by the power sensor, as the front panel delta, then press [OK].
   - Press [Close] to exit from the menu.

This FPDelta value remains valid until the measurement patchcord is removed or reconnected at the module.

**Termination Calibration using the Measurement Patchcord**

Use this procedure to calibrate the Return Loss module against a terminated patchcord, that is when there are no reflections returning from its end.

1 Making sure all the connectors are clean, set up the instrument as shown in Figure 118 on page -196 if you are using an External Source.

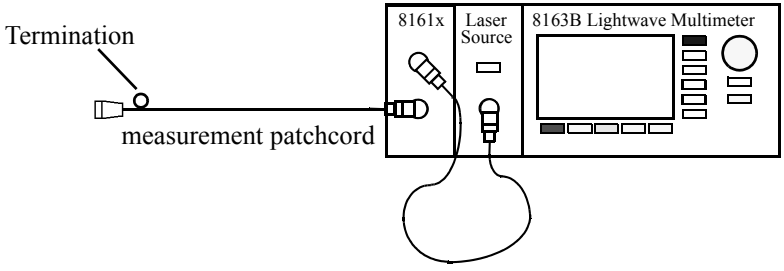



Figure 118 Measuring the Termination Parameter - External Source

or Figure 119 on page -196if you are using an internal source.

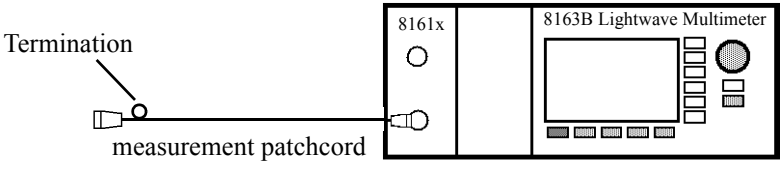



Figure 119 Measuring the Termination Parameter - Internal Source

2 Terminate the measurement patchcord so that there are no reflections coming from the end.

**Tip:** You can do this by wrapping the fiber five times around the shaft of a screwdriver (or some similar object with a diameter of between 5 mm and 7 mm).

3 Move to [*Terminated calibration*] and press *Enter*. The instrument measures the power reflected by the component, and sets the [*Para*] values used by the Return Loss monitor's power sensor and monitor diode.

## How to Measure Return Loss

It is not necessary to make new calibration measurements for each DUT. You can make the calibration measurements for your system, and then measure the return loss of many devices.

The value shown in the result field for the Return Loss channel is the measured return loss.

1 Attach the DUT to the measurement patchcord. In the example shown in Figure 120 on page -198, the DUT is a connector pair.

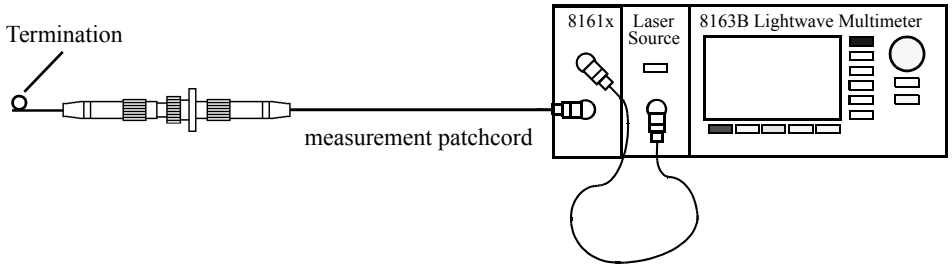



Figure 120 Measuring the Return Loss of the DUT (in this example: a Connector Pair)

**Tip:** Terminate your system close to the DUT to make sure that you are only measuring reflections from the DUT.

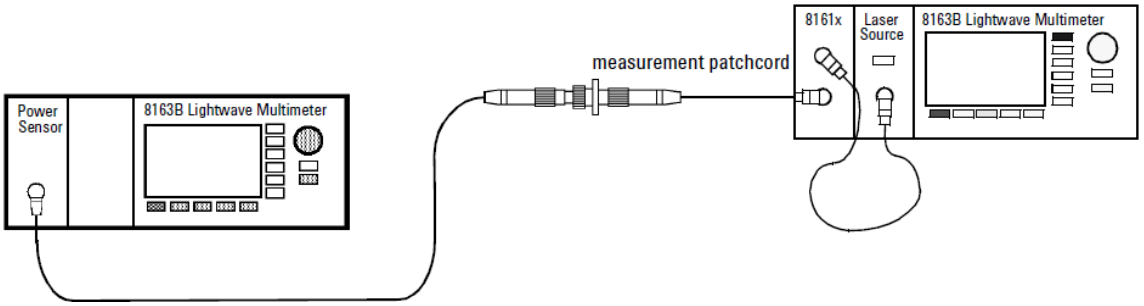



Figure 121 Measuring the Power Transmitted through the DUT (a Connector Pair)

### Measuring the Insertion Loss

To measure insertion loss, you measure the power transmitted through the DUT, as shown in Figure 121 on page -198.

As you have already, in step 6, set the [*Ref*] parameter to the power transmitted through the Reference Cable. The displayed power in dB is equal to the insertion loss.

**NOTE** **Set the Front Panel Delta as described on Front Panel Delta Calibration on page 193.**

## Viewing the Calibration Values

The Return Loss module calibration values used are either the most recently measured, where these are available, or factory default values.

If you are unsure of the calibration values you are using, or if you have changed your measurement setup, make the appropriate calibration measurements again.

1 Press [Menu]. Move to the <*Show calibration*> menu item. The *Calibration parameters* screen for the *Return Loss Diode* appears, as displayed in Figure 122 on page -200. This screen shows current value for the following quantities:

- [*Para*], the parasitic power value measured by the Return loss Module's internal power sensor in dBm. This value is determined by the termination calibration, or you can use the default setting held in the factory calibration.
- [*Ref*], the power measured by the Return loss Module's internal power sensor during the reflectance calibration in dBm
- [*Meas*], the power currently measured by the Return loss Module's internal power sensor in dBm

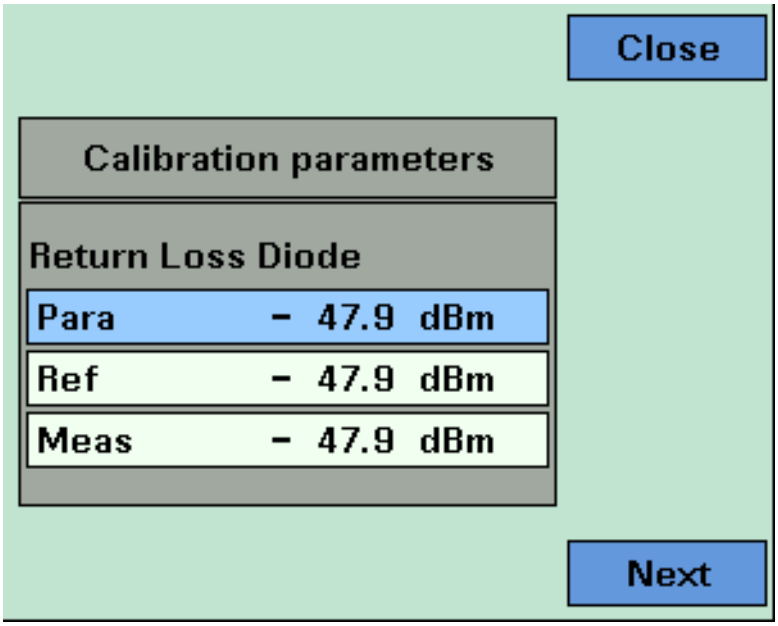



Figure 122 The Calibration Parameters Screens - Return Loss Diode

2 Press [Next]. The *Calibration parameters* screen for the *Monitor Diode* appears, as displayed in Figure 123 on page -201. This screen shows current value for the following quantities:

- [*Para*], the parasitic power value measured by the Return Loss module's monitor diode in dBm. This value is determined by the termination calibraion, or you can use the default setting held in the factory calibration.
- [*Ref*], the power measured by the Return Loss module's monitor diode during the reflectance calibration in dBm
- [*Meas*], the power currently measured by the Return loss Module's internal monitor diode in dBm

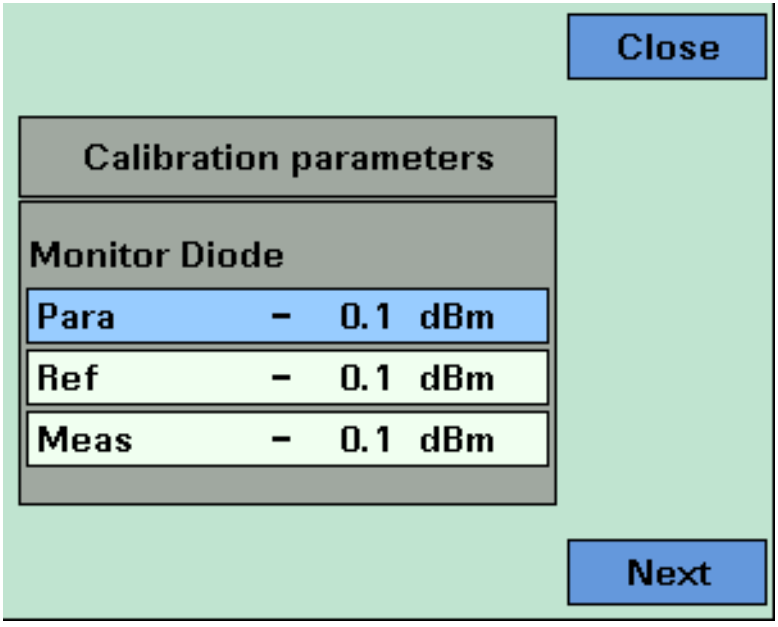



Figure 123 The Calibration Parameters Screens - Monitor Diode

3 Press [Next]. The *Calibration parameters* screen for *User Data* appears, as displayed in Figure 124 on page -202. This screen shows current value for the following quantities:

- [*FPDelta*], the loss correction, in dB, due to differences between the reference cable and the measurement cable, such as differences in the front panel connector.
- [*RLref*] the value of the return loss of the reference relector used. If you areusing a reference cable, this value will be around 14.6 dB

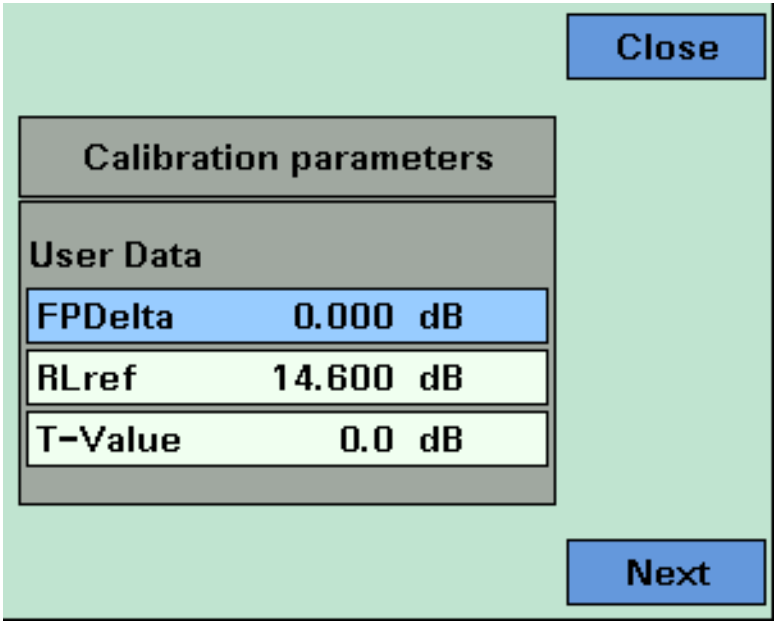



Figure 124 The Calibration Parameters Screens - User Data

## A Background to Return Loss Measurement

### Measuring the Reflected Power from a Component with Known Reflection Factor

First, attach a component with a known reflection factor in place of the DUT, and measure the power reflected. This component is called the reflection reference.

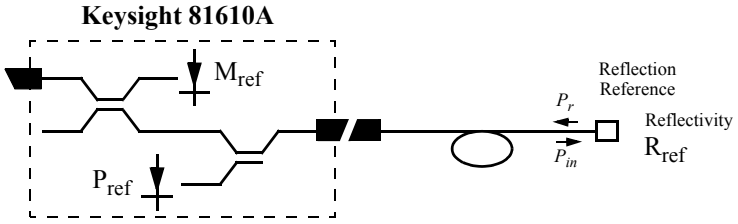



Figure 125 Measuring the Power from a Component with a Known Reflection Factor

This measured power from the reflection reference is called $P_{Ref}$.

The following two components are recommended for use as a reflection reference:

- the Keysight 81610CC Reference Cable, or
- the Keysight 81000BR Back Reflector.

**NOTE** **You can only measure the Front Panel Delta if you use a Reflection Reference Cable.**

The reflection factor for the component is called $R_R$. Normally the return loss for the component ($RL_R$) is specified, but these values are related:

$$RL_R = -10\log R_R = -10\log\frac{P_r}{P_{in}}$$

Measuring the Power Transmitted Through the Reflection Reference

**NOTE** **You can only measure the Front Panel Delta if you use the a Reflection Reference Cable.**

Connect your a Reflection Reference Cable to a Power Meter and measure the transmitted power, $E_{ref}$. You can use $E_{ref}$ to calculate the front panel delta, see Calculating the Front Panel Delta on page 209.

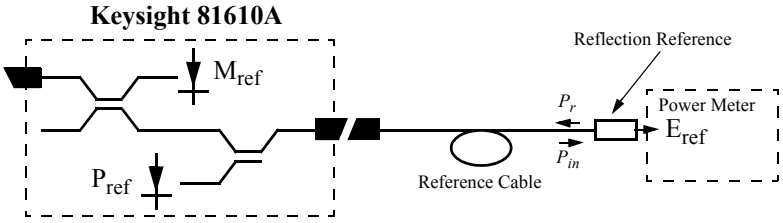



Figure 126 Measuring the Power transmitted through the Reflection Reference

### Measuring the Power when there are No Reflections

Next, terminate the measurement patchcord so that there are no reflections from the end. All the power measured by the sensor now, is due to the non-ideal nature of the measurement system. This is our termination parameter.

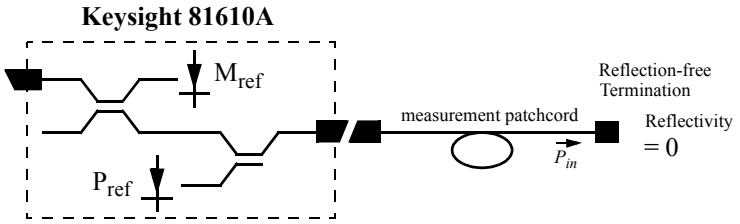



Figure 127 Measuring the Power with the Connector Terminated

This measured power for the termination parameter is called $P_T$.

### Measuring the Power Transmitted Through the Measurement Patchcord

Connect the measurement patch cord (the cable you will use to connect to the Device Under Test, DUT) directly to a Power Meter and measure the transmitted power, $E_{Meas}$. You can use $E_{Meas}$ to calculate the front panel delta, see Calculating the Front Panel Delta on page 209 and to calculate the insertion loss, see Calculating the Insertion Loss of the DUT on page 211.

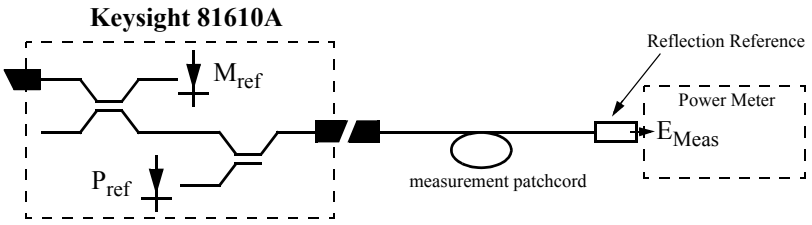



Figure 128 Measuring the Power transmitted through the Measurement Patchcord

### Measuring the Reflections from the DUT

Now detach the measurement patchcord from the Power Meter and attach it to the DUT. The DUT should be terminated.

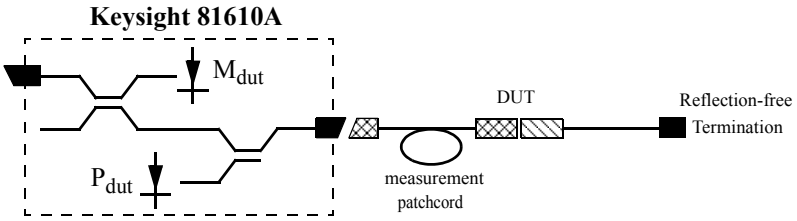



Figure 129 Measuring the Reflections from the Device Under Test

The instrument measures the power reflected from the DUT. This power is called $P_{DUT}$.

### Measuring the Power Transmitted Through the DUT

Remove the termination from the DUT and connect the DUT to a Power Meter so that the power that is transmitted through the DUT can be measured. This power is called $E_{il}$

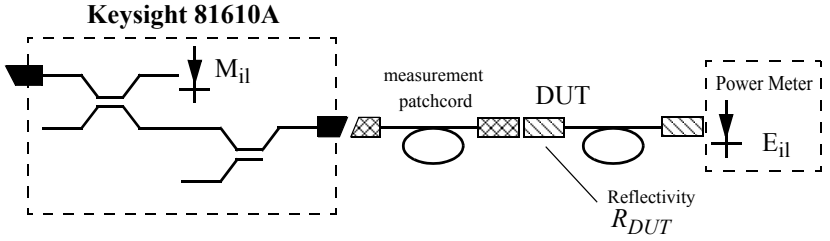
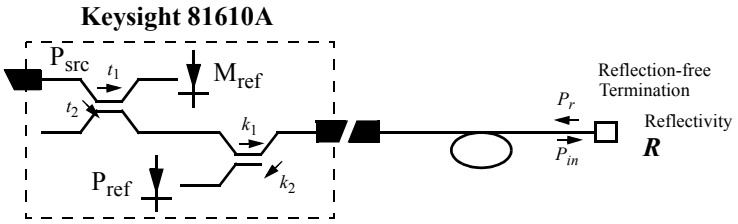



Figure 130 Measuring the Power transmitted through the Device Under Test

You can use $E_{il}$ to calculate the insertion loss, see Calculating the Insertion Loss of the DUT on page 211.

## Calculating the Return Loss of the DUT

The system may be represented by the general diagram shown below:




The reflected power, measured by the instrument, (*P*), from the component with the known reflection factor, is given by the sum of:

- the part of the power, reflected by the component, which is transmitted through the coupler, and
- the reflections due to the measurement system.

That is:

$$P = t_2\, k_1\, k_2\, P_{src} R + t_2\, s\, M$$

where:

$$M = t_1\, P_{src}$$

$$c_1 = \frac{t_2}{t_1}\, k_1\, k_2$$

$$c_2 = \frac{t_2}{t_1}\, s$$

$$\Rightarrow P = c_1\, M\, R + c_2\, M \qquad (1)$$

The constants $t_1$, $t_2$, $k_1$ and $k_2$ are multipliers giving the proportion of power transmitted through the coupler from the Input port to the Output port and from the Output port to the sensor port respectively. In other words, when optical power is input at the Output port, $k_2$ times that power is output at the sensor port. It is not necessary to know the value for these constants, they can be eliminated later.

The constant *s* is a multiplier giving the scattering factor. The scattering factor accounts for the directivity of the second coupler, backscatter in the fiber, and reflections of connectors. The calibration procedure helps you to eliminate the affect of these on return loss measurements.

For Return Loss Measurement on page 184, the reflection factor of the component is known. Here we refer to the reflection factor as $R_{Ref}$. This gives the following equation:

$$P_{Ref} = c_1 \ M_{Ref} \ R_{Ref} + c_2 \ M_{Ref} \tag{2}$$

For Measuring the Power when there are No Reflections on page 205, the value of the reflection factor is zero. This gives the following equation:

$$P_{para} = c_2 \ M_{para} \tag{3}$$

For Measuring the Reflections from the DUT on page 206, the value of the reflection factor of the DUT is called $R_{DUT}$. This gives the following equation:

$$P_{DUT} = c_1 \ M_{DUT} \ R_{DUT} + c_2 \ M_{DUT} \tag{4}$$

If we substitute equation 3 into equations 2 and 4, this gives us the following two equations:

$$P_{Ref} = c_1 \ M_{Ref} \ R_{Ref} + \frac{M_{ref}}{M_{para}} \ P_{para} \tag{5}$$

$$P_{DUT} = c_1 \ M_{DUT} \ R_{DUT} + \frac{M_{DUT}}{M_{para}} \ P_{para} \tag{6}$$

If we subtract $P_{para}$ from equations 5 and 6, this gives us the following equations:

$$P_{Ref} - \frac{M_{Ref}}{M_{para}} \ P_{para} = c_1 \ M_{Ref} \ R_{Ref} \tag{7}$$

$$P_{DUT} - \frac{M_{DUT}}{M_{para}} \ P_{para} = c_1 \ M_{DUT} \ R_{DUT} \tag{8}$$

If we divide equation 8 by equation 7, this gives us the following equations:

$$R_{DUT} = \frac{M_{Ref}}{M_{DUT}} \frac{P_{DUT} - \frac{M_{DUT}}{M_{para}} P_{para}}{P_{Ref} - \frac{M_{Ref}}{M_{para}} P_{para}} R_{Ref} \quad (9)$$

Thus we can use the equation below to calculate return loss:

$$RL_{DUT} = -10 \log R_{DUT}$$

$$= -10 \log \frac{M_{Ref}}{M_{DUT}} \frac{P_{DUT} - \frac{M_{DUT}}{M_{para}} P_{para}}{P_{Ref} - \frac{M_{Ref}}{M_{para}} P_{para}} - 10 \log R_{Ref} \quad (10)$$

The return loss of the reference reflection is given by:

$$RL_{Ref} = -10 \log R_{Ref} \quad (11)$$

## Calculating the Front Panel Delta

The Front Panel Delta is the change in loss variation that is caused by replacing the reference cable, as used in **Reflectance Calibration** on page 192, with the measurement patchcord, as used in How to Measure Return Loss on page 198. This is caused by differences in reflections from the front panel connector and also differences in the backscatter level of the fibers.

To measure the front panel delta you must measure the power transmitted through the reference cable, Measuring the Power Transmitted Through the Reflection Reference on page 204, and the power transmitted through the measurement cable, see Measuring the Power Transmitted Through the Measurement Patchcord on page 205. The system may be represented by Figure 131 on page -210:

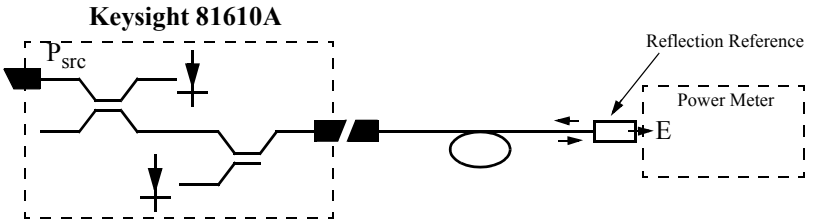



Figure 131 Generalization of a Return Loss Measurement

The transmitted power, (*E*), is directly proportional $P_{src}$.

That is:

$$E = aP_{src} \tag{12}$$

The constant *a* is a multiplier giving the proportion of power that the light source emits that is measured by the power meter.

The constants $a_{Ref}$ and $a_{Meas}$ apply to the setups described in Measuring the Power Transmitted Through the Reflection Reference on page 204 and in Measuring the Power Transmitted Through the Measurement Patchcord on page 205 respectively.

This gives the following two equations:

$$E_{Ref} = a_{Ref}P_{src} \tag{13}$$

$$E_{Meas} = a_{Meas}P_{src} \tag{14}$$

If we divide equation 11 by equation 12, this gives the following equation:

$$\frac{E_{Ref}}{E_{Meas}} = \frac{a_{Ref}}{a_{Meas}} \tag{15}$$

The loss variation, $\Delta L$, due to exchanging the reference cable for the measurement cable is given by:

$$\Delta L = -10\log\frac{a_{Ref}}{a_{Meas}} = -10\log\frac{E_{Ref}}{E_{Meas}} \tag{16}$$

When you enter a value for the Front Panel Delta, <*FPDelta*>, the instrument automatically performs the following calculation:

$$RL = RL_{DUT} + 2\Delta L \quad (17)$$

## Calculating the Insertion Loss of the DUT

Insertion Loss is explained in What is Insertion Loss? on page 178.

To measure the insertion loss you must measure the power transmitted through the measurement cable, see Measuring the Power Transmitted Through the Measurement Patchcord on page 205 and the power transmitted through the DUT, see Measuring the Power Transmitted Through the DUT on page 206.

The equation below gives the insertion loss of the DUT, $IL_{DUT}$:

$$IL_{DUT} = -10\log\frac{E_{il}}{E_{Meas}} \quad (18)$$

# 8 Setting Attenuation and/or Power Levels

Keysight 8157xA Variable Optical Attenuator modules / 214
How to Use a Variable Optical Attenuator module / 216

This chapter explains how to use the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, or 8166A/B Lightwave Multichannel System together with the 8157xA family of Variable Optical Attenuator modules to attenuate and control optical power in single-mode optical fibers.

Here you will find:

- A brief description of the modular Keysight 8157xA Variable Optical Attenuator family,
- A description of how to use these modules, including applying an attenuation factor, setting an output power, applying offset factors, constructing a λ offset table, and (for the 81576A and 81577A) using the power control feature.

## Keysight 8157xA Variable Optical Attenuator modules

The Keysight 8157xA Variable Optical Attenuator family includes three attenuator modules and two attenuator modules with power control.

**Table 14 The Keysight 8157xA Variable Optical Attenuator family**

| Module | Description |
|---|---|
| 81570A | high power, single slot, straight connectors |
| 81571A | high power, single slot, angled connectors |
| 81573A | high power, single slot, SMF pigtail |
| 81576A | high power, dual slot, power control, straight connectors |
| 81577A | high power, dual slot, power control, angled connectors |
| 81578A | high power, single slot, multimode |

The 81570A, 81571A, 81573A and 81578A single-slot modules offer a small footprint, high resolution and low insertion loss. They also offer high power handling and a filter technology that is wavelength flat.

The 81576A and 81577A dual-slot modules incorporate a powermeter so that you can set the output power level of the attenuator directly. In addition, these modules feature power control functionality, high power handling and a filter technology that is wavelength flat.

Figure 132 on page -215 shows how a signal from a photo-diode after a monitor coupler is used as an active feedback loop

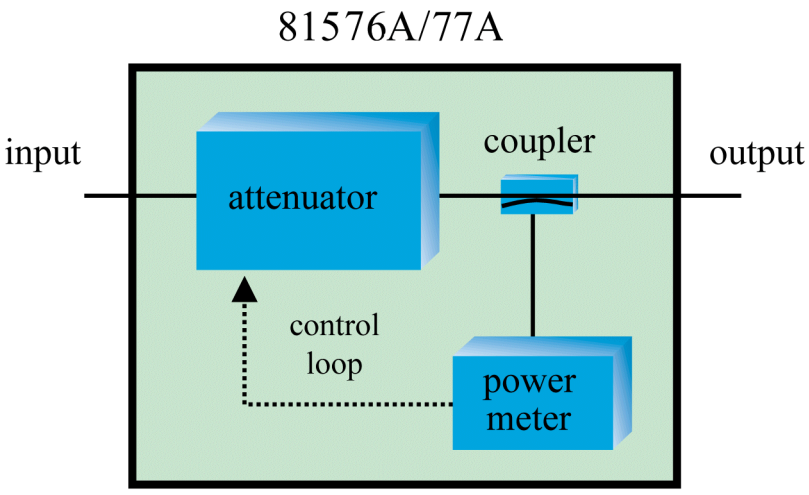



Figure 132 81576A/77A Attenuator module power control loop

# How to Use a Variable Optical Attenuator module

## The User Interface

### The Overview Display

Figure 133 on page -216 is an Overview screen taken from an 8164A/B mainframe.




Figure 133 81570A/71A/73A Attenuator module, 8164A/B GUI Overview

Here:

- Slot 1 hosts a tunable laser,
- Slot 2 hosts an 81570A/71A/73A Attenuator module,
- Slot 4 hosts a reference powermeter.

### Hosting a Reference Powermeter

A reference powermeter is used to calibrate for losses in the optical test setup. The Keysight 81576xA Variable Optical Attenuator modules' user interface includes features that allow quick and easy calibration if the reference powermeter is hosted by the same mainframe as the Attenuator module.

- If the Attenuator module is not hosted by the same mainframe, the calibration can be done manually by entering the offset value and reference power level.
- If the Attenuator module and the reference powermeter are not hosted by the same mainframe, but the mainframes are connected via a GP-IB bus to a PC or host computer, GP-IB commands can be used to perform the calibration steps. The procedures used are outlined in our Application Note 5988-3159EN : "Variable Optical Attenuator in BER Test Applications".

### The Attenuator Details Display

To display the full user interface for the Attenuator module, as shown in Figure 134 on page -218, use the Cursor key to highlight the Attenuator slot, then press the [Details] softkey:

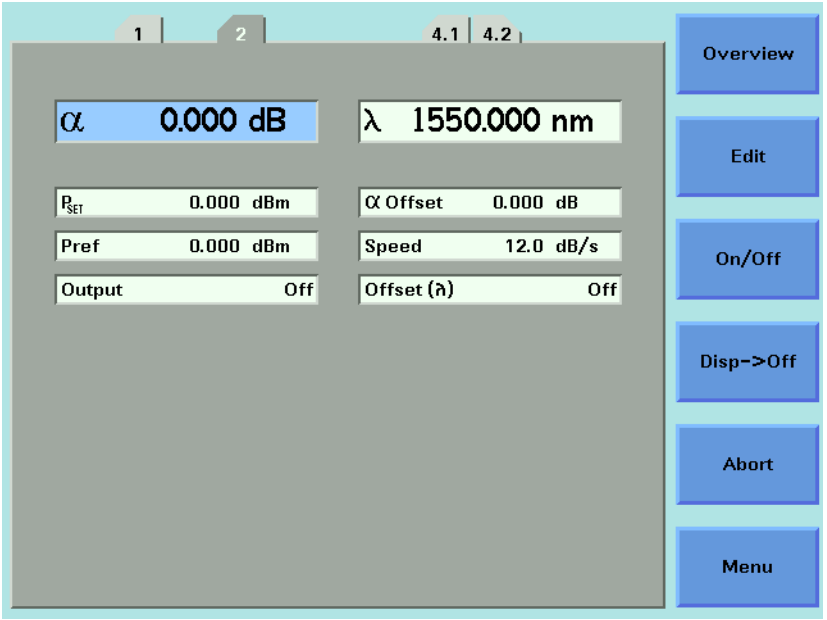



Figure 134 81570A/71A/73A Attenuator module, 8164A/B GUI Details

### Screen Elements

All the figures in this chapter are taken from an 8164A/B mainframe. The user interface for an 8163A, 8163B, 8166A or 8166B mainframe may display fewer elements. Use the equivalent menu selection instead.

### Number of Digits displayed

To select the number of significant decimal places displayed:

1 Press the [Menu] softkey.

2 Use the Cursor key to highlight <*Number of Digits*>, then press *Enter*.

3 Select <*1*>, <*2*>, <*3*> or <*4*>.

4 Press [OK], then press [Close].

### Power Units

To select the units used to display power values:

1 Use the Cursor key to highlight a power parameter ($P_{set}$ or $P_{ref}$ ), then press the [Pwr Unit] softkey.

2 Select <*W*> or <*dBm*>.

3 Press [OK].

The menu item <*Power Unit*> is functionally equivalent to the [Pwr Unit] softkey.

## How to Control the Shutter

The optical path of the Attenuator module is controlled by a shutter, which you can use both for protection purposes or to simulate channel drops.

When the shutter is open, the green LED on the attenuator module's front panel is lit.

### The Enable button

Press the *Enable* button, located on the front panel of the Attenuator module, to toggle the shutter state.

### The On/Off Softkey

Press the [On/Off] softkey to toggle the shutter state.

The menu item <*Output State*>, and the parameter [*Output*], is functionally equivalent to the [On/Off] softkey.

### Output at Startup

To select the shutter state at startup:

1 Press the [Menu] softkey.

2 Use the Cursor key to highlight <*Output at Startup*>, then press *Enter*.

3 Select <*Off* > or <*On*>.

4 Press [OK], then press [Close].

### Remote Interlock

The Attenuator module's shutter state is protected by mainframe's Remote Interlock (RIL) feature. The shutter cannot be opened if the 50W resistor is removed from the RIL connector on the back panel of the mainframe. See The Remote Interlock (RIL) connector on page 337.

## How to Set Attenuation

Before applying an attenuation factor, set the Attenuator module to the appropriate wavelength.

### 8157xA modules

The instrument utilizes a filter technology with a very low wavelength dependence. Nevertheless, for the best possible accuracy:

- If the source is of a particular wavelength, set the Attenuator module to that wavelength.
- If the source is a multi-wavelength DWDM signal, set the Attenuator module to the weighted wavelength of the spectrum.

Figure 135 on page -220 shows an attenuation factor α of 4.000 dB applied to a 1550nm source.

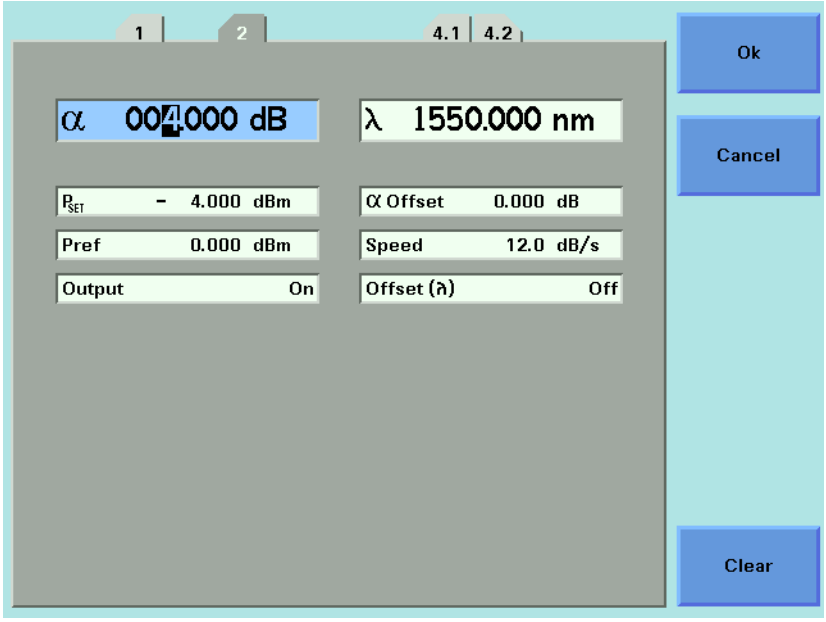



Figure 135 Attenuation factor set to 4.000 dB

To apply an attenuation factor:

1 Use the Cursor key to highlight the λ parameter, then press [Edit]
2 Use the Cursor key to enter the appropriate wavelength, in nm.
3 Press [OK].
4 Use the Cursor key to highlight the α parameter, then press [Edit].
5 Use the Cursor key to enter the required attenuation factor, in dB.
6 Press [OK].

### Filter Transition Speed

By default, the Attenuator's filter transitions to a new α setting as quickly as possible. If your test setup requires a slower filter transition speed, press [Menu], then select the <*Speed*> option. Select a speed between 0.1 and 12 dB/s, then press [OK].

While the Attenuator module is transitioning to a new setting, its status is shown as 'B' (or 'Busy').

**NOTE** Using very slow speeds may block this attenuator channel for several minutes.

---

**How to Apply an Attenuation Offset**

Attenuating an input signal to a DUT introduces additional connectors and other components into your optical test setup. An attenuation offset is typically applied to calibrate for the intrinsic insertion loss of these components. First you measure this insertion loss using a reference powermeter, then you compensate by entering the result into the Attenuator module's $\alpha_{\text{Offset}}$ parameter.

### 81570A/71A/73A/78A modules

1 Set the reference powermeter's λ parameter to the appropriate wavelength, its <*Power Unit*> to dB, and to an appropriate measurement <*Averaging Time*>.
2 Use a patchcord to connect the source output to the reference powermeter.
3 Press the powermeter's [Disp -> Ref] softkey. Power is now measured relative to this reference value, so the powermeter displays 0.000 dB

4 Set the Attenuator module's λ parameter to the appropriate wavelength. Set the Attenuator module's α parameter, the attenuation factor, to 0.000 dB.

5 Connect the source output to the Attenuator module input.

6 Use another patchcord to connect the Attenuator module output to the reference powermeter input.

7 Note the insertion loss measurement displayed by the powermeter.

8 Select the details screen for the Attenuator.

9 Use the cursor key to select the $\alpha_{Offset}$ parameter, then press [Edit].

10 Use the cursor key to enter the insertion loss measured at Step 7, then press [OK].

11 Disconnect the patchcord from the reference powermeter and connect it to the DUT input.

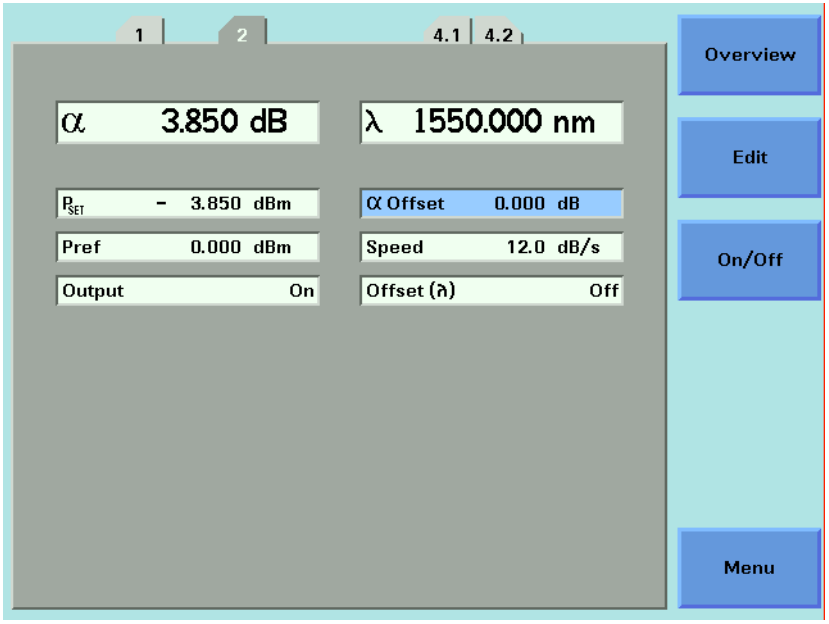



Figure 136 81570A/71A/73A - Attenuation factor applied with no offset

Figure 136 on page -222 shows an attenuation factor α of 3.850 dB applied with no $\alpha_{Offset}$.




Figure 137 81570A/71A/73A Attenuation Offset

Figure 137 on page -223 shows an $\alpha_{Offset}$ of 1.651 dB 'added in' to the attenuation factor $\alpha$ to calibrate for intrinsic insertion losses in the test setup.

### 81576A/77A modules

The [PM -> Off ] softkey offered by the $\alpha_{Offset}$ parameter is functionally equivalent to the [PM -> Off ] softkey offered by the $P_{Offset}$ parameter. You can use the [PM -> Off ] softkey to offset the difference between the power measured by the internal powermeter and your reference powermeter, as described Calibrating Test Setups that use an 81570A/71A/73A/78A Attenuator module on page 225.

- When the $\alpha_{Offset}$ parameter is selected, [PM -> Off ] writes to $\alpha_{Offset}$
- When the $P_{Offset}$ parameter is selected, [PM -> Off ] writes to $P_{Offset}$

These functions are mathematically identical.

Neither function is a measurement of total intrinsic insertion loss as described in 81570A/71A/73A/78A modules on page 221, since the insertion loss of the Attenuator module itself is not included.

#### The Dsp -> Off softkey

For all Attenuator modules, the [Dsp -> Off] softkey offered by the $\alpha$ parameter copies the negative of the current value of $\alpha$ into $\alpha_{Offset}$. The $\alpha$ field now displays zero, and 'Offs' is displayed to show that the offset has been applied.

You can now set the $\alpha$ parameter relative to $\alpha_{Offset}$.

### How to Set a Power Level

#### Single-wavelength signals

Set the $\lambda$ parameters to the wavelength of the source.

You can edit $P_{SET}$ to set the power output of the Attenuator directly.

#### Multi-wavelength DWDM signals

If you wish to set the output power of a multi-wavelength DWDM signal, use an 8157xA Attenuator module (rather than a now discontinued 8156xA Attenuator module) since these modules include a filter with minimum wavelength dependency.

The 81576A and 81577A modules incorporate a powermeter whose responsivity varies over wavelength. The module-specific response data is accessible via a computer interface, so an effective wavelength $\lambda_{effective}$ for your input signal's optical spectrum can be determined most readily, but not exclusively, by using the hp816x VXI PnP Spectral Calibration function (hp816x_spectralCalibration).

Refer to:

- Measuring the Dependence of Optical Amplifiers on Input Power Using an Attenuator. Application Note.
  Keysight Technologies publication number 5988-5260EN.
- 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, and 8166A/B Lightwave Multichannel System, Programming Guide, part number 08164-90B65 (or a later edition).

**NOTE** **For accurate power measurements, the simple weighted wavelength of a multi-wavelength DWDM signal is insufficient.**

## Calibrating Test Setups that use an 81570A/71A/73A/78A Attenuator module

### Requirement for Calibration

$P_{SET}$ is a relative measurement that is meaningful only after your test setup has been calibrated against a reference powermeter.

### Preconditions

- To make the calibration as quick and simple as possible, host your reference powermeter in the same mainframe as the Attenuator module, as described in Hosting a Reference Powermeter on page 217.
- Before taking a power measurement, make sure the source is warmed up so that its power output is stable.
- It is good practice to zero the reference powermeter before calibrating your test setup. Refer to How to Remove Electrical Offsets on page 106.

