Keysight 8160xx Series Tunable Laser Family

User's Guide

Notices

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CAUTION

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WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Contents

1 Getting Started

This chapter describes the Keysight 8160xx Series Tunable Laser Family.

General 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.

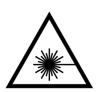
Before operation, review the instrument and manual, including the red safety page, for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, 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.

Safety Symbols

The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.



Hazardous laser radiation.

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 Performance Tests give procedures 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, etc.).**

WARNING **You MUST return instruments with malfunctioning laser modules to a Keysight Technologies Sales/Service Center for repair and calibration.**

Line Power Requirements

All Keysight 8160xx Series Tunable Laser Family modules operate when installed in the 8164B Lightwave Measurement System mainframe.

Keysight 81600B Tunable Laser modules operate when installed in either the 8164A or the 8164B Lightwave Measurement System mainframe.

Operating Environment

The safety information in the 8164A/B Lightwave Multimeter (and the 8163A/B Lightwave Measurement System, & 8166A/B Lightwave Multichannel System) User's Guide summarizes the operating ranges for the Keysight 8160xx Series Tunable Laser Family modules. In order for these modules to meet specifications, the operating environment must be within the limits specified for your mainframe.

Input/Output Signals

CAUTION **There are two BNC connectors on the front panel of the Keysight 81600B and on 8160xA; 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.

Storage and Shipment

These modules can be stored or shipped at temperatures between -40 ^{o}C and +70 ^{o}C. Protect the module from temperature extremes that may cause condensation within it.

Initial Safety Information for Keysight 8160xx Family Modules

The laser sources specified by this user's 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 Laser Source Specification

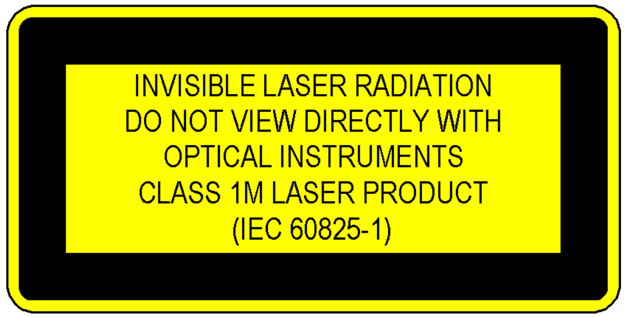
	81600B #201	81600B #200	81600B #160	81600B #150	81600B #140	81600B #130	81600B #142	81600B #132
Laser Type	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP
Wavelength range	1455 - 1640 nm	1440 - 1640 nm	1495 - 1640 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 2 Laser Source Specification

	81606A #216 81608A #216 81609A #216	81606A #116 81607A #116 81608A #116 81609A #116	81602A #013	81606A #113 81608A #113 81609A #113	81606A #114 81608A #114 81609A #114
Laser type	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP
Wavelength range	1450 – 1650 nm	1490 – 1650 nm	1250 - 1370 nm	1240 - 1380 nm	1340 - 1495 nm
Max. CW output power	< 25 mW	< 25 mW	< 80 mW	< 30 mW	< 60 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 (2014)	1M	1M	3B	1M	1M
Max. permissible CW output power	163 mW	163 mW	500 mW	55 - 500 mW	163 - 500 mW
* Max. CW output power is defined as the highest possible optical power that the laser source can produce at its output connector.					

Laser Safety Labels

Laser class 1M label



Laser class 3B label

Figure 1 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

Please pay attention to the following laser safety warning:

- The laser output can be controlled by GUI, GPIB state command and the front panel button. The built in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye safe conditions.
  Note: The remote interlock function interrupts the laser current when the connector is open.
- 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 optical instruments with this product will increase eye hazard.
- 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".

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 range of tunable laser modules also allow you to set the output power, and to choose between continuous wave or modulated power.

Installation

Every Keysight 8160xx Series Tunable Laser Family module is backloadable into Slot 0 of a 8164B mainframe. In addition, Keysight 81600B Tunable Laser modules operate in the 8164A mainframe; see “How to Fit and Remove Modules” in the 8163A/B Lightwave Multimeter, 8164A/B, Lightwave Measurement System, & 8166A/B Lightwave Multichannel System User’s Guide.

Front Panels

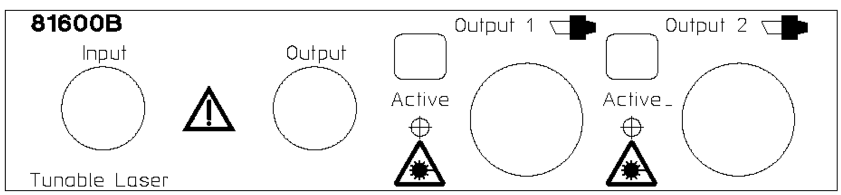


Figure 2 Keysight 81600B Tunable Laser Source Family modules (dual output, angled contact connectors)

Figure 2 illustrates a typical front panel for a dual-output Keysight 81600B Tunable Laser Source Family module, such as options #201, #200, #160, #150, #140 or #130. In this case, angled contact interfaces (81600B-072) are indicated. The two large circles indicate the optical ports, while the two smaller circles at the left are BNC connectors.