### Calibration Procedure

To calibrate a test setup that utilizes an 81570A/71A/73A/78A Attenuator module, first measure the power applied by your test set up to the DUT input, then store this value as the Attenuator's $P_{ref}$ parameter.

After calibration, you edit the Attenuator's $P_{SET}$ parameter to set the power applied to the DUT.

1 Disconnect the DUT input in your test setup and connect it to your reference powermeter.
   - Set the λ parameter for the reference powermeter to the source wavelength or, for a multi-wavelength DWDM signal, the effective wavelength $\lambda_{effective}$
   - Set an appropriate measurement <*Averaging Time*>.

2 Display the details screen for the Attenuator module.

   Make sure the l parameter set for the Attenuator module matches the source wavelength or, for a multi-wavelength DWDM signal, $\lambda_{effective}$ .

3 If the reference powermeter is hosted by the same mainframe as the Attenuator module:
   - Select the $P_{ref}$ field,
   - Press the [PM-> ref ] softkey,
   - Select the channel used to host your reference powermeter,
   - Press [OK].

The power value measured by your reference powermeter is copied to the Attenuator and stored as $P_{ref}$ .

4 If the reference powermeter is hosted by another mainframe:
   - Manually enter the value of $P_{ref}$ such that $P_{SET}$ equals the power value measured by your reference powermeter.
5 Disconnect the input to the reference powermeter, then connect it to the DUT input.
6 Edit the $P_{SET}$ parameter to set the power applied to the DUT.

The attenuation, $\alpha$ , displayed is updated to reflect the new $P_{SET}$ value.

**NOTE**

**Your calibration is valid until there is some change to the power applied to the input of the Attenuator module. For example, if you change the optical path to the Attenuator module, you must recalibrate.**

**For a multi-wavelength DWDM signal, your determined effective wavelength l effective is valid until there is some change to the signal's optical power vs wavelength spectrum.**

### Calibrating Test Setups that use an 81576A/77A Attenuator module

#### Requirement for Calibration

81576A/77A Attenuator modules with Power Control incorporate a powermeter that allows you to control the output power level of the module. After calibration for the losses in the patchcords and connectors between this output and the DUT input, you can set absolute power levels at the DUT input.

Furthermore, when the Attenuator's Power Control feature is enabled, the Attenuator module automatically corrects for power changes at its input to maintain your desired output power.

#### Preconditions

- To make the calibration as quick and simple as possible, host your reference powermeter in the same mainframe as the Attenuator module, as described in Hosting a Reference Powermeter on page 217.
- Before taking a power measurement, make sure the source is warmed up so that its power output is stable.
- It is good practice to zero the powermeters in your test setup . Refer to Hosting a Reference Powermeter on page 217.
- To zero the powermeter incorporated in the Attenuator module, press [Menu] , then select <*Zero*>.

- To zero all the powermeters hosted by the same mainframe as the Attenuator module (including the Attenuator module and, for example, the powermeter incorporated in a return loss module), press [Menu] , then select <*Zero All*>.
- To set the measurement Averaging Time used by the powermeter incorporated in the Attenuator module, press [Menu] , select <*Averaging Time*>, press [OK], select your preferred Averaging Time, press [OK], then press [Close].
- As with any powermeter, a longer Averaging Time increases accuracy and noise rejection, but increases response time.

### Calibration Procedure

The power level measured by the integrated powermeter at the output of the module is displayed as $P_{actual}$. To calibrate your test setup, you apply a $P_{Offset}$ to calibrate for the patchcord and connector losses that occur between the Attenuator module output and the DUT input.

After calibration, you edit the Attenuator's $P_{SET}$ parameter to control the absolute power applied to the DUT.

1 Disconnect the DUT input in your test setup and connect it to your reference powermeter.
   - Set the λ parameter for the reference powermeter to the source wavelength or, for a multi-wavelength DWDM signal, the effective wavelength $\lambda_{effective}$
     Refer to Multi-wavelength DWDM signals on page 224.
   - Set an appropriate measurement <*Averaging Time*>.
2 Display the details screen for the Attenuator module.
   - Make sure the λ parameter set for the Attenuator module matches the source wavelength or, for a multi-wavelength DWDM signal, $\lambda_{effective}$ .
   - Make sure that the Averaging Time set for the integrated powermeter matches that set for the reference powermeter.
3 If the reference powermeter is hosted by the same mainframe as the Attenuator module:
   - Select the $P_{Offset}$ field,
   - Press the [PM-> Off ] softkey,
   - Select the channel used to host your reference powermeter,
   - Press [OK].

The difference between the power level measured by your reference powermeter and the power value measured by your Attenuator $P_{actual}$ is stored by the Attenuator module as $P_{Offset}$ , then applied to $P_{SET}$ and $P_{actual}$ .

4 If the reference powermeter is hosted by another mainframe:
   - Manually enter the value of $P_{Off}$
   - $P_{Off} = P_{actual} - P_{ref}$
   - where $P_{ref}$ is the power level measured by your reference powermeter.

5 Disconnect the input to the reference powermeter, then connect it to the DUT input.

6 Edit the $P_{SET}$ parameter to control the absolute power applied to the DUT. The attenuation, $\alpha$ , displayed is updated to reflect the new $P_{SET}$ value.

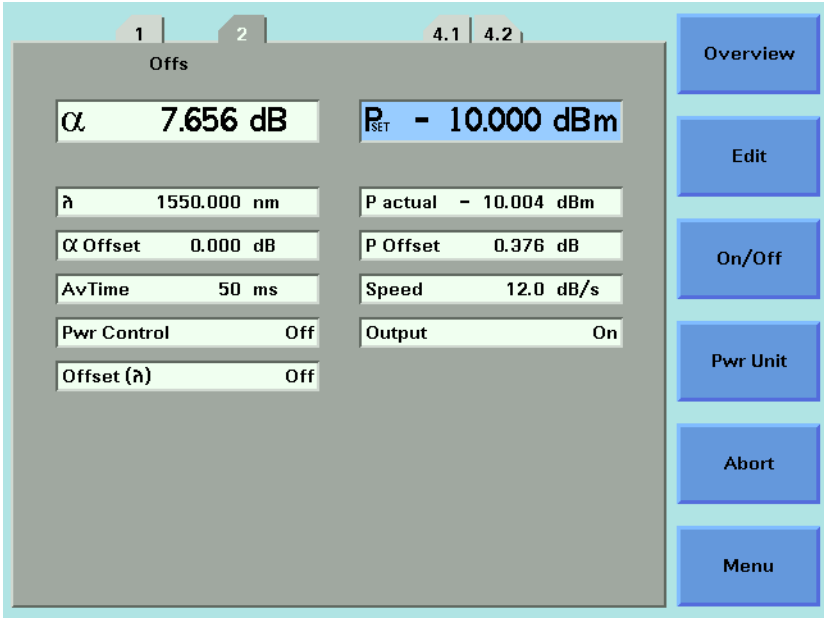



Figure 138 81576A/77A Setting $P_{SET}$ after calibration using [PM->Off]

Figure 138 on page -228shows an absolute power $P_{SET}$ of -10 dBm applied to a DUT. Here:

- A power offset $P_{Offset}$ of 0.376 dB is applied to calibrate for losses between the Attenuator and the DUT.
- An attenuation factor $\alpha$ of 7.656 dB is applied by the Attenuator's filter.

**NOTE**

Your calibration is valid until there is some change to the optical path between the Attenuator module and your DUT. Changes to the power applied to the input of the Attenuator module are detectable by the integrated powermeter.

For a multi-wavelength DWDM signal, your determined effective wavelength l effective is valid until there is some change to the signal's optical power vs wavelength spectrum.

If either too much, or too little, input power is applied for the Attenuator to maintain your desired P SET, the Attenuator status display includes 'Exp'.

Refer to How to Use the Power Control Feature on page 78 for information about compensating for changes in input power.

## How to Compensate for Wavelength Dependencies in your test setup

To allow you to compensate for wavelength dependencies in your test setup, your attenuator module can store an array of up to 1000 wavelength: Offset pairs in a λ Offset Table.

**How to Apply a λ Offset Table**

Select the [*Offset* (λ)] parameter to enable or disable the Wavelength Offset Table <*On*> or <*Off* >.

The Menu item <*Offset (λ)* > is functionally equivalent to the [*Offset* (λ)] parameter.

**Editing the λ Offset Table**

If you have previously characterized the output path:

1 Press the [Menu] softkey.

2 Set <*Offset* (λ) > to <*off* >.

You cannot edit the λ Offset Table if the Offset (λ) function is on.

3 Press the [Table] softkey (or select the Menu item <*Offset Table*>)

- For an 8164A/B mainframe, the first three λ Offset Table entries are displayed.
- For an 8163A/B mainframe, or an 8166A/B mainframe, the first λ Offset Table entry is displayed.

If there are no entries, the message “Offset Table is Empty” is displayed.

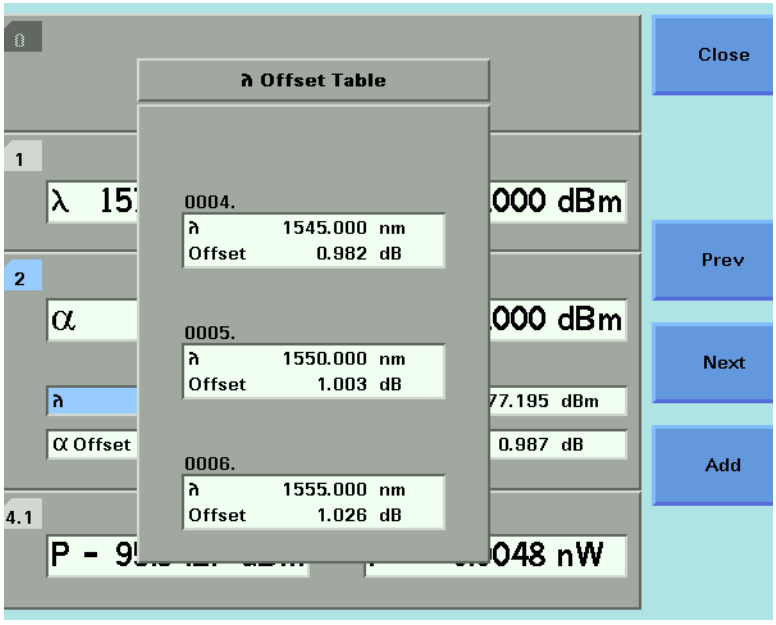



Figure 139 The λ Offset Table

Figure 139shows the fourth, fifth and sixth entries in a λ Offset Table displayed on an 8164A/B mainframe.

- To display the previous three entries, press the [Prev] softkey.
- To display the next three entries, press the [Next] softkey.

4 Press the [Add] softkey.

- Enter the wavelength λ.
- Select, then enter the corresponding Offset

5 Press [OK] to store the result in the λ Offset Table.

- The λ Offset Table is automatically ordered by wavelength, there is no need to enter wavelenght; offset pairs in any particular order.
- To edit the offset applied to an existing entry, use the cursor key to select its λ field, press [Add], enter the new offset, then press [OK].
- To remove an existing entry, use the cursor key to select its λ field, then press [Del]. The indices of the remaining table entries are automatically updated; [Del] does not leave a blank entry.

### How to Construct a λ Offset Table

The procedures used to store the results of wavelength calibration process using GP-IB commands are outlined in our Application Note 5988-3159EN: “Variable Optical Attenuator in BER Test Applications”.

For simplicity, the following manual procedure assumes your reference powermeter is hosted by the same mainframe as the Attenuator module, as described in Hosting a Reference Powermeter on page 217.

For each wavelength of interest:

1 Set the source to the wavelength of interest.

2 Set the attenuator’s λ parameter to this wavelength.

3 Set the reference powermeter to this wavelength.

4 Press the [Menu] softkey.

5 Set <*Offset* (λ) > to <*off* >.

You cannot edit the λ Offset Table if the Offset (λ) function is on.

6 Press the [Table] softkey (or select the Menu item <*Offset Table*>)

7 Press the [Add] softkey.

- Enter the wavelength λ.
- Select <*Offset*>
- Press the [PM -> off] softkey.
- Select the channel used to host the reference powermeter.
- Press [OK] to confirm.

The difference between the power measured by the Attenuator module’s integrated powermeter and that measured by the reference powermeter is stored in the λ Offset Table as a wavelength:Offset pair.

8 Press [OK] to store the result in the λ Offset Table.

9 Press [Close].

**NOTE** If your Attenuator module is not hosted by the same mainframe as your reference powermeter you can, at step 7, enter the appropriate Offset manually.

During a test that utilizes the λ Offset Table

When the Offset (λ) feature is on the exact offset applied depends on how the operating wavelength λ you set for the Attenuator module relates to the λ Offset Table entries, as shown in Figure 140 on page -232.

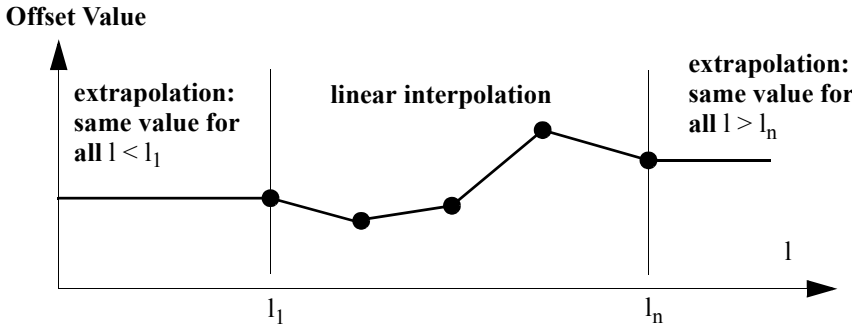



Figure 140 Extrapolation and Interpolation of Offset Values

- If the operating wavelength matches a wavelength stored in the λ Offset Table, the exact offset value is used. The Attenuator status display includes 'Exa'.
- If the operating wavelength is between two wavelengths stored in the λ Offset Table, the offset applied is calculated by linear interpolation. The Attenuator status display includes 'Int'.
- If the operating wavelength is greater than, or less than, the range of wavelengths stored in the λ Offset Table, the offset value for the closest wavelength is extrapolated. The Attenuator status display includes 'Ext'.

## How to Use the Power Control Feature

81576A/77A Attenuator modules incorporate Power Control functionality that automatically corrects for power changes at its input to maintain your desired output power.

This feature is designed to compensate, for example, for output power drift by the source.

When Power Control is On:

- If $P_{actual}$ deviates by more than 0.1 dB from your desired $P_{SET}$ value, the Attenuator module automatically restores $P_{SET}$ at the maximum possible filter transition speed of 12 dB/s.
- Input power is measured using your set Averaging Time.
- To avoid 'hunting', and consequent wear on the filter motor mechanism in response to an unstable source, for differences between $P_{SET}$ and $P_{actual}$ greater than 0.01 dB, but less than 0.1 dB, $P_{SET}$ is updated approximately every 30 s.
- The Attenuator module does not respond to a power difference of 0.01dB or less. Such a change is regarded as noise.
- If the attenuation is driven beyond 0 dB, Exp ("Excessive Power") is displayed. There is now insufficient input power for the Attenuator to maintain your desired $P_{SET}$.

### Power Control On/Off

To enable or disable Power Control, select the [*Pwr Ctrl*] parameter.

When Power Control is On the Attenuator's status display includes 'PC'.

The Menu item <*Pwr Control*> is functionally equivalent to the [*Pwr Control*] parameter.

## Attenuator Menu Options

### 81570A/71A/73A Menu Options

Press the [Menu] softkey to display the window shown in Figure 141 on page -234.

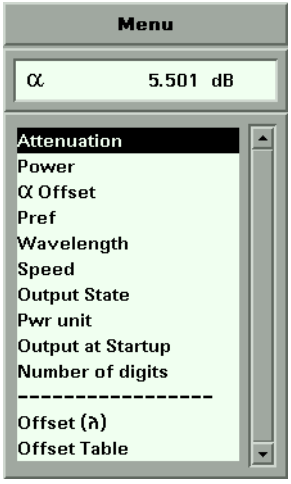



Figure 141 81570A/71A/73A Attenuator Menu Options

### 81576A/77A Menu Options

Press the [Menu] softkey to display the window shown in Figure 142 on page -235:

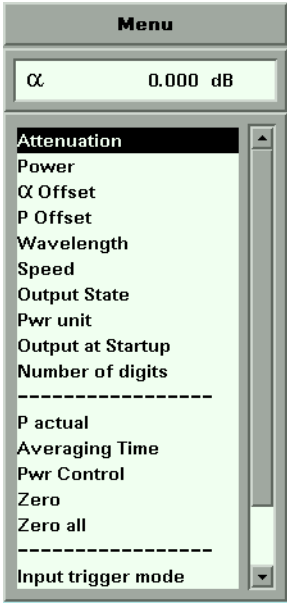



Figure 142 81576A/77A Attenuator Menu Options

- Use the Cursor key to scroll to two additional options: <*Offset* (λ)>, and <*Offset Table*>.
- The <*P actual*>, <*Averaging Time*>, <*Zero*>, <*Zero all* >, and <*Input trigger mode*> options are associated with the Attenuator's integrated powermeter.
- For more information about the <*Input trigger mode*> option, refer to How to Use Triggers on page 119.

## Attenuator Status Indicators

| Status Indicator | Description |
|---|---|
| B (or Busy) | The Attenuator's filter is transitioning to a new setting. |
| Offs | Any combination of an a offset, P offset, or Offset ($\lambda$) has been applied. |
| Exa | An exact $\lambda$ offset has been applied. |
| Int | An interpolated $\lambda$ offset has been applied. |
| Ext | An extrapolated $\lambda$ offset has been applied. |
| PC | The Power Control feature is on (81576A/77A) |
| Exp (81566A/67A/76A/ 77A only) | There is either too much, or too little, input power for the Attenuator module to set or maintain your desired $P_{SET}$. |
| RiL | The Remote Interlock Connector of your mainframe is open. No measurement is possible until the connection at the Remote Interlock Connector closes. |

# 9 Switching Optical Routes

Keysight 8159xB Optical Switch modules / 238
How to Use an Optical Switch module / 240
Typical Applications / 244

This chapter explains how to use the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, or 8166A/B Lightwave Multichannel System together with the 8159xB family of Optical Switch modules to change optical routes during a test without having to disconnect and reconnect fibers.

Here you will find:

- A brief description of the modular Keysight 8159xB Optical Switch family,
- Some examples of typical test configurations that utilize these Optical Switch modules.

# Keysight 8159xB Optical Switch modules

The Keysight 8159xB Optical Switch family includes 1x2 Switch modules, 2x2 Switch modules, and 1x4 Switch modules. The switches are available in single-mode version (option 009) with angled 9/125 µm FC/APC connector interface or multimode version (option 062) with straight 50/125 µm FC/PC connector interface.

The discontinued 81591A, 81591S, 81592A, 81592S, 81594A, 81594S, and 81595A, 81595S are fully supported by the 816xA/B mainframes.

**Table 15 The Keysight 8159xB Optical Switch family**

| Module | Description |
|---|---|
| 81591B | Optical Switch, 1x2 |
| 81594B | Optical Switch, 2x2 non-blocking (crossover) |
| 81595B | Optical Switch, 1x4 |

## Options

Option 009:

Single-mode 9/125 µm, fixed FC/APC connector interfaces.

Option 062:

Multimode 50 (62.5)/125 µm, fixed FC/PC connector interfaces.




Figure 143 Keysight 81595B Optical Switch module ( 1x4, angled contact connectors)

# How to Use an Optical Switch module

## The User Interface

### The Overview Display

Figure 144 on page -240 is an Overview screen taken from an 8164A/B mainframe.

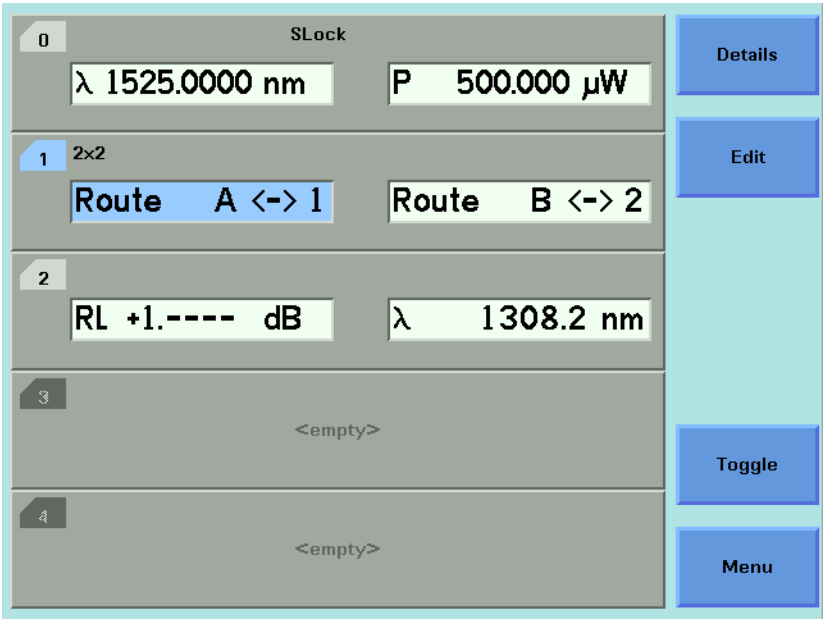



Figure 144 Optical Switch module, User Interface Overview display

Here:

- Slot 0 hosts a backloadable tunable laser,
- Slot 1 hosts a Keysight 81594B 2x2 non-blocking (crossover) switch,
- Slot 2 hosts a return loss module.

### The Optical Switch Details Display

To display the full user interface for the Optical Switch module, as shown in Figure 145 on page -241, use the Cursor key to highlight the Optical Switch slot, then press the [Details] softkey:

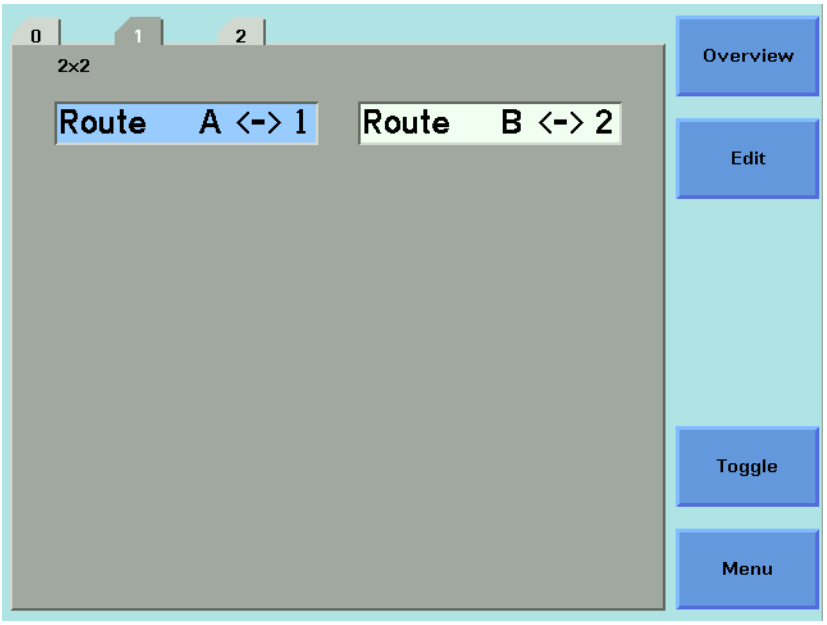



Figure 145 Optical Switch module, 8164A/B User Interface Details

### Screen Elements

All the figures in this chapter are taken from an 8164A/B mainframe. The user interface for an 8163A, 8163B, 8166A or 8163B mainframe may differ in detail but the available functionality is identical.

### Configuration

The Optical Switch configuration is indicated at the top left of the user interface.

In Figure 145 on page -241, 2x2 indicates that this is a 81594B 2x2 non-blocking (crossover) switch.

### Route

The [*Route A* <->] field describes the route between port A and another numbered port within the Optical Switch module.

If present, the [*Route B* <->] field describes the route between port B and another numbered port within the Optical Switch module.

In Figure 145 on page -241:

- The [*Route A* <->] field shows that, within the Optical Switch module, port A is connected to port 1.
- The [*Route B* <->] field shows that, within the Optical Switch module, port B is connected to port 2.

**NOTE** **For all switch modules the signal paths are bi-directional.**

## Dependent and Independent Routing

### Dependent Routing

If Route A <-> is dependent on Route B <->, editing the number of the port assigned to Route A <-> automatically updates the number of the port assigned to Route B <->.

For example, a 81594B 2x2 non-blocking (crossover) switch has two routes described by [*Route A* <-> *1*] [*Route B* <-> *2*] and [*Route A* <-> *2*] [*Route B* <-> *1*].

### Independent Routing (Only possible for discontoninued 81592A/S switch modules)

If Route A <-> is independent of Route B <->, there are two separate switched channels. There are two numbered ports that you can assign to Route A, and two separate numbered ports that you can assign to Route B.

For example, a 81592B dual 1x2 switch allows you to switch Route A <-> to [*Route A* <-> *1*] or [*Route A* <-> *2*], and Route B <-> to [*Route B* <-> *1*] or [*Route B* <-> *2*].

## How to set Route A

To switch the route between port A and another numbered port:

1 Use the Cursor key to highlight [*Route A* <->], then press *Enter*.

2 Use the Cursor key to enter the number of the port required.

If the Switch module incorporates independent routing, you cannot select a numbered port assigned to port B.

3 Press [OK].

If the switch module has dependent routing, [*Route B* <->] is updated automatically.

The [Edit] softkey is functionally equivalent to the *Enter* hardkey.

The [Menu] softkey allows you to assign a route for port A and port B in turn.

How to set Route B

To switch the route between port B and another numbered port:

1 Use the Cursor key to highlight [*Route B* <->], then press *Enter*.

2 Use the Cursor key to enter the number of the port required.

If the Switch module incorporates independent routing, you cannot select a numbered port assigned to port A.

3 Press [OK].

If the switch module has dependent routing, [*Route A* <->] is updated automatically.

The [Edit] softkey is functionally equivalent to the *Enter* hardkey.

The [Menu] softkey allows you to assign a route for port A and port B in turn.

How to Toggle the Switch path

You can use [Toggle] softkey, or the *Toggle* button located on the Optical Switch module front panel, to select each of the available routes for a channel in turn.

**NOTE**

**The route selected between port A and another numbered port is indicated in the user interface and by two lit green LEDs on the front panel of the Optical Switch module.**

**The route selected between port B, if present, and another numbered port is indicated in the user interface, and by two lit amber LEDs on the front panel of the Optical Switch module.**

# Typical Applications

This section provides some examples of typical test configurations that demonstrate how a 8159xB Optical Switch module can be used to achieve test automation, and improve test repeatability.

## Selecting a Laser Source

In Figure 146 on page -244, a 81591B 1x2 Optical Switch is used to select one of two different sources (different wavelengths) as the input to the DUT.

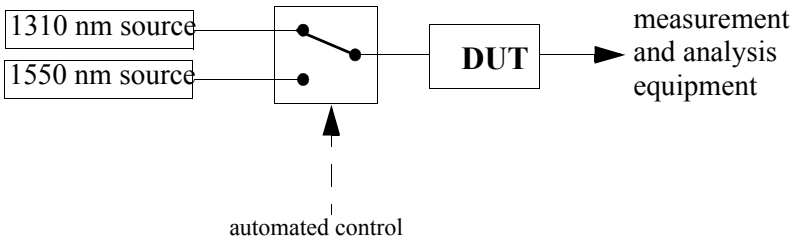



Figure 146 Laser Source selection

## Selecting Measurement and Calibration Paths

In Figure 147 on page -244, a 81591B 1x2 Optical Switch is used to select between the measurement path and the calibration path.

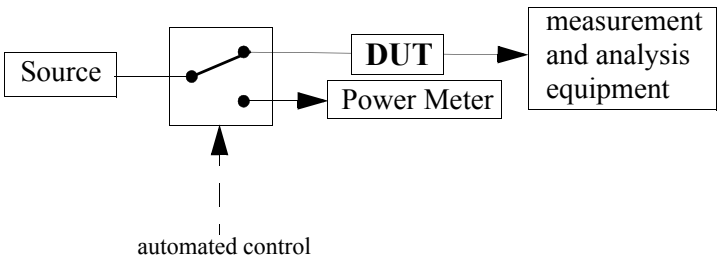



Figure 147 Measurement Path selection

### Inserting or Bypassing an Optical Component

In Figure 148 on page -245, a 81594B 2x2 non-blocking (crossover) Optical Switch is used to insert or bypass a fiber spool.

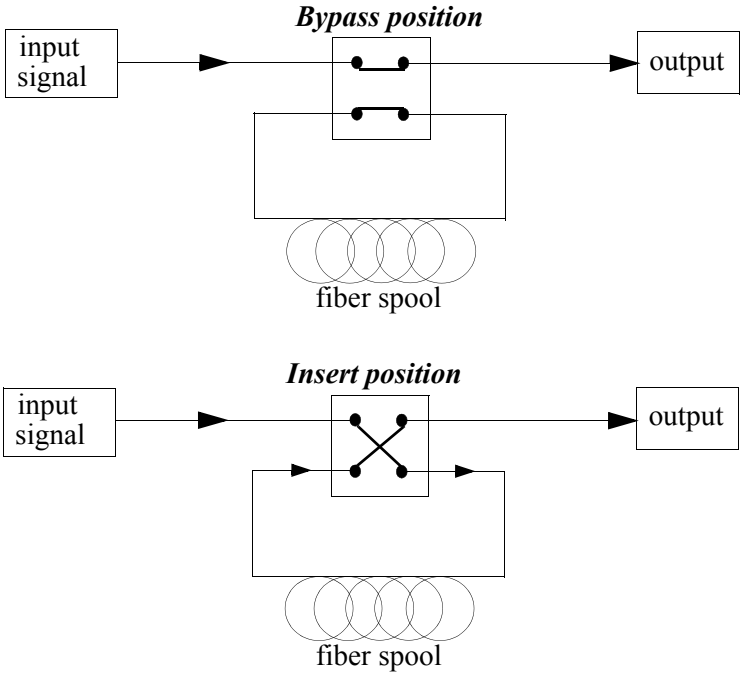



Figure 148 Circuit selection with crossover switch

### Selecting one of several DUTs in a parallel test setup

In Figure 149 on page -246, two 81595B 1x4 Optical Switches are used to select one of up to four DUTs in a parallel test setup

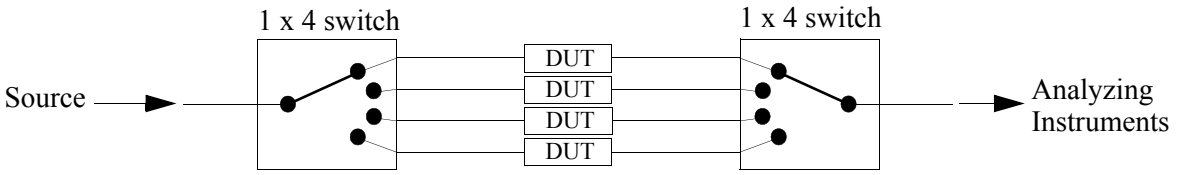



Figure 149 DUT selection in a parallel test setup

### Selecting one of several instruments

In Figure 150 on page -246, a 81595B 1x4 Optical Switch is used to select one of up to four analysing instrument.

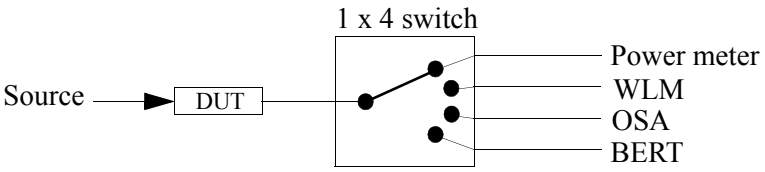



Figure 150 Test instruments selection

In each case, the advantages to be gained from using switch modules include speedier changes to the test setup, and improved measurement repeatability.

# 10 Applications

Working with Application Graphs / 249
The Logging Application / 261
The Stability Application / 274
The PACT Application / 287
The Pmax Curve / 302
The Return Loss Application / 303
Recording Measurement Results / 307

This chapter explains how to set up and perform the following applications using the 8163A/B Lightwave Multimeter or 8164A/B Lightwave Measurement System:

- The Logging application logs and displays power measurements. The Logging application performs measurements consecutively without the possibility of any pause between measurements.
- The Stability application logs and displays power measurements. The Stability application differs from the Logging application because:
  - you may use auto-ranging mode, and
  - the period time, the time it takes from the start of one measurement period until another measurement period starts, may be greater than or equal to the averaging time.
- The PACT application coordinates a wavelength sweep using a Tunable Laser module and power measurement using Power Meters.
- The Pmax Curve application displays the maximum power across the wavelength range of your Tunable Laser module.
- The Return Loss application can be used to measure return loss and insertion loss and to calibrate the instrument for this measurement.

**NOTE** These simple applications do not offer the full functionality of all the instruments, which is better accessed with remote programming.

**NOTE** These applications are not available for the 8166A/B Lightwave Multichannel System. The Return Loss Application is only available for the 8163A/B Lightwave Multimeter.

You can access these applications by pressing the Appl hardkey.

**NOTE** After you exit from the application, any modules that were available for use by these applications will automatically be preset, all parameters will be set to their default values.

## Working with Application Graphs

If you press the [Graph] softkey, a graph similar to Figure 151appears. This section explains how to use the graph.

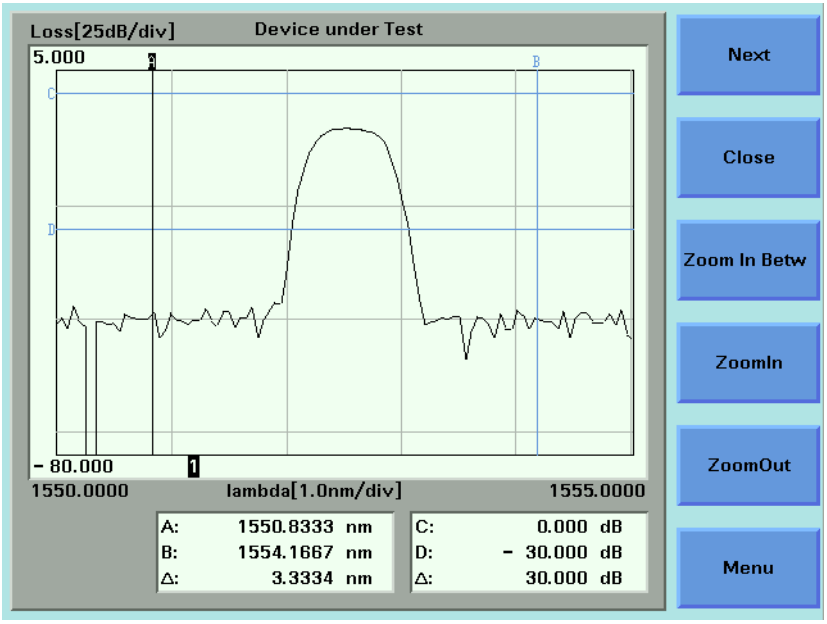



Figure 151 The Application Graph

There are four markers A, B, C, and D. You can use these markers to choose the area of the graph that you wish to zoom into.

For the Logging and Stability applications, the time values of A and B are displayed at the bottom of the screen in units of seconds. The symbol Δ that is listed directly beneath these values, displays the difference between A and B in seconds.

For the PACT application, the wavelength values of A and B are displayed at the bottom of the screen in units of nanometers (nm). The symbol Δ that is listed directly beneath these values, displays the difference between A and B in nanometers (nm).

The power values of C and D are displayed at the bottom of the screen in the chosen power units. The symbol Δ that is listed directly beneath these values, displays the difference between C and D in the chosen power units.

**NOTE** As a default, the C and D markers are out of range when you first open a graph. See How to Set Markers on page 250, for more information on setting moving markers.

How to Set Markers

To position a marker:

1 Move to the marker by pressing [Next], the *Enter* hardkey, or the Modify Knob repeatedly until the marker is selected.

2 You can change the position of a marker in one of the following ways:

- Press [Menu], move to <*Set Active Marker*>, and press *Enter*. The current setting for the selected marker appears. Edit this value to your required value and press *Enter*.
- For A or B, use the left and right cursor keys to position the marker.
- For C or D, use the up and down cursor keys to position the marker.
- Use the Modify Knob to position the marker, this is quicker than using the cursor keys.

**NOTE** The Modify Knob is only available for the 8164A/B Lightwave Measurement System.

How to Zoom In

To zoom in one level around the active marker:

1 Press the [Next] softkey until you move to your chosen marker.

2 Position the marker using the cursor key.

3 Press the [ZoomIn] softkey to zoom in one level around the active marker. In this way, you can zoom in around the active marker and the zoom function is separate for the x and y axes.

You can also zoom in between markers:

1 Set each marker as described above in Figure How to Set Markers on page 250.

2 Press the [Zoom In Betw] softkey to zoom in between the markers.

### How to Zoom Out

To zoom out one level around the active marker:

1 Press the [Next] softkey until you move to your chosen marker.

2 Position the marker using the cursor key.

3 Press the [ZoomOut] softkey to zoom out one level from the active marker. In this way, you can zoom out from the active marker and the zoom function is separate for the x and y axes.

To zoom out to the fullest extent:

4 Press the [Menu] softkey. The menu appears.

5 Move to <*Zoom to Overview*>.

### To Switch the Grid On/Off

As a default, the graph is displayed with gridlines.

To switch this grid off:

1 Press the [Menu] softkey. The menu appears.

2 Move to <*Grid Off*>.

If the grid has been switched off, to switch the grid on:

1 Press the [Menu] softkey. The menu appears.

2 Move to <*Grid On*>.

### How to Use Legends

Legends are used to identify Power Meter channels on the graph in the following ways:

- Legend numbers that are displayed on the graph.
- Legend texts can be accessed by pressing the [Menu] softkey and moving to <*Legend*>.

#### How to Identify Curves

Legend numbers can be related to the curves they represent in the following ways:

- For the 8163A/B Lightwave Multimeter the legend number is displayed at the same height as the first sample of the power measurement channel on the right-hand side of the screen.
- For the 8164A/B Lightwave Measurement System, the legend numbers are directly beneath the graph. Each number is the same colour as the curve it represents.

### How to Change the Legend Label

To change the legend label:

**NOTE** You cannot edit a legend label while a measurement is running.

1 Press the [Menu] softkey and move to <*Legend*>. A list of the Power Meter channels appears that is similar to Figure 152 on page -252, where all the Power Meters are listed numerically with regard to legend number. All legend texts, if you have not previously edited the legend text, are of the "PM *x.y*", where *x* represents the slot number and *y* represents the channel number.

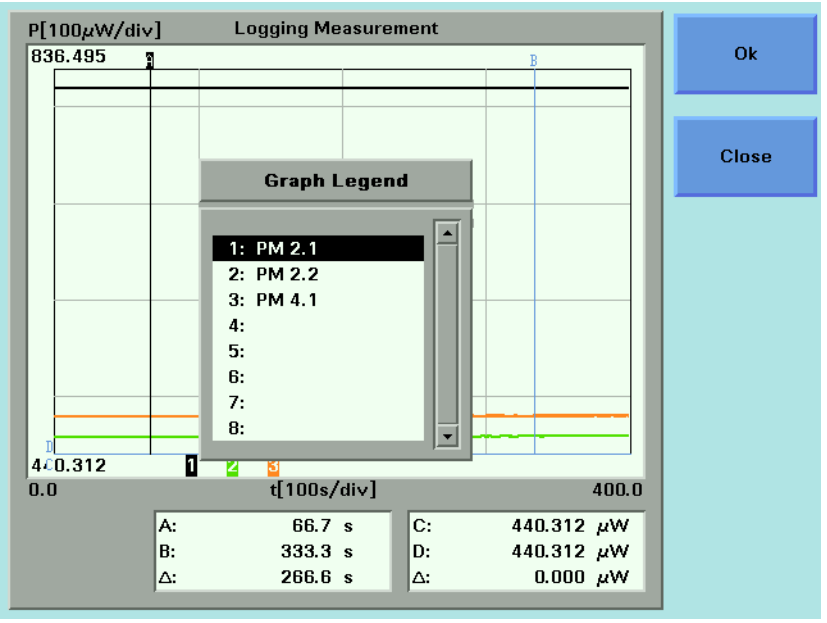



Figure 152 The Graph Legend Screen

2 Move to the legend number you wish to edit using the cursor keys and press *Enter*. The on-screen keyboard appears.

3 Use the on-screen keyboard to edit the legend label and press *Enter*.

The on-screen keyboard uses the following softkeys:

- Move to the required character using the cursor keys and press the [Select] softkey to select to add the selected character to the end of the legend label.
- Press the [Delete] softkey to delete the last character of the legend label.
- Press the [CapsLock] softkey to toggle between upper and lower case characters.
- Press the [Cancel] to reject the edited legend label and return to the menu.
- Press the [OK] to accept the edited legend label and return to the menu.

### How to Select the Samples Display

The samples display determines how the curves of the graph are represented. To choose the samples display:

1 Press the [Menu] softkey and move to <*Samples Display*>. A box displaying the following options appears:

- <*Line*> - the curve will be displayed using a line that connects between each sample of the curve.

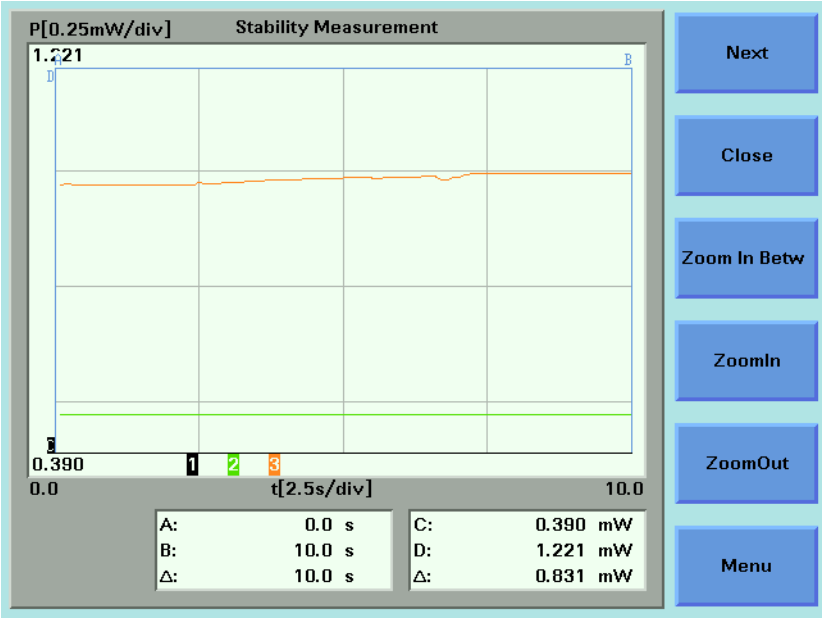



Figure 153 Samples Display - <*Line*>

- <*Samples*> - the curve will be displayed using dots to represent each sample of the curve. Depending on the zoom level you choose, if these dots are very close to each other, the curve will resemble a line.

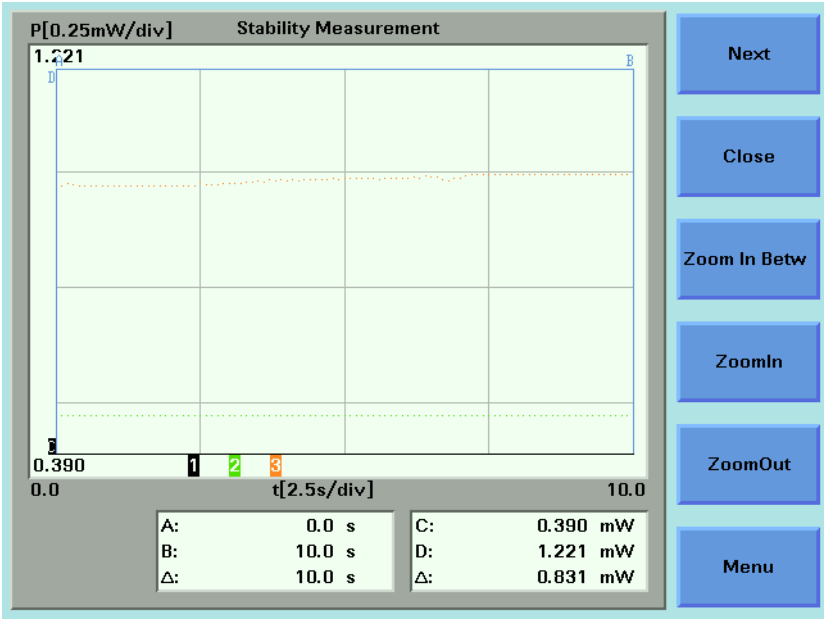



Figure 154 Samples Display - <*Samples*>

- <*Samples & Line*> - the curve will be displayed using both symbols for each sample of the curve and a line connecting each sample.

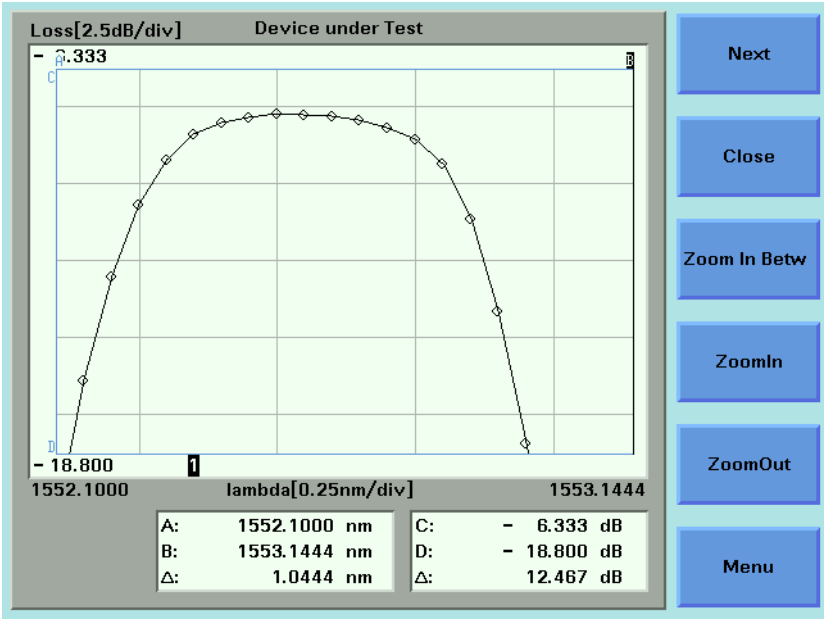



Figure 155 Samples Display - <*Samples & Line*>

2 Move to your selected option and press *Enter*.

3 Press the [Close] softkey to return to the graph.

## How to Read Curve Values

You can lock markers A or B to a curve in order to move between individual samples. In this way, you can read the time/wavelength and power values that relate to each sample and the difference between these values for markers A and B.

### How to Lock Markers to the Curve

You can lock markers A and B to curves by performing the following instructions:

1 Press the [Menu] softkey and move to <*Lock to Curve*>. A menu displaying the options displayed in The Lock to Curve Menu on page 257 appears.

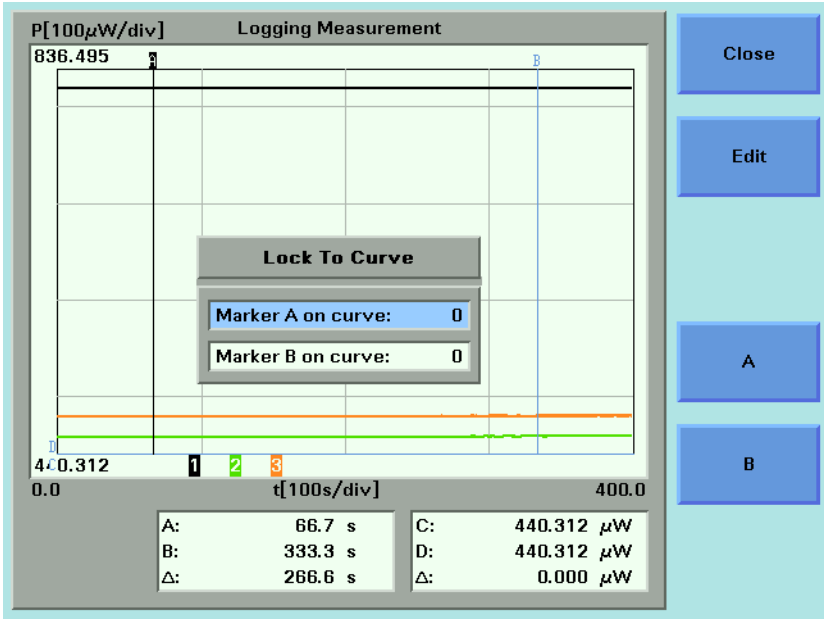



Figure 156 The Lock to Curve Menu

2 Press the [A] softkey to lock marker A to a curve. The number opposite **Marker A on curve:** is highlighted.

3 Use the cursor key to move to the legend number of the curve to which you want to lock marker A.

4 Press *Enter*. Marker B will be locked to the same curve as marker A, if it was assigned to curve 0 immediately before, that is, it was unassigned immediately before.

5 If you want to assign marker B to another curve, press the [B] softkey, use the cursor key to move to the legend number of the curve to which you want to lock marker B, and press *Enter*.

6 Press Close to return to the graph.

### How to Unlock Markers from the Curve

You can unlock markers A and B from the curve by performing the following instructions:

1 Press the [Menu] softkey.

2 Move to <*Unlock From Curve*> and press *Enter* to return to the graph.

### How to Lock/Unlock Markers to Samples

You can choose to lock the markers to samples, that is, the results that are returned are actual measurement results.

Figure 157 on page -258shows a graph where markers A and B are locked to samples. If you press the cursor key, the marker will move to another sample.

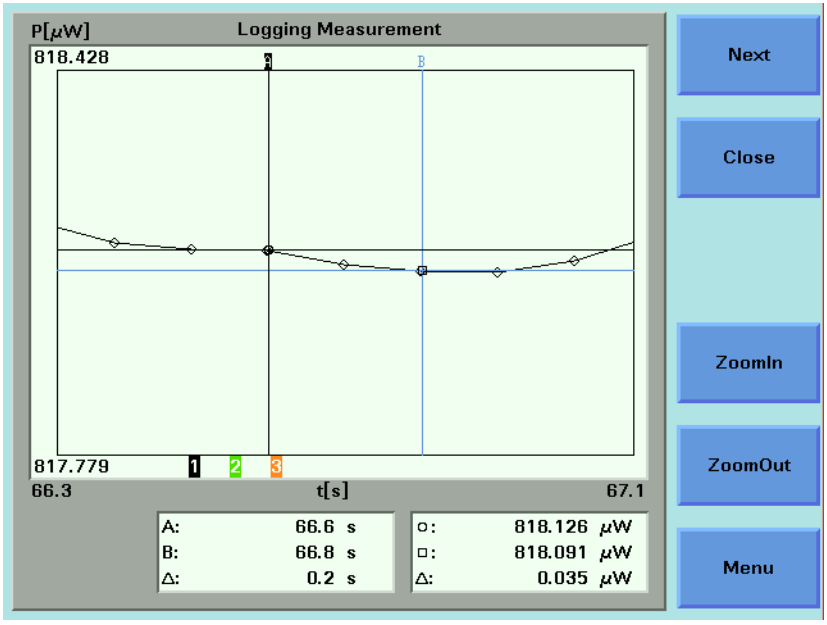



Figure 157 Lock to Samples On

Figure 158 on page -259shows a graph where markers A and B are not locked to samples. If you press the cursor key, the marker will move along the curve.

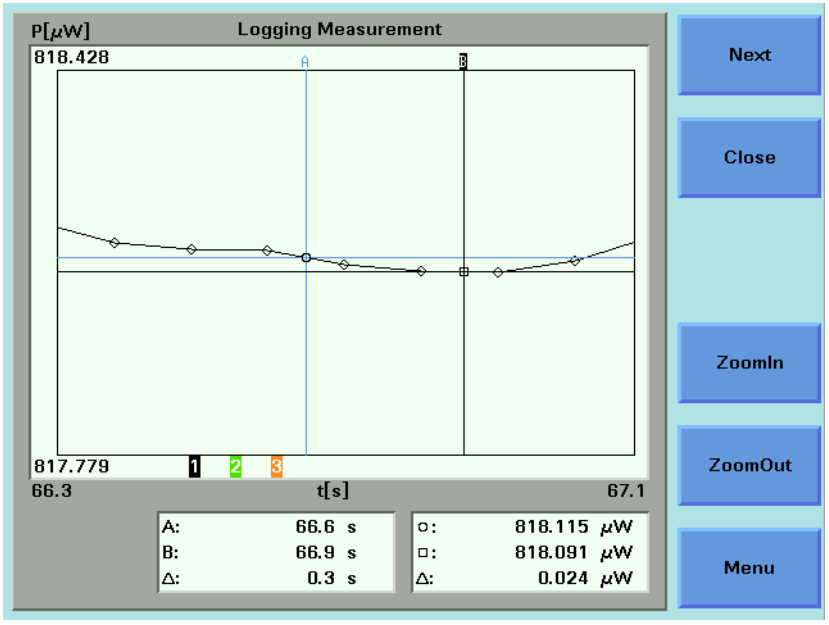



Figure 158 Lock the Samples Off

**NOTE** You can only lock/unlock markers to samples if you have already locked markers to the curve, see How to Lock Markers to the Curve on page 257.

To lock/unlock markers to samples:

1 Press the [Menu] softkey.

2 Move to one of the following menu items:

- <Lock to Samples On>, to lock markers to samples or
- <Lock to Samples Off>, to lock markers to the curve.

**NOTE** Only one of these menu items will be available for selection.

3 Press *Enter* to return to the graph.

## The Logging Application

The Logging data acquisition application logs a series of power measurements for a number of Power Meter channels, plots the results as a graph, and generates a statistical analysis of the results.

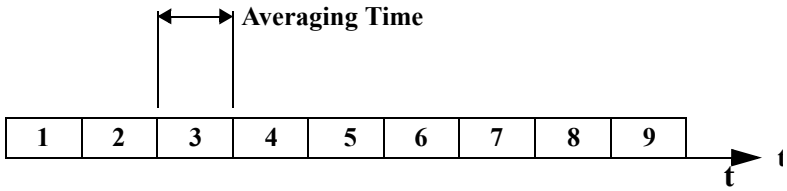



Figure 159 Example Logging Application

The most important parameters for the logging application are:

- [*Samples*], this is the number of samples that will be performed during the logging application, and
- [*AvgTime*], the averaging time is the length of time over which a signal is averaged. Longer averaging times increase the accuracy and improve the noise rejection. Longer averaging times also decrease sensitivity.

The total time for a logging application is the number of samples multiplied by the averaging time.

The Logging application differs from the The Stability Application on page 274 because all power measurements are performed consecutively without the possibility of any pause between measurements, as shown in Figure 159 on page -261.

All results can be:

- displayed on the screen,
- printed out to hardcopy.

## How to Set Up a Logging Function

To set up a logging function:

1 Press the *Appl* hardkey. The Applications menu, as shown in Figure 160 on page -262, appears.

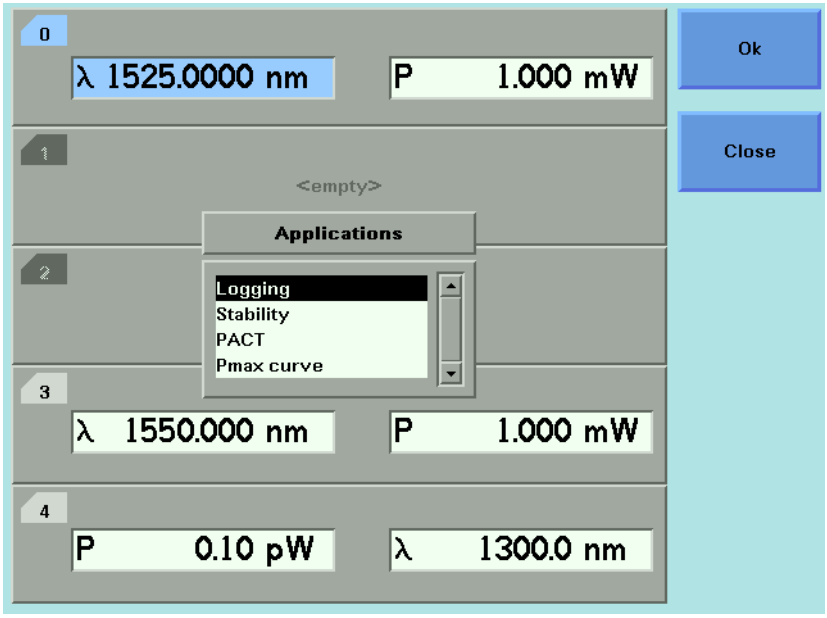



Figure 160 The Applications Menu

2 Move to <*Logging*> and press *Enter*. The 8164A/B Logging Setup Screen, as shown in Figure 161 on page -263, or the 8163A/B Logging Modules Setup Screen, as shown in Figure 162 on page -264, appears depending on the mainframe instrument you are using.

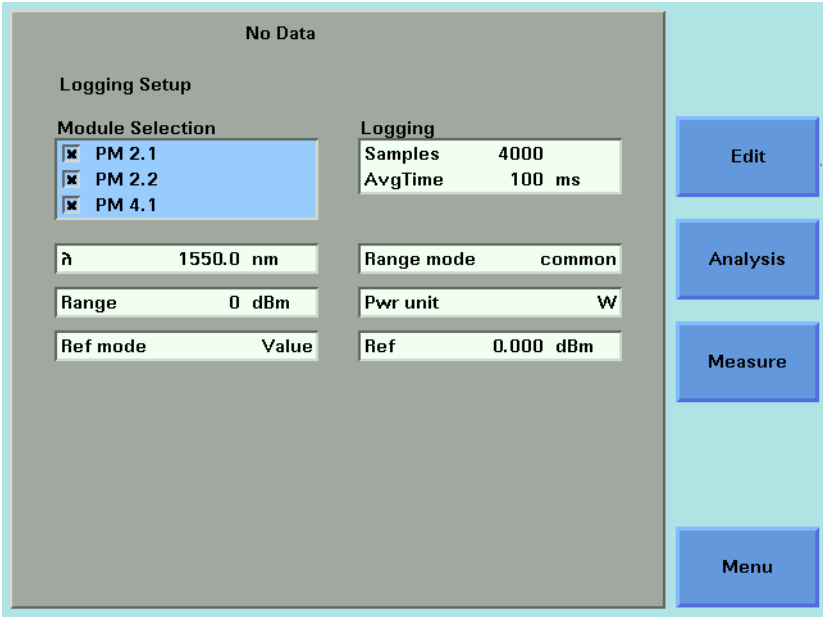



Figure 161 The 8164A/B Logging Setup Screen

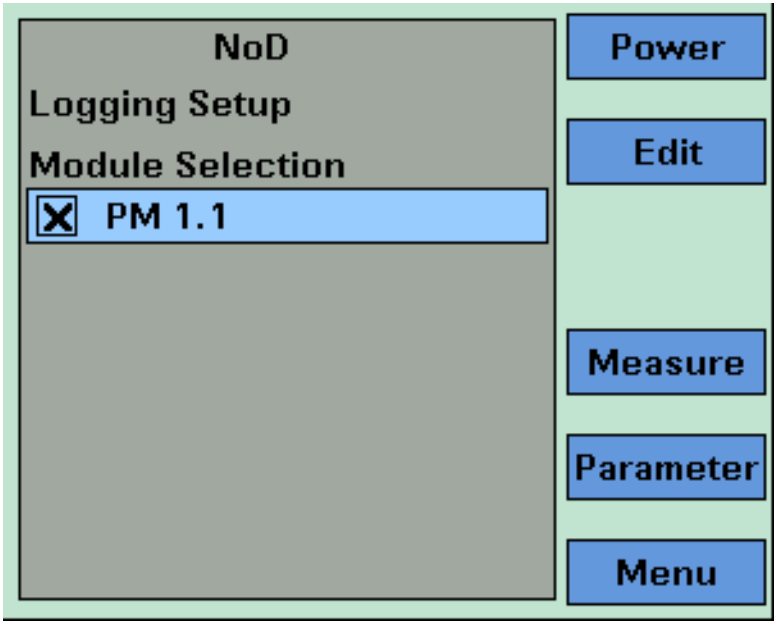



Figure 162 The Keysight 8163B Logging Modules Setup Screen

### Selecting/Deselecting Power Meters

1. Move to the Module Selection box. As a default, all Power Meters are selected, this means that all Power Meters will log power measurements. Press [Edit].
2. To deselect a Power Meter channel, move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Unset].
3. To select a Power Meter channel, press [Edit], move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Set].
4. Perform steps until you have selected the required Power Meters for your application and press *Enter*.

**NOTE** If no Power Meter channel is selected, you cannot 'exit' by pressing Enter.

Setting Power Meter Parameters

**NOTE** If you are using the 8164A/B Lightwave Multimeter, you may set all Power meter parameters from the Logging Setup Screen, see Figure 161 on page -263.

**NOTE** If you are using the 8163A/B Lightwave Multimeter, press [Parameter] to access the Logging Parameter Setup Screen, as shown in Figure 163 on page -265. To return to the Logging Modules Setup Screen, press [Modules].

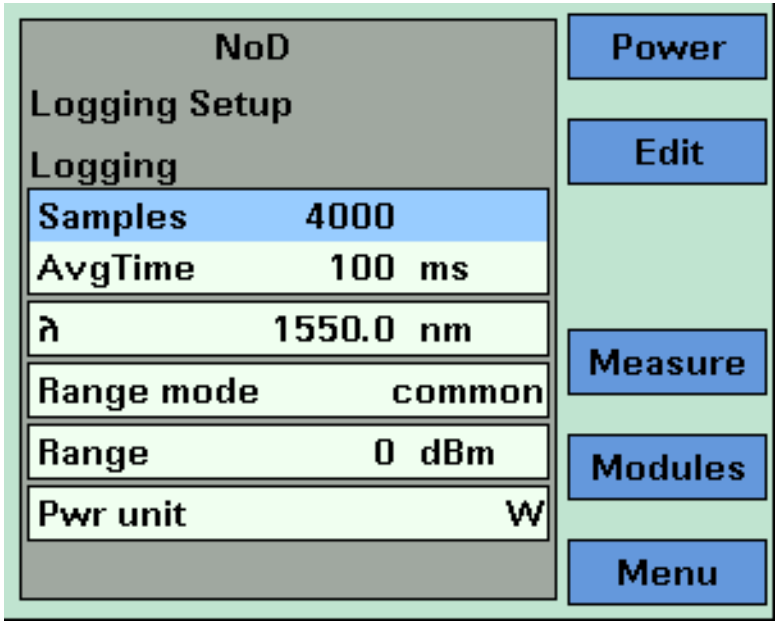



Figure 163 The Keysight 8163B Logging Parameter Setup Screen

1 Press [Menu] to access the Logging application menu screen.

2 Move to <*Pwr unit*>, press *Enter*, move to <*dBm*>, <*W*>, or <*dB*>, and press *Enter*. See What are the Power Units ? on page 101 for an explanation of power units.

3 Move to <λ>, press *Enter*, enter the wavelength value of your optical source, and press *Enter*.

**NOTE** Make sure that you install Power Meters that have similar wavelength ranges. The wavelength range of the application is the overlapping wavelength range of all installed Power Meters

4 Move to <*Range Mode*>, press *Enter*, move to one of the following range modes:

- <*common*>, you set the same <*Range*> for each Power Meter,
- <*individual*>, you must choose an individual <*Range*> for each Power Meter, and
- press *Enter*.

**NOTE** Auto-ranging mode is not available from the <Range Mode> menu. If you wish to use the auto-ranging mode, see The Stability Application on page 274.

5 Move to <*Range*> and press *Enter*.

6 If you have chosen <*common*> as the <*Range Mode*>, move to a range setting and press *Enter*.

If you have chosen <*individual*> as the <*Range Mode*>, a screen displaying all the selected Power Meter channels and their corresponding range settings is displayed. For each selected Power Meter channel, press *Enter*, move to a range setting, and press *Enter*.

**NOTE** If you have chosen <individual> as the <Range Mode> and want to access the screen displaying all the selected Power Meter channels and their corresponding range settings from the Logging Setup screen, move to [Range], press the [Edit] softkey.

7 Move to <*Ref Mode*>, press *Enter*, move to one of the following referencing modes:

- <*Value*>, you set a reference value using <*Ref*>, see step 8,

- <*First Sample*>, the first sample for each channel of the logging function is selected as the reference value for all subsequent measurements for that channel,
- <*Channel 1*>, the value that Channel 1 measures is updated as the reference value for each set of power measurements (thus, each data value for channel 1 will be 0 dB), and
- press *Enter*.

**NOTE** These settings only have an effect when you choose <dB> as the <Pwr unit>. See step 8 or step 3.

8 If you have chosen <*Value*> as the <*Ref Mode*>, move to <*Ref*>, press the [Edit] softkey, enter a value for the reference, and press *Enter*.

### Setting Logging Parameter

9 Move to [*Samples*], press *Enter*, enter an integer value between 1 and 4000, and press *Enter*.

10 Move to <*AvgTime*>, press *Enter*, move to an averaging time period, and press *Enter*.

## Running a Logging Application

1 You can run the logging application by pressing [Measure]. The Logging Measurement screen, as shown in Figure 164 on page -268, appears. A progress bar shows the proportion of the logging application that has been completed.

**NOTE** If the averaging time [AvgTime] is less than 100 ms for a 8163xA/B series powermeter, the progress bar and the graph are not updated until the measurement completes.




Figure 164 The Logging Measurement Screen - Measurement Running

2 There are two softkeys available from the Logging Measurement screen.
   - Press [Graph] to view a graph of the Measurement results as the results are measured. Press [Close] to return to the Logging Measurement screen. See Working with Application Graphs on page 249 for information on zooming in and out.
   - Press [Cancel] to return to the Logging Setup screen without completing the logging application.
3 When the logging application completes, you hear a beep, an hourglass appears momentarily. If you are viewing the Logging Measurement Screen the available softkeys change as shown in Figure 165 on page -269.

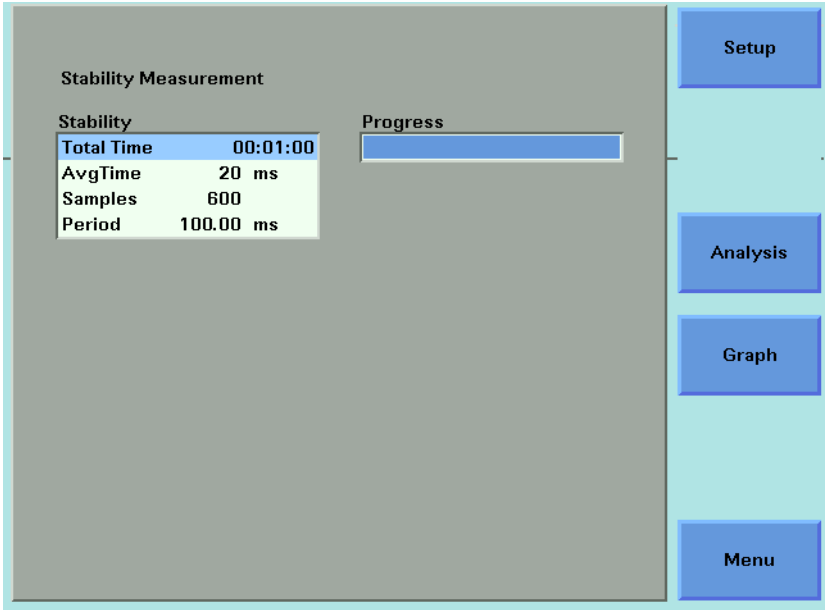



Figure 165 The Logging Measurement Screen - Measurement Completed

## Analysing a Logging Application

You can access the Logging Analysis screen after the logging application completes, by completing the following instructions:

1 You cannot access the Logging Analysis screen from the graph. If you are viewing the graph, press [Close].

2 Press [Analysis]. The Logging Analysis screen appears as shown in Figure 166 on page -270 for the 8164A/B and Figure 163for the Keysight 8163B.

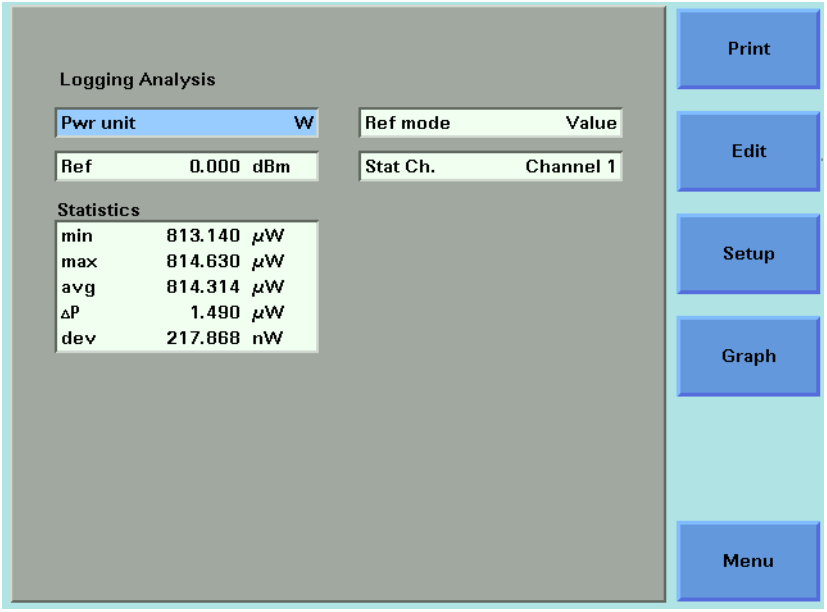



Figure 166 The 8164A/B Logging Analysis Screen

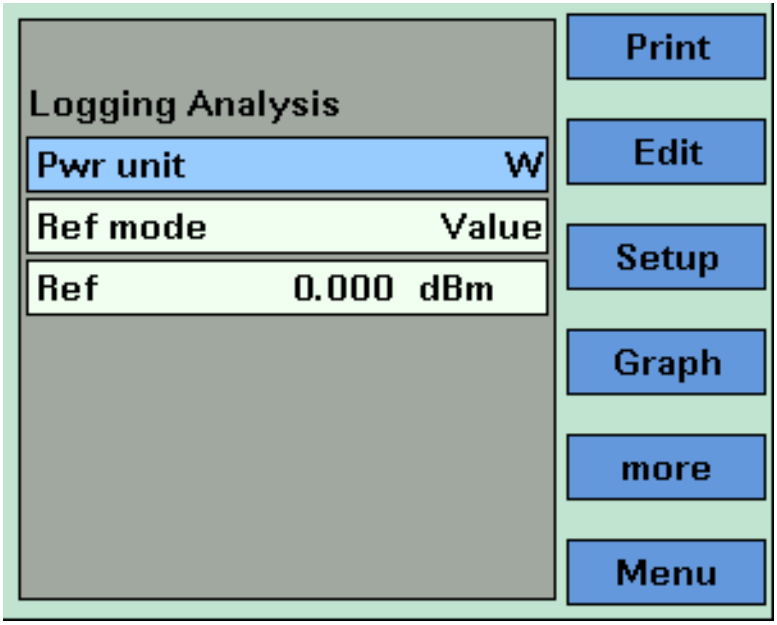



Figure 167 The Keysight 8163B Logging Analysis Screen - First Screen

Setting Analysis Parameters

3 To edit the power units used for the analysis, move to [*W*], press *Enter*, move to <*dBm*>, <*W*>, or <*dB*>, and press *Enter*. See What are the Power Units ? on page 101 for an explanation of power units.

4 To edit the reference mode used for the analysis, move to <*Ref Mode*>, press *Enter*, move to one of the following referencing modes:

- <*Value*>, you set a reference value using <*Ref*>, see step 5,
- <*First Sample*>, the first sample of the logging function is selected as the reference value,
- <*Channel 1*>, the value that Channel 1 measures is updated as the reference value for each set of power measurements (thus, each data value for channel 1 will be 0 dB), and
- press *Enter*.

**NOTE** These settings have an effect when you choose <dB> as the <Pwr unit>. See step 2 or step 3.

5 If you have chosen <*Value*> as the <*Ref Mode*>, move to <*Ref*>, press *Enter*, enter a value for the reference, and press *Enter*.

### Viewing the Statistics for a Power Meter Channel

1 If you are using the 8164A/B, move to [*Stat Ch.*], press *Enter*, move to a Power Meter channel, and press *Enter*.

If you are using the 8163A/B, press [More], the screen in Figure 168 on page -272 appears, move to [*Stat Ch.*], press *Enter*, move to a Power Meter channel, and press *Enter*.

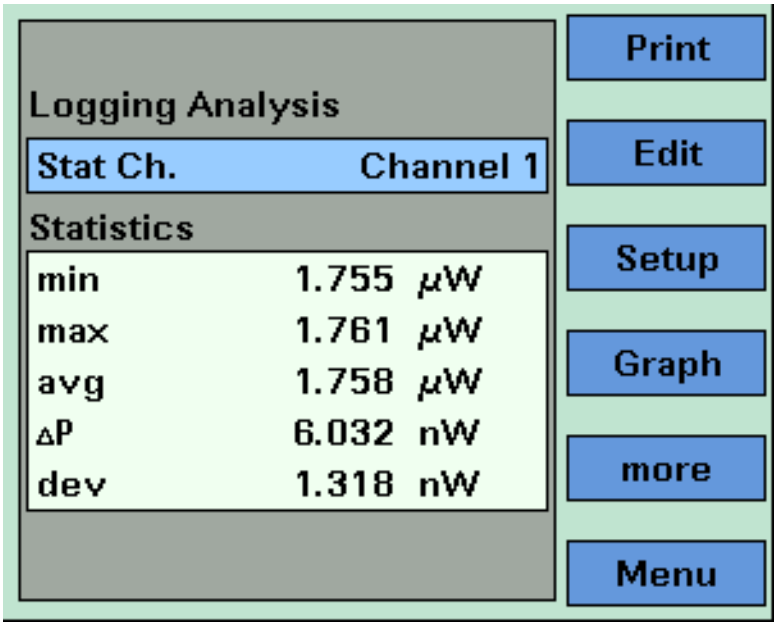



Figure 168 The 8163B Logging Analysis Screen - Second Screen

2 The following statistics are displayed for the chosen Power Meter channel:

- [*min*], the minimum power measurement measured,
- [*max*], the maximum power measurement measured,
- [*avg*], the average of all power measurements measured,
- [Δ*P*], the difference between [*max*] and [*min*],
- [*dev*], the standard deviation of all power measurements measured.

## On-Screen Messages

The messages listed in the table below may appear at the top of the screen during the Logging application.

**Table 16 Logging Application On-Screen Messages**

| Keysight 8163A/B Message | Keysight 8164A/B Message | Description |
|---|---|---|
| OvR | Overrange | One of the Power Meter channels has reported an overrange. The over-ranged value is clipped, statistical data is invalid. |
| NoH | No Head | There is an Optical Head Interface module inserted in the mainframe that does not have an Optical Head connected to it. No measurement is possible using this channel until you either:<br>reconnect an Optical Head or<br>deselect this Optical Head channel as a power measurement channel. |
| NoD | No Data | No data has been measured or measurement is not yet finished. You cannot access the Analysis Screen yet. Printout and file operations are not yet possible. |

## The Stability Application

The Stability data acquisition application logs a series of power measurements for a number of Power Meter channels, plots the results as a graph, and generates a statistical analysis of the results.

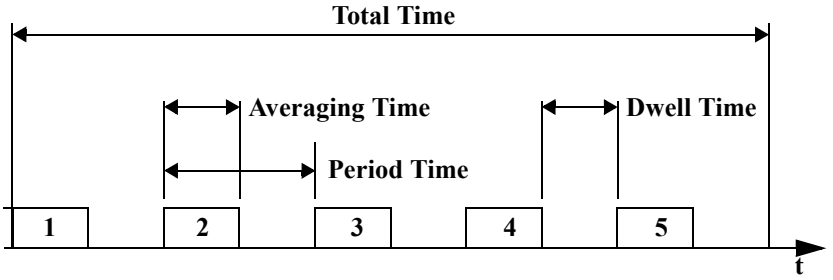



Figure 169 Example Stability Application

The Stability application differs from the The Logging Application on page 261 because you set the averaging time, the total time, and the maximum number of measurements and all power measurements and the instrument calculates a period time, a new measurement is started after the completion of every period time. Period time may be greater than or equal to the averaging time you set and is always greater than or equal to 100 ms.

This leaves the following two possibilities:

- The averaging time is less than the period time, there is a dwell time between the commencement of each power measurement, as shown in Figure 169 on page -274. This can happen because:
  - the maximum number of power measurements multiplied by the averaging time is less than the total time or
  - the averaging time is less than 100 ms.
- The averaging time is equal to the period time, all power measurement are performed without any dwell time.

**NOTE**

The total time concludes after the last dwell time period, not after the last averaging time period.

The Stability application enables you to make periodic power measurements over a relatively long time period (23 hours, 59 minutes and, 59 seconds).

The Stability application differs from The Logging Application on page 261 because you may use auto-ranging mode, see step 9 on <Cross Reference Color>page 89 for more information.

All results can be:

- displayed on the screen,
- printed out to hardcopy.

### How to Set Up a Stability Function

To set up a stability function:

1 Press the *Appl* hardkey. The Applications menu, as shown in Figure 160 on page -262, appears.

Move to <*Stability*> and press *Enter*. The Stability Setup Screen, as shown in Figure 170 on page -276, appears.

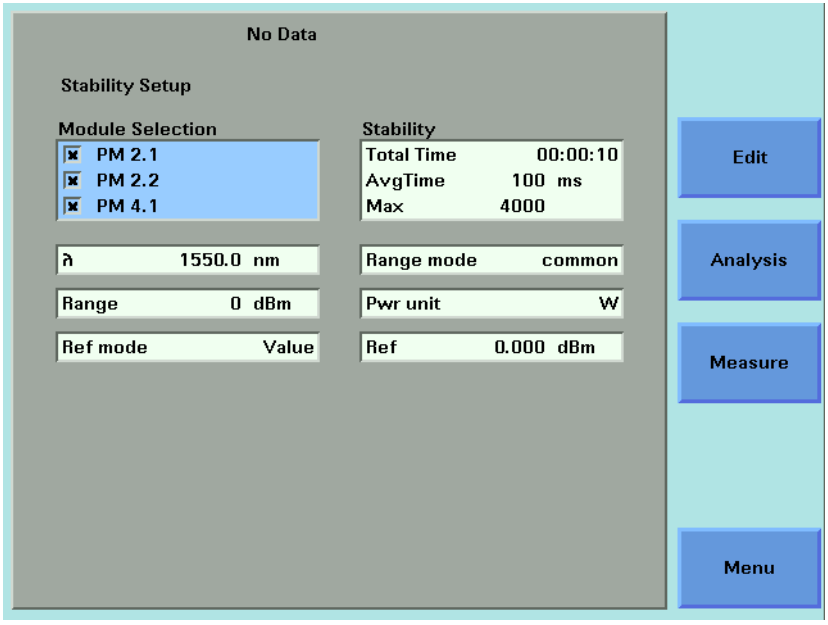



Figure 170 The Keysight 8164A/B Stability Setup Screen

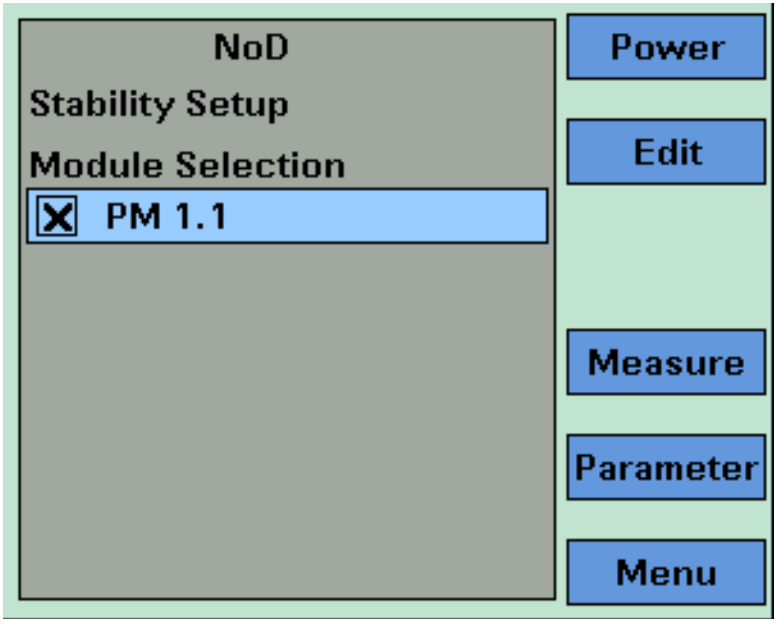



Figure 171 The Keysight 8163B Stability Module Setup Screen

### Selecting/Deselecting Power Meters

2 Move to the Module Selection box. As a default, all Power Meters are selected, this means that all Power Meters will log power measurements. Press [Edit].

3 To deselect a Power Meter channel, move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Unset].

4 To select a Power Meter channel, press [Edit], move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Set].

5 Perform steps until you have selected the required Power Meters for your application and press *Enter*.

**NOTE** If no Power Meter channel is selected, you cannot exit by pressing Enter.

Setting Power Meter Parameters

**NOTE** If you are using the Keysight 8163B Lightwave Multimeter, press [Modules] to access the Stability Setup Screen. Not all parameters are available from the Stability Setup Screen.

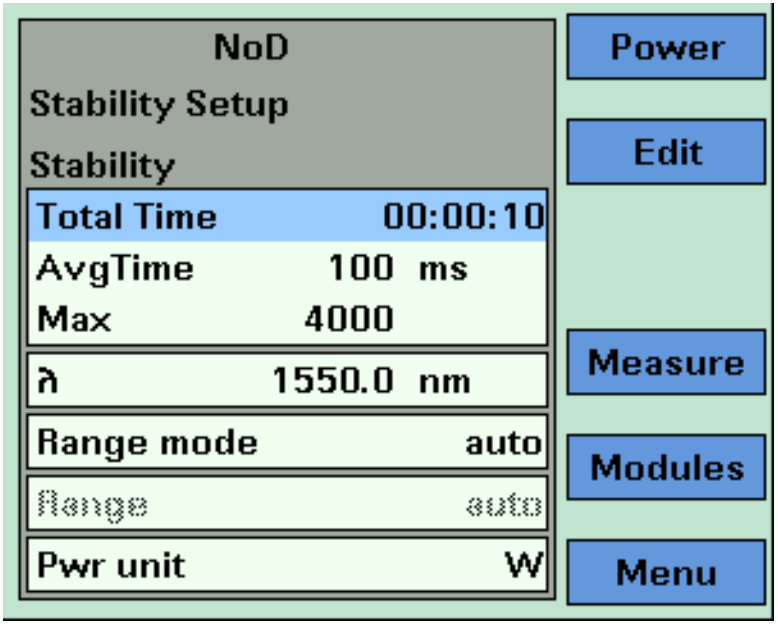



Figure 172 The Keysight 8163B Stability Parameter Setup Screen

6 Press [Menu] to access the Stability application menu screen.

7 Move to <*Pwr unit*>, press *Enter*, move to <*dBm*>, <*W*>, or <*dB*>, and press *Enter*. See What are the Power Units ? on page 101 for an explanation of power units.