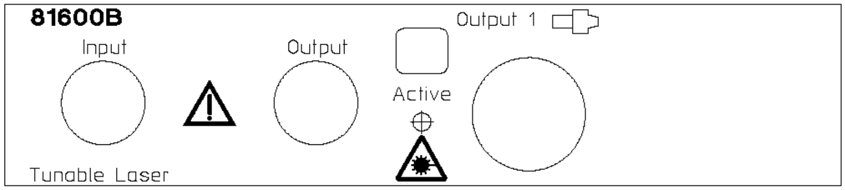


Figure 3 Keysight 81600B Tunable Laser Source Family module (single output, straight contact connectors)

Figure 3 illustrates a typical front panel for a single-output Keysight 81600B Tunable Laser Source Family module, such as options #142 or #132. In this case, straight contact interfaces (81600B#071) are indicated. The large circle indicates the optical port, while the two smaller circles at the left are BNC connectors.

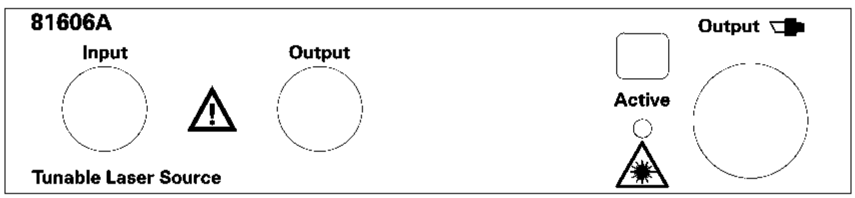


Figure 4 Keysight 81606A Tunable Laser Source module

Figure 4 illustrates the front panel for the Keysight 81606A Tunable Laser Source module, options #216, #116, #114 and #113. Angled contact interfaces (81606A-072) are mandatory for this module. The large circle indicates the optical port, while the two smaller circles at the left are BNC connectors.

Front Panel Controls and Indicators

Switch the laser output on or off using the button on its front panel, using the [State] parameter in the instrument's Graphical User Interface, or remotely using GPIB commands. When the 'Active' LED is lit the output is enabled. When the active LED is not lit, the output is disabled.

Typical Use Models

The Keysight 8160xx Family of Tunable Laser Sources offers the full wavelength range from 1240 nm to 1650 nm with no wavelength gaps. All 8160xx Tunable Laser Sources are modules for the bottom slot of the Keysight 8164B Lightwave Measurement System mainframe. This provides test instrumentation with maximum flexibility.

81606A #216, #116, #114 and #113

The 81606A Top Line Tunable Laser Source is the new flagship model, featuring fast, two-way sweeping up to 200 nm/s, and an outstanding dynamic wavelength accuracy and repeatability. The excellent low-SSE performance of better than 80 dB/nm signal-to-source spontaneous emission ratio (signal-to-SSE ratio) and the high signal power of >+12 dBm permit measurements of wavelength isolation to 100 dB, most often limited by power meter sensitivity.

The 81606A option 216 offers a wide tuning range of 200 nm, option 116 covers a range of 150 nm, option 114 covers 155 nm in the E-band, and option 113 tunes across 140 nm in the O-band.

81607A #116, 81608A #216, #116, #114 and #113

The new 81607A Value Line Tunable Laser Source complements the Top Line 81606A model at a more moderate output power. With a typical wavelength repeatability of ±1 pm even during two-way sweeps with up to 200 nm/s, it is ideal for high-throughput test and automated adjustment of passive optical components.

The new 81608A, another member of the Value Line Tunable Laser sources, offers a peak output power of >+12 dBm, at least 75 dB/nm above its spontaneous emission level. It features a typical wavelength repeatability of ±1.5 pm at two-way sweeps up to 200 nm/s. The laser’s balance of features, performance and price makes it suitable for both coherent transmission experiments and cost-effective manufacturing-floor component testing.

81609A #216, #116, #114 and #113

The new 81609A Basic Line module can step within 300 milliseconds to discrete wavelengths with a resolution of 0.1 pm and a typical wavelength repeatability of ±3 pm, making it ideal for cost-effective testing of broadband optical devices. Like the other modules in the family, it delivers >+12 dBm peak output power with low spontaneous emission levels. At ±0.01 dB power stability over an hour, it can also serve as a static local oscillator with a wide tuning range for receiver testing or transmission experiments.

E-band model for CWDM8 component testing

The new 8160xA option 114 covers the wavelength range from 1340 nm to 1495 nm. Combined with the other options, this allows measurements over all CWDM channels, such as for CWDM8 devices. Components for Raman amplification also use this wavelength range.

81602A #013

The new 81602A Extra High Power Tunable Laser Source reaches an optical power level of over +18 dBm (63 mW). The high output power helps compensate for the coupling loss of optical surface probes or the insertion loss of external modulators during the verification of integrated photonic designs. This allows testing photonic devices at relevant signal levels and wavelengths. With a tuning range of 1250 nm to 1370 nm, the laser addresses the latest silicon photonics research. It shares the same excellent power flatness, repeatability and stability, the outstanding wavelength accuracy and the fast repetition rate with the 8160xA Family of Tunable Laser Sources.

81600B #201 and #200

The 81600B options 200 and 201 feature a wide tuning range of up to 200 nm and a 70 dB/nm signal-to-SSE ratio. The excellent low-SSE performance typically allows crosstalk measurements of better than 70 dB for an 8 channel CWDM multiplexer.

81600B #160, 150, 140, 130

The 81600B option 160, 150, 140 and 130 Tunable Laser Sources offer other wavelength ranges and are equipped with two optical outputs, like the option 200. By selecting the port, high power or low-SSE can be obtained.