8 Move to <λ>, press *Enter*, enter the wavelength value of your optical source, and press *Enter*.

**NOTE** Make sure that you install Power Meters that have similar wavelength ranges. The wavelength range of the application is the overlapping wavelength range of all installed Power Meters.

9 Move to <*Range Mode*>, press *Enter*, move to one of the following range modes:
- <*common*>, you set the same <*Range*> for each Power Meter,
- <*individual*>, you must choose an individual <*Range*> for each Power Meter,
- <*Auto*>, the auto-ranging mode, ensures that the result has a displayed value between 9% and 100% of full scale, and
- press *Enter*

**NOTE** If you choose <Auto> and the power range changes, the time base of the stability application will be disrupted.

10 Move to <*Range*> and press *Enter*.

11 If you have chosen <*common*> as the <*Range Mode*>, move to a range setting and press *Enter*.

If you have chosen <*individual*> as the <*Range Mode*>, a screen displaying all the selected Power Meter channels and their corresponding range settings is displayed. For each selected Power Meter channel, press *Enter*, move to a range setting, and press *Enter*.

12 Move to <*Ref Mode*>, press *Enter*, move to one of the following referencing modes:
- <*Value*>, you set a reference value using <*Ref*>, see step 13,
- <*First Sample*>, the first sample of the stability function is selected as the reference value,
- <*Channel 1*>, the value that Channel 1 measures is updated as the reference value for each set of power measurements (thus, each data value for channel 1 will be 0 dB), and
- press *Enter*.

**NOTE** These settings have an effect when you choose <dB> as the <Pwr unit>. See step 7 or step 22.

13 If you have chosen <*Value*> as the <*Ref Mode*>, move to <*Ref*>, press *Enter*, enter a value for the reference, and press *Enter*.

### Setting Stability Parameter

14 Move to [*Total Time*], press *Enter*. [*Total Time*] is a value of the form xx:yy:zz, where xx is a value in hours (maximum 23 hours), yy is a value in minutes (maximum 59 minutes), and zz is a value in seconds (maximum 59 seconds).

Enter a two-digit time value in hours, press the right cursor key, enter a two-digit time value in minutes, press the right cursor key, enter a two-digit time value in seconds, and press *Enter*.

15 Move to [*AvgTime*], press *Enter*, move to an averaging time period, and press *Enter*.

16 Move to [*Max*], press *Enter*, enter an integer value between 1 and 4000, and press *Enter*.

### Running a Stability Application

17 You can run the stability application by pressing [Measure]. The Stability Measurement screen, as shown in Figure 173 on page -281, appears. A progress bar shows the proportion of the stability application that has been completed.

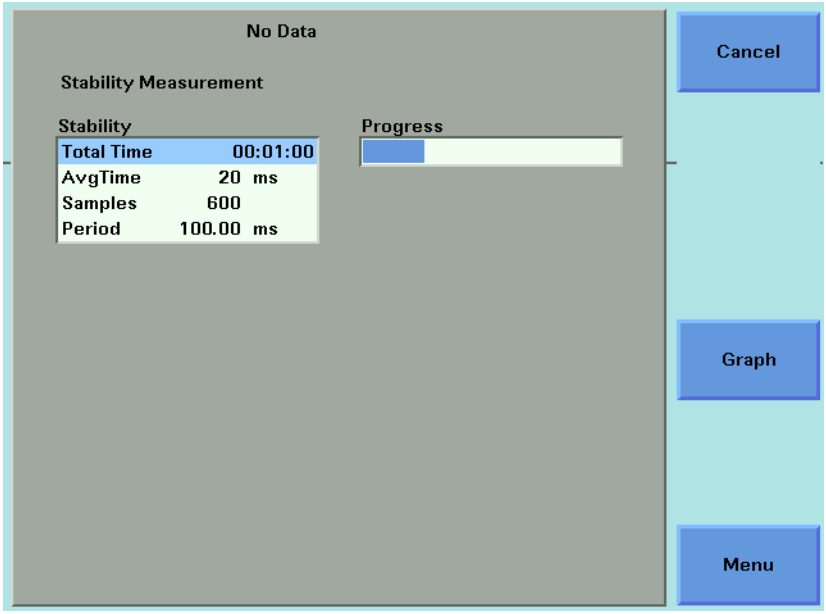



Figure 173 The Stability Measurement Screen - Measurement Running

18 There are two softkeys available from the Stability Measurement screen.

- Press [Graph] to view a graph of the Measurement results as the results are measured. Press [Close] to return to the Stability Measurement screen. See Working with Application Graphs on page 249 for information on zooming in and out.
- Press [Cancel] to return to the Stability Setup screen without completing the stability application.

19 When the stability application completes, you hear a beep, an hourglass appears momentarily. If you are viewing the Stability Measurement Screen, the available softkeys change as shown in Figure 173 on page -281.

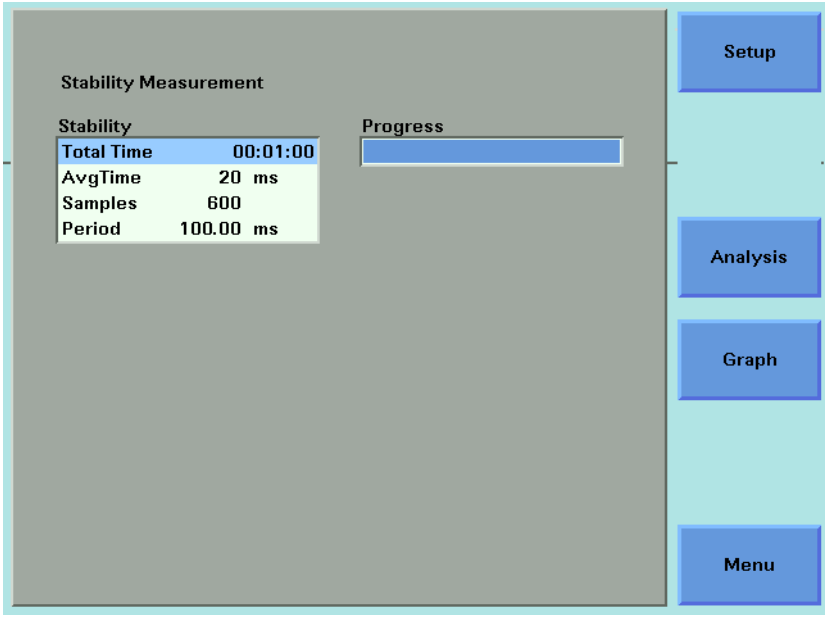



Figure 174 The Stability Measurement Screen - Measurement Completed

## Analysing a Stability Application

You can access the Stability Analysis screen after the stability application completes, by completing the following instructions:

20 You cannot access the Stability Analysis screen from the graph. If you are viewing the graph, press [Close].

21 Press [Analysis]. The Stability Analysis screen appears as shown in Figure 175 on page -283 for the Keysight 8164A/B and Figure 175 on page -283for the Keysight 8163B.

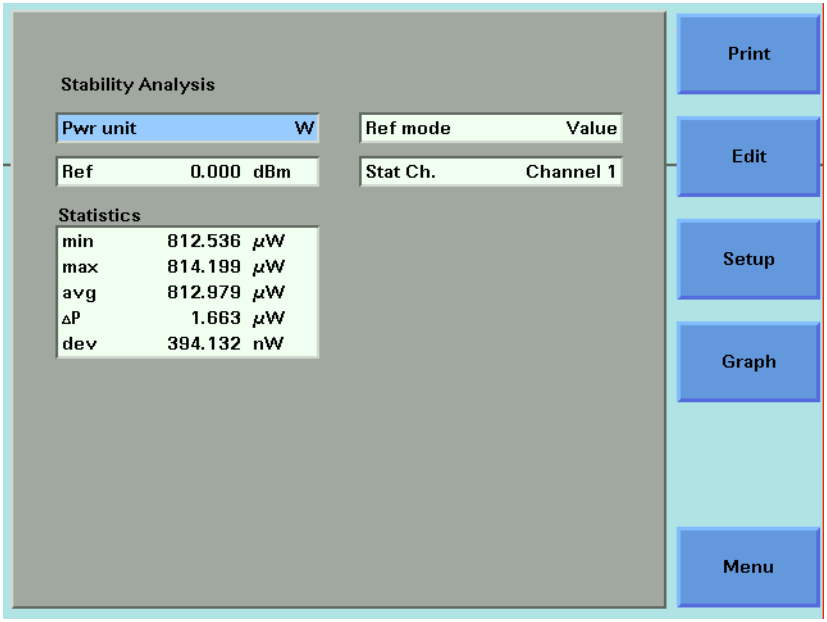



Figure 175 The Keysight 8164A/B Stability Analysis Screen

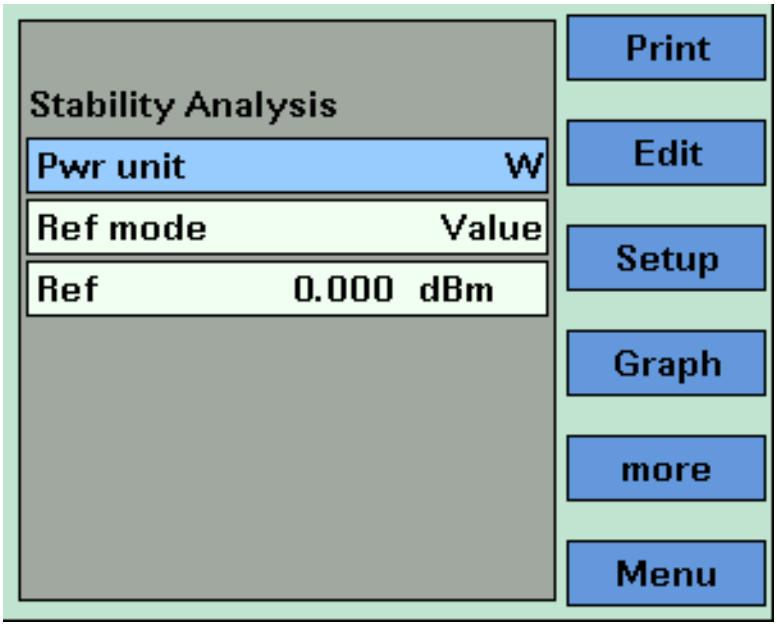



Figure 176 The Keysight 8163B Stability Analysis Screenn - First Screen

### Setting Analysis Parameters

22 To edit the power units used for the analysis, move to [*W*], press *Enter*, move to <*dBm*>, <*W*>, or <*dB*>, and press *Enter*. See What are the Power Units ? on page 101 for an explanation of power units.

23 To edit the reference mode used for the analysis, move to <*Ref Mode*>, press *Enter*, move to one of the following referencing modes:

- <*Value*>, you set a reference value using <*Ref*>, see step 24,
- <*First Sample*>, the first sample of the stability function is selected as the reference value,
- <*Channel 1*>, the value that Channel 1 measures is updated as the reference value for each set of power measurements (thus, each data value for channel 1 will be 0 dB), and
- press *Enter*.

**NOTE** These settings have an effect when you choose <dB> as the <Pwr unit>. See step 7 or step 22.

24 If you have chosen <*Value*> as the <*Ref Mode*>, move to <*Ref*>, press *Enter*, enter a value for the reference, and press *Enter*.

### Viewing the Statistics for a Power Meter Channel

25 If you are using the Keysight 8164A/B, move to [*Stat Ch.*], press *Enter*, move to a Power Meter channel, and press *Enter*.

If you are using the Keysight 8163A/B, press [More], a screen similar to that shown in Figure 177 on page -285appears, move to [*Stat Ch.*], press *Enter*, move to a Power Meter channel, and press *Enter*.

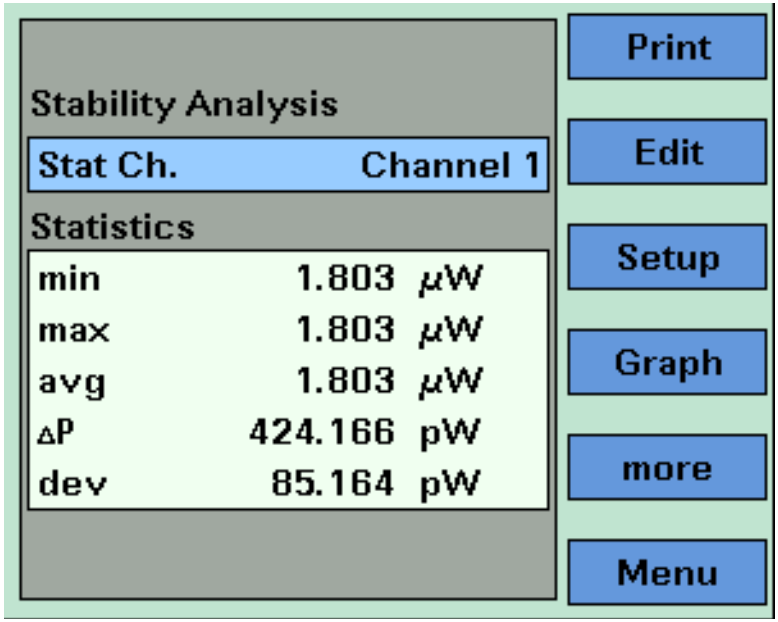



Figure 177 The Keysight 8163A/B Stability Analysis Screen - Second Screen

The following statistics are displayed for the chosen Power Meter channel:

- [*min*], the minimum power measurement measured,
- [*max*], the maximum power measurement measured,
- [*avg*], the average of all power measurements measured,
- [Δ*P*], the difference between [*max*] and [*min*],
- [*dev*], the standard deviation of all power measurements measured.

## On-Screen Messages

The messages listed in the table below may appear at the top of the screen during the Stability application.

**Table 17 Stability Application On-Screen Messages**

| Keysight 8163A/B Message | Keysight 8164A/B Message | Description |
|---|---|---|
| OvR | Overrange | One of the Power Meter channels has reported an overrange. The over-ranged value is clipped, statistical data is invalid. |
| NoH | No Head | There is an Optical Head Interface module inserted in the mainframe that does not have an Optical Head connected to it. No measurement is possible using this channel until you either:<br>reconnect an Optical Head or<br>deselect this Optical Head channel as a power measurement channel. |
| NoD | No Data | No data has been measured or measurement is not yet finished. You cannot access the Analysis Screen yet. Printout and file operations are not yet possible. |

# The PACT Application

## What is the PACT ?

PACT (Passive Component Test Software) makes it possible to use your 8163A/B Lightwave Multimeter or 8164A/B Lightwave Measurement System to control a system for testing pigtailed or connectorized passive devices (filters, couplers, and isolators) over wavelength. You must first install a Tunable Laser module and Power Meters in your 8163A/B Lightwave Multimeter or 8164A/B Lightwave Measurement System.

Depending on the configuration of the system you use, you can measure insertion loss (single channel power measurement) over wavelength.

All results can be:

- displayed on the screen,
- printed out to hardcopy.

This can be a convenient tool for quick tests. Much more powerful PACT testing is available with the N7700A software for remote control.

## How to Set Up PACT

To set up PACT:

1 Insert a Tunable Laser module and at least one Power Meter module into your 8163A/B Lightwave Multimeter or 8164A/B Lightwave Measurement System.

2 Turn your instrument on.

3 Press the *Appl* hardkey. The Applications menu, as shown in Figure 160 on page -262, appears.

4 Move to <*PACT*> and press *Enter*. The PACT Setup Screen, as shown in Figure 178 on page -288, appears.

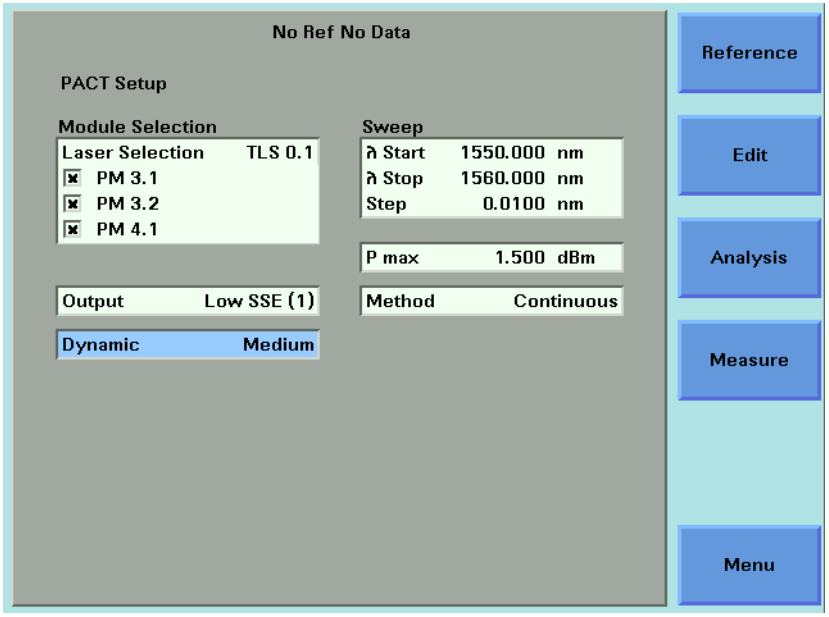



Figure 178 The PACT Setup Screen

### Selecting a Tunable Laser Module

5 Move to the Module Selection box. As a default, the Tunable Laser module with the lowest slot number is selected. Move to [*Laser Selection*]. Press [Edit].

6 To select a Tunable Laser module, press [Edit], use the cursor key to move to your preferred Tunable Laser module as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, and press *Enter*.

7 Perform steps until you have selected the required Tunable Laser modules for your application and press *Enter*.

**NOTE** If no Tunable Laser module is selected, you cannot exit by pressing Enter. PACT is not available for 81606A, 81607A, 81608A and 81609A. Instead use the free N7700A IL Engine software for a PC.

### Selecting/Deselecting Power Meters

8 Move to the Module Selection box. As a default, all Power Meters are selected, this means that all Power Meters will log power measurements. Press [Edit].

9 To deselect a Power Meter channel, move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Unset].

To select a Power Meter channel, press [Edit], move to the Power Meter as denoted by slot and channel numbers, see Slot and Channel Numbers on page 39, press [Set].

10 Perform steps until you have selected the required Power Meters for your application and press *Enter*.

**NOTE** If no Power Meter channel is selected, you cannot exit by pressing Enter.

### Setting Sweep Parameters

11 Move to [λ *Start*], press *Enter*, enter the start wavelength of the sweep, and press *Enter*.

12 Move to [λ *Stop*], press *Enter*, enter the stop wavelength of the sweep, and press *Enter*.

13 Move to [*Step*], press *Enter*, enter the step size for the sweep, and press *Enter*.

**NOTE** The step size defines:

the size of the change in the wavelength for each step of a stepped sweep and

the wavelength interval between power measurements, the first power measurement is taken at [λ Start] and the last must be taken at [λ Stop].

14 Move to [*P max*], press *Enter*, enter the maximum power in dBm for the sweep, and press *Enter*. The instrument chooses a constant power level for the measurement using the following constraints:

- the power will be less than or equal to the [*P max*] value you set and

- the power will be less than or equal to the maximum power possible for the chosen Tunable Laser module across the chosen wavelength range.

15 Move to [*Method*], press *Enter*, and move to one of the following sweep modes:

- <*Stepped*>, which dwells at wavelengths that are separated by a certain step size, or
- <*Continuous*>, which sweeps continually at the speed you set.
- Press *Enter*.

**NOTE** **Continuous sweep mode is not available for the 81609A, 81689A, 81949A, 81950A, 81989A Tunable Laser module.**

**[Dynamic]**

The [*Dynamic*] parameter, which is only relevant for <*Continuous*> sweep mode, allows you to achieve a higher dynamic range than is possible using one wavelength sweep. Depending on the menu item you choose, the Tunable Laser will be swept once, twice, or three times and the chosen Power Meters will be set to different power ranges for each wavelength sweep. The sweeps are combined using a "stitching" process to generate the final results.

This feature is useful when you wish to measure the transmission characteristics of a component that transmits or absorbs specific wavelengths selectively, for example, a Fiber Bragg Grating.

16 Move to [*Dynamic*], press *Enter*, and move to one of the following:

- <*Low*>, the wavelength is swept once, achieving a lower dynamic range but sweeping more quickly,
- <*Medium*>, the wavelength is swept twice, achieving a medium dynamic range and medium speed, and
- <*High*>, the wavelength is swept three times, achieving a higher dynamic range but sweeping less quickly.
- Press *Enter*.

17 If your Tunable Laser module has two optical outputs perform the step below.

Move to [*Optical Output*] and press *Enter*. Use the Modify Knob to move to one of the following:

- <*High Power (2)*>, a high power optical output, for example, for use in tesing Erbium Doped Fiber Amplifiers (EDFAs), you see a screen similar to Figure 78 on page -137,
- <*Low SSE (1)*>, a lower power optical output with low Source Spontaneous Emission (SSE), for example, for use in passive component test, you see a screen similar to Figure 79 on page -139,
- <*Both (master:2)*>, where both optical outputs can be enabled but only the output of the high power optical output can be regulated, and
- <*Both (master:1)*>, where both optical outputs can be enabled but only the output of the low SSE optical output can be regulated.
- Press *Enter*.

How to Measure the Reference

18 Press [Reference].

**NOTE**

If [*Step*] does not divide exactly into the difference between [λ *Stop*] and [λ *Start*], the parameters are automatically corrected to meet the constraints of PACT.

The PACT Reference Screen, as shown in Figure 179 on page -292, appears. The number of samples that each Power Meter will record and the output laser power are displayed If <*Continuous*> was selected as the sweep [*Method*], the sweep speed, [*V Sweep*], is displayed.




Figure 179 PACT Reference Screen

**NOTE** The application chooses the power, [P], see step 14 for more information.

19 Press [New Ref]. A box similar to the box in Figure 180 on page -293 appears prompting you to connect a fiber to the first Power Meter channel.

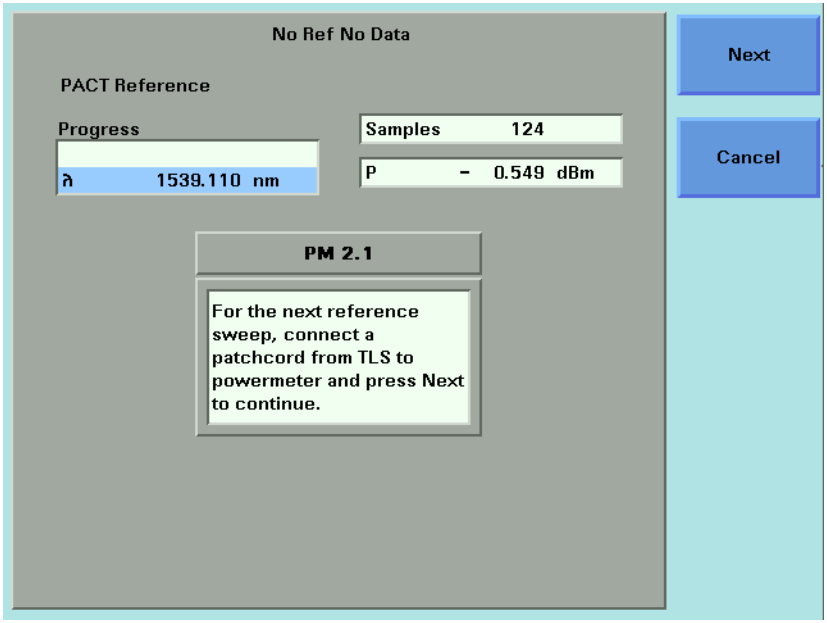



Figure 180 Connection Prompt Screen

20 Connect the Tunable Laser module to the Power Meter channel through all the system components, but excluding the Device Under Test. Press [Next] to start the reference measurement.

The PACT Reference Measurement screen, as shown in Figure 181 on page -294, appears. A progress bar shows the proportion of the stability application that has been completed. The wavelength, λ, shows you the current wavelength of the Tunable Laser module.

21 There are two softkeys available from the PACT Reference Measurement screen.

- Press [Graph] to view a graph of the Measurement results as the results are measured. Press [Close] to return to the PACT Reference Measurement screen. See Working with Application Graphs on page 249 for information on zooming in and out.
- Press [Cancel] to return to the PACT Reference screen without completing the reference measurement, all reference values that were measured will be deleted.

22 When the PACT Reference Measurement completes, you hear a beep, an hourglass appears momentarily.

If there is another Power Meter channel to reference, you will be prompted to perform this reference measurement from the user interface by a prompt box similar to the box in Figure 180 on page -293. Restart this procedure at step 20.

If you are viewing the PACT Reference Measurement Finished box, reference sweeps have been performed for all selected Power Meters.

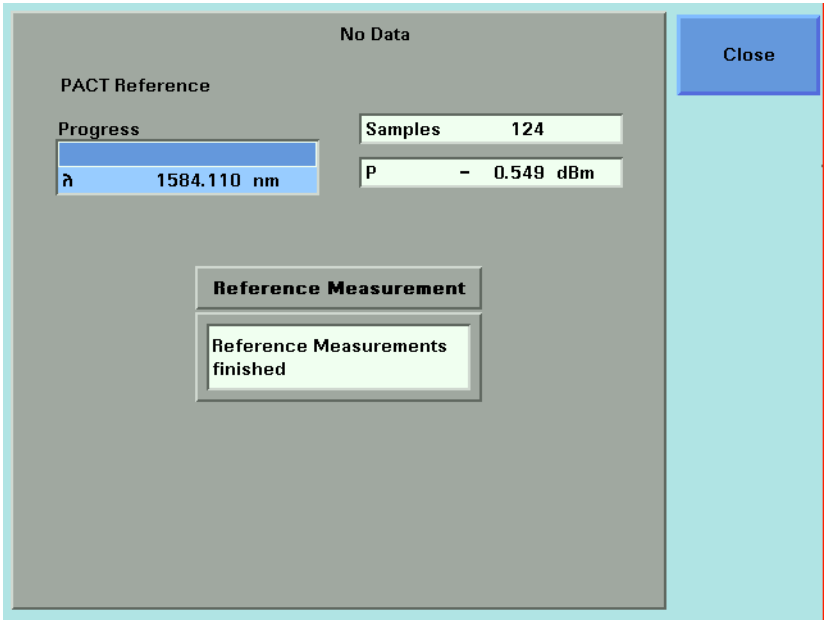



Figure 181 PACT Reference Measurement Finished Box

How to Perform a Loss Measurement

23 To return to the Setup screen, pressing [Menu], move to <*Setup*>, and press *Enter*.

**NOTE** **If you change any measurement parameters, the reference measurement becomes invalid.**

24 Connect the Tunable Laser module to the Power Meter channel through all the system components, including the Device Under Test. Press [Measure].

**NOTE**

If [Step] does not divide exactly into the difference between [λ Stop] and [λ Start], the parameters are automatically corrected to meet the constraints of PACT.

If the step size is very large in comparison to the sweep range, a box requesting you to correct the [λ Stop], [λ Start], and [Step] may appear.

The PACT Measurement Screen, as shown in Figure 182 on page -295, appears. The number of samples that each Power Meter will record and the output laser power are displayed. If <*Continuous*> was selected as the sweep [*Method*], the sweep speed, [*V Sweep*], is displayed.

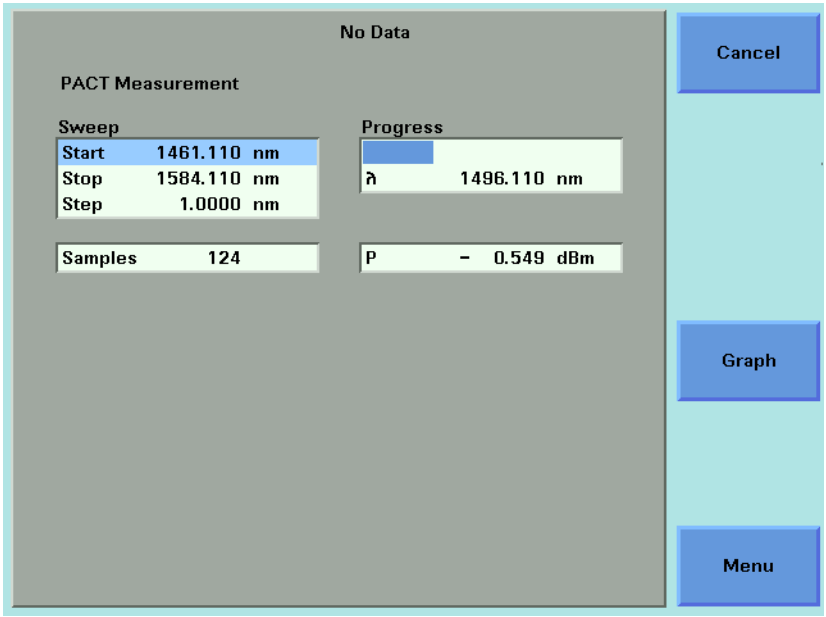



Figure 182 PACT Measurement Screen

**NOTE** The application chooses the power level, [P], see step 15 for more information.

The application chooses the power level, [P], see step 14 for more information.

25 There are two softkeys available from the PACT Measurement screen.

- Press [Graph] to view a graph of the Measurement results as the results are measured. Press [Close] to return to the PACT Reference Measurement screen. See Working with Application Graphs on page 249 for information on zooming in and out.
- Press [Cancel] to return to the PACT Reference screen without completing the stability application.

**NOTE** If you choose <High> or <Medium> as the [Dynamic] parameter and <Continuous> sweep mode, the graph will update at the end of each sweep. Figure 34 on page -72 shows a graph with low dynamic range that is the result of a single sweep. Figure 49 on page -87 shows a graph with high dynamic range that is the result of a three sweeps that were combined using a "stitching" process.

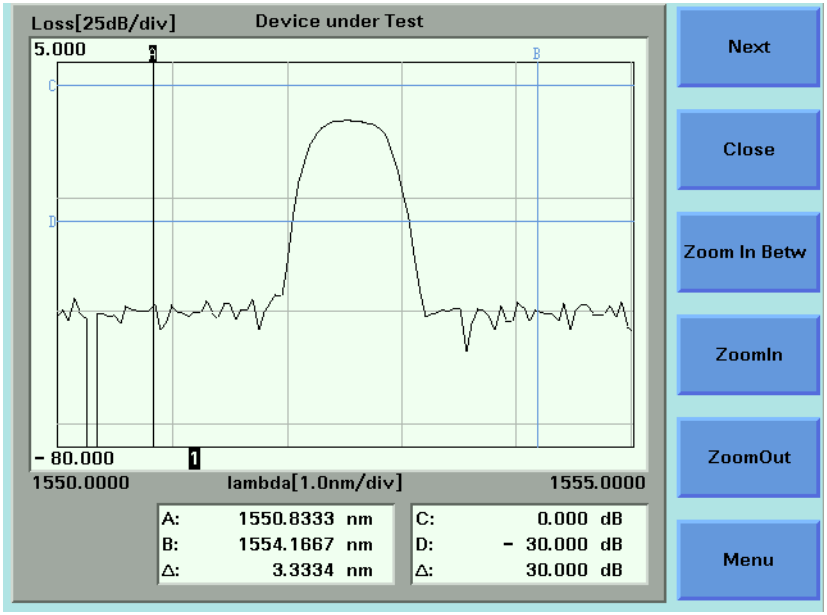



Figure 183 Low Dynamic Range

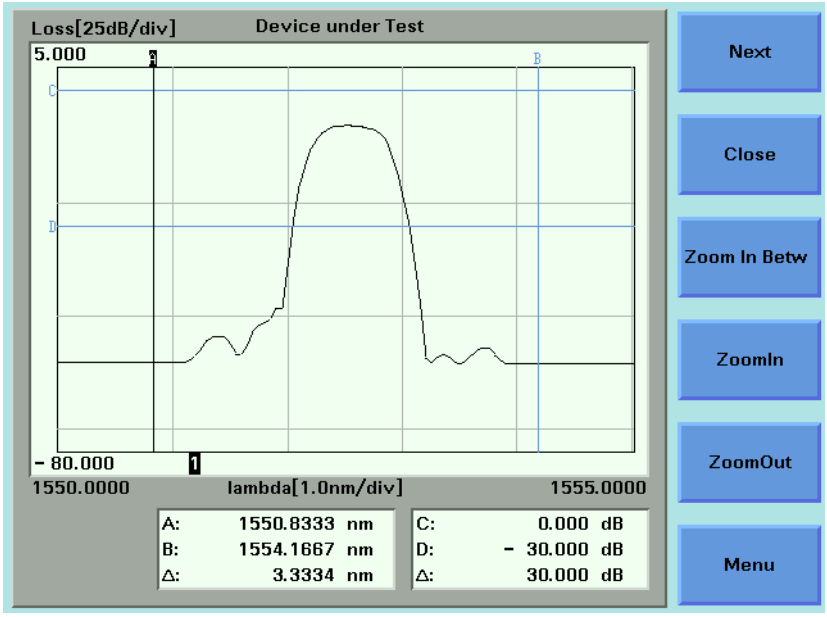



Figure 184 High Dynamic Range

26 When the PACT Measurement application completes, you hear a beep, an hourglass appears momentarily. If you are viewing the PACT Measurement Screen, the available softkeys change as shown in Figure 185 on page -299.

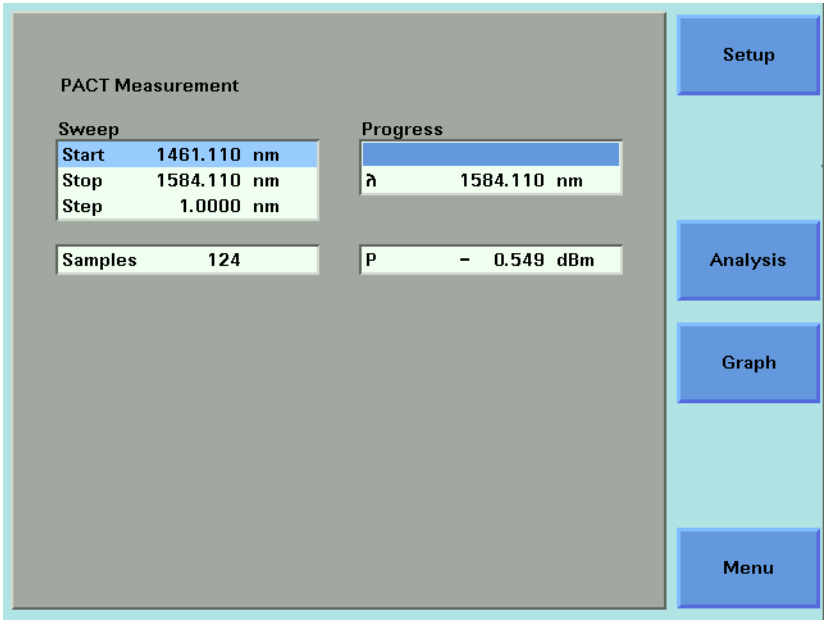



Figure 185 The PACT Measurement Screen - Measurement Completed

## Analysing a PACT Measurement

You can access the PACT Analysis screen after the PACT Measurement completes, by completing the following instructions:

27 You cannot access the PACT Analysis screen from the graph. If you are viewing the graph, press [Close].

28 Press [Setup]. The Logging Analysis screen appears as shown in Figure 166 on page -270.

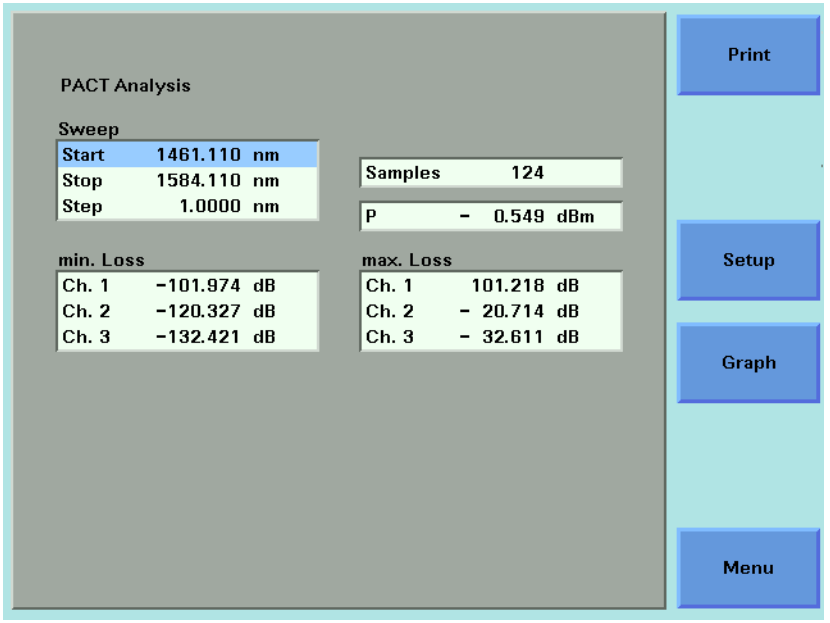



Figure 186 The PACT Analysis Screen

The sweep parameters are shown.

The following results of the PACT Measurement are shown for each selected Power Meter channel:

- min. Loss, the minimum loss value for the particular Power Meter channel for the sweep, and
- max. Loss, the maximum loss value for the particular Power Meter channel for the sweep.

## On-Screen Messages

The messages listed in the table below may appear at the top of the screen during the PACT application.

**Table 18 PACT Application On-Screen Messages**

| Keysight 8163A/B Message | Keysight 8164A/B Message | Description |
|---|---|---|
| SLck | SLock | The Tunable Laser module is locked. No measurement is possible until you unlock the module, see How to Lock/Unlock the High-Power Laser Sources on page 67 for details. |
| RiLck | RILock | The Remote Interlock Connector of your mainframe is open. No measurement is possible until the connection at the Remote Interlock Connector closes, see The Remote Interlock (RIL) connector on page 337 for details. |
| NoH | No Head | There is an Optical Head Interface module inserted in the mainframe that does not have an Optical Head connected to it. No measurement is possible using this channel until you either:<br>reconnect an Optical Head or<br>deselect this Optical Head channel as a power measurement channel. |
| NoD | No Data | No data has been measured or measurement is not yet finished. You cannot access the Analysis Screen yet. Printout and file operations are not yet possible. |
| Set | Settling | A Tunable Laser module is settling. The instrument is busy and no measurement can be performed yet. |
| NoR | No Ref | No reference sweep has been performed. Loss will be calculated using nominal laser power as a reference. |

# The Pmax Curve

## What is the Pmax Curve ?

The Pmax Curve shows the maximum laser output power for your Tunable Laser module across the wavelength range of your Tunable Laser module.

## How to View the Pmax Curve

To view the Pmax Curve:

1 Press the *Appl* hardkey. The Applications menu, as shown in Figure 160 on page -262, appears.

2 Move to <*Pmax curve*> and press *Enter*. The Pmax Curve Screen, as shown in Figure 187 on page -302, appears.

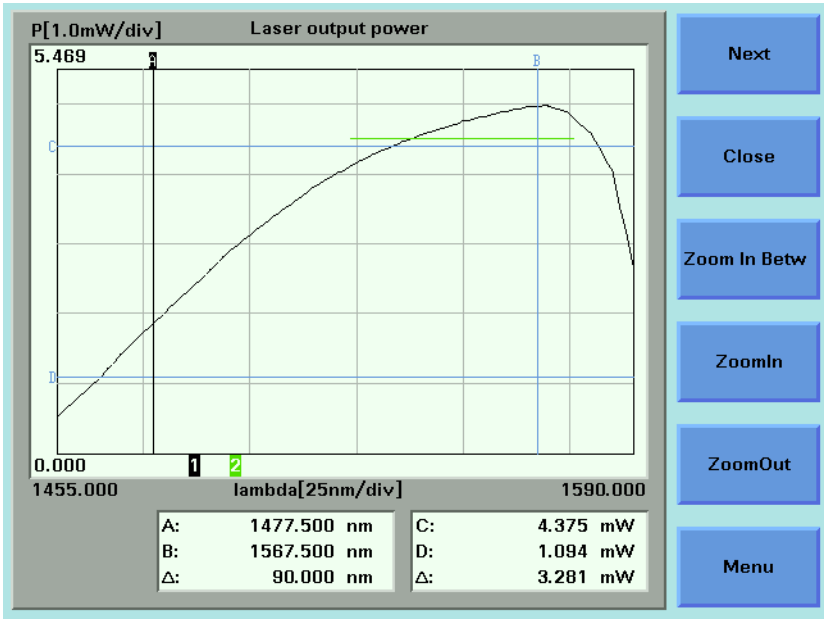



Figure 187 The Pmax Curve Screen

3 See Working with Application Graphs on page 249 for information on zooming in and out.

4 Press [Close] to exit from the Pmax Curve application.

# The Return Loss Application

**NOTE**

**The Return Loss Application supports the 81610A-81613A Return Loss Modules. The Application is not available for the 8164A/B Lightwave Measurement System or the 8166A/B Lightwave Multichannel System.**

**The Return Loss application allows measurement of Return Loss and/or Insertion Loss. Both values are displayed on the Keysight 8163A/B Lightwave Multimeter at the same time, depending on the calibration and configuration status. In addition, the Return Loss Application provides a simple step-by-step guided procedure for calibration of the instrument.**

## Starting the Application

As the other applications, the Return Loss Application can be configured to start up automatically. Alternatively, it can be started by pressing the “Appl” hardkey on the front of the 8163A/B Lightwave Multimeter.

## Measuring Return Loss

To measure return loss, insert a Return Loss Module into the 8163A/B Lightwave Multimeter Multimeter and connect it to the Device under Test (DUT). The Return Loss value is displayed on the Multimeter. You can freeze the measurement value during measurement either by pressing the “Hold/Cnt” softkey or by using a foot pedal if this option has been enabled via the “Config” hardkey. (See How to Configure your Foot Pedal on page 70 for further details). For general information on measuring Return Loss, please refer to Return Loss Measurement on page 177.

## Measuring Return Loss and Insertion Loss

To measure return loss and insertion loss insert a Return Loss module and a Power Sensor module into the 8163A/B Lightwave Multimeter. Connect the Return Loss Module to the Power Sensor Module via the Device Under Test (DUT). Both values are shown simultaneously on the display depending on the calibartion and configuration status. You can freeze the measurement values during measurement either by pressing the “Hold/Cnt” softkey or by using a foot pedal if this option has been enabled

via the “Config” hardkey. (See How to Configure your Foot Pedal on page 70 for further details). For general information on measuring return loss and insertion loss, please refer toReturn Loss Measurement on page 177.

**NOTE** The Return Loss Application always uses the first available power meter channel on dual power meters.

## On-Screen Messages

**Table 19 Return Loss Application On-Screen Messages**

| Keysight 8163A/B Message | Description |
|---|---|
| Hold | Either the **Hold/Cnt** Softkey or the foot pedal have been pressed to freeze the measurement value |
| UnCal | Application has not performed a calibration cycle with selected wavelength. If dual wavelength is selected, at least one wavelength is uncalibrated. |
| NoH | There is an Optical Head Interface module inserted in the mainframe that does not have an Optical Head connected to it. No measurement is possible using this channel until you reconnect an optical head |

## Configuration

The Return Loss Application can be configured according to your measurement requirements. The following paramters can be configured:

- the tool used for reflection calibration (reference reflector or reference cable)
- the return loss reference value RLref of the reflector device
- the averaging time
- the wavelength of the return loss module.

User Interface

When the Return Loss Application is started the following screen appears on the 8163A/B Lightwave Multimeter:

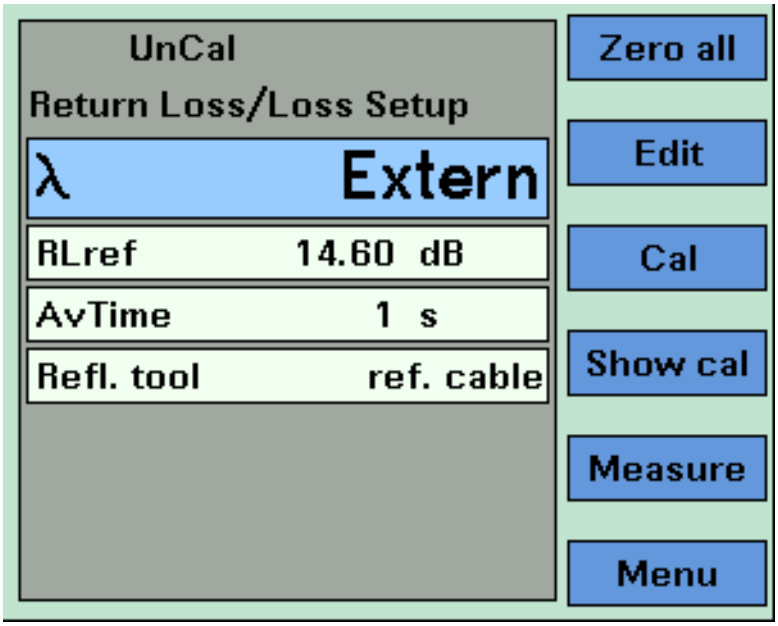



Figure 188 Main Screen of the Return Loss Application

The softkeys on the screen have the following functions:

Zero all

The Zero all softkey zeros all power measurement channels within the mainframe (Return Loss and optional Power Meter) at the same time.

Edit

The currently selected item on the main screen can be modified using this key.

Cal

This key starts the guided calibration procedure. Please follow the instructions on the screen to perform a Reflectance Calibration, a Termination Calibration and a Loss Calibration. You will be guided step by step through each stage of the calibration process.

Show Cal

To display the calibration parameters of the last calibration, press this key.

Measure

Press this key to start a new Return Loss and/or Insertion Loss measurement.

Menu

Press this key to access all parameters and functions that apply to the Return Loss Application.

# Recording Measurement Results

## Printing Application Measurement Results

You can print application measurement results by completing the following instructions.

1 Perform any of the following applications as described above:

- The Logging Application on page 261,
- The Stability Application on page 274, or
- The PACT Application on page 287.

2 Move to the Analysis Screen.

3 Connect your printer to the instrument as described in How to Connect a Printer on page 97.

4 Select the printer type as described in How to Select the Printer Type on page 89.

5 Press [Menu], move to <*Print*>, and press *Enter*. The screen, shown in Figure 189 on page -307, appears.

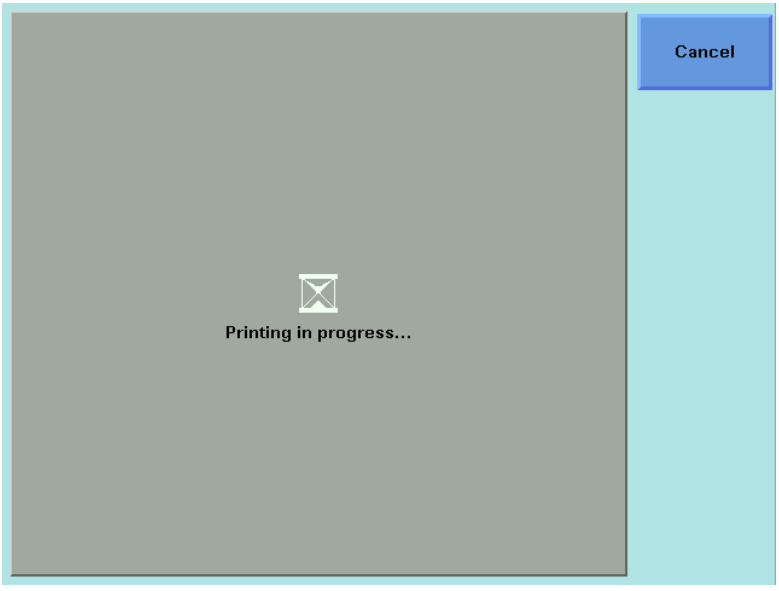
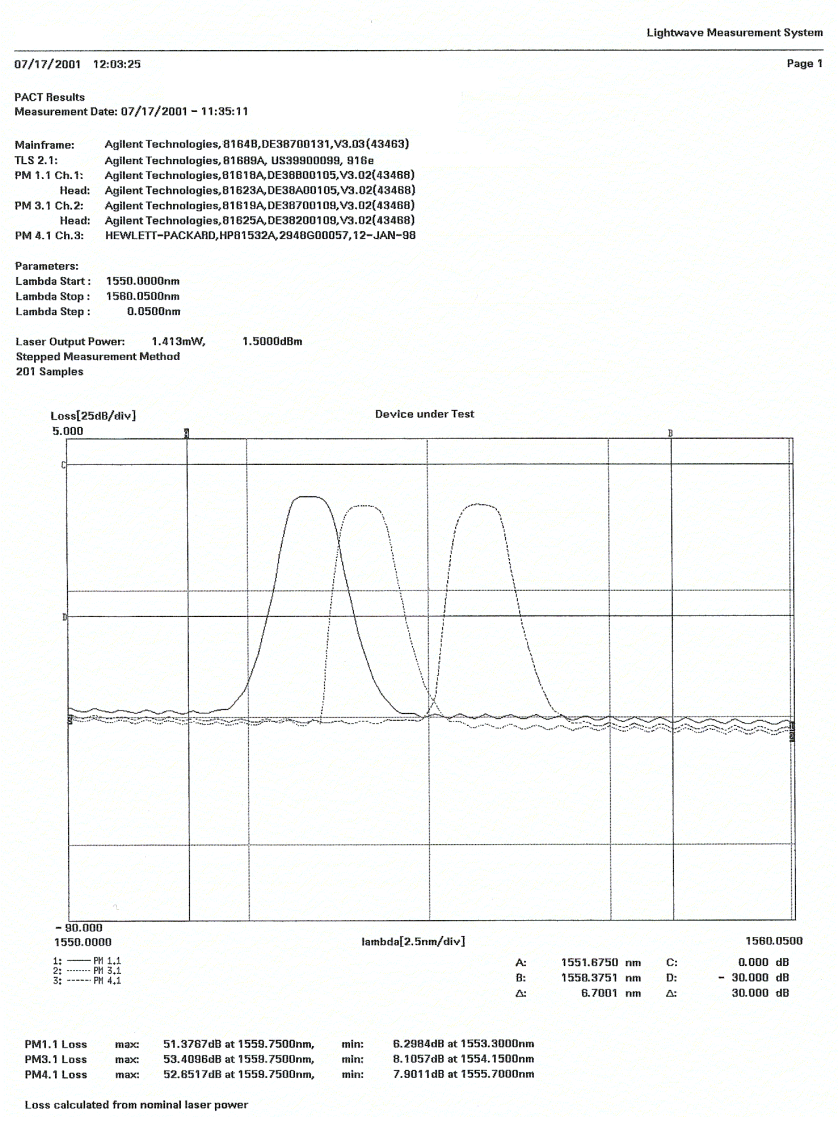



Figure 189 The Printing in Progress Screen

**NOTE** If you want to cancel the print job, press the [Cancel] softkey.

6 The printed results should resemble the page shown in Figure 190 on page -309.



Lightwave Measurement System

07/17/2001 12:03:25 Page 1

PACT Results
Measurement Date: 07/17/2001 – 11:35:11

Mainframe: Agilent Technologies, 8164B,DE38700131,V3.03(43463)
TLS 2.1: Agilent Technologies, 81689A, US39900099, 916e
PM 1.1 Ch.1: Agilent Technologies,81618A,DE36B00105,V3.02(43468)
Head: Agilent Technologies,81623A,DE38A00105,V3.02(43468)
PM 3.1 Ch.2: Agilent Technologies,81619A,DE38700109,V3.02(43468)
Head: Agilent Technologies,81625A,DE38200109,V3.02(43468)
PM 4.1 Ch.3: HEWLETT-PACKARD,HP81532A,2948G00057,12-JAN-98

Parameters:
Lambda Start : 1550.0000nm
Lambda Stop : 1560.0500nm
Lambda Step : 0.0500nm

Laser Output Power: 1.413mW, 1.5000dBm
Stepped Measurement Method
201 Samples



PM1.1 Loss max: 51.3787dB at 1559.7500nm, min: 6.2984dB at 1553.3000nm
PM3.1 Loss max: 53.4096dB at 1559.7500nm, min: 8.1057dB at 1554.1500nm
PM4.1 Loss max: 52.6517dB at 1559.7500nm, min: 7.9011dB at 1555.7000nm

Loss calculated from nominal laser power

Figure 190 Printed Results

### Saving Application Measurement Results to Diskette (not available on later units)

If you are using the 8164A/B Lightwave Measurement System, you can save application measurement results to diskette by completing the following instructions:

1 Perform any of the following applications as described above:
   - The Logging Application on page 261,
   - Figure on page -274, or
   - Figure on page -287.
2 Move to the Analysis Screen.
3 Insert a floppy disk in the diskette drive of your 8164A/B Lightwave Measurement System.
4 Press [Menu].
5 Move to one of the following options:
   - <*Save Ascii File*>, the data will be saved in Ascii-text format, that can be opened by all text editors.
   - <*Save CSV File*>, the data will be saved in CSV format, that can be opened by Microsoft Excel.
6 Press *Enter*.The File Name Editor, as shown in Figure 191 on page -310, appears.

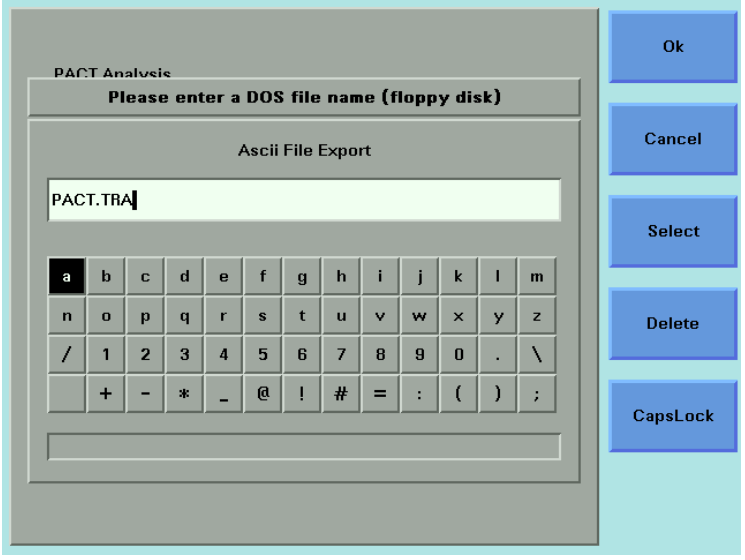



Figure 191 The File Name Editor

7 If you wish to change the suggested file name, use the on-screen keyboard to modify the name.

8 Press [OK] to save the data to diskette using the displayed file name.

**NOTE** Keysight 8164B Lightwave Measurement System mainframes do not include a diskette ("floppy disk") drive.

# 11 Installation and Maintenance

Safety Considerations / 314
Initial Inspection / 315
AC Line Power Supply Requirements / 316
Operating and Storage Environment / 321
Using Modules / 327
Input and Output Connectors / 335
GPIB Interface / 338
GPIB Logic Levels / 340
Serial Interface / 341
Parallel Port, PCMCIA Slot, Keyboard connector and 24V DC Output / 342
Claims and Repackaging / 343

This chapter provides installation instructions for the 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System. It also includes information about initial inspection and damage claims, preparation for use, packaging, storage, and shipment.

## Safety Considerations



The 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System are Safety Class 1 instruments (that is, instruments with a metal chassis directly connected to earth via the power supply cable). The shown symbol is used to show a protective earth terminal in the instrument.

Before operation, review the instrument and manual for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

Some 8164A/B Lightwave Measurement System and 8166A/B Lightwave Multichannel System circuits are powered whenever the instrument is connected to the AC power source. To disconnect from the line power, disconnect the power cord either at the rear power inlet, or at the AC line power source (receptacle). One of these must always be accessible. If the instrument is in a cabinet, it must be disconnected from the line power by the system's line power switch.

## Initial Inspection

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically.

The Function Tests give a procedure for checking the operation of the instrument. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Keysight Technologies Sales/Service Office.

**WARNING** **To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, and so on).**

# AC Line Power Supply Requirements

## Line Power Requirements

The 8163A/B Lightwave Multimeter System complies with overvoltage category II and can operate from the single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range 50 to 60 Hz.The maximum power consumption is 120 VA with all options installed.

The 8164A/B Lightwave Measurement System complies with overvoltage category II and can operate from any single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range from 50 to 60 Hz. The maximum power consumption is 270 VA with all options installed.

The 8166A/B Lightwave Multichannel System complies with overvoltage category II and can operate from any single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range from 50 to 60 Hz. The maximum power consumption is 450 VA with all options installed.

## Line Power Cable

In accordance with international safety standards, the instrument has a three-wire power cable. When connected to an appropriate AC power receptacle, this cable earths the instrument cabinet. For the part number of the power cable for your country and instrument see Accessories on page 345.

.



Figure 192 8163A/B Lightwave Multimeter System Power Key

**CAUTION**

If you need to turn off the power, unplug the instrument at the mains or remove the power cable connector from the appliance coupler at the rear of the instrument. For this reason, the power cable connection should be easily accessible - allowing you to turn off the power quickly. If the instrument is in a cabinet, it must be disconnected from the line power by the system's line power switch.

**CAUTION**

Please note that the power key on the front panel of the 8164A/B Lightwave Measurement System does not stop the flow of power to the instrument. The power key allows you to switch between stand-by mode and power-on mode.

When the green power-on LED is lit, you can use the instrument. When the orange stand-by mode LED is lit, the Lightwave Measurement System is in stand-by mode. Do not remove the instrument covers - the power supply is still operating in stand-by mode.

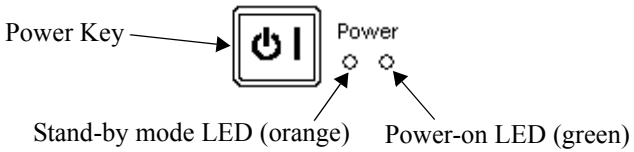



Figure 193 8164A/B Lightwave Measurement System Power Key

**CAUTION**

If you need to turn off the power, unplug the instrument at the mains or remove the power cable connector from the appliance coupler at the rear of the instrument. For this reason, the power cable connection should be easily accessible - allowing you to turn off the power quickly. If the instrument is in a cabinet, it must be disconnected from the line power by the system's line power switch.

**CAUTION** Please note that the power key on the front panel of the 8164A/B Lightwave Measurement System does not stop the flow of power to the instrument. The power key allows you to switch between stand-by mode and power-on mode.

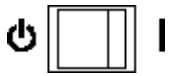


Figure 194 8166A/B Lightwave Multichannel System Power Key

**CAUTION** If you need to turn off the power, unplug the instrument at the mains or remove the power cable connector from the appliance coupler at the rear of the instrument. For this reason, the power cable connection should be easily accessible - allowing you to turn off the power quickly. If the instrument is in a cabinet, it must be disconnected from the line power by the system's line power switch.

The type of power cable shipped with each instrument depends on the country of destination.

**NOTE** You only need to use the line power cable to connect to the AC adapter.

**WARNING** To avoid the possibility of injury or death, you must observe the following precautions before switching on the instrument.

Insert the power cable plug only into a socket outlet provided with a protective earth contact. Do not negate this protective action by the using an extension cord without a protective conductor.

Do not interrupt the protective earth connection intentionally.

The AC power requirements are summarized on the rear panel of the instrument.

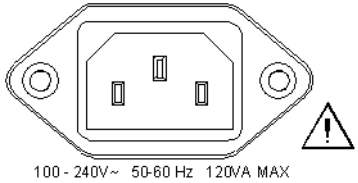



Figure 195 AC Power Requirement Markings - 8163A/B

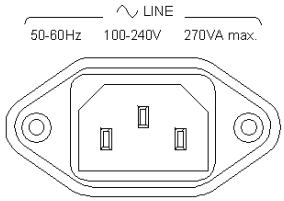



Figure 196 AC Power Requirement Markings - 8164A/B

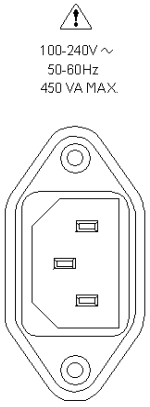



Figure 197 AC Power Requirement Markings - 8166A/B

## Changing the Battery

**CAUTION**

The 8163A Lightwave Multimeter System, 8164A Lightwave Measurement System, and the 8166A Lightwave Multichannel System contain a disc shaped Lithium Thionyl Chloride battery.

The 8163B Lightwave Multimeter System, 8164B Lightwave Measurement System, and the 8166B Lightwave Multichannel System contain a cylindrical Lithium Manganese Dioxode battery.

The battery is not user replaceable. The battery is protected against loading by a special circuit and must be installed with the correct polarity. Changing the battery should be carried out only by Keysight Technologies service personnel. If you need to get the battery replaced refer to your nearest Keysight Technologies Sales/Service Office.

## Changing the Fuse

**CAUTION**

There is no user replaceable fuse for the 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System. Changing the fuse should be carried out only by Keysight Technologies service personnel. If you need to get the fuse replaced refer to your nearest Keysight Technologies Sales/Service Office.

The 8163A/B contains a F5.0A/250V fast-acting fuse.

The 8164A/B and 8166A/B contain a F10.0A/250V fast-acting fuse.

## Operating and Storage Environment

The following summarizes the operating environment ranges. In order for the 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System to meet specifications, the operating environment must be within these limits.

**WARNING** **The 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System are not designed for outdoor use. To prevent potential fire or shock hazard, do not expose the instrument to rain or other excessive moisture.**

### Temperature

The instrument should be protected from temperature extremes and changes in temperature that may cause condensation within it.

The storage and operating temperature for the Lightwave Measurement System are given in the table below.

**Table 20 Specified Temperature Ranges**

| Mainframe | Operating Range | Storage Range |
|---|---|---|
| 8163A/B | 0° C to +45° C | -40°C to +70°C |
| 8164A/B | +10° C to +35° C | -40°C to +70°C |
| 8166A/B | 0° C to +45° C | -40°C to +70°C |

### Humidity

The operating humidity for the 8164A/B Lightwave Measurement System is < 80% from 10°C to +35°C.

The operating humidity for the 8163A/B Lightwave Multimeter System and the 8166A/B Lightwave Multichannel System is up to 95% from 0°C to 45°C.

### Altitude

The maximum operating altitude of the 8163A/B Lightwave Multimeter System, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System is
2000 m.

### Pollution Protection

The 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System are designed for pollution degree 2.

### Storage and Shipment

The instrument can be stored or shipped at temperatures between -40×C and +70×C. The instrument should be protected from temperature extremes that may cause condensation within it.

### Instrument Cooling

The 8163A/B Lightwave Multimeter System and the 8164A/B Lightwave Measurement System have a cooling fan mounted internally.

The 8166A/B Lightwave Multichannel System has cooling fans mounted internally.

Mount or position your instrument upright and horizontally, as shown in Figure 198 on page -323, Figure 199 on page -323, or Figure 200 on page -324so that air can circulate through it freely.

#### Operating Position

When operating the 8163A/B, 8164A/B, or 8166A/B choose a location that provides at least 75 mm (3 inches) of clearance at the rear, and at least 25 mm (1 inch) of clearance at each side. Failure to provide adequate air clearance may result in excessive internal temperature, reducing instrument reliability. The instrument should not be operated when mounted on its rear or side panels.

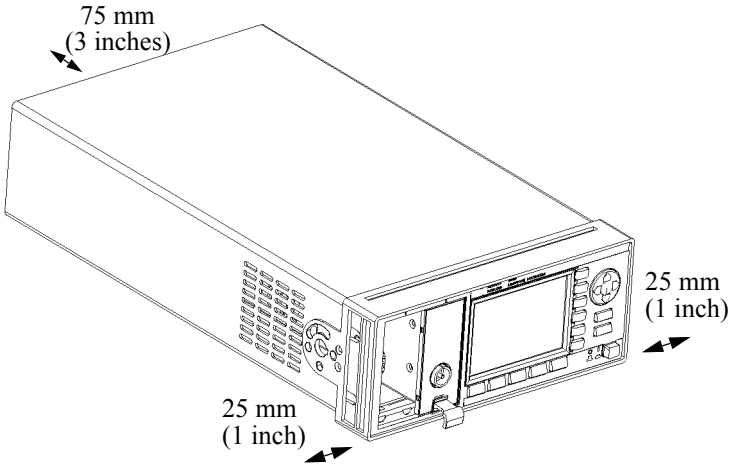



Figure 198 Correct Operating Position of the 8163A/B

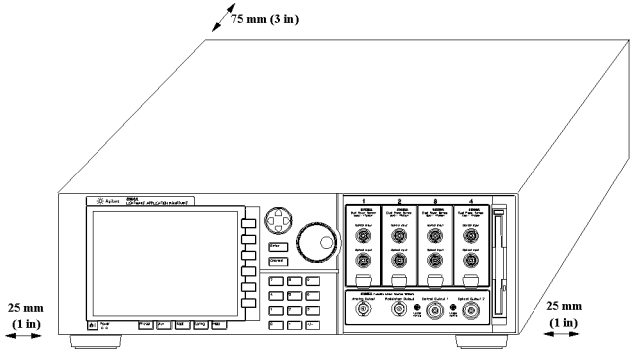



Figure 199 Correct Operating Position of the 8164A/B

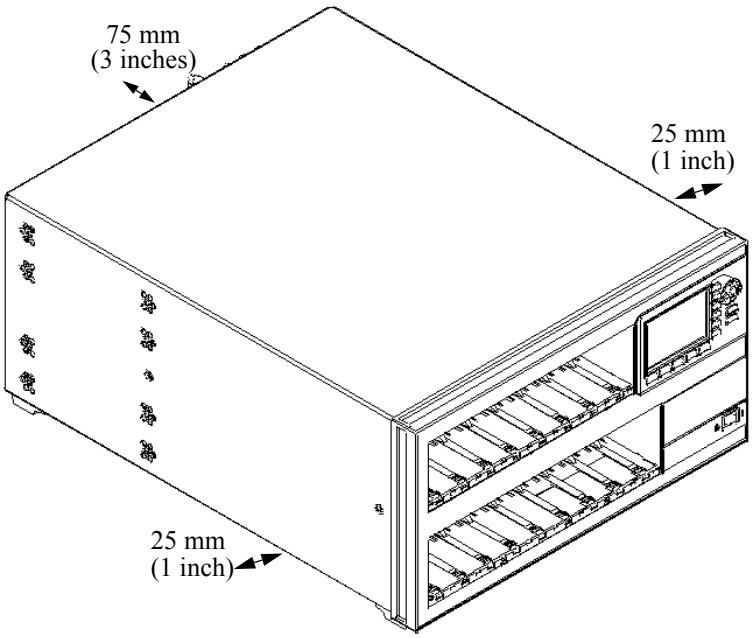



Figure 200 Correct Operating Position of the 8166A/B

### Storage Position

The Keysight 8164A/B Lightwave Measurement System can be stored in its operating position, as shown in Figure 198, or on its back legs as shown in Figure 201 on page -325. The back legs protect the connectors on the back panel from damage.

**CAUTION** **Before positioning the 8164A/B Lightwave Measurement System on its back legs. Make sure that the instrument is in stand-by mode and disconnect all connections to the back panel.**

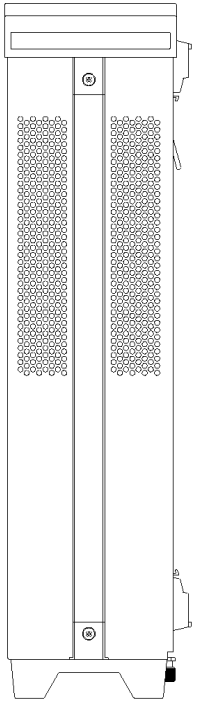


Figure 201 Storing the 8164A/B on its Back Legs.

## Carrying the Instrument

When carrying the 8164A/B Lightwave Measurement System, grip the strap at the side of the instrument as shown in Figure 202 on page -325.

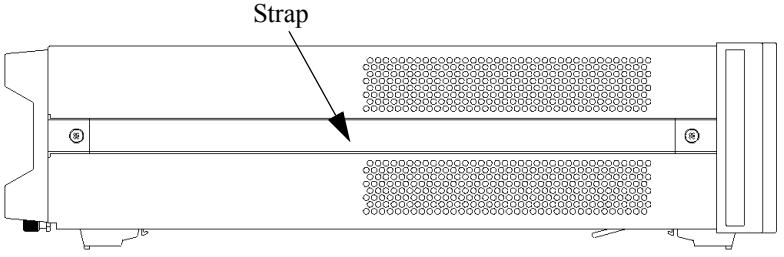



Figure 202 Carry the 8164A/B Lightwave Measurement System using this Strap

**WARNING**

If you need to lift the 8166A/B Lightwave Multichannel System ensure the following:

- that you do not attempt to lift the instrument alone, at least two people are needed to carry the instrument,
- that your back is straight and you bend your legs rather than your spine,
- that the load is as close to your body as possible,
- when carrying, you never arch your spine backwards, and
- that you can cope with the weight of your load.

# Using Modules

## How to Fit and Remove Modules

You can use two types of module:

- Front-loadable modules - these modules fit in the four module slots at the front of the 8164A/B Lightwave Measurement System or the two module slots at the front of the 8163A/B Lightwave Multimeter System or the 17 module slots at the front of the 8166A/B Lightwave Multichannel System.
- Back-loadable modules - these tunable laser source modules fit in the large module slot at the rear of the 8164A/B Lightwave Measurement System.

### How to Remove a Front-Loadable Module

**CAUTION**

**Do not use the electrical or optical connectors to pull the module out of the instrument, as this can cause damage to the connectors.**

**Make sure that the line power is switched off before you remove a module.**

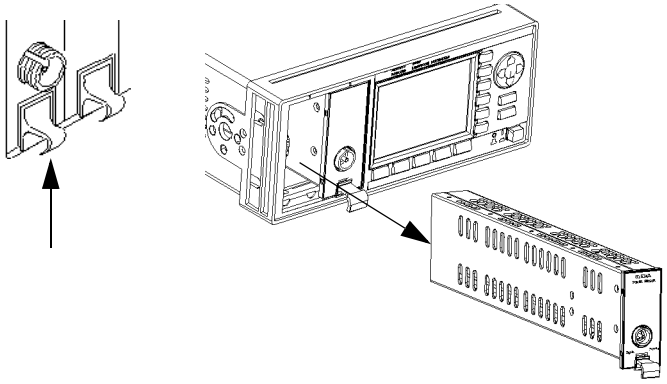


Figure 203 How to Remove a Front-Loadable Module

1 Lift the catch at the bottom front of the module.
2 With the catch lifted, pull the module out of the instrument. If the module does not slide out freely, check that you have lifted the catch high enough.

### How to Fit a Front-Loadable Module

**CAUTION**

Do not use the electrical or optical connectors to push the module into the instrument, as this can cause damage to the connectors.

Make sure that the line power is switched off before you fit a module.

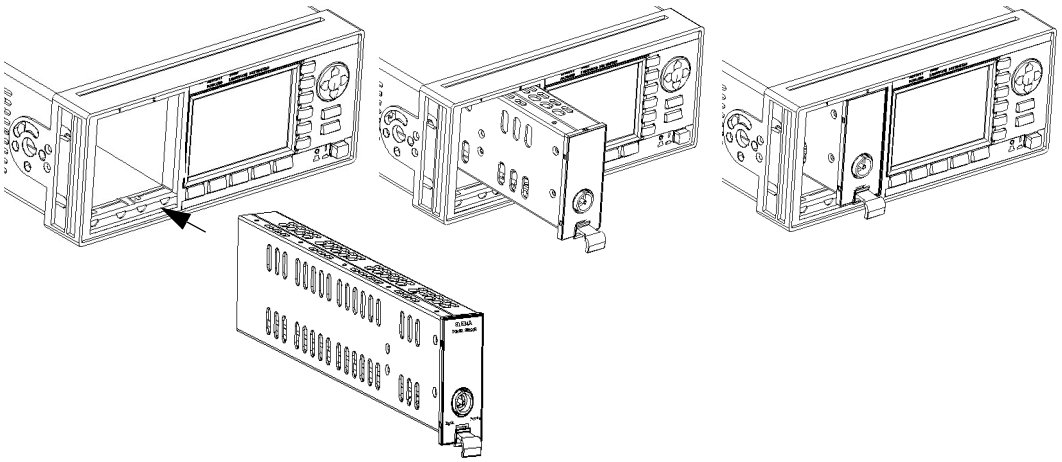


Figure 204 How to Insert a Front-Loadable Module

1 Position the module at an unoccupied slot, with the catch at the bottom front of the module.
2 Insert the module into the slot and onto the tracks. If the module does not slide in freely, check that you have correctly positioned and correctly oriented it and that there is no obstruction to its movement.
3 Apply pressure to the front panel, and push the module as far as it goes. You hear a small click when the module reaches its installed position. This is the catch making contact.

### How to Remove a Back-Loadable Module

**CAUTION**

**Disconnect all electrical and optical connectors before you remove this module from the instrument, as this can cause damage to the connectors.**

**Make sure that the instrument is in stand-by mode, see page 55, before you remove a module.**

1 Untighten the retaining screws, see Figure 205 on page -330, that secure the module in the instrument.

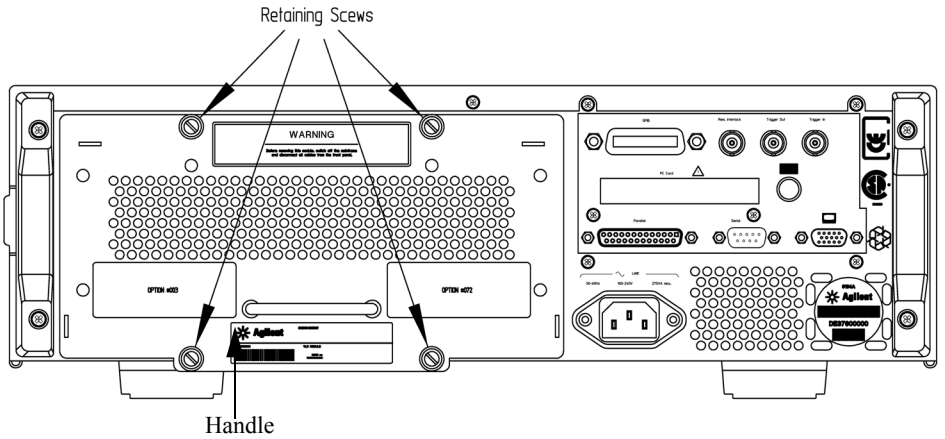



Figure 205 Back Panel of 8164B Lightwave Measurement System

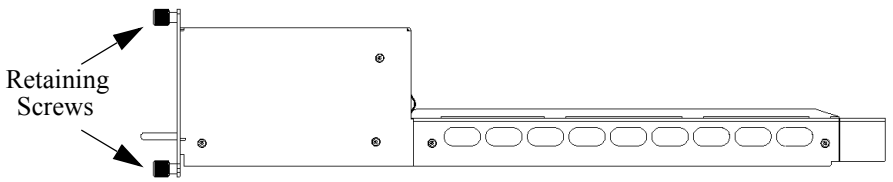



Figure 206 Side View of a Back-Loadable Module

2 Pull the module out of the mainframe, using the handle, being careful to keep the module completely flat.

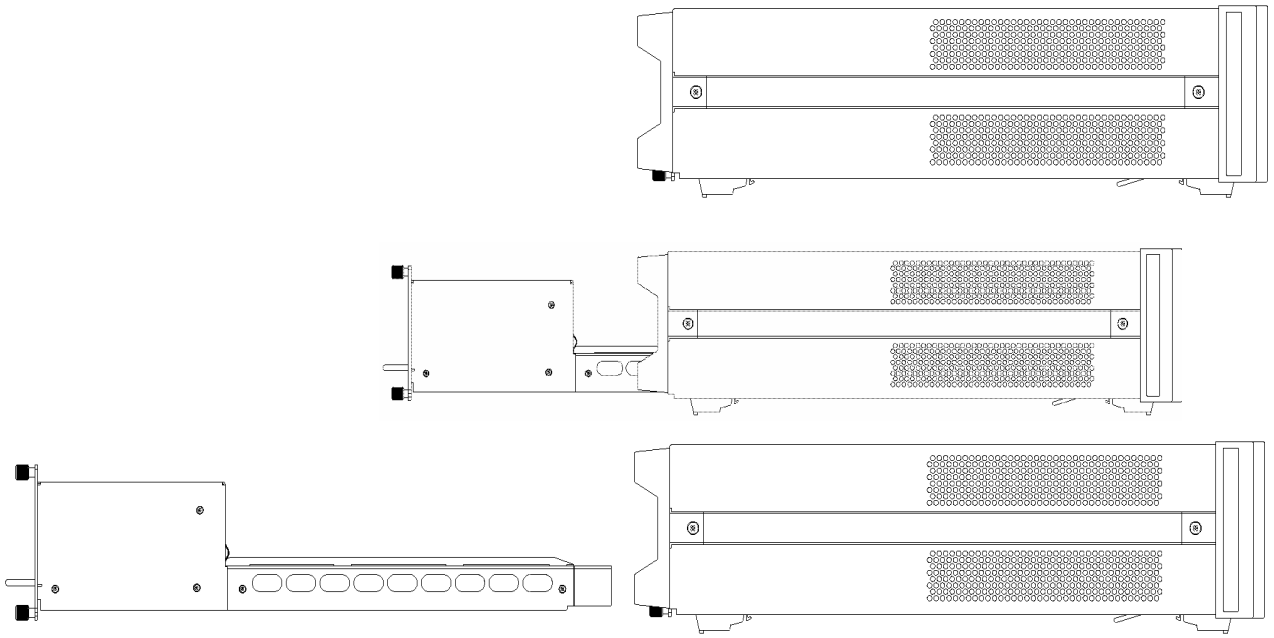


Figure 207 Removing a Back-Loadable Module from the 8164A/B

**CAUTION** If you pull the module out at an angle or vertically, you may damage the instrument and the module. You should pull the module out along the direction shown in Figure 207 on page -331

### How to Fit a Back-Loadable Module

**CAUTION** Disconnect all electrical and optical connectors before you fit this module into the instrument, as this can cause damage to the connectors.

Make sure that the instrument is in stand-by mode, before you remove a module.

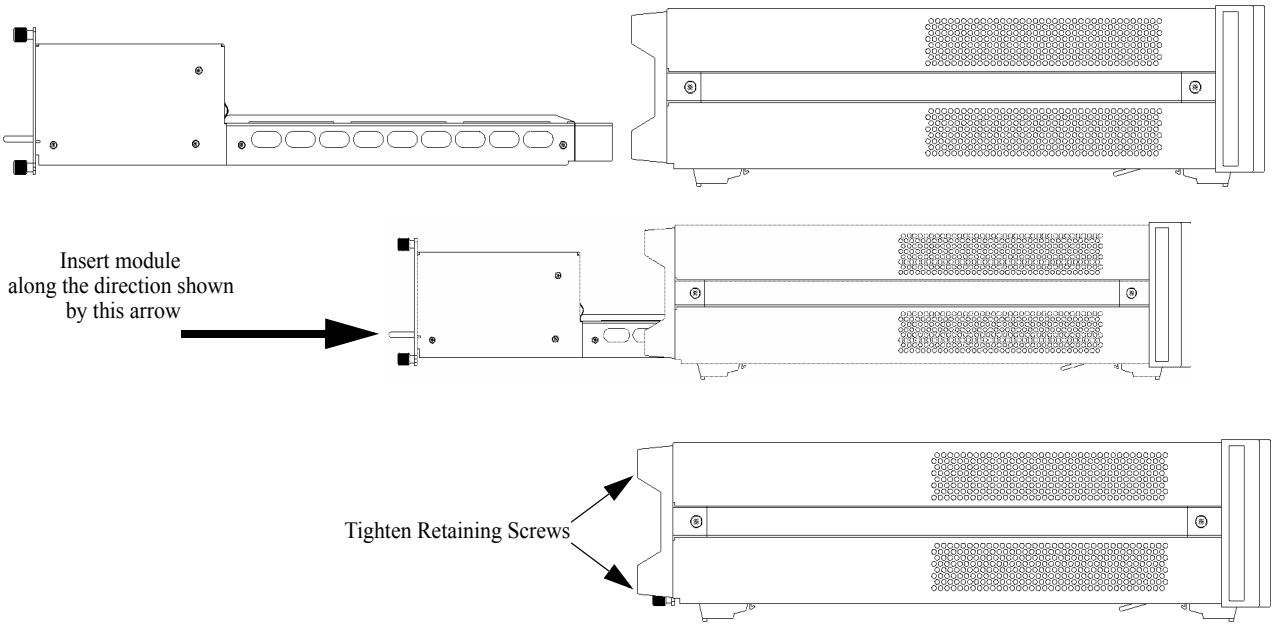



Figure 208 Fitting a Back-Loadable Module

1 Position the module at the rear of the instrument as shown in Figure 208 on page -332.

2 Insert the module into the mainframe, using the handle, being careful to keep the module completely flat. If the module does not slide freely, check that you have correctly oriented it and that there is no obstruction to its movement.

**CAUTION** **If you insert the module at an angle or vertically, you may damage the instrument and the module. You should insert the module along the direction shown by the arrow in Figure 208 on page -332.**

3 Apply pressure to the handle, and push the module as far as it goes. You hear a small click when the module reaches its installed position. This is the catch making contact.

4 Tighten retaining screws, to hold module in place.

### Adding a Connector Interface

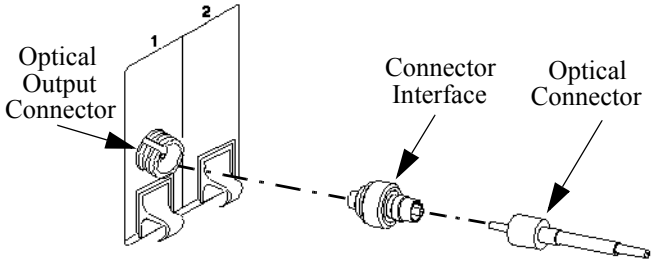



Figure 209 Adding a Connector Interface

**NOTE** **Before you attach a connector and fiber, you should clean them both.** **See Cleaning Instructions on page 423**

To use a connector interface to connect a module to an optical-fiber patchcord connector:

1 Select a connector interface to suit the optical connector that your optical fiber is terminated with.

2 Connect the connector interface to the optical output connector of the module, see Figure 209 on page -333.

3 You can now attach the optical connector to the connector interface.

### Protecting Empty Module Slots

Fitting a Blind Panel or Filler Module helps to:

- prevent dust pollution and
- optimize cooling by guiding the air flow.

### Fitting Blind Panels for Front-Loadable Module Slots

The newer filler panels can be inserted much like a front-loadable module and have the part number 08163-44101. To fit the older blind panel (part number - 08163-40199), perform the following procedure.

1 Position the blind panel as shown in Figure 210 on page -334. Position the end closest to the handle against the bottom edge of the slot.

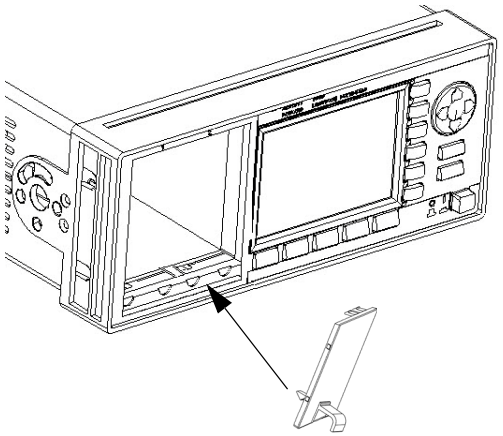


Figure 210 Fitting a Blind Panel

2 Push the top of the blind panel so that it clicks into position.

**NOTE** **To remove a blind panel, pull the handle.**

### Fitting a Filler Module for Back-Loadable Module Slots

The 81645A Filler Module must be used if you have not installed a back-loadable Tunable Laser module into the 8164A/B Lightwave Measurement System.