81600B #142, 132

The 81600B option 142 and 132 Tunable Laser Sources have a single high power output port. The 81600B option 132 covers the wavelength range from 1260 nm to 1375 nm.

Realize the cost efficiency and performance benefits in WDM component tests

The testing of optical filters and multiplexers is based on a generic principle, namely the stimulus response test. The state-of-the-art approach uses a tunable laser source that is capable of fast and precise sweeps across the entire wavelength range with one or more optical power meters to simultaneously measure all output ports of the component.

For DWDM components, high wavelength accuracy and dynamic range are critical. For CWDM and PON components, a wide wavelength range, dynamic range and tight costing are key targets. If the investment in the test solution can be shared among many different types of filters, the contribution to each individual filter is minimized. In this way, cost targets for CWDM and PON components can be met without sacrificing accuracy.

Investing in the Keysight 8160xx TLS family can realize both the cost efficiency and performance benefits required.

Integrated solutions for swept-wavelength spectral measurements

The 8160xA family is supported with the N7700A software suite for spectral measurements of insertion loss, polarization dependent loss and polarization mode dispersion in combination with Keysight power meters and polarization instruments. These provide optimal measurement performance and quick time-to measurement by simplifying system integration. The N7700A software suite has a measurement engine for

IL and PDL that can combine the sweeps of up to 3 tunable laser wavelength ranges. See the N7700A brochure for details. www.keysight.com/find/n7700

Swept Measurements As manufacturing yield expectations becomes more and more stringent, it is important that all instruments deliver optimum performance under all measurement conditions. The Keysight 81602A, 81606A, 81607A and 81608A Tunable Laser Sources can sweep as fast as 200 nm/s in both directions with specified accuracy during the sweep.

High Dynamic Range The low SSE output port of 81606A, 81607A, 81608A and 81609A delivers a signal with ultra-low source spontaneous emission. It enables accurate crosstalk measurement of DWDM and CWDM wavelength filtering components by producing light only at the desired wavelength.

For example, you can characterize steep notch filters such as Fiber Bragg Gratings by using the low SSE output and a power sensor module.

High Power The Keysight 81602A offers the highest output power in the 8160xx product family with more than +17 dBm, 50dB/nm above its spontaneous emission level. The Keysight 81606A, 81608A and 81609A feature a single optical output power with over +12 dBm output power. At 80 dB/nm signal-to-SSE level, they combine the lowest SSE level in the 8160xx family with high output power. The 81607A offers >+8 dBm output power. For all 8160xA lasers, the output power can be reduced to 0 dBm by the user.

For Keysight 81600B options 200, 160, 150,140 and 130, the second output port provides high optical power, adjustable over a power range of more than 60 dB via a built-in optical attenuator.

The Keysight 81600B options 142 and 132 simply provide an output port with high stimulus power for applications where the SSE level is not critical. The 81600B option 142 can also be equipped with a built-in optical attenuator (option #003), to provide an adjustable power range of 60 dB.

Precision The Keysight 8160xx Family of Tunable Laser Sources includes a built-in real time wavelength meter which realizes the family’s excellent absolute and relative wavelength accuracy, and delivers wavelength logging data after each sweep.

The new Keysight 81602A, 81606A, 81607A, 81608A and 81609A take this concept even further by adding a gas cell for long-term stability and absolute referencing. The wavelength reference unit’s fast response and fine wavelength resolution enable the 81602A and 81606A to sweep with sub-picometer repeatability. It is the key to their superior accuracy and temperature stability, and it enables a greater degree of self-diagnosis than previously possible.

The 81607A and 81608A Value Line models, while offering more moderate wavelength accuracy levels than 81606A, benefit from the same long-term stability as the Top Line model. The 81609A Basic Line model, unlike the other models, is a step-tunable laser source with similar long-term stability.

Testing Integrated Optical devices

The 8160xx Tunable Laser Source Family's PMF output ports provide a well-defined state of polarization to ensure constant measurement conditions for waveguide devices. A PMF cable easily connects to an external optical modulator.

Optical Output

Polarization Maintaining Fiber

All Keysight 8160xx Series Tunable Laser Family modules include polarization maintaining fiber (PMF) outputs, aligned to maintain the state of polarization.

The fiber is of Panda type, with the electrical field oriented in the slow axis in line with the connector key. A well defined state of polarization ensures constant measurement conditions.

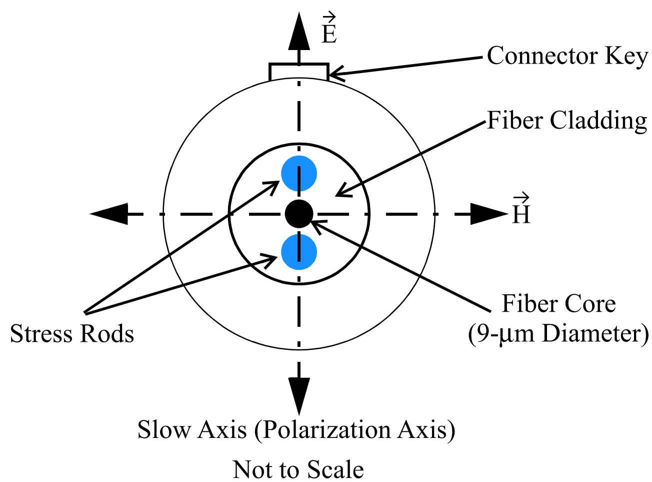


Figure 5 PMF Output Connector

Angled and Straight Contact Connectors

Angled contact connectors help you to control return loss. With angled fiber end-faces, reflected light tends to reflect into the cladding, reducing the amount of light that reflects back to the source. When reflected light remains in the fiber core at two or more locations along the optical path, such as at an open straight-polished connector output to a power meter, double reflections result in multi-path interference of the coherent light and thus power instability in the measurements.