The Keysight 81645A Filler Module can be fitted in the same way as any back-loadable module, see How to Fit and Remove Modules on page 327.

The Keysight 81645A Filler Module can be removed in the same way as any back-loadable module, see How to Remove a Back-Loadable Module on page 329.

## Input and Output Connectors

There are three BNC connectors on the rear panel of your instrument. These are the Remote Interlock, the Trigger Out and the Trigger In connectors.

**CAUTION**

**There are two input BNC connectors: the Remote Interlock Connector and the Trigger Input, see Figure 211 on page -335. These are TTL inputs. A maximum of 5 V can be applied as an external voltage to either of these input connectors.**

There is one output BNC connector: the Trigger Output, see Figure 211or Figure . This is a TTL output. Do not apply an external voltage to this connector.

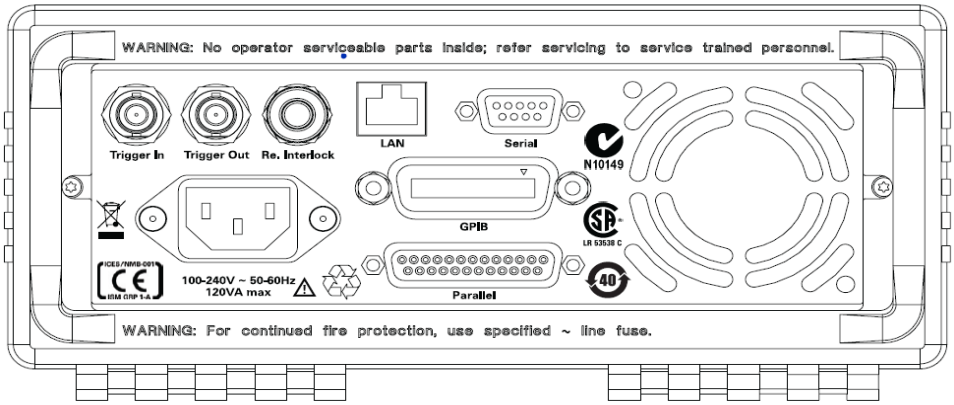



Figure 211 Rear Panel of the 8163B Lightwave Multimeter System

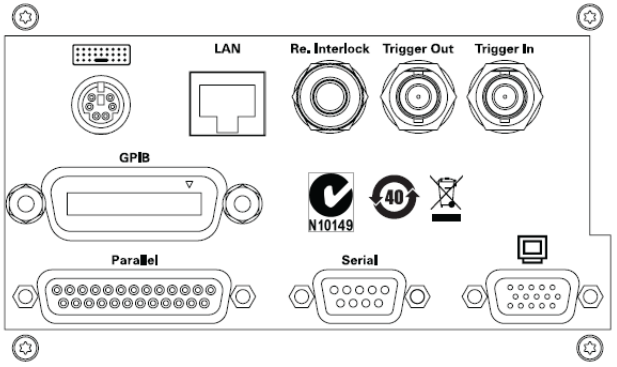



Figure 212 Rear Panel of the 8164B Lightwave Measurement System

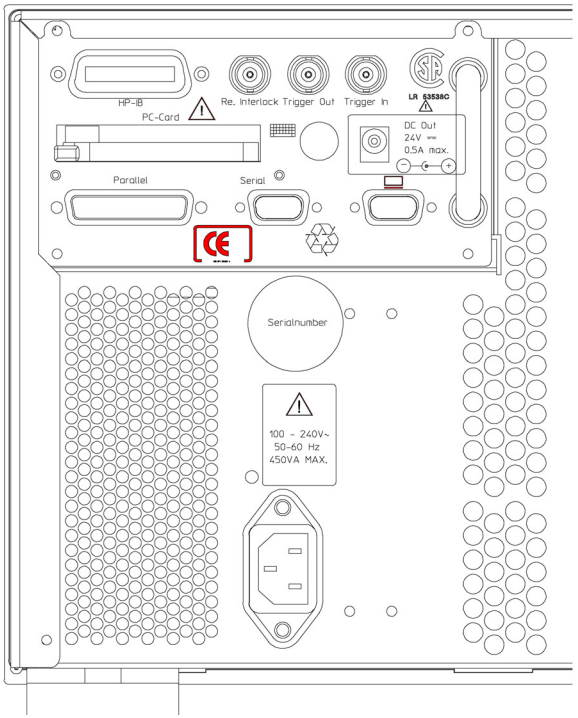



Figure 213 Rear Panel of the 8166B Lightwave Multichannel System

The Remote Interlock (RIL) connector

**CAUTION**

There is a Remote Interlock (RIL) connector at the back of the 8163A/B Lightwave Multimeter System, 8164A/B Lightwave Measurement System, and 8166A/B Lightwave Multichannel System for the purpose of the optional connection of a safety interlock switch. If the short circuit at this BNC connector is opened, the laser is switched off immediately and cannot be switched on until it is closed again.

# GPIB Interface

You can connect your GPIB interface into a star network, a linear network, or a combination star and linear network. The limitations imposed on this network are as follows:

- The total cable length cannot exceed 20 meters
- The maximum cable length per device is 2 meters
- No more than 15 devices may be interconnected on one bus.

## Cables and Adapters

See Accessories on page 345 for details on cables and adapters.

## Connector

The following figure shows the connector and pin assignments.

Connector Part Number: 1251-0293

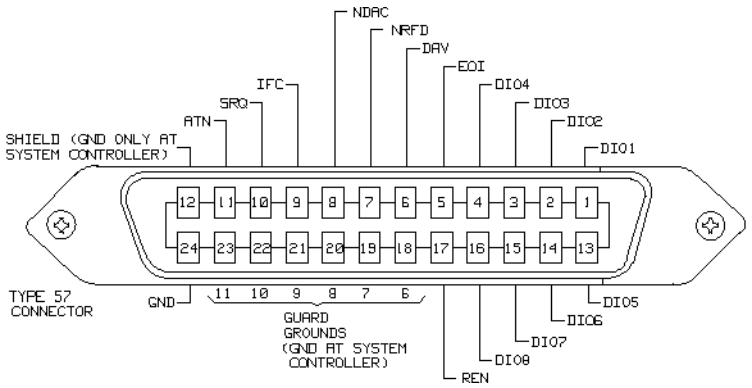



Figure 214 GPIB Connector

**CAUTION**

**Keysight Technologies products are equipped with connectors having ISO metric-threaded lock screws and stud mounts (ISO M3.5′0.6) that are black in color. Earlier connectors may have lock screws and stud mounts with English-threaded lock screws and stud mounts (6-32 UNC) that have a shiny nickel finish.**

**CAUTION**

It is recommended that you do not stack more than three connectors, one on top of the other.

Hand-tighten the connector lock screws. Do not use a screwdriver.

## GPIB Logic Levels

The instrument's GPIB lines use standard TTL logic, as follows:

- True = Low = digital ground or 0 Vdc to 0.4 Vdc
- False = High = open or 2.5 Vdc to 5 Vdc

All GPIB lines have LOW assertion states. High states are held at 3.0 Vdc by pull-ups within the instrument. When a line functions as an input, it requires approximately 3.2 mA to pull it low through a closure to digital ground. When a line functions as an output, it will sink up to 48 mA in the low state and approximately 0.6 mA in the high state.

**NOTE** The GPIB line screens are not isolated from ground.

# Serial Interface

The mainframe's serial interface has configurable and fixed parameters.

- The Baudrate set for the serial interface of the instrument should match that set for the PC serial interface connected to it.
- The PC serial interface should be configured to match the instrument's fixed parameters.

### Configurable Parameters

Baudrate. Refer to How to Set the Speed of the Serial Interface on page 87.

### Fixed Parameters

These are:

| Serial Interface Configuration - Fixed Parameters | |
|---|---|
| Data Bits | 8 |
| Parity | None |
| Stop Bits | 1 |
| Flow Control | Hardware (RTS/CTS) |

**NOTE** For serial communication use the null modem cable provided with your instrument (Keysight P/No. 5180-2477). This is primarily used for the firmware upgrade process.

## Parallel Port, PCMCIA Slot, Keyboard connector and 24V DC Output

- These interfaces are not present on all models. The 8164A Lightwave Measurement System also has a PS/2 mouse connector.
- The parallel port is a standard centronics printer interface.
- The keyboard connector is a standard PS/2 connector.

**NOTE** **The PCMCIA Slot and the 24V DC output are not used.**

## Claims and Repackaging

If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Keysight Technologies Sales/Service Office. The Keysight Technologies Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

### Return Shipments to Keysight Technologies

If the instrument is to be shipped to a Keysight Technologies Sales/Service Office, attach a tag showing owner, return address, model number and full serial number and the type of service required.

The original shipping carton and packing material may be reusable, but the Keysight Technologies Sales/Service Office will provide information and recommendation on materials to be used if the original packing is no longer available or reusable. General instructions for repackaging are as follows:

- Wrap instrument in heavy paper or plastic.
- Use strong shipping container. A double wall carton made of 350-pound test material is adequate.
- Use enough shock absorbing material (3 to 4 inch layer) around all sides of the instrument to provide a firm cushion and prevent movement inside container. Protect control panel with cardboard.
- Seal shipping container securely.
- Mark shipping container FRAGILE to encourage careful handling.
- In any correspondence, refer to instrument by model number and serial number.

# 12 Accessories

Instrument and Options - Keysight 8163A/B / 346
Instrument and Options - Keysight 8164A/B / 347
Instrument and Options - Keysight 8166A/B / 348
GPIB Cables and Adapters / 354

This chapter only covers the currently available KEYSIGHT 816xB mainframes.

The Keysight 8163B Lightwave Multimeter, the Keysight 8164B Lightwave Measurement System, and the Keysight 8166B Lightwave Multichannel System are available in various configurations for the best possible match to the most common applications.

This appendix provides information on the available options and accessories. See also the Lightwave Solution Platform Configuration Guide: Pub. Nr. 5988-1571EN.

# Instrument and Options - Keysight 8163A/B

| Product | Opt | Description | Part Number |
|---|---|---|---|
| Keysight 8163B | | Lightwave Multimeter Mainframe | |
| | | Additional User's Guide | 08164-90B15 |
| | | Additional Programmer's Guide | 08164-90B64 |
| | 1CM | Rack Mount Kit | |
| | 900 | Power Cord - United Kingdom | 8120-1351 |
| | 901 | Power Cord - Australia & New Zealand | 8120-1369 |
| | 902 | Power Cord - Continental Europe | 8120-1689 |
| | 903 | Power Cord - United States (120 V) | 8120-1378 |
| | 905 | Power Cord - Systems Cabinet Use - IEC 320 | 8120-1860 |
| | 906 | Power Cord - Switzerland | 8120-2104 |
| | 912 | Power Cord - Denmark | 8120-3997 |
| | 917 | Power Cord - Republic of South Africa and India | 8120-4211 |
| | 918 | Power Cord - Japan | 8120-4753 |
| | 919 | Power Cord - Israel | 8120-5182 |
| | 922 | Power Cord - China | 8120-8376 |
| | 927 | Power Cord - Thailand | 8120-8871 |

## Instrument and Options - Keysight 8164A/B

| Product | Opt | Description | Part Number |
|---|---|---|---|
| Keysight 8164B | | Lightwave Measurement System Mainframe | |
| | | Additional User's Guide | 08164-90B15 |
| | | Additional Programmer's Guide | 08164-90B64 |
| | 1CN | Front Handle Kit | |
| | 1CM | Rack Mount Kit | |
| | 900 | Power Cord - United Kingdom | 8120-1351 |
| | 901 | Power Cord - Australia & New Zealand | 8120-1369 |
| | 902 | Power Cord - Continental Europe | 8120-1689 |
| | 903 | Power Cord - United States (120 V) | 8120-1378 |
| | 905 | Power Cord - Systems Cabinet Use - IEC 320 | 8120-1860 |
| | 906 | Power Cord - Switzerland | 8120-2104 |
| | 912 | Power Cord - Denmark | 8120-3997 |
| | 917 | Power Cord - Republic of South Africa and India | 8120-4211 |
| | 918 | Power Cord - Japan | 8120-4753 |
| | 919 | Power Cord - Israel | 8120-5182 |
| | 922 | Power Cord - China | 8120-8376 |
| | 927 | Power Cord - Thailand | 8120-8871 |

# Instrument and Options - Keysight 8166A/B

| Product | Opt | Description | Part Number |
|---|---|---|---|
| Keysight 8166B | | Lightwave Multimeter Mainframe | |
| | | Additional User's Guide | 08164-90B15 |
| | | Additional Programmer's Guide | 08164-90B64 |
| | 1CM | Rack Mount Kit | |
| | 900 | Power Cord - United Kingdom | 8120-1351 |
| | 901 | Power Cord - Australia & New Zealand | 8120-1369 |
| | 902 | Power Cord - Continental Europe | 8120-1689 |
| | 903 | Power Cord - United States (120 V) | 8120-1378 |
| | 905 | Power Cord - Systems Cabinet Use - IEC 320 | 8120-1860 |
| | 906 | Power Cord - Switzerland | 8120-2104 |
| | 912 | Power Cord - Denmark | 8120-3997 |
| | 917 | Power Cord - Republic of South Africa and India | 8120-4211 |
| | 918 | Power Cord - Japan | 8120-4753 |
| | 919 | Power Cord - Israel | 8120-5182 |
| | 922 | Power Cord - China | 8120-8376 |
| | 927 | Power Cord - Thailand | 8120-8871 |

## Modules

| Power Sensor Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81630B | High Power module, +28 to -70 dBm, analog out |
| Keysight 81634B | Power Sensor, +10 to -110 dBm, analog out |
| Keysight 81635A | Dual Sensor InGaAs, +10 to -80 dBm |
| Keysight 81636B | Fast Power Sensor InGaAs, +10 to -80 dBm, analog out |

| Optical Heads | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81620B | Si Head, 450 - 1020 nm, -90 to +10 dBm, Analog Output |
| Keysight 81623B | Ge Head, +10 to -80 dBm, Analog Output |
| Keysight 81624B | InGaAs Head, +10 to -90 dBm, Analog Output |
| Keysight 81626B | High Power Head, +27 to -70 dBm, Analog Output |
| Keysight 81628B | High Power Head, integrating sphere +40 to -60 dBm, Analog Output |

Each Optical Head listed above, must be used with one of the following Optical Head Interface modules:

| Optical Head Interfaces | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81618A | Single Channel Interface |
| Keysight 81619A | Dual Channel Interface |

| Accessories for Optical Heads | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81624CE | Head extension cable (4 m) |
| Keysight 81624DD | D-shape head adapter (magnetic) |
| Keysight 81624RM | Head mount kit (2 heads) |
| Keysight 81625RM | Head mount kit (4 heads) |

| Fabry-Perot Laser Diode Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81655A | LD Module 1310 nm, +13 dBm |
| Keysight 81656A | LD Module 1550 nm, +13 dBm |
| Keysight 81657A | LD Module 1310/1550 nm, +13 dBm |

| DFB Laser Diode Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81663A | DFB LD Module +13 dBm. |

| High Power Compact Tunable Laser Source Module | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81980A | Compact TLS with continuous sweeping 1465-1575 nm. |
| Keysight 81940A | Compact TLS with continuous sweeping 1520-1630 nm. |
| Keysight 81960A | Compact TLS with specified continuous sweeping 1505-1630 nm. |
| Keysight 81989A | Compact TLS, stepped sweeping, 1465-1575 nm. |
| Keysight 81950A | Compact tunable laser for system test, non-sweeping applications, C-band or L-band option. |
| Keysight 81949A | Compact TLS, stepped sweeping, 1520-1630 nm. |

| Return Loss Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81610A | RL Module - no internal source |
| Keysight 81613A | RL Module - 1310/1550 nm internal source |

| Attenuator Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81570A | high power, single slot, straight connectors |
| Keysight 81571A | high power, single slot, angled connectors |
| Keysight 81576A | high power, dual slot, power control, straight connectors |
| Keysight 81577A | high power, dual slot, power control, angled connectors |
| Keysight 81578A | high power, single slot, multimode, straight connectors |

| Switch Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81595B | 1x4 switch |

| Transponder Modules | |
|---|---|
| **Model No.** | **Description** |
| Keysight 81490A | Reference Transmitter, dual slot |
| Keysight 81495A | Reference Receiver |

| Backloadable Tunable Laser Source Modules (only used with 8164B; 81600B can also be used in 8164A) | |
|---|---|
| **Model No.** | **Description** |
| 81606A #216 | Tunable Laser Source, High Power and Low SSE, Top Line,<br>1450 - 1650 nm |
| 81606A #116 | Tunable Laser Source, High Power and Low SSE, Top Line,<br>1490 - 1640 nm |
| 81607A #116 | Tunable Laser Source, Low SSE, Value Line,<br>1490 - 1640 nm |
| 81608A #216 | Tunable Laser Source, High Power and Low SSE, Value Line,<br>1450 - 1650 nm |
| 81608A #116 | Tunable Laser Source, High Power and Low SSE, Value Line,<br>1490 - 1640 nm |
| 81609A #216 | Step-tunable Laser Source, High Power and Low SSE, Basic Line,<br>1450 - 1650 nm |
| 81609A #116 | Step-tunable Laser Source, High Power and Low SSE, Basic Line,<br>1490 - 1640 nm |
| 81600B #201 | Low SSE TLS for the Test of Critical Components<br>1455 - 1640 nm |
| Keysight 81600B #200 | Low SSE TLS for the Test of Critical Components<br>1400 - 1640 nm |
| Keysight 81600B #160 | Low SSE TLS for the Test of Critical Components<br>1495 - 1640 nm |
| Keysight 81600B #150 | Low SSE TLS for the Test of Critical Components<br>1450 - 1590 nm |
| Keysight 81600B #140 | Low SSE TLS for the Test of Critical Components<br>1370 - 1495 nm |
| Keysight 81600B #142 | HIgh Power TLS for the Test of Critical Components<br>1370 - 1495 nm |
| Keysight 81600B #132 | High Power TLS for the Test of Critical Components<br>1260 - 1375 nm |
| Keysight 81600B #130 | Low SSE TLS for the Test of Critical Components<br>1260 - 1375 nm |

### Keysight 81645A Filler Module

The Keysight 81645A Filler Module is required to operate the 8164A/B mainframe if it is used without a back-loadable tunable laser module. See Fitting a Filler Module for Back-Loadable Module Slots on page 334 for more details.

## GPIB Cables and Adapters

The GPIB connector is compatible with the connectors on the following cables and adapters:

- GPIB Cable, 10833A, 1 m (3.3 feet)
- GPIB Cable, 10833B, 2 m (6.6 feet).
- GPIB Cable, 10833C, 4 m (13.2 feet)
- GPIB Cable, 10833D, 0.5 m (1.6 feet)
- GPIB Adapter, 10834A, 2.3 cm extender. Use this adapter if there is no space to connect your GPIB cable directly to a GPIB interface.

# 13 Specifications and Regulations Compliance

8163A Specifications / 356
Keysight 8163B Specifications / 357
8164A Specifications / 358
Keysight 8164B Specifications / 359
8166A Specifications / 360
Keysight 8166B Specifications / 361
Declarations of Conformity / 362
Regulations Information / 368

The 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System are produced to the ISO 9001 international quality system standard as part of Keysight Technologies' commitment to continually increasing customer satisfaction through improved quality control.

Specifications describe the instrument's warranted performance.

Supplementary performance characteristics describe the instrument's non-warranted typical performance.

Because of the modular nature of the instrument, the performance specifications apply to the modules rather than the mainframe unit. The specifications for a module are supplied with that module.

# 8163A Specifications

The 8163A Lightwave Multimeter displays two channels.

| | |
|---|---|
| Display | Graphical display 190 × 300 points visible, monochrome. |
| Display Resolution (Power Meters) | 0.0001 dB/dBm, 0.01 pW to 10 pW (depending on power range), up to 6.5 digits (user definable). |
| Compatibility | The 8163A mainframe supports all 8153A Series.[1] |
| Data Acquisitions<br>Memory><br>Selectable data averaging time<br>Selectable total data averaging time | <br>4000 measurement results / channel<br>depends on sensor module<br>20 ms to 23:59:59 h |
| Trigger | True synchronous on all channels |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to +70° C<br>0° C to +45° C<br><95% R.H. from 0° C to +45° C |
| Power | AC 100 - 240 V ± 10%, 48 - 66 Hz, 100 VA max. |
| Dimensions | 88 mm × 213 mm × 380 mm<br>(3.5" × 8.4" × 15") |
| Weight | net 4.200 kg (9.3 lbs); shipping 6.5 kg (14.5 lbs) |
| GPIB interface<br>Function code | All modes and parameters accessible via GPIB interface<br>SCPI standard [2] |
| Interfaces | Parallel port (Centronics)<br>Serial port (RS232) |
| Number of Modules | 2 Modules |

[1] 8163A Series modules are NOT compatible with the 8153A Lightwave Multimeter.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-91016.

# Keysight 8163B Specifications

The Keysight 8163B Lightwave Multimeter displays two channels.

| | |
|---|---|
| Display | Graphical color display 300 × 240 points visible |
| Display Resolution (Power Meters) | 0.0001 dB/dBm, 0.01 pW to 10 pW (depending on power meter), up to 6.5 digits (user definable). |
| Compatibility | The Keysight 8163B mainframe supports all HP 8153A Series and 8163A/B Series modules.[1] |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to +70° C<br>0° C to +45° C<br><95% R.H. from 0° C to +45° C |
| Power | AC 100 - 240 V ± 10%, 50 - 60 Hz, 120 VA max. |
| Dimensions | 88 mm × 213 mm × 380 mm<br>(3.5" × 8.4" × 15") |
| Weight | net 4.200 kg (9.3 lbs); shipping 6.5 kg (14.5 lbs) |
| GPIB interface<br>Function code | All modes and parameters accessible via GPIB interface<br>SH1, AH1, T6, L4, SR0, RL1, PP0, DC1, DT0, C0.<br>SCPI standard [2] |
| GPIB Interface Performance | max. 300 kB/s (burst data rate during read of 12001 points from a power meter). |
| Trigger | True synchronous on all channels |
| Trigger Bandwidth | max. 100 kHz for triggering, and<br>max. 1 MHz (50% duty cycle) for external digital modulation. |
| RS232C Interface: max. baud rate | 115200 bps |
| Parallel Printer Interface | Centronics |
| Number of Modules | 2 Modules |
| Local Area Network (LAN) | 10/100BASE-T Ethernet port |

[1] Keysight 8163B Series modules are NOT compatible with the 8153A Lightwave Multimeter.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-90B61.

# 8164A Specifications

The 8164A Lightwave Measurement System displays five channels.

| | |
|---|---|
| Display | 600 × 400 pixels visible, active colour LCD.<br>VGA connector for external monitor. |
| Compatibility | The Keysight 8164A mainframe supports all 8153A Series and Keysight 8163A Series modules.[1] |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to 70° C<br>10° C to 35° C<br>< 80% R.H. from 10° C to 35°C |
| Power | 100 - 240 $V_{rms}$ ± 10%, 50 - 60 Hz, 280 VA max. |
| Dimensions | 145 mm × 426 mm × 545 mm<br>(5.8" × 16.9" × 21.6") |
| Weight | net, 20 kg (45 lb.), 23 kg (51 lb.), including modules. |
| GPIB interface<br>Function code | <br>SH1, AH1, T6, L4, SR1, RL1, PP0, DC2, DT0, C0. SCPI standard; [2] |
| RS232C Interface: max. baud rate | 115200 bps |
| Parallel Printer Interface | Centronics |
| Number of Modules | 4 front-loadable Modules, 1 back-loadable Module |
| PC-Card slot | PCMCIA 2.0/JEIDA 4.0 |
| Data Storage | Internal Hard Disk Drive: 3250 MByte<br>Memory cards according to PCMCIA type I, II, and III. |
| External Keyboard | PS/2 connector |

[1] 8163A Series modules are NOT compatible with the 8153A Lightwave Multimeter.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-91016.

# Keysight 8164B Specifications

The Keysight 8164B Lightwave Measurement System displays five channels.

| | |
|---|---|
| Display | Graphic color display 640 × 480 pixels visible.<br>VGA connector for external monitor. |
| Compatibility | The Keysight 8164B mainframes support all HP 8153A Series and 8163A/B Series modules.[1] |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to 70° C<br>10° C to 35° C<br>< 80% R.H. from 10° C to 35° C |
| Power | AC 100 - 240 V ± 10%, 50 - 60 Hz, 280 VA max. |
| Dimensions | 145 mm × 426 mm × 545 mm<br>(5.8" × 16.9" × 21.6") |
| Weight | net, 20 kg (45 lb.), 23 kg (51 lb.), including modules. |
| GPIB interface<br>Function code | All modes and parameters accessible via GPIB interface.<br>SH1, AH1, T6, L4, SR0, RL1, PP0, DC1, DT0, C0.<br>SCPI standard; [2] |
| GPIB Interface Performance | max. 300 kB/s (burst data rate during read of 12001 points from a power meter). |
| Trigger | True synchronous on all channels |
| Trigger Bandwidth | max. 100 kHz for triggering, and<br>max. 1 MHz (50% duty cycle) for external digital modulation. |
| RS232C Interface: max. baud rate | 115200 bps |
| Parallel Printer Interface | Centronics |
| Number of Modules | 4 front-loadable Modules, 1 back-loadable Module |
| External Keyboard | PS/2 connector (reserved for future use) |
| Local Area Network (LAN) | 10/100BASE-T Ethernet port |

[1] Keysight 8163B Series modules are NOT compatible with the 8153A Lightwave Multimeter.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-90B61.

# 8166A Specifications

The 8166A Lightwave Multichannel System displays 17 channels.

| | |
|---|---|
| Display | Graphical display 190 × 300 points visible, monochrome. |
| Display Resolution (Power Meters) | 0.0001 dB/dBm, 0.01 pW to 10 pW (depending on power range), up to 6.5 digits (user definable). |
| Compatibility | The 8166A supports all 8163A Series modules.[1] |
| Trigger | True synchronous on all channels |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to +70° C<br>0° C to +45° C<br><95% R.H. from 0° C to +45° C |
| Power | AC 100 - 240 V ± 10%, 50 - 60 Hz, 450 VA max. |
| GPIB interface<br>Function code | All modes and parameters accessible via GPIB interface<br>SCPI standard [2] |
| Interfaces | Parallel port (Centronics)<br>Serial port (RS232) |
| Number of Modules | 17 Modules |
| Dimensions | 240 mm × 430 mm × 580mm (9.5" × 17" × 23") |
| Weight | net 23 kg (50.7 lbs); shipping 45 kg (94.8 lbs) |

[1] Modules designed for the 8153A Lightwave Multimeter are NOT compatible with the 8166A Lightwave Multichannel System.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-91016.

# Keysight 8166B Specifications

The Keysight 8166B Lightwave Multichannel System displays 17 channels.

| | |
|---|---|
| Display | Graphical color display 300 × 240 points visible. |
| Display Resolution (Power Meters) | 0.0001 dB/dBm, 0.01 pW to 10 pW (depending on power range), up to 6.5 digits (user definable). |
| Compatibility | The Keysight 8166B supports all 8163A/B Series modules.[1] |
| Environmental<br>Storage temperature<br>Operating temperature<br>Humidity | <br>-40° C to +70° C<br>0° C to +45° C<br><95% R.H. from 0° C to +45° C |
| Power | AC 100 - 240 V ± 10%, 50 - 60 Hz, 450 VA max. |
| Dimensions | 240 mm × 430 mm × 580mm (9.5" × 17" × 23") |
| Weight | net 23 kg (50.7 lbs); shipping 45 kg (94.8 lbs) |
| GPIB interface<br>Function code | All modes and parameters accessible via GPIB interface<br>SH1, AH1, T6, L4, SR0, RL1, PP0, DC1, DT0, C0.<br>SCPI standard; [2] |
| GPIB Interface Performance | max. 300 kB/s (burst data rate during read of 12001 points from a power meter). |
| Trigger | True synchronous on all channels |
| Trigger Bandwidth | max. 100 kHz for triggering, and<br>max. 1 MHz (50% duty cycle) for external digital modulation. |
| RS232C Interface: max. baud rate | 115200 bps |
| Parallel Printer Interface | Centronics |
| Number of Modules | 17 Modules |

[1] Modules designed for the 8153A Lightwave Multimeter are NOT compatible with the 8166A/B Lightwave Multichannel System.

[2] For code compatibility to the 8153A Lightwave Multimeter please refer to the mainframe's Programming Guide, part number 08164-90B61.

# Declarations of Conformity

## Keysight 8163A Lightwave Multimeter

**DECLARATION OF CONFORMITY**
According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

CE

**Manufacturer's Name:** Agilent Technologies Deutschland GmbH
**Manufacturer's Address:** Photonic Measurement Division (PMD)
Herrenberger Str. 130
D-71034 Boeblingen

**Declares, that the product**

**Product Name:** **Lightwave Multimeter Mainframe**
**Model Number:** **8163A**
**Product Modules:**

| | |
|---|---|
| **81611A** (1) | Return Loss Module 1300nm |
| **81612A** (1) | Return Loss Module 1550nm |
| **81613A** (1) | Return Loss Module 1310/1550nm |
| **81614A** (1) | Return Loss Module 1550/1625nm |
| **81650A** (1) | Laser Module 1310nm |
| **81651A** (1) | Laser Module 1550nm |
| **81652A** (1) | Laser Module 1550/1625nm |
| **81653A** (1) | Laser Module 1650nm |
| **81654A** (1) | Laser Module 1310/1550nm |
| **81655A** (1) | Laser Module 1310nm |
| **81656A** (1) | Laser Module 1550nm |
| **81657A** (1) | Laser Module 1310/1550nm |
| **81662A** (1) | DFB Laser Module 1500nm-1650nm |
| **81663A** (1) | DFB Laser Module 1500nm-1650nm |
| **81649A** (1) | Compact Tunable Laser Module 1570nm-1620nm |
| **81689A** (1) | Compact Tunable Laser Module 1525nm-1575nm |
| **81689B** (1) | Compact Tunable Laser Module 1525nm-1575nm |
| **81940A** (2) | Compact Tunable Laser Module 1520nm-1630nm |
| **81949A** (2) | Compact Tunable Laser Module 1520nm-1630nm |
| **81980A** (2) | Compact Tunable Laser Module 1465nm-1575nm |
| **81989A** (2) | Compact Tunable Laser Module 1465nm-1575nm |

***Conforms with the following European Directives:***

*The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.*

**Conforms with the following product standards:**

| | Standard | Limit |
|---|---|---|
| **EMC** | *IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998* | |
| | *CISPR 11:1997 / EN 55011:1998* | *Group 1 Class B* |
| | *IEC 61000-3-2:2000 / EN 61000-3-2:1995+A1:1997+A2:1998* | |
| | *IEC 61000-3-3:1994 / EN 61000-3-3:1995* | |
| | *IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995* | *4kV CD, 8kV AD* |
| | *IEC 61000-4-3:1995 / EN 61000-4-3:1995* | *3 V/m, 80-1000 MHz* |
| | *IEC 61000-4-4:1995 / EN 61000-4-4:1995* | *0.5kV signal lines, 1kV power lines* |
| | *IEC 61000-4-5:1995 / EN 61000-4-5:1995* | *0.5 kV line-line, 1 kV line-ground* |
| | *IEC 61000-4-6:1996 / EN 61000-4-6:1996* | *3V, 0.15-80 MHz* |
| | *IEC 61000-4-11:1994 / EN 61000-4-11:1994* | *1 cycle/100%* |
| | *Canada: ICES-001:1998* | |
| | *Australia/New Zealand: AS/NZS 2064.1* | |
| **Safety** | *IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995* | |
| | *IEC 60825-1:2001 / EN 60825-1:1994+A11:1996+A2:2001* | |
| | *Canada: CSA C22.2 No. 1010.1:1992* | |
| | *USA:UL 3111-1:1994; FDA 21CFR1040.10+Laser Notice No. 50* | |

**Supplemental Information:**

*The product was tested in a typical configuration with Agilent Technologies test systems.*
*(1) FDA Accession Number 9521220-54*
*(2) FDA Accession Number 9122175-10*

2003-May-14
Date

Hans-Martin Fischer
Name

Product Regulations Representative
Title

For further information, please contact your local Agilent Technologies sales office, agent or distributor.
*Authorized EU-representative: Agilent Technologies Deutschland GmbH, Herrenberger Strasse 130, D-71034 Boeblingen, Germany*

Revision: G Issue Date: 2003-May-14

Keysight 8163B Lightwave Multimeter

Click the following link to download the latest Declarations of Conformity:

http://www.keysight.com/go/conformity

## Keysight 8164A Lightwave Measurement System

**DECLARATION OF CONFORMITY**
According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

CE

**Manufacturer's Name:** Agilent Technologies Deutschland GmbH
**Manufacturer's Address:** Photonic Measurement Division (PMD)
Herrenberger Str. 130
D-71034 Boeblingen

**Declares, that the product**

**Product Name:** **Lightwave Measurement System**
**Model Number:** **8164A**
**Product Modules:**

| | |
|---|---|
| **81611A** | Return Loss Module 1300nm |
| **81612A** | Return Loss Module 1550nm |
| **81613A** | Return Loss Module 1310/1550nm |
| **81614A** | Return Loss Module 1550/1625nm |
| **81650A** | Laser Module 1310nm |
| **81651A** | Laser Module 1550nm |
| **81652A** | Laser Module 1550/1625nm |
| **81653A** | Laser Module 1650nm |
| **81654A** | Laser Module 1310/1550nm |
| **81655A** | Laser Module 1310nm |
| **81656A** | Laser Module 1550nm |
| **81657A** | Laser Module 1310/1550nm |
| **81662A** | DFB Laser Module 1500nm-1650nm |
| **81663A** | DFB Laser Module 1500nm-1650nm |
| **81480A/B** | Tunable Laser Source Module 1370nm-1480nm |
| **81482B** | Tunable Laser Source Module 1370nm-1495nm |
| **81640A/B** | Tunable Laser Source Module 1510nm-1640nm |
| **81642A/B** | Tunable Laser Source Module 1510nm-1640nm |
| **81672B** | Tunable Laser Source Module 1260nm-1375nm |
| **81680A/B** | Tunable Laser Source Module 1460nm-1580nm |
| **81682A/B** | Tunable Laser Source Module 1460nm-1580nm |
| **81649A** | Compact Tunable Laser Module 1570nm-1620nm |
| **81689A/B** | Compact Tunable Laser Module 1525nm-1575nm |
| **81940A** | Compact Tunable Laser Module 1520nm-1630nm |
| **81949A** | Compact Tunable Laser Module 1520nm-1630nm |
| **81980A** | Compact Tunable Laser Module 1465nm-1575nm |
| **81989A** | Compact Tunable Laser Module 1465nm-1575nm |

***Conforms with the following European Directives:***

*The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.*

**Conforms with the following product standards:**

| | Standard | Limit |
|---|---|---|
| **EMC** | *IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998* | |
| | *CISPR 11:1997 / EN 55011:1998* | *Group 1 Class A* |
| | *IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995* | *4kV CD, 8kV AD* |
| | *IEC 61000-4-3:1995 / EN 61000-4-3:1995* | *3 V/m, 80-1000 MHz* |
| | *IEC 61000-4-4:1995 / EN 61000-4-4:1995* | *0.5kV signal lines, 1kV power lines* |
| | *IEC 61000-4-5:1995 / EN 61000-4-5:1995* | *0.5 kV line-line, 1 kV line-ground* |
| | *IEC 61000-4-6:1996 / EN 61000-4-6:1996* | *3V, 0.15-80 MHz* |
| | *IEC 61000-4-11:1994 / EN 61000-4-11:1994* | *1 cycle/100%* |
| | *Canada: ICES-001:1998* | |
| | *Australia/New Zealand: AS/NZS 2064.1* | |
| **Safety** | *IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995* | |
| | *IEC 60825-1:2001 / EN 60825-1:1994+A11:1996+A2:2001* | |
| | *Canada: CSA C22.2 No. 1010.1:1992* | |
| | *USA:UL 3111-1:1994; FDA 21CFR1040.10+Laser Notice No. 50* | |

**Supplemental Information:**

*The product was tested in a typical configuration with Agilent Technologies test systems.*
*FDA Accession Numbers 9521220-54 and 9122175-10*

2003-May-14
Date

Hens-Martin Fischer
Name

Product Regulations Representative
Title

For further information, please contact your local Agilent Technologies sales office, agent or distributor.
*Authorized EU-representative: Agilent Technologies Deutschland GmbH, Herrenberger Strasse 130, D-71034 Boeblingen, Germany*

Revision: G Issue Date: 2003-May-14

Keysight 8164B Lightwave Measurement System

Click the following link to download the latest Declarations of Conformity:

http://www.keysight.com/go/conformity

## Keysight 8166A Lightwave Multichannel System

### DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

CE

**Manufacturer's Name:** Agilent Technologies Deutschland GmbH
**Manufacturer's Address:** Photonic Measurement Division (PMD)
Herrenberger Str. 130
D-71034 Boeblingen

**Declares, that the product**

| | | |
|---|---|---|
| **Product Name:** | **Lightwave Multi-Channel System** | |
| **Model Number:** | **8166A** | |
| **Product Modules:** | **81611A** (1) | Return Loss Module 1300nm |
| | **81612A** (1) | Return Loss Module 1550nm |
| | **81613A** (1) | Return Loss Module 1310/1550nm |
| | **81614A** (1) | Return Loss Module 1550/1625nm |
| | **81650A** (1) | Laser Module 1310nm |
| | **81651A** (1) | Laser Module 1550nm |
| | **81652A** (1) | Laser Module 1550/1625nm |
| | **81653A** (1) | Laser Module 1650nm |
| | **81654A** (1) | Laser Module 1310/1550nm |
| | **81655A** (1) | Laser Module 1310nm |
| | **81656A** (1) | Laser Module 1550nm |
| | **81657A** (1) | Laser Module 1310/1550nm |
| | **81662A** (1) | DFB Laser Module 1500nm-1650nm |
| | **81663A** (1) | DFB Laser Module 1500nm-1650nm |
| | **81649A** (1) | Compact Tunable Laser Module 1570nm-1620nm |
| | **81689A** (1) | Compact Tunable Laser Module 1525nm-1575nm |
| | **81689B** (1) | Compact Tunable Laser Module 1525nm-1575nm |

***Conforms with the following European Directives:***

*The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.*

**Conforms with the following product standards:**

| | **Standard** | **Limit** |
|---|---|---|
| **EMC** | *IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998* | |
| | *CISPR 11:1997 / EN 55011:1998* | *Group 1 Class B* |
| | *IEC 61000-3-2:2000 / EN 61000-3-2:1995+A1:1997+A2:1998* | |
| | *IEC 61000-3-3:1994 / EN 61000-3-3:1995* | |
| | *IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995* | *4kV CD, 8kV AD* |
| | *IEC 61000-4-3:1995 / EN 61000-4-3:1995* | *3 V/m, 80-1000 MHz* |
| | *IEC 61000-4-4:1995 / EN 61000-4-4:1995* | *0.5kV signal lines, 1kV power lines* |
| | *IEC 61000-4-5:1995 / EN 61000-4-5:1995* | *0.5 kV line-line, 1 kV line-ground* |
| | *IEC 61000-4-6:1996 / EN 61000-4-6:1996* | *3V, 0.15-80 MHz* |
| | *IEC 61000-4-11:1994 / EN 61000-4-11:1994* | *1 cycle/100%* |
| | *Canada: ICES-001:1998* | |
| | *Australia/New Zealand: AS/NZS 2064.1* | |
| **Safety** | *IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995* | |
| | *IEC 60825-1:2001 / EN 60825-1:1994+A11:1996+A2:2001* | |
| | *Canada: CSA C22.2 No. 1010.1:1992* | |
| | *USA:UL 3111-1:1994; FDA 21CFR1040.10+Laser Notice No. 50* | |

**Supplemental Information:**

*The product was tested in a typical configuration with Agilent Technologies test systems.*
*(1) FDA Accession Number 9521220-54*

2003-May-14
Date

Hans-Martin Fischer
Name

Product Regulations Representative
Title

For further information, please contact your local Agilent Technologies sales office, agent or distributor.
*Authorized EU-representative: Agilent Technologies Deutschland GmbH, Herrenberger Strasse 130, D-71034 Boeblingen, Germany*

Revision: F Issue Date: 2003-May-14

Keysight 8166B Lightwave Multichannel System

Click the following link to download the latest Declarations of Conformity:

http://www.keysight.com/go/conformity

## Regulations Information

Safety Canada




EMC Canada

These ISM devices comply with Canadian ICES-001.
Ces appareils ISM sont conformes à la norme NMB-001 du Canada.

EMC Australia/New Zealand



# 14 Error Messages

SYST:ERR? / 370
Screen Status Messages / 372
Mainframes / 373
Errors appearing on pop-up menus / 377
Tunable Laser Sources / 382
Return Loss Meters / 395
Power Meters & Interface Modules with Optical Head / 400
Fixed Laser Sources (Fabry Perot) / 407
DFB Laser Sources / 412
Attenuator Modules / 415
Optical Switch modules / 418

## SYST:ERR?

The syst:err? command returns the next error from the error queue (refer to the *Programming Guide* for details).

Each error has an error code and a short description of the error, separated by comma. Please note that the error codes are returned as signed integer numbers in a range from -32768 to +32767 (INT16). Negative error numbers are defined by the SCPI standard, positive error numbers are device dependent.

Please find below a complete list of all implemented error codes:

-185, "Subop out of range"
-200, "Execution error (StatExecError)"
+200, "Please be patient - GPIB currently locked out"
-205, "Powermeter not running (StatMeterNotRunning)"
-211, "Trigger ignored"
-212, "Arm ignored"
-213, "Init ignored"
-220, "Parameter error (StatParmError)"
-220, "Parameter error (StatParmOutOfRange)"
-220, "Parameter error (StatParmIllegalVal)"
-221, "Settings conflict (StatParmInconsistent)"
-222, "Data out of range (StatParmTooLarge)"
-222, "Data out of range (StatParmTooSmall)"
-231, "Data questionable (StatValNYetAcc)"
-231, "Data questionable (StatRangeTooLow)"
-261, "Math error in expression (StatUnitCalculationError)"
-284, "Function currently running (StatModuleBusy)"
-286, "No function currently running"
-290, "Application currently running - no GPIB support"
-300, "Internal error"
-300, "Internal error (StatValsLost)"
-300, "Internal error (StatInternalError)"

-301, "Module doesn't support this command (StatCmdUnknown)"
-302, "Internal timeout error (StatTimedOut)"
-303, "Module slot empty or slot / channel invalid"
-304, "Command was aborted (StatAborted)"
-305, "Internal messaging error (StatCmdError)"
-305, "Internal messaging error (StatCmdNotAllowed)"
-305, "Internal messaging error (StatWrongLength)"
-305, "Internal messaging error (StatWrongReceiver)"
-305, "Internal messaging error (StatBufAllocError)"
-305, "Internal messaging error (StatDPRamFull)"
-305, "Internal messaging error (StatSemError)"
-306, "Channel doesn't support this command (StatCmdUnknownForSlave)"
-307, "Channel without head connection (StatHeadless)"
-322, "Flash programming error (StatFlashEraseFailed)"
-322, "Flash programming error (StatFlashWriteFailed)"
-322, "Flash programming error (StatFlashDataCntError)"
-322, "Flash programming error (StatFlashDPAlgoFailed)"
-330, "Self-test failed"
-340, "Printing error (StatPrintError)"
-341, "Printing error - paper out (StatPaperOut)"
-342, "Printing error - offline (StatOffline)"

# Screen Status Messages

| Message | | Meaning | Description |
|---|---|---|---|
| 8163A/B | 8164A/B | | |
| SL | SLock | Security Lock | The module is locked for security reasons. No measurement is possible until you unlock the module |
| RiL | RiLock | Remote InterLock | The remote interlock connector of your mainframe is open. No measurement is possible until the connection at the remote interlock connector closes |
| NoH | No Head | No Head | There is an optical head interface module inserted in the mainframe that does not have an Optical Head connected to it. No measurement is possible using this channel until you:<br>- reconnect an optical head or<br>- deselect this optical channel as a power measurement channel |
| NoD | No Data | No Data | No data has been measured or measurement is not finished. You cannot access the analysis screen yet. Printout and file operations are not yet possible. |
| Set | Settling | Settling | A tunable laser source module is settling. The instrument is busy and no measurement can be performed yet. |
| NoR | No Ref | No Reference | No reference sweep has been performed. Loss will be calculated using nominal laser power as a reference. |
| B | Busy | Busy | Module is busy performing last operation. |

## Mainframes

After initializing the instrument, the following bootup screen appears, listing all selftests of the instrument.

A FlashDisk selftest failure may occur after a firmware download to the instrument and is of no harm. No reboot is necessary for operation of the mainframe. However, after a reboot of the instrument, the FlashDisk test will pass again.

8163A

<Fw Rev>

ProductNo(SerialNo)Selftest:

** HW Revision <HWRevNo>

** SYSBIOS <SysBiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo> <Date>

** FPGA <FPGARevNo> <Date>

** BRAM <BRAMSize>-<passed/failed>

** FlashDisk <FlashSize>-<passed/failed>

**NOTE** If one of the selftests fails, please try to reboot the instrument. If the selftest continues to fail, please return the mainframe to your local service center for repair.

8163B

<Fw Rev>

ProductNo(SerialNo)Selftest:

** PCB Revision <PCBRevNo>

** BIOS <BiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo> <Date>

** FPGA <FPGARevNo> <Date>

** CPLD <CPLDRevNo>

** BRAM <BRAMSize>-<passed/failed>

** HDD <passed/failed>

**NOTE** If one of the selftests fails, please try to reboot the instrument. If the selftest continues to fail, please return the mainframe to your local service center for repair.

8164A

<Fw Rev>

ProductNo(SerialNo)Selftest:

** HW Revision <HWRevNo>

** SYSBIOS <SysBiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo>

** VGABIOS <VGABiosRev>

** FPGA <FPGARevNo> <Date>

** BRAM <BRAMSize>-<passed/failed>

** FDD -<passed/failed>

** HDD -<passed/failed>

Remedial Action:

If one of the selftests fails, please try to reboot the instrument. If the selftest continues to fail, please return the mainframe to your local service center for repair.

8164B

<Fw Rev>

ProductNo(SerialNo)Selftest:

** PCB Revision <PCBRevNo>

** BIOS <BiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo> <Date>

** FPGA <FPGARevNo> <Date>

** CPLD <CPLDRevNo>

** BRAM <BRAMSize>-<passed/failed>

** FDD <passed/failed>

** HDD <passed/failed>

** FDD -<passed/failed>

** HDD -<passed/failed>

Remedial Action:

If one of the selftests fails, please try to reboot the instrument. If the selftest continues to fail, please return the mainframe to your local service center for repair.

8166A

<Fw Rev>

ProductNo(SerialNo)Selftest:

** HW Revision <HWRevNo>

** SYSBIOS <SysBiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo> <Date>

** FPGA <FPGARevNo> <Date>

** FPGA2 <FPGA2RevNo> <Date>

** BRAM <BRAMSize>-<passed/failed>

** FlashDisk <FlashSize>-<passed/failed>

Remedial Action:

If one of the selftests fails, please try to reboot the instrument. If the selftest is continues to fail, please return the mainframe to your local service center for repair.

8166B

<Fw Rev>

ProductNo(SerialNo)Selftest:

** PCB Revision <PCBRevNo>

** BIOS <BiosRevNo> <Date>

** EXTBIOS <ExtBiosRevNo> <Date>

** FPGA <FPGARevNo> <Date>

** CPLD <CPLDRevNo>

** BRAM <BRAMSize>-<passed/failed>

** HDD <passed/failed>

**Remedial Action:**

If one of the selftests fails, please try to reboot the instrument. If the selftest is continues to fail, please return the mainframe to your local service center for repair.

## Errors appearing on pop-up menus

### Error on Module




| | |
|---|---|
| error message | Calibration data corrupted |
| description | The calibration data loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) |
| affected modules | all modules |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Laser safety error |
| description | The laser control circuit has switched of the laser. Either the laser current or the laser power was too high. |
| affected modules | TLS |
| action | Try to run the automatic realign from the menu or to operate the laser at a lower power level. If the failure persists, please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Temperature out of range |
| description | The temperature to operate the tunable laser source module was measured outside given limits. |
| affected modules | TLS |
| action | Verify the fan is working and the ventilation system is not blocked. If the failure persists, please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Zeroing failed. Light? |
| description | Zeroing has still detected some light. Either the input is not darkened properly or there is some error on the powermeter module/head. |
| affected modules | Powermeter |
| action | Darken the optical input(s) properly. If the failure persists, please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Selftest failed |
| description | The selftest of the module in slot <slot> has failed. If the slot is occupied by an optical head interface module, the head selftest has failed. |
| affected modules | all |
| action | Please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | BRAM corrupted |
| description | The battery buffered RAM is corrupted. |
| affected modules | Mainframe |
| action | Please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Please run realign (from menu) |
| description | The alignment of laser cavity is not ideal. |
| affected modules | TLS |
| action | Please follow this instruction and run the realignment, which can be selected from the menu of the tunable laser source module. If the failure persists, please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Out of specification |
| description | The unit has been found outside the specification.This may happen due to various reasons. |
| affected modules | TLS |
| action | Please run LambdaZero from the menu first. If the failure persists, reboot the mainframe and run realign from the menu. If this does not help, please return the unit to your local service center for repair. |

| | |
|---|---|
| error message | Duty cycle out of range |
| description | The power control loop cannot control the correct output power anymore, because the duty cycle of the external modulation is too small. |
| affected modules | TLS |
| action | Increase the duty cycle (that is, increase the on-state duration of the modulated signal) |

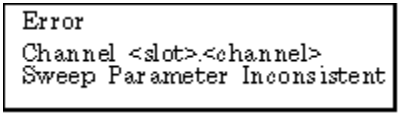
| | |
|---|---|
| error message | Beampath safety error |
| description | A problem on the module has lead to an unsafe operation state. For this reason, the shutter has been closed. |
| affected modules | All attenuators |
| action | If this problem occurs several times, please send the module to the local Keysight service center for repair. |

| | |
|---|---|
| error message | Module communication error |
| description | There was an error in communication between module and mainframe. For safety reasons, the module was disabled and the shutter closed. |
| affected modules | All attenuators |
| action | If this problem occurs several times, please send the module to the local Keysight service center for repair. |

| | |
|---|---|
| error message | Offset table is empty |
| description | The user has tried to activate the Offset(Lambda) function, but the table of wavelength dependent offsets is empty. |
| affected modules | All attenuators |
| action | Please construct a table with at least one entry, before activating this mode. |

| | |
|---|---|
| error message | Lambda offset active |
| description | The user has tried to program the table of wavelength dependent offsets, but the Offset(Lambda) mode is activated. |
| affected modules | All attenuators |
| action | Please deactivate the Offset(Lambda) mode first. |

Error




One or more of the following reasons may cause this error message:

| | |
|---|---|
| firmware revision | all |
| modus | stepped sweep |
| parameter(s) | lambda logging on |
| action | switch lambda logging off |

| | |
|---|---|
| firmware revision | <= 2.5x |
| modus | continuous sweep |
| parameter(s) | stop wavelength <= start wavelength |
| | sweep time too small (< 0.001s) |
| | sweep time too large (t > 400s) |
| | trigger frequency too high (f > 10kHz) |
| | lambda logging:<br>- coherence control active<br>- cycles ≠ 1<br>- trigger ≠ step finished |
| action | check settings and correct where appropriate |

| | |
|---|---|
| firmware revision | > 2.6 |
| modus | continuous sweep |
| parameter(s) | stop wavelength <= start wavelength |
| | sweep time too small (< 0.001s) |
| | sweep time too large (t > 400s) |
| | trigger frequency too high (f > 40kHz) |
| | lambda logging:<br>- coherence control active<br>- trigger ≠ step finished |
| action | check settings and correct where appropriate |

# Tunable Laser Sources

## Initialization Tests

These tests are executed every time the instrument is powered on, before the selftests start.

| error message | Initialization Error (AttInitialize(), error value) | |
|---|---|---|
| description | Error during attenuator initialization. No ready message from attenuator DSP after ... | |
| error value | 1 | reset |
| | 2 | init motor |
| | 4 | find index |
| | 8 | move to min position |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (AttMovePos(zeroPos), error value) | |
|---|---|---|
| description | No ready message from attenuator DSP after moving to zero position taken from caldata | |
| error value | 8 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (CalData CRC wrong: *crc1*, stored: *crc2*!) | |
|---|---|---|
| description | The checksum stored in the caldata does not match the calculated checksum | |
| error value | crc1 | calculated checksum |
| | crc2 | checksum read from caldata |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (Calibration Data Invalid, error value) | |
|---|---|---|
| description | The calibration data was tagged as invalid before it was loaded on to the module | |
| error value | 0 | not significant |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (CalOptZeroMeas, error value) | |
|---|---|---|
| description | Error in optical zero measurement | |
| error value | 1 | not significant |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (DspMainCalcKFactor failed, error value) | |
|---|---|---|
| description | DSP K factor calibration failed | |
| error value | -1 | no TCFS (according to caldata) |
| | 1 | error when calibrating TCFS |
| | 2 | DSP sweep failed |
| | 4 | laser safety |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (DspMainWriteCaldata(), error value) | |
|---|---|---|
| description | Error while writing cal data to DSP | |
| error value | 5 | tried to access invalid array position |
| | 6 | wrong dimension |
| | 7 | unknown type found in variable array |
| | 8 | wrong parameter when trying to access one of the DSPs cal arrays |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (Firmware CRC wrong: crc1, stored: crc2!) | |
|---|---|---|
| description | The checksum stored in the firmware does not match the calculated checksum | |
| error value | crc1 | calculated checksum |
| | crc2 | checksum read from caldata |
| action | Reload the firmware of the module. If the failure persists, please return the unit to your local service center for repair | |

| error message | Initialization Error (HwAccessInit, error value) | |
|---|---|---|
| description | Error setting DAC | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (InitDacs, error value) | |
|---|---|---|
| description | Error setting DAC | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (InstSettingInit, error value) | |
|---|---|---|
| description | Error creating semaphore | |
| error value | 2 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (LaserEEPROMInit, error value) | |
|---|---|---|
| description | Error reading laser EEPROM | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (MainEEPROMInit, error value) | |
|---|---|---|
| description | Error reading main EEPROM | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (MotorSelfCali failed, error value) | |
|---|---|---|
| description | Motor self calibration failed | |
| error value | -1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (MotorZero, error value) | |
|---|---|---|
| description | DSP motor zero not finished in time | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (OptZero, error value) | |
|---|---|---|
| description | Optical zero disabled in caldata | |
| error value | -1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (OptZero Opc, error value) | |
|---|---|---|
| description | Timeout while waiting for laser diode (16) and thermopositioner (64) to settle while preparing optical zero measurement | |
| error value | 16 | waiting for laser diode |
| | 64 | waiting for thermopositioner |
| action | Reboot the instrument. If the failure persists, please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Initialization Error (TASK_TIMEOUT, *id1*)) | |
| description | An init task has not finished in time | |
| error value | id1 | task name |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (TASK_VERIFY, *id1*, *id2*) | |
|---|---|---|
| description | A task could not be started | |
| error value | id1 | task name |
| | id2 | maximum available memory |
| action | Reboot the instrument. If the failure persists, please return the unit to your local service center for repair | |

If one of the selftests fails, please try to reboot the instrument. If the selftest continues to fail, please return the mainframe to your local service center for repair.

| error message | Initialization Error (Tcfs Amplifier Calibration failed, error value) | |
|---|---|---|
| description | The calibration of the tuning control feedback system amplifier has failed | |
| error value | 0 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (TcfsAdpEEPROMInit, error value) | |
|---|---|---|
| description | Error reading tuning control feedback system adapter board EEPROM | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| error message | Initialization Error (TcfsEEPROMInit, error value) | |
|---|---|---|
| description | Error reading tuning control feedback system EEPROM | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Initialization Error (Tcfs temperature not settled, error value) | |
| description | Temperature has not settled at the tuning control feedback system | |
| error value | 0 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Initialization Error (TmpCalDataInit, error value) | |
| description | Error accessing caldata | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Initialization Error (UpPiezoEnable, error value) | |
| description | Over current | |
| error value | 1 | (not significant) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Initialization Error - module temperature out of range<br>(please wait a little bit and try again)! | |
| description | Module temperature is too high | |
| error value | | (no error value) |
| action | Doublecheck whether the fan is working and not blocked. Wait some time and reboot the instrument. If the failure persists, please return the unit to your local service center for repair. | |

| | | |
|---|---|---|
| error message | Initialization Error - module temperature too high<br>(please wait a little bit and try again)! | |
| description | Module temperature is too high | |
| error value | | (no error value) |
| action | Doublecheck whether the fan is working and not blocked. Wait some time and reboot the instrument. If the failure persists, please return the unit to your local service center for repair. | |

## Selftests

These tests are started after initialization of the instrument. This test measures defined parameters, and tests them to limits.

| | | |
|---|---|---|
| error message | Main Peltier Temp. Selftest Failed (error value) | |
| description | Verifies whether the peltier temperature of the laser diode is within a given range | |
| error value | 13010 | Peltier temperature is not in target range |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Main Thermo Temp. Selftest Failed (error value) | |
| description | Verifies whether the temperature of the thermopositioner is within a given range | |
| error value | 13020 | Thermopositioner is not in target temperature range |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Main Peltier Curr. Selftest Failed (error value) | |
| description | Checks if peltier current for the laser diode peltier is below maximum | |
| error value | 13050 | Laser peltier current is above maximum value |
| action | Please return the unit to your local service center for repair | |

| error message | TCFS Temp. Selftest Failed (error value) | |
|---|---|---|
| description | Verifies if the peltier temperature is within target with a given uncertainty | |
| error value | 15010 | TCFS peltier temperature is not in target range |
| action | Please return the unit to your local service center for repair | |

| error message | TCFS Resistor Selftest Failed (error value) | |
|---|---|---|
| description | This test measures the $R_d$ of the photodiodes at channel A, B and M | |
| error value | 15021 | Photodiode $R_d$ in channel A is below limit |
| | 15022 | Photodiode $R_d$ in channel B is below limit |
| | 15023 | Photodiode $R_d$ in channel C is below limit |
| action | Please return the unit to your local service center for repair | |

| error message | TCFS Attenuator Selftest Failed (error value) | |
|---|---|---|
| description | Verifies whether an attenuator position is repeatable. | |
| error value | 15030 | Attenuator could not be positioned |
| action | Please return the unit to your local service center for repair | |

| error message | Main DC Selftest Failed (error value) | |
|---|---|---|
| description | Tests all fixed DC voltages available at the mainboard mux | |
| error value | 23011 | +15V Measurement DC voltage not in limits |
| | 23012 | -15V Measurement DC voltage not in limits |
| | 23013 | +5V Reference DC voltage not in limits |
| | 23014 | -5V Reference DC voltage not in limits |
| | 23015 | negative supply voltage of laser current source not in limits |
| | 23016 | positive pezo supply voltage not in limits |
| action | Please return the unit to your local service center for repair | |

| error message | Main Temperature Selftest Failed (error value) | |
|---|---|---|
| description | Checks whether the temperature sensors are within given limits | |
| error value | 23021 | internal temperature sensor above limit |
| | 23022 | T_FIRE_DIODE is possibly not connected |
| | 23023 | T_OPTIZ_DIODE is possibly not connected |
| | 23024 | T_BASEPLATE is possibly not connected |
| action | Please return the unit to your local service center for repair | |

| error message | Main Power Loop Selftest Failed (error value) | |
|---|---|---|
| description | Verifies the electronic of the power loop regulator | |
| error value | 23051 | power loop CW path failed |
| | 23052 | power loop modulation path failed |
| | 23053 | power loop regulator circuit failed |
| action | Please return the unit to your local service center for repair | |

| error message | Main Shutter. Selftest Failed (error value) | |
|---|---|---|
| description | Verifies the shutter drive electronic | |
| error value | 23061 | shutter 1 drive electronic failed |
| | 23062 | shutter 2 drive electronic failed |
| action | Please return the unit to your local service center for repair | |

| error message | Main Laser Safety Selftest Failed (error value) |
|---|---|
| description | Verifies if the test laser current is within limits and whether the safety current sets an alarm if a current limit is reached |

| | | |
|---|---|---|
| error value | 23071 | test laser current not in limits |
| | 23072 | current laser safety did not trigger at overcurrent |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Main Piezo Amp. Selftest Failed (error value) | |
| description | Verifies if the piezo amplifier reaches the upper and lower limit. An error may indicate a defect amplifier transistor | |
| error value | 23091 | piezo amplifier could not set to maximum voltage |
| | 23092 | piezo amplifier could not set to minimum voltage |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | Main Cavity Motor Selftest Failed (error value) | |
| description | Verifies the functionality of the cavity motor | |
| error value | 23081 | indicates an open motor connector |
| | 23082 | indicates that a motor coil is defect |
| | 23083 | indicates a short in a motor coil |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS DC Selftest Failed (error value) | |
| description | Tests all fixed DC voltages available at the TCFS board mux | |
| error value | 25011 | +10V measurement voltage on TCFS board not in limits |
| | 25012 | -10V measurement voltage on TCFS board not in limits |
| | 25013 | +5V reference voltage on TCFS board not in limits |
| | 25014 | -5V reference voltage on TCFS board not in limits |
| | 25015 | +2.5V reference voltage on TCFS board not in limits |

| | | |
|---|---|---|
| | 25016 | +5V attenuator encoder voltage on TCFS board not in limits |
| | 25017 | +2.5V attenuator encoder voltage on TCFS board not in limits |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS Temperature Selftest Failed (error value) | |
| description | Verifies whether the TCFS temperature sensors are working correctly | |
| error value | 25021 | TCFS board temperature sensor U620 above limit |
| | 25022 | TCFS case temperature sensor possibly not connected |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS Amp. Offset Selftest Failed (error value) | |
| description | Checks whether an applied offset for channel A, B and M is measured within limits | |
| error value | 25031 | TCFS Chan A offset not in limits |
| | 25032 | TCFS Chan B offset not in limits |
| | 25034 | TCFS Chan M offset not in limits |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS Amplifier Selftest Failed (error value) | |
| description | This test calibrates the TCFS A, B and M channel and verifies if all resulting values are in limits | |
| error value | 25041 | TCFS Hybrid amplifier offset could not be removed |
| | 25042 | One of the channels A, B or M failed during calibration |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS Adj. Cicuit Selftest Failed (error value) | |
| description | Checks whether a signal between +15V and +21V can be selected at the 20V reference with the DAC | |
| error value | 25050 | TCFS 20V adjust is not possible |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | TCFS Shutter Selftest Failed (error value) | |
| description | This test verifies the shutter driver by applying a designated test pattern | |
| error value | 25060 | TCFS shutter driver electronic fails |
| action | Please return the unit to your local service center for repair | |

## Return Loss Meters

| | | |
|---|---|---|
| error message | E10010: Invalid Caldata | |
| description | The Caldata loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) | |
| test value | | (no parameter) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10012: Dual ported RAM write/read test failed | |
| description | Writing bit patterns and reading them back to/from the dual ported ram failed | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10013: FPGA not correctly initialized | |
| description | Loading the FPGA with data failed. This indicates a defective FPGA or an FPGA access problem | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10014: Firmware corrupt, checksum error (a,b) | |
| description | Firmware in flash has an invalid checksum. Either the image which was programmed was corrupt or the flash memory has a failure | |
| test value | a | is the stored checksum |
| | b | is the calculated checksum |
| action | Reload the module firmware. If the failure persists, please return the unit to your local service center for repair | |

| error message | E1x031: 0.25 ref out of limits (a, b, c) | |
|---|---|---|
| description | The 0.25V reference voltage measured through the 16bit ADC is out of the acceptable limits | |
| test value | a | shows the ADC reading (0.25V = 3276) |
| | b | shows the lower limit |
| | c | shows the upper limit |
| | x | refers to the internal PM channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E10040: 10bit ADC test failed (a, b, c) | |
|---|---|---|
| description | The 10bit ADC has returned a value other than 512 | |
| test value | a | shows the ADC reading |
| | b | shows the lower limit |
| | c | shows the upper limit |
| action | Please return the unit to your local service center for repair | |

| error message | E10051: Laser <a> temp out of limits (b) | |
|---|---|---|
| description | The laser temperature is outside the allowed range | |
| test value | a | laser number |
| | b | measured laser temperature |
| action | Verify whether the module is operated within the specified ambient temperature. If the failure persists, please return the unit to your local service center for repair | |

| error message | E10052: Photodiode <a> temp out of limits (b) | |
|---|---|---|
| description | The photodiode temperature is outside the allowed range | |
| test value | a | photodiode number |
| | b | measured photodiode temperature |
| action | Verify whether the module is operated within the specified ambient temperature. If the failure persists, please return the unit to your local service center for repair | |

| error message | E1x060: 0.25V offset failed (a, b) | |
|---|---|---|
| description | Verifies that the offset voltage for the 16-bit ADC (250 mV) is correctly added to the input signal | |
| test value | a | shows the ADC reading |
| | b | shows the maximum difference to the exact ADC reading of 3277 |
| | x | refers to the internal PM channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x061: PGA DAC adj failed (a, b, c) | |
|---|---|---|
| description | Tries to adjust the offset voltage of the PGA | |
| test value | a | shows the ADC Offset reading |
| | b | shows the limit for an upper offset |
| | c | shows the limit for a lower offset |
| | x | refers to the internal PM channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x062: PGA gain adj failed (a, b, c) | |
|---|---|---|
| description | Verifies the gain settings of the PGA (x 1/10/100). A voltage of 25 mV is applied to the input of the PGA and then amplified | |
| test value | a | if 1, the required division has failed<br>if 0, the calculated factors are correct |
| | b | shows the measured values for an amplification by 10 |
| | c | shows the measured values for an amplification by 100 |
| | x | refers to the internal PM channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x063: Lambda Dac adj failed (a, b, c, d) | |
|---|---|---|
| description | Verifies the gain of the responsiveness correction stage | |
| test value | a | if 1, the quotient d could not be calculated, otherwise 0 |
| | b | shows the difference between DAC settings 1024 and 2048 |
| | c | shows the difference between DAC settings 2048 and 4096 |
| | d | shows the quotient of b divided by c |
| | x | refers to the internal PM channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E10070: Laser <a> control failed (b, c) | |
|---|---|---|
| description | Checks the laser current source | |
| test value | a | laser number |
| | b | low power setting |
| | c | high power setting |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10080: Laser <a> control for safety test failed | |
| description | To test the current safety comparator the laser current needs to be set to two different values | |
| test value | a | laser number |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10081: Safety comparator <a> test failed (b, c) | |
| description | Checks whether laser current safety comparator includes at the right conditions a safety interrupt at the CPU | |
| test value | a | laser number |
| | b | shows whether the interrupt flag was raised when the current was lower than the limit |
| | c | shows whether the interrupt flag was raised when the current was higher than the limit |
| action | Please return the unit to your local service center for repair | |

## Power Meters & Interface Modules with Optical Head

| | | |
|---|---|---|
| error message | E10010: Invalid Caldata | |
| description | The Caldata loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10012: Dual ported RAM write/read test failed | |
| description | Writing bit patterns and reading them back to/from the dual ported ram failed | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10013: FPGA not correctly initialized | |
| description | Loading the FPGA with data failed. This indicates a defective FPGA or an FPGA access problem | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E1x020: Communication with head failed | |
| description | An external head is available but it was not possible to access the registers of the head's FPGA | |
| test value | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x021: Invalid head caldata | |
|---|---|---|
| description | The head calibration data was detected as invalid | |
| test value | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x031: 0.25V ref out of limits (a, b, c) | |
|---|---|---|
| description | The 0.25V reference voltage measured through the 16bit ADC is out of the acceptable limits | |
| test value | a | shows the ADC reading (0.25 = 3276) |
| | b | shows the lower limit |
| | c | shows the upper limit |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E10040: 10bit ADC test failed (a, b, c) | |
|---|---|---|
| description | The 10bit ADC has returned a value other than 512 | |
| test value | a | shows the ADC reading |
| | b | shows the lower limit |
| | c | shows the upper limit |
| action | Please return the unit to your local service center for repair | |

| error message | E1x050: TEC NTC temp ou of limits (a, b, c, d) | |
|---|---|---|
| description | The sensor temperature is out of the acceptable limits | |
| test value | a | shows the sensor NTC temperature |
| | b | shows the sensor NTC temperature ADC reading |
| | c | shows the lower limit |
| | d | shows the upper limit |
| | x | refers to the module channel tested |
| action | Verify whether the module is operated within the specified ambient temperature. If the failure persists, please return the unit to your local service center for repair. | |

| error message | E1x051: TEC current out of limits (a, b, c) | |
|---|---|---|
| description | Verifies whether the TEC current is within a given range | |
| test value | a | shows the ADC reading of the TEC current |
| | b | shows the lower limit |
| | c | shows the upper limit |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x052: TEC comparator test failed (a, b, c, d) | |
|---|---|---|
| description | Checks the TEC regulation voltage comparator | |
| test value | a | shows the 10bit ADC reading for the high output voltage |
| | b | shows the 10bit ADC reading for the low output voltage |
| | c | shows the lower limit |
| | d | shows the upper limit |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x053: TEC default temp invalid (a) | |
|---|---|---|
| description | Verifies whether the default temperature is within a given range | |
| test value | a | shows the default temperature |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x054: TEC control failed (a, b, c) | |
|---|---|---|
| description | When the TEC is enabled the temperature must move towards the default temperature, coming from a previous temperature before the TEC was enabled. The moving direction must be correct and the overshoot must be less than a certain limit | |
| test value | a | shows the temperature before the TEC was enabled |
| | b | shows the actual temperature while TEC is enabled |
| | c | shows the target temperature, where b should move to |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x060: 0.25V offset failed (a, b) | |
|---|---|---|
| description | Verifies that the offset voltage for the 16-bit ADC (250 mv) is correctly added to the input signal | |
| test value | a | shows the ADC reading |
| | b | shows the maximum difference to the exact ADC reading of 3277 |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x061: PGA DAC adj failed (a, b, c) | |
|---|---|---|
| description | Tries to adjust the offset voltage of the PGA | |
| test value | a | shows the ADC offset reading |
| | b | shows the limit for an upper offset |
| | c | shows the limit for a lower offset |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x062: PGA gain adj failed (a, b, c) | |
|---|---|---|
| description | Verifies the gain settings of the PGA (x 1/10/100). A voltage of 25 mV is applied to the input of the PGA and then amplified | |
| test value | a | if 1, the required division has failed<br>if 0, the calculated factors are correct |
| | b | shows the measured values for an amplification by 10 |
| | c | shows the measured values for an amplification by 100 |
| | d | shows the quotient of b divided by c |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x063: Lambda DAC adj failed (a, b, c, d) | |
|---|---|---|
| description | Verifies the gain of the responsiveness correction stage | |
| test value | a | if 1, the quotient d could not be calculated, otherwise 0 |
| | b | shows the difference between DAC settings 1024 and 2048 |
| | c | shows the difference between DAC settings 2048 and 4096 |
| | d | shows the quotient of b divided by c |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| error message | E1x080; TEC settling failed (a, b) | |
|---|---|---|
| description | Verifies the comparator output of the regulation circuit after the TEC is enabled and expects an ADC reading of about 512 | |
| test value | a | shows the ADC reading of the comparator output |

| | | |
|---|---|---|
| | b | shows the time when the temperature regulation has reached the default temperature. Waits maximum 30 seconds |
| | x | refers to the module channel tested |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E1x081: TEC current to temperature mismatch | |
| description | If the TEC temperature difference does not correspond to the measured Peltier current this test will fail | |
| test value | x | refers to the module channel tested |
| action | Verify whether the module is operated within the specified ambient temperature. If the failure persists, please return the unit to your local service center for repair. | |

## Fixed Laser Sources (Fabry Perot)

| | | |
|---|---|---|
| error message | E10010: Invalid Caldata | |
| description | The Caldata loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10012: Dual ported RAM write/read test failed | |
| description | Writing bit patterns and reading them back to/from the dual ported ram failed | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10013: FPGA not correctly initialized | |
| description | Loading the FPGA with data failed. This indicates a defective FPGA or an FPGA access problem | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10040: 10bit ADC test failed (a, b, c) | |
| description | The 10bit ADC has returned a value other than 512 | |
| test value | a | shows the ADC reading |
| | b | shows the lower limit |
| | c | shows the upper limit |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10050: Board temp out of limits (a) | |
| description | The board temperature is outside the allowed range | |
| test value | a | measured board temperature |
| action | Please return the unit to your local service center for repair | |

| error message | E10051: Laser <a> temp out of limits (b) | |
|---|---|---|
| description | The laser temperature is outside the allowed range | |
| test value | a | laser number |
| | b | measured laser temperature |
| action | Verify whether the module is operated within the specified ambient temperature. If the failure persists, please return the unit to your local service center for repair | |

| error message | E10060: Laser <a> control failed (b, c, d, e) | |
|---|---|---|
| description | Checks the laser current source | |
| test value | a | laser number |
| | b | measured current at low power and normal current source setting |
| | c | measured current at low power and high current source setting |
| | d | measured current at high power and normal current source setting |
| | e | measured current at high power and high current source setting |
| action | Please return the unit to your local service center for repair | |

| error message | E10070: Peltier <a> temp diff amp failed | |
|---|---|---|
| description | Checks whether the comparator output changes from low to high values while the temperature DAC is set to two different temperatures | |
| test value | a | laser number |
| action | Please return the unit to your local service center for repair | |

| error message | E10071: Peltier <a> current control test failed (b, c, d, e) | |
|---|---|---|
| description | The Peltier temperature is set close to the ambient temperature. Using the current offset circuit, two different currents are set and measured. If the differences between vary more than a specific percentage this test fails | |
| test value | a | laser number |
| | b | delta current setting |
| | c | delta current measured |
| | d | actual difference between b and c |
| | e | allowed difference between b and c |
| action | Please return the unit to your local service center for repair | |

| error message | E10080: Laser <a> control for safety test failed | |
|---|---|---|
| description | To test the current safety comparator the laser current needs to be set to two different values | |
| test value | a | laser number |
| action | Please return the unit to your local service center for repair | |

| error message | E10081: Safety comparator <a> test failed (b, c) | |
|---|---|---|
| description | Checks whether laser current safety comparator includes at the right conditions a safety interrupt at the CPU | |
| test value | a | laser number |
| | b | shows whether the interrupt flag was raised when the current was lower than the limit |
| | c | shows whether the interrupt flag was raised when the current was higher than the limit |
| action | Please return the unit to your local service center for repair | |

| error message | E10090: Peltier <a> regulation failed (b, c, d) | |
|---|---|---|
| description | During boot time, when the Peltier control was disabled it is enabled for two seconds and the temperature moving direction is checked. If the movement delta is not approaching the target default temperature or if the temperature has not reached the default within the given ranges this test fails | |
| test value | a | laser number |
| | b | default temperature |
| | c | temperature with disabled peltier |
| | d | temperature with enabled peltier |
| action | Please return the unit to your local service center for repair | |

| error message | E10091: Peltier <a> regulation failed (b, c) | |
|---|---|---|
| description | Verifies whether the temperature is around the default value with the given limits | |
| test value | a | laser number |
| | b | default temperature |
| | c | actual temperature |
| action | Please return the unit to your local service center for repair | |

## DFB Laser Sources

| | | |
|---|---|---|
| error message | E10010: Invalid Caldata | |
| description | The Caldata loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10012: Dual ported RAM write/read test failed | |
| description | Writing bit patterns and reading them back to/from the dual ported ram failed | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10013: FPGA not correctly initialized | |
| description | Loading the FPGA with data failed. This indicates a defective FPGA or an FPGA access problem | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10040: 10bit ADC test failed (a, b, c) | |
| description | The 10bit ADC has returned a value other than 512 | |
| test value | a | shows the ADC reading |
| | b | shows the lower limit |
| | c | shows the upper limit |
| action | Please return the unit to your local service center for repair | |

| | | |
|---|---|---|
| error message | E10050: Board temp out of limits (a) | |
| description | The board temperature is outside the allowed range | |
| test value | a | measured board temperature |
| action | Please return the unit to your local service center for repair | |

| error message | E10060: Laser <a> control failed (b, c, d, e) | |
|---|---|---|
| description | Checks the laser current source | |
| test value | a | laser number |
| | b | measured current at low per and normal current source setting |
| | c | measured current at low power and high current source setting |
| | d | measured current at high power and normal current source setting |
| | e | measured current at high power and high current source setting |
| action | Please return the unit to your local service center for repair | |

| error message | E10080: Laser <a> control for safety test failed | |
|---|---|---|
| description | To test the current safety comparator the laser current needs to be set to two different values | |
| test value | a | laser number |
| action | Please return the unit to your local service center for repair | |

| error message | E10081: Safety comparator <a> test failed (b, c) | |
|---|---|---|
| description | Checks whether laser current safety comparator includes at the right conditions a safety interrupt at the CPU | |
| test value | a | laser number |
| | b | shows whether the interrupt flag was raised when the current was lower than the limit |
| | c | shows whether the interrupt flag was raised when the current was higher than the limit |
| action | Please return the unit to your local service center for repair | |

## Attenuator Modules

The following Error Codes are applicable to attenuator modules.

Codes E10010, E10012, and E10014 are valid for all attenuators. The remaining codes are only valid for attenuators with power control

.

| error message | E10010: Invalid Caldata | |
|---|---|---|
| description | The Caldata loaded on the module is invalid. Either the caldata version number is not compatible with the firmware or the caldata is corrupt (checksum incorrect) | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| error message | E10012: Dual ported RAM write/read test failed | |
|---|---|---|
| description | Writing bit patterns and reading them back to/from the dual ported ram failed | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| error message | E10013: FPGA not correctly initialized | |
|---|---|---|
| description | Loading the FPGA with data failed. This indicates a defective FPGA or an FPGA access problem | |
| test value | | (no test value) |
| action | Please return the unit to your local service center for repair | |

| error message | E10014: Firmware corrupt, checksum error (a,b) | |
|---|---|---|
| description | Firmware in flash has an invalid checksum. Either the image which was programmed was corrupt or the flash memory has a failure | |
| test value | a | is the stored checksum |
| | b | is the calculated checksum |
| action | Reload the module firmware. If the failure persists, please return the unit to your local service center for repair | |

| error message | E10031: 0.25 ref out of limits (a, b, c) | |
|---|---|---|
| description | The 0.25V reference voltage measured through the 16bit ADC is out of the acceptable limits | |
| test value | a | shows the ADC reading (0.25V = 3276) |
| | b | shows the lower limit |
| | c | shows the upper limit |
| action | Please return the unit to your local service center for repair | |

| error message | E1060: 0.25V offset failed (a, b) | |
|---|---|---|
| description | Verifies that the offset voltage for the 16-bit ADC (250 mV) is correctly added to the input signal | |
| test value | a | shows the ADC reading |
| | b | shows the maximum difference to the exact ADC reading of 3277 |
| action | Please return the unit to your local service center for repair | |

| error message | E10061: PGA DAC adj failed (a, b, c) | |
|---|---|---|
| description | Tries to adjust the offset voltage of the PGA | |
| test value | a | shows the ADC Offset reading |
| | b | shows the limit for an upper offset |
| | c | shows the limit for a lower offset |
| action | Please return the unit to your local service center for repair | |

| error message | E10062: PGA gain adj failed (a, b, c) | |
|---|---|---|
| description | Verifies the gain settings of the PGA (x 1/10/100). A voltage of 25 mV is applied to the input of the PGA and then amplified | |
| test value | a | if 1, the required division has failed<br>if 0, the calculated factors are correct |

| | | |
|---|---|---|
| | b | shows the measured values for an amplification by 10 |
| | c | shows the measured values for an amplification by 100 |
| action | Please return the unit to your local service center for repair | |

| error message | E10063: Lambda Dac adj failed (a, b, c, d) | |
|---|---|---|
| description | Verifies the gain of the responsiveness correction stage | |
| test value | a | if 1, the quotient d could not be calculated, otherwise 0 |
| | b | shows the difference between DAC settings 1024 and 2048 |
| | c | shows the difference between DAC settings 2048 and 4096 |
| | d | shows the quotient of b divided by c |
| action | Please return the unit to your local service center for repair | |

The following error codes are attenuator module specific:

- Error Creating message queue!
- Error Init MCB!
- Error spawning tLowlvlMsgHandler!
- Error spawning tKeyPressed!
- Error spawning tTempCtrl!
- Error spawning tPowCtrl!
- Error checking firmware CRC!

# Optical Switch modules

| | |
|---|---|
| error message | InitError() failed! |
| description | Initialization of internal error buffer failed. |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Invalid Caldata! |
| description | The calibration data loaded on the module is invalid.<br>Either the version number is nir compatible with the firmware or the calibration data is corrupt (checksum incorrect). |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitModule() failed! |
| description | Module initialization failed. |
| note | Normally something more descriptive appears (i.e. one of the other messages mentioned here.) |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | SanityChecks():channel X, configArray != -1<br>SanityChecks():channel X, configs == 0<br>SanityChecks() failed |
| description | Calibration data seems not to be correct |
| test value | X Channel number |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitModuleStruct() failed |
| description | Initialization of module structures failed |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Unsupported module type |
| description | Module type described in calibration data not supported by the firmware or incorrect calibration data |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitSwitchAccess():AllocTpuChannels() for switch failed<br>InitSwitchAccess():Unsupported switchLocation<br>SwitchAccessSwitch():Unsupported switchLocation<br>SwitchInitSequence():Unsupported switchLocation<br>InitSwitchAccess(): failed |
| description | Initialization of the functionality used to access the switch hardware failed. Probably a calibration data problem. |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitSwitchAccess():AllocTpuChannels() for LEDs failed<br>InitSwitchAccess():Unsupported ledLocation<br>SwitchAccessLED():Unsupported ledLocation |
| description | Initialization of the functionality used to access the LEDs failed. Probably a calibration data problem. |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitKey (&SendInternalKeyMsg) failed<br>InitKey(): called more than once<br>InitKey(): couldn't create enableMsgQ.<br>InitKey(): couldn't spawn KeyEnableTask.<br>InitKey(): couldn't create isrWatchdog.<br>InitKey(): init() failed<br>InitKey(): KeyEnable() failed<br>KeyInitPortF(): wrong interrupt number<br>KeyInitPortF(): intConnect() failed<br>KeyInitTPU(): AllocTpuItc() failed<br>KeyInitTPU(): intConnect() failed |
| description | Initialization of front panel key failed. Probably a calibration data or firmware problem. |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | KeyDisable(): ERROR<br>KeyDisable(): disabledCnt >= disabledMax<br>KeyDisableTask(): received wrong channel number.<br>KeyDisableTask(): disabledCnt <0.<br>KeyDisableTask(): couldn't send myself a msg.<br>KeyEnablePortF(): wrong interrupt number<br>KeyDisablePortF(): wrong interrupt number |
| description | Problem when enabling or disabling a front panel key. Probably a calibration data or firmware problem. |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | KeySelftest() called without calling KeyInit() before<br>KeySelftest(): KeyDisable() failed<br>KeySelftest(): selftestPre() failed<br>KeySelftest(): key pressed during selftest or hardware problem<br>KeySelftest(): selftestPost() failed<br>KeySelftest(): KeyEnable() failed<br>KeySelftestExecPortF(): wrong interrupt number<br>KeySelftestPreTPU(): FreeTpultc() failed<br>KeySelftestExecTPU(): GetTpuDioState() failed<br>KeySelftestPostTPU(): AllocTpultc() failed<br>Selftest (stAll, 0) failed |
| description | Selftest problem. Possible causes:<br>- hardware failure<br>- key pressed during selftest<br>- calibration data or firmware incorrect |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitKey(): unsupported keyLocation<br>KeyAck(): unsupported keyLocation<br>KeyEnable(): unsupported keyLocation<br>KeyDisable(): unsupported keyLocation<br>KeySelftestPre(): unsupported keyLocation<br>KeySelftestExec(): unsupported keyLocation<br>KeySelftestPost(): unsupported keyLocation |
| description | Calibtation data incorrect |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Preset (0) failed<br>Preset(): channel X, config Y failed |
| description | Preset failed, probably due to incorrect calibration data |
| test value | X module channel<br>Y switch configuration number |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Error checking firmware CRC! |
| description | The firmware CRC is wrong |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | Unknown internal error during init |
| description | Error with unknown cause occured |
| test value | |
| action | Please return the unit to your local service center for repair |

| | |
|---|---|
| error message | InitDefaultCaldata(): couldn't alloc defaultCalData<br>InitDefaultCaldata(): only 2 channels supported in default caldata<br>InitDefaultCaldata(): unknown type |
| description | This only occurs when running special debug software |
| test value | |
| action | Please return the unit to your local service center for repair |

# 15 Cleaning Instructions

Safety Precautions / 425
Why is it important to clean optical devices ? / 426
What do I need for proper cleaning? / 427
Preserving Connectors / 432
Cleaning Instrument Housings / 433
Cleaning Instrument Housings / 433
Which Cleaning Procedure should I use ? / 434
How to clean connectors / 435
How to clean connector adapters / 438
How to clean connector interfaces / 439
How to clean lenses / 441
How to clean instruments with a fixed connector interface / 442
How to clean instruments with an optical glass plate / 443
How to clean instruments with a physical contact interface / 444
How to clean instruments with a recessed lens interface / 446
How to clean optical devices which are sensitive to mechanical stress and pressure / 447
How to clean metal filters or attenuator gratings / 448
Additional Cleaning Information / 449
Other Cleaning Hints / 451

The following Cleaning Instructions contain some general safety precautions, which must be observed during all phases of cleaning. Consult your specific optical device manuals or guides for full information on safety matters.