Keysight 8160xx Series Tunable Laser modules can have the following connector interface options:

- Option 071, Polarization-maintaining fiber, Panda-type, for straight contact connectors, or
- Option 072, Polarization-maintaining fiber, Panda-type, for angled contact connectors.

Keysight 81602A, 81606A, 81607A, 81608A and 81609A Tunable Laser Sources come with Option 072.

CAUTION **If the contact connector on your instrument is angled, you can only use cables with angled connectors with the instrument.**

Figure 6 Angled and Straight Contact Connector Symbols

Figure 6 shows the symbols that tell you whether the contact connector of your Tunable Laser Source module is angled or straight. The angled contact connector symbol is colored green.

Figure 3 and Figure 7 show the front panel of the Keysight 81600B Family Tunable Laser Source module with straight and angled contact connectors respectively.

You should connect straight contact fiber end connectors with neutral sleeves to straight contact connectors and connect angled contact fiber end connectors with green sleeves to angled contact connectors.

NOTE **You cannot connect angled non-contact fiber end connectors with orange sleeves directly to the instrument.**

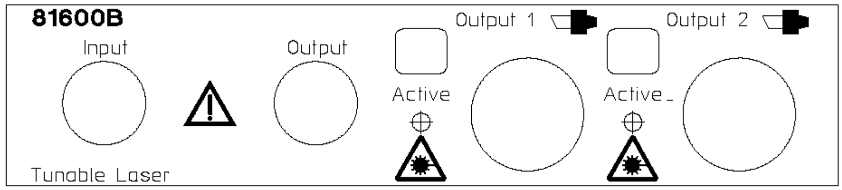


Figure 7 Keysight 81600B Tunable Laser Module (angled contact connector)

Refer to the *User Guide* for further details on connector interfaces and accessories.

Signal Input and Output

CAUTION

There are two BNC connectors on the front panel of a Keysight 8160xx Series Tunable Laser module - 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.

2 Accessories

The Keysight 8160xx Series Tunable Laser Family modules are available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

Keysight 8160xx Series Tunable Laser Modules and Options

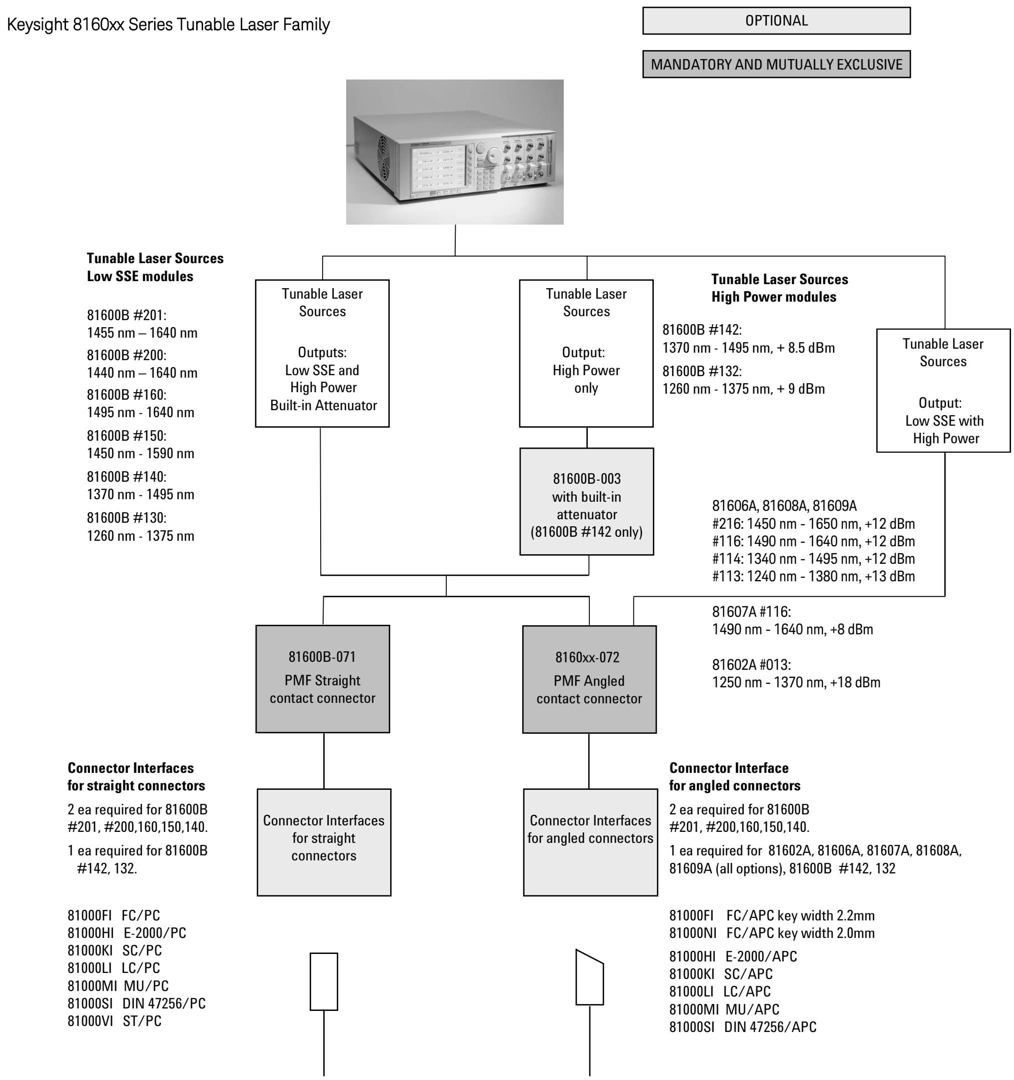


Figure 8 8164A/B mainframes, Keysight 8160xx Series Modules and Options

NOTE

Option 81600B-072 is highly recommended over option 81600B-071 to reduce front panel reflections, which will greatly reduce interference noise and spectral ripple in the test setup. 81602A, 81606A, 81607A, 81608A and 81609A come with option 072. Use an adapter cable for straight contact connections if absolutely required.

Module Options

The 8164B Lightwave Measurement System mainframe supports one Keysight 8160xx Family Tunable Laser Source module. The 8164A Lightwave Measurement System mainframe supports one 81600B Tunable Laser module.

Table 3 Keysight 81600B Family Tunable Laser Sources

Keysight 81600B Tunable Laser Sources	
Option	**Description**
#201	Low SSE Tunable Laser Source (1455 nm - 1640 nm).
#200	Low SSE Tunable Laser Source module (1440 nm - 1640 nm).
#130	Low SSE Tunable Laser Source module (1260 nm - 1375 nm).
#140	Low SSE Tunable Laser Source module (1370 nm - 1495 nm).
#150	Low SSE Tunable Laser Source module (1450 nm - 1590 nm).
#160	Low SSE Tunable Laser Source module (1495 nm - 1640 nm).
#132	High Power Tunable Laser Source module (1260 nm - 1375 nm), + 9 dBm.
#142	High Power Tunable Laser Source module (1370 nm - 1495 nm), + 8.5 dBm.

Table 4 Keysight 8160xA Tunable Laser Sources

Keysight 81602A Tunable Laser Source	
Option	**Description**
#013	Extra high power tunable laser source, 1250 nm to 1370 nm, top line

Keysight 81606A Tunable Laser Sources	
Option	Description
#216	Tunable laser source 1450 nm to 1650 nm, top line, high power with lowest SSE.
#116	Tunable laser source 1490 nm to 1640 nm, top line, high power with lowest SSE.
#114	Tunable laser source 1340 nm to 1495 nm, top line, high power with lowest SSE.
#113	Tunable laser source 1240 nm to 1380 nm, top line, high power with lowest SSE.

Keysight 81607A Tunable Laser Sources	
Option	Description
#116	Tunable laser source 1490 nm to 1640 nm, value line, low SSE.

Keysight 81608A Tunable Laser Sources	
Option	Description
#216	Tunable laser source 1450 nm to 1650 nm, value line, high power with low SSE.
#116	Tunable laser source 1490 nm to 1640 nm, value line, high power with low SSE.
#114	Tunable laser source 1340 nm to 1495 nm, value line, high power with low SSE.
#113	Tunable laser source 1240 nm to 1380 nm, value line, high power with low SSE.

Keysight 81609A Tunable Laser Sources	
Option	Description
#216	Step-tunable laser source 1450 nm to 1650 nm, basic line, high power with low SSE.
#116	Step-tunable laser source 1490 nm to 1640 nm, basic line, high power with low SSE.
#114	Step-tunable laser source 1340 nm to 1495 nm, basic line, high power with low SSE.
#113	Step-tunable laser source 1240 nm to 1380 nm, basic line, high power with low SSE.

Filler Module

Table 5 Filler Module

Filler Module	
Model No.	**Description**
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 Source module. It is used to help:

- prevent dust pollution, and
- optimize cooling by guiding the air flow.

See the "Installation and Maintenance" chapter of the Keysight 8160xx Tunable Laser Source Family User's Guide for more details on installing the Keysight 81645A Filler Module.

User's Guides

Table 6 User's Guide

User's Guides	
Description	**Part No.**
Keysight 8160xx Series Tunable Laser Family User's Guide	81606-90B01
8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, & 8166A/B Lightwave Multichannel System Programming Guide	08164-90B65
8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, & 8166A/B Lightwave Multichannel System User's Guide	08164-90B16

Options

Option 003 - Keysight 81600B #142 only

Built-in optical attenuator with 60 dB attenuation range.

NOTE Keysight 81600B #201, 200, 160,150, and 140 have a built-in optical attenuator as standard for Output 2, the High Power output.

Connector Interfaces and Other Accessories

The Keysight 81600B Tunable Laser Source modules are supplied with one of two connector interface options:

- Option 071, Polarization-maintaining fiber, Panda-type, for straight contact connectors, or
- Option 072, Polarization-maintaining fiber, Panda-type, for angled contact connectors.

The Keysight 81602A, 81606A, 81607A, 81608A and 81609A Tunable Laser Sources come with option 072, polarization-maintaining fiber, Panda-type, for angled contact connectors.