Please try, whenever possible, to use physically contacting connectors, and dry connections. Clean the connectors, interfaces, and bushings carefully after use.

If you are unsure of the correct cleaning procedure for your optical device, we recommend that you first try cleaning a dummy or test device.

Keysight Technologies assume no liability for the customer's failure to comply with these requirements.

### Cleaning Instructions for this Instrument

The Cleaning Instructions apply to a number of different types of Optical Equipment. Table 21 on page -424 lists the sections that are relevant to the various modules that can be installed in this instrument.

**Table 21 Cleaning Instructions for Modules**

| Modules | Instruction |
|---|---|
| Optical Heads | How to clean instruments with an optical glass plate on page 443 |
| Laser Source Modules | How to clean instruments with a physical contact interface on page 444 |
| Tunable Laser Modules | How to clean instruments with a physical contact interface on page 444 |
| Return Loss Modules | How to clean instruments with a physical contact interface on page 444 |
| LED Source Modules | How to clean instruments with a physical contact interface on page 444 |
| Power Sensor Modules | How to clean instruments with a recessed lens interface on page 446 |

## Safety Precautions

Please follow the following safety rules:

- Do not remove instrument covers when operating.
- Ensure that the instrument is switched off throughout the cleaning procedures.
- To prevent electrical shock, disconnect the instrument from the mains before cleaning. Use a dry cloth, or one slightly dampened with water, to clean the external case parts. Do not attempt to clean internally.
- After cleaning, do not switch on the instrument when there is no termination to the optical output connector, to the optical fiber or to the attached device. The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.

**For Class 3B lasers**

**WARNING** The built-in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye and skin safe conditions.

**CAUTION** Protect your extra-high power tunable laser from damage:

- Clean the instrument's output connector and all interfaces of attached fibers and termination devices to avoid burning-in dust and other residue!
- Do not leave plastic caps on the output connector or on the end of a connected fiber when you activate the laser – you risk damaging the connector surface with deposit from hot plastic!
- Make sure the optical path is terminated properly and confirm that the termination can cope with an optical power level of over +18.5 dBm or 70 mW!
- Use a metal cap to cover the laser outputs when open. Terminate open patchcord ends with a commercially available "fiber optic light trap".

## Why is it important to clean optical devices ?

In transmission links optical fiber cores are about 9 μm (0.00035") in diameter. Dust and other particles, however, can range from tenths to hundredths of microns in diameter. Their comparative size means that they can cover a part of the end of a fiber core, and as a result will reduce the performance of your system.

Furthermore, the power density may burn dust into the fiber and cause additional damage (for example, 0 dBm optical power in a single mode fiber causes a power density of approximately 16 million $W/m^2$). If this happens, measurements become inaccurate and non-repeatable.

Cleaning is, therefore, an essential yet difficult task. Unfortunately, when comparing most published cleaning recommendations, you will discover that they contain several inconsistencies. In this section, we want to suggest ways to help you clean your various optical devices, and thus significantly improve the accuracy and repeatability of your lightwave measurements.

# What do I need for proper cleaning?

Some Standard Cleaning Equipment on page 427 is necessary for cleaning your instrument. For certain cleaning procedures, you may also require certain Additional Cleaning Equipment on page 429.

## Standard Cleaning Equipment

Before you can start your cleaning procedure you need the following standard equipment:

- Dust and shutter caps on page 427
- Isopropyl alcohol on page 427
- Cotton swabs on page 428
- Soft tissues on page 428
- Pipe cleaner on page 429
- Compressed air on page 429

### Dust and shutter caps

All of Keysight Technologies' lightwave instruments are delivered with either laser shutter caps or dust caps on the lightwave adapter. Any cables come with covers to protect the cable ends from damage or contamination.

We suggest these protected coverings should be kept on the equipment at all times, except when your optical device is in use. Be careful when replacing dust caps after use. Do not press the bottom of the cap onto the fiber too hard, as any dust in the cap can scratch or pollute your fiber surface.

If you need further dust caps, please contact your nearest Keysight Technologies sales office.

### Isopropyl alcohol

This solvent is usually available from any local pharmaceutical supplier or chemist's shop.

If you use isopropyl alcohol to clean your optical device, do not immediately dry the surface with compressed air (except when you are cleaning very sensitive optical devices). This is because the dust and the dirt is solved and will leave behind filmy deposits after the alcohol is evaporated. You should therefore first remove the alcohol and the dust with a soft tissue, and then use compressed air to blow away any remaining filaments.

If possible avoid using denatured alcohol containing additives. Instead, apply alcohol used for medical purposes.

Never try to drink this alcohol, as it may seriously damage to your health.

Do not use any other solvents, as some may damage plastic materials and claddings. Acetone, for example, will dissolve the epoxy used with fiber optic connectors. To avoid damage, only use isopropyl alcohol.

### Cotton swabs

We recommend that you use swabs such as Q-tips or other cotton swabs normally available from local distributors of medical and hygiene products (for example, a supermarket or a chemist's shop). You may be able to obtain various sizes of swab. If this is the case, select the smallest size for your smallest devices.

Ensure that you use natural cotton swabs. Foam swabs will often leave behind filmy deposits after cleaning.

Use care when cleaning, and avoid pressing too hard onto your optical device with the swab. Too much pressure may scratch the surface, and could cause your device to become misaligned. It is advisable to rub gently over the surface using only a small circular movement.

Swabs should be used straight out of the packet, and never used twice. This is because dust and dirt in the atmosphere, or from a first cleaning, may collect on your swab and scratch the surface of your optical device.

### Soft tissues

These are available from most stores and distributors of medical and hygiene products such as supermarkets or chemists' shops.

We recommend that you do not use normal cotton tissues, but multi-layered soft tissues made from non-recycled cellulose. Cellulose tissues are very absorbent and softer. Consequently, they will not scratch the surface of your device over time.

Use care when cleaning, and avoid pressing on your optical device with the tissue. Pressing too hard may lead to scratches on the surface or misalignment of your device. Just rub gently over the surface using a small circular movement.

Use only clean, fresh soft tissues and never apply them twice. Any dust and dirt from the air which collects on your tissue, or which has gathered after initial cleaning, may scratch and pollute your optical device.

### Pipe cleaner

Pipe cleaners can be purchased from tobacconists, and come in various shapes and sizes.The most suitable one to select for cleaning purposes has soft bristles, which will not produces scratches.

There are many different kinds of pipe cleaner available from tobacco shops.

The best way to use a pipe cleaner is to push it in and out of the device opening (for example, when cleaning an interface). While you are cleaning, you should slowly rotate the pipe cleaner.

Only use pipe cleaners on connector interfaces or on feed through adapters. Do not use them on optical head adapters, as the center of a pipe cleaner is hard metal and can damage the bottom of the adapter.

Your pipe cleaner should be new when you use it. If it has collected any dust or dirt, this can scratch or contaminate your device.

The tip and center of the pipe cleaner are made of metal. Avoid accidentally pressing these metal parts against the inside of the device, as this can cause scratches.

### Compressed air

Compressed air can be purchased from any laboratory supplier.

It is essential that your compressed air is free of dust, water and oil. Only use clean, dry air. If not, this can lead to filmy deposits or scratches on the surface of your connector. This will reduce the performance of your transmission system.

When spraying compressed air, hold the can upright. If the can is held at a slant, propellant could escape and dirty your optical device. First spray into the air, as the initial stream of compressed air could contain some condensation or propellant. Such condensation leaves behind a filmy deposit.

Please be friendly to your environment and use a CFC-free aerosol.

## Additional Cleaning Equipment

Some Cleaning Procedures need the following equipment, which is not required to clean each instrument:

- Microscope with a magnification range about 50X up to 300X on page 430
- Ultrasonic bath on page 430

- Warm water and liquid soap on page 430
- Premoistened cleaning wipes on page 431
- Polymer film on page 431
- Infrared Sensor Card on page 431


### Microscope with a magnification range about 50X up to 300X

A microscope can be found in most photography stores, or can be obtained through or specialist mail order companies. Special fiber-scopes are available from suppliers of splicing equipment.

Ideally, the light source on your microscope should be very flexible. This will allow you to examine your device closely and from different angles.

A microscope helps you to estimate the type and degree of dirt on your device. You can use a microscope to choose an appropriate cleaning method, and then to examine the results. You can also use your microscope to judge whether your optical device (such as a connector) is severely scratched and is, therefore, causing inaccurate measurements.

### Ultrasonic bath

Ultrasonic baths are also available from photography or laboratory suppliers or specialist mail order companies.

An ultrasonic bath will gently remove fat and other stubborn dirt from your optical devices. This helps increase the life span of the optical devices.

Only use isopropyl alcohol in your ultrasonic bath, as other solvents may damage.

### Warm water and liquid soap

Only use water if you are sure that there is no other way of cleaning your optical device without corrosion or damage. Do not use hot water, as this may cause mechanical stress, which can damage your optical device.

Ensure that your liquid soap has no abrasive properties or perfume in it. You should also avoid normal washing-up liquid, as it can cover your device in an iridescent film after it has been air-dried.

Some lenses and mirrors also have a special coating, which may be sensitive to mechanical stress, or to fat and liquids. For this reason we recommend you do not touch them.

If you are not sure how sensitive your device is to cleaning, please contact the manufacturer or your sales distributor.

### Premoistened cleaning wipes

Use pre-moistened cleaning wipes as described in each individual cleaning procedure. Cleaning wipes may be used in every instance where a moistened soft tissue or cotton swab is applied.

### Polymer film

Polymer film is available from laboratory suppliers or specialist mail order companies.

Using polymer film is a gentle method of cleaning extremely sensitive devices, such as reference reflectors and mirrors.

### Infrared Sensor Card

Infrared sensor cards are available from laboratory suppliers or specialist mail order companies.

With this card you are able to control the shape of laser light emitted. The invisible laser beam is projected onto the sensor card, then becomes visible to the normal eye as a round spot.

Take care never to look into the end of a fiber or any other optical component, when they are in use. This is because the laser can seriously damage your eyes.

## Preserving Connectors

Listed below are some hints on how best to keep your connectors in the best possible condition.

### Making Connections

Before you make any connection you must ensure that all cables and connectors are clean. If they are dirty, use the appropriate cleaning procedure.

When inserting the ferrule of a patchcord into a connector or an adapter, make sure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise you will rub the fiber end against an unsuitable surface, producing scratches and dirt deposits on the surface of your fiber.

### Dust Caps and Shutter Caps

Be careful when replacing dust caps after use. Do not press the bottom of the cap onto the fiber as any dust in the cap can scratch or dirty your fiber surface.

When you have finished cleaning, put the dust cap back on, or close the shutter cap if the equipment is not going to be used immediately.

Keep the caps on the equipment always when it is not in use.

All of Keysight Technologies' lightwave instruments and accessories are shipped with either laser shutter caps or dust caps. If you need additional or replacement dust caps, contact your nearest Keysight Technologies Sales/Service Office.

### Immersion Oil and Other Index Matching Compounds

Where it is possible, do not use immersion oil or other index matching compounds with your device. They are liable to impair and dirty the surface of the device. In addition, the characteristics of your device can be changed and your measurement results affected.

## Cleaning Instrument Housings

Use a dry and very soft cotton tissue to clean the instrument housing and the keypad. Do not open the instruments as there is a danger of electric shock, or electrostatic discharge. Opening the instrument can cause damage to sensitive components, and in addition your warranty will be voided.

## Which Cleaning Procedure should I use ?

### Light dirt

If you just want to clean away light dirt, observe the following procedure for all devices:

- Use compressed air to blow away large particles.
- Clean the device with a dry cotton swab.
- Use compressed air to blow away any remaining filament left by the swab.

### Heavy dirt

If the above procedure is not enough to clean your instrument, follow one of the procedures below. Please consult Cleaning Instructions for this Instrument on page 424 for the procedure relevant for this instrument.

If you are unsure of how sensitive your device is to cleaning, please contact the manufacturer or your sales distributor

## How to clean connectors

Cleaning connectors is difficult as the core diameter of a single-mode fiber is only about 9 µm. This generally means you cannot see streaks or scratches on the surface. To be certain of the condition of the surface of your connector and to check it after cleaning, you need a microscope.

In the case of scratches, or of dust that has been burnt onto the surface of the connector, you may have no option but to polish the connector. This depends on the degree of dirtiness, or the depth of the scratches. This is a difficult procedure and should only be performed by skilled personal, and as a last resort as it wears out your connector.

**WARNING**

Please pay attention to the following laser safety warnings:

- Do not switch on the instrument when there is no termination to the optical output connector, to the optical fiber or to the attached device. The laser radiation can seriously damage your eyesight.
- The use of other optical instruments with this product will increase the hazard to your eyes.
- To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the output of the connector. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

**For Class 3B lasers**

**WARNING** The built-in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye and skin safe conditions.

**CAUTION** Protect your extra-high power tunable laser from damage:

- Clean the instrument's output connector and all interfaces of attached fibers and termination devices to avoid burning-in dust and other residue!
- Do not leave plastic caps on the output connector or on the end of a connected fiber when you activate the laser – you risk damaging the connector surface with deposit from hot plastic!
- Make sure the optical path is terminated properly and confirm that the termination can cope with an optical power level of over +18.5 dBm or 70 mW!
- Use a metal cap to cover the laser outputs when open. Terminate open patchcord ends with a commercially available "fiber optic light trap".

### Preferred Procedure

Use the following procedure on most occasions.

1 Clean the connector by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the connector:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the connector by rubbing the cotton-swab over the surface using a small circular movement.

3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

4 Blow away any remaining lint with compressed air.

### An Alternative Procedure

A better, more gentle, but more expensive cleaning procedure is to use an ultrasonic bath with isopropyl alcohol.

1 Hold the tip of the connector in the bath for at least three minutes.

2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

## How to clean connector adapters

**CAUTION** Some adapters have an anti-reflection coating on the back to reduce back reflection. This coating is extremely sensitive to solvents and mechanical abrasion. Extra care is needed when cleaning these adapters.

### Preferred Procedure

Use the following procedure on most occasions.

1. Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.
2. Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the adapter:

1. Moisten a new cotton-swab with isopropyl alcohol.
2. Clean the adapter by rubbing the cotton-swab over the surface using a small circular movement.
3. Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
4. Blow away any remaining lint with compressed air.

## How to clean connector interfaces

**CAUTION**

**Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the interface.**

**Do not use pipe-cleaners on optical head adapters, as the hard core of normal pipe cleaners can damage the bottom of an adapter.**

### Preferred Procedure

Use the following procedure on most occasions.

1. Clean the interface by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.
2. Then clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
3. Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface:

1. Moisten a new pipe-cleaner with isopropyl alcohol.
2. Clean the interface by pushing and pulling the pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.
3. Moisten a new cotton-swab with isopropyl alcohol.
4. Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
5. Using a new, dry pipe-cleaner, and a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.
6. Blow away any remaining lint with compressed air.

### How to clean bare fiber adapters

Bare fiber adapters are difficult to clean. Protect from dust unless they are in use.

**CAUTION** Never use any kind of solvent when cleaning a bare fiber adapter as solvents can damage the foam inside some adapters.

They can deposit dissolved dirt in the groove, which can then dirty the surface of an inserted fiber.

Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the adapter:

1 Clean the adapter by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.

**CAUTION** Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the adapter.

2 Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

## How to clean lenses

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings.

Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little alcohol as possible, as it can get between the lenses and in doing so can change the properties of projection.

### Preferred Procedure

Use the following procedure on most occasions.

1 Clean the lens by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the lens:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the lens by rubbing the cotton-swab over the surface using a small circular movement.

3 Using a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.

4 Blow away any remaining lint with compressed air.

## How to clean instruments with a fixed connector interface

**NOTE** Both the surface and the jacket of the attached connector should be completely dry and clean.

You should only clean instruments with a fixed connector interface when it is absolutely necessary. This is because it is difficult to remove any used alcohol or filaments from the input of the optical block.

It is important, therefore, to keep dust caps on the equipment at all times, except when your optical device is in use.

If you do discover filaments or particles, the only way to clean a fixed connector interface and the input of the optical block is to use compressed air.

If there are fluids or fat in the connector, please refer the instrument to the skilled personnel of Keysight's service team.

**CAUTION** Only use clean, dry compressed air. Make sure that the air is free of dust, water, and oil. If the air that you use is not clean and dry, this can lead to filmy deposits or scratches on the surface of your connector interface. This will degrade the performance of your transmission system.

Never try to open the instrument and clean the optical block by yourself, because it is easy to scratch optical components, and cause them to be misaligned.

## How to clean instruments with an optical glass plate

Some instruments, for example, the optical heads from Keysight Technologies have an optical glass plate to protect the sensor. Clean this glass plate in the same way as optical lenses (see How to clean lenses on page 441).

## How to clean instruments with a physical contact interface

Remove any connector interfaces from the optical output of the instrument before you start the cleaning procedure.

Cleaning interfaces is difficult as the core diameter of a single-mode fiber is only about 9 µm. This generally means you cannot see streaks or scratches on the surface. To be certain of the degree of pollution on the surface of your interface and to check whether it has been removed after cleaning, you need a microscope.

**WARNING**

Please pay attention to the following laser safety warnings:

- Do not switch on the instrument when there is no termination to the optical output connector, to the optical fiber or to the attached device. The laser radiation can seriously damage your eyesight.
- The use of other optical instruments with this product will increase the hazard to your eyes.
- To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the interface. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

**For Class 3B lasers**

**WARNING** The built-in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye and skin safe conditions.

**CAUTION** Protect your extra-high power tunable laser from damage:

- Clean the instrument's output connector and all interfaces of attached fibers and termination devices to avoid burning-in dust and other residue!
- Do not leave plastic caps on the output connector or on the end of a connected fiber when you activate the laser – you risk damaging the connector surface with deposit from hot plastic!
- Make sure the optical path is terminated properly and confirm that the termination can cope with an optical power level of over +18.5 dBm or 70 mW!
- Use a metal cap to cover the laser outputs when open. Terminate open patchcord ends with a commercially available "fiber optic light trap".

### Preferred Procedure

Use the following procedure on most occasions.

1 Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.

2 Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface:

1 Moisten a new cotton-swab with isopropyl alcohol.

2 Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.

3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

4 Blow away any remaining lint with compressed air.

## How to clean instruments with a recessed lens interface

**WARNING**

**For instruments with a deeply recessed lens interface (for example the Keysight 81633A and 81634A Power Sensors) do NOT follow this procedure. Alcohol and compressed air could damage your lens even further.**

**Keep your dust and shutter caps on, when your instrument is not in use. This should prevent it from getting too dirty. If you must clean such instruments, please refer the instrument to the skilled personnel of Keysight's service team.**

### Preferred Procedure

Use the following procedure on most occasions.

1. Blow away any dust or dirt with compressed air. If this is not sufficient, then
2. Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
3. Blow away any remaining lint with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the interface, and using the procedure for light dirt is not sufficient. Using isopropyl alcohol should be your last choice for recessed lens interfaces because of the difficulty of cleaning out any dirt that is washed to the edge of the interface:

1. Moisten a new cotton-swab with isopropyl alcohol.
2. Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
3. Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
4. Blow away any remaining lint with compressed air.

## How to clean optical devices which are sensitive to mechanical stress and pressure

Some optical devices, such as the Keysight 81000BR Reference Reflector, which has a gold plated surface, are very sensitive to mechanical stress or pressure. Do not use cotton-swabs, soft-tissues or other mechanical cleaning tools, as these can scratch or destroy the surface.

### Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

### Procedure for Stubborn Dirt

To clean devices that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.

2 Remove the film and any dirt with special adhesive tapes.

### Alternative Procedure

For these types of optical devices you can often use an ultrasonic bath with isopropyl alcohol. Only use the ultrasonic bath if you are sure that it won't cause any damage anything to the device.

1 Put the device into the bath for at least three minutes.

2 Blow away any remaining liquid with compressed air.

If there are any streaks or drying stains on the surface, repeat the cleaning procedure.

## How to clean metal filters or attenuator gratings

This kind of device is extremely fragile. A misalignment of the grating leads to inaccurate measurements. Never touch the surface of the metal filter or attenuator grating. Be very careful when using or cleaning these devices. Do not use cotton-swabs or soft-tissues, as there is the danger that you cannot remove the lint and that the device will be destroyed by becoming mechanically distorted.

### Preferred Procedure

Use the following procedure on most occasions.

1 Use compressed air at a distance and with low pressure to remove any dust or lint.

### Procedure for Stubborn Dirt

Do not use an ultrasonic bath as this can damage your device.

Use this procedure particularly when there is greasy dirt on the device:

1 Put the optical device into a bath of isopropyl alcohol, and wait at least 10 minutes.

2 Remove the fluid using compressed air at some distance and with low pressure. If there are any streaks or drying stains on the surface, repeat the whole cleaning procedure.

# Additional Cleaning Information

The following cleaning procedures may be used with other optical equipment:

- How to clean bare fiber ends on page 449
- How to clean large area lenses and mirrors on page 449

## How to clean bare fiber ends

Bare fiber ends are often used for splices or, together with other optical components, to create a parallel beam. The end of a fiber can often be scratched. You make a new cleave. To do this:

1 Strip off the cladding.

2 Take a new soft-tissue and moisten it with isopropyl alcohol.

3 Carefully clean the bare fiber with this tissue.

4 Make your cleave and immediately insert the fiber into your bare fiber adapter in order to protect the surface from dirt.

## How to clean large area lenses and mirrors

Some mirrors, as those from a monochromator, are very soft and sensitive. Therefore, never touch them and do not use cleaning tools such as compressed air or polymer film.

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings.

Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little liquid as possible, as it can get between the lenses and in doing so can change the properties of projection.

### Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

### Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the lens:

**CAUTION**

Only use water if you are sure that your device does not corrode.

Do not use hot water as this can lead to mechanical stress, which can damage your device.

Make sure that your liquid soap has no abrasive properties or perfume in it, because they can scratch and damage your device.

Do not use normal washing-up liquid as sometimes an iridescent film remains.

1 Moisten the lens or the mirror with water.
2 Put a little liquid soap on the surface and gently spread the liquid over the whole area.
3 Wash off the emulsion with water, being careful to remove it all, as any remaining streaks can impair measurement accuracy.
4 Take a new, dry soft-tissue and remove the water, by rubbing gently over the surface using a small circular movement.
5 Blow away remaining lint with compressed air.

**Alternative Procedure A**

To clean lenses that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.
2 Remove the film and any dirt with special adhesive tapes.

**Alternative Procedure B**

If your lens is sensitive to water then:

1 Moisten the lens or the mirror with isopropyl alcohol.
2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
3 Blow away remaining lint with compressed air.

## Other Cleaning Hints

Selecting the correct cleaning method is an important element in maintaining your equipment and saving you time and money. This Appendix highlights the main cleaning methods, but cannot address every individual circumstance.

This section contain some additional hints which we hope will help you further. For further information, please contact your local Keysight Technologies representative.

### Making the connection

Before you make any connection you must ensure that all lightwave cables and connectors are clean. If not, then use appropriate cleaning methods.

When you insert the ferrule of a patchcord into a connector or an adapter, ensure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise, the fiber end will rub up against something which could scratch it and leave deposits.

### Lens cleaning papers

Note that some special lens cleaning papers are not suitable for cleaning optical devices like connectors, interfaces, lenses, mirrors and so on. To be absolutely certain that a cleaning paper is applicable, please ask the salesperson or the manufacturer.

### Immersion oil and other index matching compounds

Do not use immersion oil or other index matching compounds with optical sensors equipped with recessed lenses. They are liable to dirty the detector and impair its performance. They may also alter the property of depiction of your optical device, thus rendering your measurements inaccurate.

### Cleaning the housing and the mainframe

When cleaning either the mainframe or the housing of your instrument, only use a dry and very soft cotton tissue on the surfaces and the numeric pad.

Never open the instruments as they can be damaged. Opening the instruments puts you in danger of receiving an electrical shock from your device, and renders your warranty void.

# 16 Firmware Upgrades

Firmware Upgrade Process / 454

This chapter provides information about the firmware upgrade process for the 8163A/B Lightwave Multimeter, the 8164A/B Lightwave Measurement System, and the 8166A/B Lightwave Multichannel System.

## Firmware Upgrade Process

You may need to upgrade firmware because:

- You may need to use new modules that cannot work without the newest firmware. Your instrument will generate an error message if you try to insert a module that is not supported by your instrument's current firmware.
- New revisions of the 816x VXI*plug&play* Instrument Driver require the newest firmware revision. The 816x VXI*plug&play* Instrument Driver is supplied on the same Support Disk as firmware upgrades.
- To enhance the usability and functionality of your instrument. New features may be available with new firmware revisions.

**CAUTION** READ THIS SECTION BEFORE UPGRADING FIRMWARE

For Keysight all modules with a particular firmware revision to operate correctly, your 8163A/B, 8164A/B, or 8166A/B mainframe must have the corresponding, or a later, firmware revision installed.

For example, for correct operation of 8165xA Laser Source modules where firmware revision 4.02 is installed, your 8163A/B, 8164A/B, or 8166A/B mainframe must have firmware revision 4.0x or higher installed.

Firmware files and update programs can be installed with the N7700A Package Manager, available from www.keysight.com/find/n7700 or from the Support CD-ROM supplied with the instrument, and can also be downloaded via www.keysight.com/find/octfirmware. If the firmware update programs are installed by the Package Manager, they will normally be linked in the Windows Start Menu folder called "Keysight Photonic Firmware Library". The files will usually be located at "*C:\Program Files (x86)\Agilent\Photonic Application Suite\InstrumentFirmwareLibrary*".

The firmware for A and B versions of our mainframes is not identical. Make sure you select the appropriate firmware for your instrument.

In addition, please note that:

- Updating mainframe firmware does not require you to update the firmware in every hosted module. New revisions of mainframe firmware are backwards compatible with older module firmware.You may find it advantageous to update module firmware. To help you determine which module firmware to update, a readme file is provided with the firmware file detailing its revision history.

### 8163A Firmware Upgrade Procedure

To upgrade firmware for the 8163A, you require a PC, running Windows, plus a serial null-modem cable, that was supplied with your 8163A mainframe.

Perform the following instructions (“xxx” in a filename should be replaced by the current release number, i.e. 402 for release 4.02):

4 On the PC, run the update tool to start the program HPFlashWinR5.exe.

5 Press the "File Selection" button, the file selection box appears.

6 Move to the file "63_flxxx.bin" under the folder *C:\Program Files (x86)\Agilent\Photonic Application Suite\InstrumentFirmwareLibrary* and click on OK.

7 Click on 'Port Settings'.

8 Select the com port where the serial cable is connected. Choose the maximum baud rate. Click on OK.

9 Turn on the 8163A and wait for the first beep.

Now you must be quick:

- Press and hold the *Preset* hardkey.
- Still holding *Preset*, press and hold the *Aux* hardkey.
- Still holding *Preset* and *Aux*, press and hold the *Appl* hardkey.

Tip: Use three fingers and place them near the keys in advance!

If you were successful, you hear a double beep and the display shows that the instrument is in download mode. Otherwise, turn off the power and try again.

10 Click on 'Program' and wait until the download completes. The instrument will reboot with the new firmware.

### Keysight 8163B Firmware Upgrade Procedure

You require a PC running MS Windows and a null-modem serial cable, such as is supplied with your 8163B mainframe.

To upgrade the 8163B firmware:

1 Connect your instrument to your PC with the serial cable.

2 Turn on the 8163B and wait until the Keysight screen appears. Quickly:

- Press, but do not hold, the Aux hardkey
- Press the Appl hardkey.

If you were successful, the instrument displays:
"Instrument Maintenance Mode".
Otherwise, turn off the power and try again.

3 At your PC, run the update tool to start ATTools_v1_2x.exe.

Click OK to confirm that you have completed steps 1 to 3.

When the serial connection has been established, which may be after a pause of around 30 seconds, the ATTools user interface is displayed.

4 Select the firmware image (file type .Z) in the file selection box, then click the Update Firmware button. Note that older 8163B units without LAN interface require a different firmware file than units with LAN.

Click OK to confirm your choice of firmware upgrade.

5 The firmware upgrade is tracked by a progress bar in the ATTools user interface.

When the update is complete, a confirmation message is displayed.

Click OK.

6 Click Exit to terminate ATTools.

Your 8163B reboots automatically.

### 8164A Firmware Upgrade Procedure

To upgrade firmware for the 8164A, you require two empty floppy disks.

Prepare the two floppy disks using the files and readme instructions in the directory: *C:\Program Files (x86)\Agilent\Photonic Application Suite\InstrumentFirmwareLibrary\8164A Mainframes* or provided in the downloaded firmware file.

1 Insert DISK_1 into the mainframe.

2 Turn on the 8164A and wait for the first beep.

Now you must be quick:

- Press and hold the *Preset* hardkey.
- Still holding *Preset*, press and hold the *Aux* hardkey.
- Still holding *Preset* and *Aux*, press and hold the *Appl* hardkey.

Tip: Use three fingers and place them near the keys in advance!

If you were successful, you hear a double beep and the display shows that the instrument is in download mode. Otherwise, turn off the power and try again.

3 Follow the instructions that appear on the screen.

4 Insert Disk_2 when requested to insert the disk containing the file "firmware.2".

5 After the programming finishes, cycle the power. The instrument will reboot with the new firmware. Don't forget to remove DISK_2.

### Keysight 8164B Firmware Upgrade Procedure

**NOTE**

**The upgrade process with floppy disks used for the 8164A is not supported for 8164B instruments.**

**You require a PC, running Windows, and a null-modem serial cable, such as is supplied with your 8164B mainframe.**

To upgrade the 8164B firmware:

1 Connect your instrument to your PC with the serial cable.

2 Turn on the 8164B and wait until the Keysight screen appears.

Quickly:

- Press, but do not hold the Aux hardkey
- Press the Appl hardkey.

If you were successful, the instrument displays:
“Instrument Maintenance Mode”.
Otherwise, turn off the power and try again.

3 At your PC, run the update tool to start ATTools_v1_2x.exe.

Click OK to confirm that you have completed steps 1 to 3.

When the serial connection has been established, which may be after a pause of around 30 seconds, the ATTools user interface is displayed.

4 Select the firmware image (file type .Z) in the file selection box, then click the Update Firmware button. Note that older 8164B units without LAN interface require a different firmware file than units with LAN.

   Click OK to confirm your choice of firmware upgrade.

5 The firmware upgrade is tracked by a progress bar in the the ATTools user interface.

   When the update is complete, a confirmation message is displayed.

   Click OK

6 Click Exit to terminate ATTools.

   Your 8164B reboots automatically.

### 8166A Firmware Upgrade Procedure

To upgrade firmware for the 8166A, you require a PC, running Windows, plus a serial null-modem cable, that was supplied with your 8166A mainframe.

Perform the following instructions (“xxx” in a filename should be replaced by the current release number, i.e. 402 for release 4.02):

1 On the PC, run the update tool to start the program HPFlashWinR5.exe.

2 Press the "File Selection" button, the file selection box appears.

3 Move to the file "66_flxxx.bin" and click on OK.

4 Click on 'Port Settings'.

5 Select the com port where the serial cable is connected. Choose the maximum baud rate. Click on OK.

6 Turn on the 8166A and wait for the first beep.

   Now you must be quick:

   - Press and hold the *Preset* hardkey.
   - Still holding *Preset*, press and hold the *Aux* hardkey.
   - Still holding *Preset* and *Aux*, press and hold the *Appl* hardkey.

Tip: Use three fingers and place them near the keys in advance!

   If you were successful, you hear a double beep and the display shows that the instrument is in download mode. Otherwise, turn off the power and try again.

7 Click on 'Program' and wait until the download completes. The instrument will reboot with the new firmware.

### Keysight 8166B Firmware Upgrade Procedure

You require a PC, running Windows, and a null-modem serial cable, such as is supplied with your 8166B mainframe.

To upgrade the 8166B firmware:

1 Connect your instrument to your PC with the serial cable.

2 Turn on the 8166B and wait until the Keysight screen appears. Quickly:

- Press, but do not hold the Aux hardkey
- Press the Appl hardkey.

If you were successful, the instrument displays:

"Instrument Maintenance Mode".
Otherwise, turn off the power and try again.

3 At your PC, run the update tool to start ATTools_v1_2x.exe.

Click OK to confirm that you have completed steps 1 to 3.

When the serial connection has been established, which may be after a pause of around 30 seconds, the ATTools user interface is displayed.

4 Select the firmware image (file type .Z) in the file selection box, then click the Update Firmware button.

Click OK to confirm your choice of firmware upgrade.

5 The firmware upgrade is tracked by a progress bar in the the ATTools user interface.

When the update is complete, a confirmation message is displayed.

Click OK

6 Click Exit to terminate ATTools.

Your 8166B reboots automatically.

### Keysight Module Firmware Upgrade Procedure

Keysight module firmware is upgraded via GPIB (recommended) or a serial null-modem cable.

You require a PC running Windows. To update via GPIB the PC must be fitted with a suitable GPIB adapter. Alternatively, a serial null-modem cable is required, such as is supplied with your mainframe.

You also require the module update program, which is supplied both on the Support CD-ROM and as a web download. Copy Module_Update.exe to a directory on your PC's hard drive, then execute Module_Update.exe to install the module update program.

Alternately the module update program can be installed with the N7700A Package Manager.

Detailed instructions for using the module update program are provided in the readme file installed together with the program.

Note that recent versions of the module update tool are faster but can have difficulty working with the older A-version mainframes. If possible, use a B-version mainframe for module updates. Otherwise an older version of the module update program should be used, like version 2.2.5.6. This is available on older support CDs or can be requested from Keysight support.

**NOTE**

The readme.htm file associated with the module update program contains

- Notification of prerequisites,
- Notification of known is

as well as detailed instructions for use.

Be sure to study this file before attempting to use the module update software.

**NOTE**

The floppy update procedure for the Keysight 81480A and 81640A/42A/80A/82A Tunable Laser Modules is no longer supported.

Please update your modules via GPIB or a null-modem serial cable as described above.

# Index


## A

AC Power, 316
Appl hardkey, 53
Application
  Appl Hardkey, 53
  Graphs, 249
  Legends, 251
  Lock to Curve, 257
  Logging, 261
  Markers, 250
  PACT, 287
  Samples Display, 253
  Stability, 274
  Zoom, 250
Attenuation
  laser sources, 126
  tunable lasers, 138
Attenuators
  Attenuation Offset, 221
  DWDM signals, 224
  Menu options, 233
  Power Control, 233
  Reference Powermeter, 217
  Setting Attenuation, 220
  Setting Power Level, 224
  Shutter, 219
  Status Indicators, 236
  User Interface, 216
  Wavelength Dependencies, 229
Auto Cal Off, 170
Automatic Realignment, 167
Auxiliary Functions, 167
  automatic realignment, 167
  wavelength zero, 169

## B

Backlight, 63
Base Wavelength, 145

## C

Calibration Offset, 102
caution, definition of, 18
CE mark, 22
Channel Numbers, 39
Coherence Control
  tunable lasers, 128, 161
Coherence control setting, 127
Compact Tunable Lasers
  SBS Suppression, 175
  User Interface, 175
Configuration, 62
  backlight, 63
  contrast, 64
  Foot Pedal, 70
  GPIB address, 72
  mainframe information, 94
  Module Update, 88
  modules information, 91
  Serial Interface, 87
  triggering, 68
Connecting a Monitor, 95
Cross-over switch
    applications, 245
CSA mark, 22

## D

dB, 101
dBm, 101
Declaration of Conformity
  Agilent 8163A, 362
  Agilent 8163B, 363
  Agilent 8164A, 364
  Agilent 8164B, 365
  Agilent 8166A, 366
  Agilent 8166B, 367
DFB
  linewidth measurement, 144
  modulation source, 160
  modules, 350
Dual-Wavelength Laser
    Sources, 124

## E

Edit Parameters, 54
  accept new values, 54
  cancel softkey, 57
  Continuous, 54
  Discrete, 56
  outside range, 57
  selecting, 54
  set to default, 57
Environment
  altitude, 322
  humidity, 321
  operating, 321
  pollution, 322
  Storage, 321
  temperature, 321

## F

Firmware Revision
  mainframe, 94
Foot Pedal, 70
Frequency Offset, 146

## G

GPIB
  Address, 72

## H

Help hardkey, 50

## I

Initial inspection, 315
Insertion Loss, 178
Inspection, 315
ISM1-A, 22

## J

Jumping between channels, 44

## K

Keypad, 37

## L

Lambda Zero, 169
Laser Sources
  attenuation, 126
  dual-wavelength sources, 124
  enable/disable output, 125
  how to use, 124
  modulation, 127
Line power cable, 316
Lock high-power laser sources, 67
Logging, 261

## M

MinMax Mode, 116
Modulation
  laser sources, 127
  tunable lasers, 155
Module
  Update, 88
Modules
  empty slots, 333

## O

Optical Output
  tunable lasers, 135
Optical Switches
  Applications, 244
  Options, 238
  Toggle, 243
  User Interface, 240
Optional features
  Agilent 8163A/B, 346
  Agilent 8164A/B, 347
  Agilent 8166A/B, 348

## P

PACT, 287
Password, 38, 67
  change, 91
  forgotten, 38, 91
Power
  laser sources, 126
  power meters, 100
  tunable lasers, 134
Power Measurement
  calibration offset, 102
  hold screen, 119
  number of digits, 100
  power units, 101
  power value, 100
  reference, 103
  reference another channel, 104
  setting wavelength, 106
Power supply requirements
  AC, 316
Power Units, 101

## R

Range
  auto, 110
  manual, 110
  range mode, 109
  setting, 110
Realignment, automatic, 167
Reference, 103
Return Loss
  Getting Started, 178
  Light Source, 180
  modules, 181

## S

Safety
  information for laser source, 23
safety symbols, 18
Sample Session, 58
Serial Interface, 87
Settling, 169
Slot Numbers, 39
Specifications
  Agilent 8163A, 356
  Agilent 8163B, 357
  Agilent 8164B, 359
  Agilent 8166A, 360
  Agilent 8166B, 361
Stability, 274
Step 7, 222
symbols, safety, 18

## T

Temperature for operation and storage, 321
Triggering
  configuration, 68
  tunable lasers, 163
Triggers
  Laser Sources, 130
  Power Meters, 119
Tunable Lasers
  analog output, 141
  atomatic realignment, 167
  attenuation, 138
  backplane modulation, 159
  BNC output, 161
  coherence control, 128, 161
  excessive power, 139
  external analog modulation, 157
  external digital modulation, 156
  external modulation, 156
  frequency offset, 144
  how to use, 134
  increase linewidth, 128, 161

input triggering, 163
internal modulation, 127, 155
lambda zero, 169
low frequency coherence control, 128, 161
modout, 162
modulation, 155
modulation output, 161
optical output, 135
power, 134
relative wavelength, 144
triggering, 163
wavelength, 143
wavelength locking, 158
wavelength mode, 144
wavelength zero, 169

## U

Unlock the Instrument, 38, 90
User Interface, 37
channel hardkey, 44
config softkey, 48
cursor key, 42
details screen, 44
features, 39
hardkeys, 39
menu softkey, 46
modify knob, 43
numerical keypad, 43
overview screen, 40
softkeys, 39

## V

Vsweep parameter, 147

## W

warning, definition of, 18
Watts, 101
Wavelength
laser sources, 124
power meters, 106
tunable lasers, 143
Wavelength Sweep, 147
continuous, 151
manual sweep, 153
performing a sweep, 149
repeat mode, 148
stepped, 149
sweep parameters, 147
Wavelength Zero, 169

## Z

Zeroing Electrical Offsets, 106
Zoom, 250

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