Option 071: Straight Contact Connector

If you want to use straight connectors (such as FC/PC, DIN, SC, ST or E2000) to connect to the instrument, you must do the following:

1. Attach your connector interface to the interface adapter. See Table 7 for a list of the available connector interfaces.
2. Connect your cable (see Table 7).

Table 7 Straight Contact Connector Interfaces

Description	Model No.
DIN 47256	Keysight 81000SI
FC / PC / SPC	Keysight 81000FI
SC / PC / SCP	Keysight 81000KI
ST	Keysight 81000VI
Diamond E-2000 APC	Keysight 81000HI

Option 072: Angled Contact Connector

If you want to use angled connectors (such as FC/APC, DIN, E2000 or SC/APC) to connect to the instrument, you must do the following:

1 Attach your connector interface to the interface adapter. See Table 8 for a list of the available connector interfaces.

2 Connect your cable (see Table 8).

Table 8 Angled Contact Connector Interfaces

Description	Model No.
Diamond E-2000 APC	Keysight 81000HI
SC / PC / APC	Keysight 81000KI
FC / APC narrow-key	Keysight 81000NI
FC/APC wide-key	Keysight 81000FI
LC/APC	Keysight 81000LI
MU/APC	Keysight 81000MI
DIN 47256-4108.6	Keysight 81000SI

3 Specifications

Keysight 8160xx Series Tunable Laser modules are produced to the ISO 9001 international quality system standard as part of Keysight's commitment to continually increasing customer satisfaction through improved quality control.

Specifications

Specifications apply, unless otherwise noted, for the stated environmental conditions, after warm-up, in CW (Continuous Wave) mode (unmodulated output, coherence control off) and at uninterrupted line voltage.

Definition of Terms

This section defines terms that are used in this chapter.

Measurement principles are indicated. Alternative measurement principles of equal value are also acceptable.

General Definitions

Attenuation mode

An operation mode where the output power is adjusted using the built-in attenator, rather than by changing the current of the laser diode.

NOTE Applicable only to Tunable Laser Source modules that include a built-in attenuator.

Constant Temperature

Where required, is a stable operating temperature within ±1 K.

Logged wavelength

This is the wavelength measured and recorded by the internal wavelength meter during a sweep at the corresponding trigger signal. This recorded wavelength can be read with the logging function.

NOTE The logged wavelength positions during a sweep depend on environmental conditions and may differ slightly between repeated sweeps.

Stepped mode

In stepped mode the tunable laser source is operated statically, so that a user's measurement is made at a fixed wavelength of the tunable laser source. When tuning to a new wavelength, the static specifications are valid after completion of the tuning operation.

Continuous sweep mode

In continuous sweep mode the tunable laser source is operated dynamically, so that a user's measurement is made while the wavelength of the tunable laser source changes in a defined way (given by start wavelength, end wavelength and sweep speed). During a continuous sweep the dynamic specifications and the "Logged wavelength" apply.

Absolute wavelength accuracy (continuous sweep mode)

The maximum difference between the "Logged wavelength" and the actual wavelength in "Continuous sweep mode". Wavelength is defined as wavelength in vacuum.

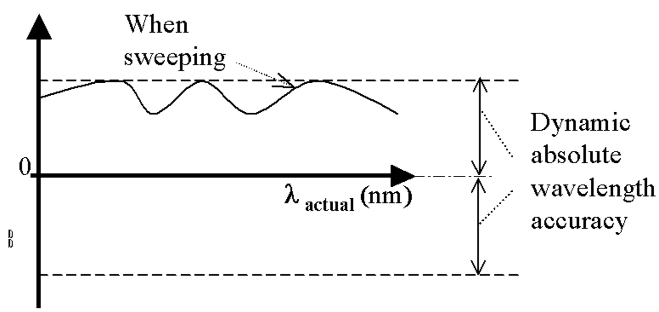


Figure 9 Absolute wavelength accuracy (continuous sweep mode)

Conditions: As specified. No mode-hop.

Absolute wavelength accuracy (stepped mode)

The maximum difference between the displayed wavelength and the actual wavelength of the tunable lase source. Wavelength is defined as wavelength in vacuum.

Conditions: Constant power level. Other conditions as specified.

Measurement: Using a wavelength meter, averaging time ≥ 1 s.

NOTE The absolute wavelength accuracy of the low-SSE output (if applicable) is the same as the absolute wavelength accuracy of the high power output (guaranteed by design).

Attenuation

The nominal attenuation of the output power selected using the built-in attenuator.

NOTE Applicable only to Tunable Laser Source modules that include a built-in attenuator.

Dynamic power reproducibility (continuous sweep mode)

Specifies the random uncertainty in reproducing the output power at the same actual wavelength in different sweeps. It is expressed as ± half the span between the maximum and minimum of all actual output powers.

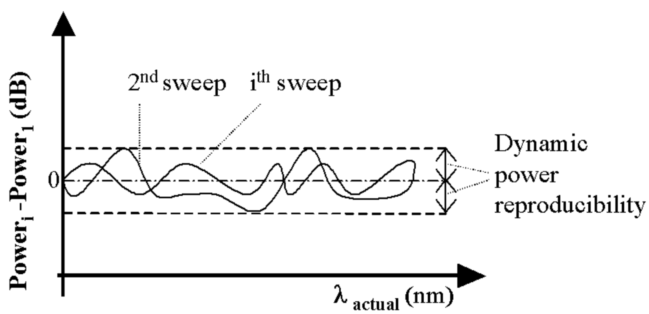


Figure 10 Dynamic power reproducibility (continuous sweep mode)

Conditions: Uninterrupted tunable laser source output power, constant temperature, no mode-hop. Other conditions as specified.

Dynamic relative power flatness (continuous sweep mode)

The high frequency part of the dynamic power flatness, obtainable by referencing the power measured at high sweep speed to the power measured at low sweep speed.

Conditions: Uninterrupted tunable laser source output power, constant power setting, constant temperature, no mode-hop. Other conditions as specified.

Measurement: Reference sweep speed value 0.5 nm/s.

Effective linewidth

The time-averaged 3 dB width of the optical spectrum, expressed in Hertz.

Conditions: Coherence control on. Other conditions as specified.

Measurement: *Using a heterodyning technique*: The output of the laser under test is mixed with another laser of the same type on a wide bandwidth photo-detector. The electrical noise spectrum of the photo-detector current is measured with a Lightwave signal analyzer, and the line-width calculated from the heterodyne spectrum. (Lightwave signal analyzer settings: resolution bandwidth 1 MHz, video bandwidth 10 kHz, sweep time 20 ms, single scan).

External analog modulation - modulation depth

Specifies half the peak-to-peak optical power change divided by the average optical power for a sinusoidal input voltage at the analog modulation input. The average power is defined as half the sum of maximum and minimum power.

Conditions: Modulation input signal as specified, modulation frequency as specified.

NOTE **Modulation depth is a value between 0 and 100%.**

Measurement: Using a photoreceiver (of sufficient bandwidth) and an oscilloscope.

External digital modulation - delay time

Specifies the time between the falling edge of the external trigger (when reaching logical zero) and the falling edge of the optical pulse (at 10% of its original value).

Conditions: Modulation input signal and duty cycle as specified, modulation frequency as specified.

Measurement: Using a photoreceiver (of sufficient bandwidth) and an oscilloscope.

Internal digital modulation - duty cycle

When the laser is internally (digitally) modulated at a frequency *f*, the duty cycle is specified as $t_{on} \times f$, where t_{on} is the time the laser is on during one modulation cycle (expressed in percent).

Conditions: Modulation frequency as specified.

Linewidth

The 3 dB width of the optical spectrum, expressed in Hertz.

Conditions: Coherence control off. Other conditions as specified.

Measurement: *Using a self-heterodyning technique*: The output of the laser under test is sent through a Mach-Zehnder interferometer in which the length difference of the two arms is longer than the coherence length of the laser. The electrical noise spectrum of the photo-detector current is measured using a Lightwave signal analyzer or Keysight Optical Modulation Analyzer, and the linewidth calculated from the heterodyne spectrum.

Alternatively, *Using a heterodyning technique*: The output of the laser under test is mixed on a wide bandwidth photo-detector with another laser of the same type or with a laser with a line-width much lower than the laser to be measured. The electrical noise spectrum of the photo-detector current is measured using a Lightwave signal analyzer or Keysight Optical Modulation Analyzer, and the linewidth calculated from the heterodyne spectrum.

Maximum output power

The maximum achievable output power of the tunable laser source and the maximum output power for which the tunable laser source specifications apply.

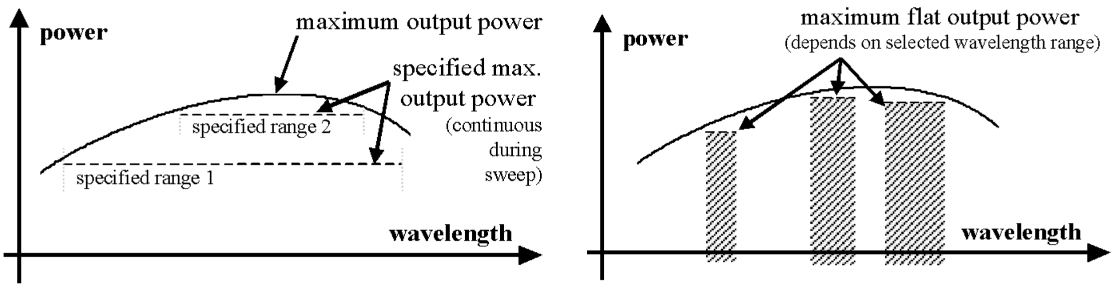


Figure 11 Maximum Output Power vs Wavelength, Maximum Flat Output Power vs Wavelength

Conditions: As specified.

Measurement: Using a power meter at the end of a 2 m single-mode fiber patchcord.

Mode-hop free tunability

Specifies the wavelength range for which no abrupt wavelength change occurs in "Stepped mode. Abrupt change is defined as change of more than the specified "Absolute wavelength accuracy (stepped mode).

Operating temperature and humidity

The ambient temperature range and humidity range of the tunable laser source for which the specifications apply.

NOTE If the optical mainframe hosting the tunable laser source module is rack-mounted, the temperature and humidity within the rack apply.

Output isolation

The insertion loss of the built-in isolator in the backward direction.

Measurement: This characteristic cannot be measured from outside the module. It is based on known isolator characteristics.

Polarization extinction ratio

Specifies the ratio of the optical power in the slow axis of a connected polarization-maintaining fiber to optical power in the fast axis, expressed in dB

NOTE

Applicable to tunable laser sources.

Utilizing polarization maintaining fiber (the electrical field oriented in the slow axis and aligned with the connector key).

Measurement: Using a polarization analyzer at the end of a polarization-maintaining patchcord, by sweeping the wavelength to create circular traces on the Poincaré sphere. Calculate the polarization extinction ratio from the diameters of these circles.

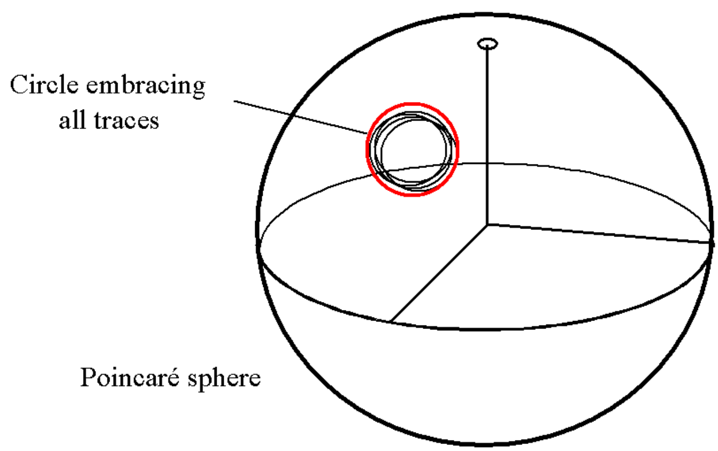


Figure 12 Circular traces on the Poincaré sphere used to calculate polarization extinction ratio.

Power flatness versus wavelength

Specifies ± half the span (in dB) between the maximum and the minimum actual power levels of the tunable laser source when changing the wavelength.

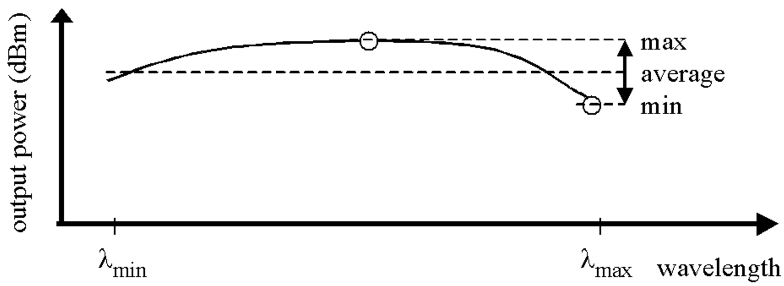


Figure 13 Power flatness vs. wavelength.

Conditions: Uninterrupted tunable laser source output power, constant power setting, constant temperature. Other conditions as specified.

Power linearity

When measuring the ratios (in dB) between the displayed power level and the actual power level for different output power levels of the tunable laser source, the power linearity is ± half the difference between the maximum and the minimum value of all ratios.

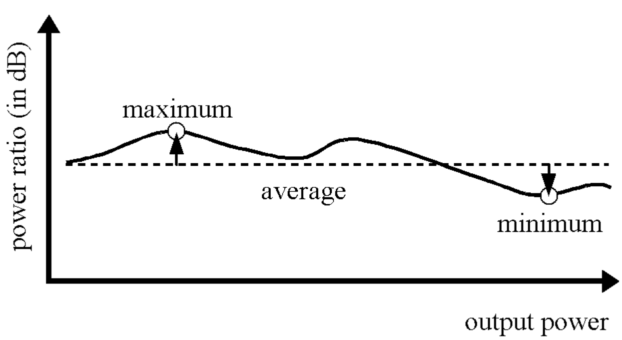


Figure 14 Power linearity.

Conditions: Uninterrupted tunable laser source output power, constant wavelength setting, constant temperature. Other conditions as specified.

Power repeatability

The uncertainty in reproducing the power level after changing and re-setting the power level. The power repeatability is ± half the span between the highest and lowest actual power.

Conditions: Uninterrupted tunable laser source output power, constant wavelength setting, constant temperature. Other conditions as specified.

NOTE **The long-term power repeatability can be obtained by taking the power repeatability and power stability into account.**

Power stability

Specifies the change of the power level of the tunable laser source over time, expressed as ± half the span (in dB) between the highest and lowest actual power.

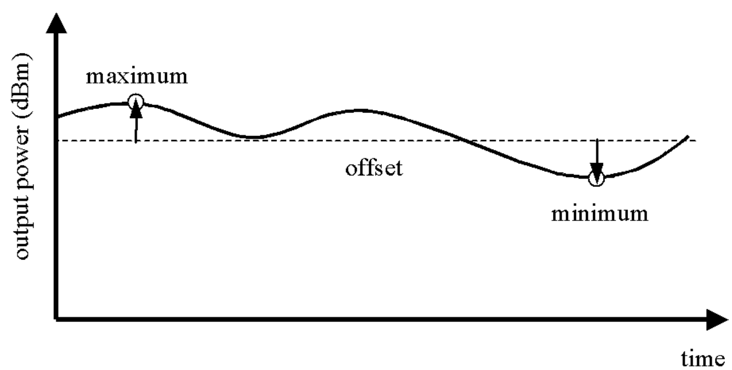


Figure 15 Power stability.

Conditions: Time span as specified. Uninterrupted tunable laser source output power, constant wavelength and power level settings, constant temperature. Other conditions as specified.

Relative intensity noise (RIN)

Specifies the ratio between the mean-square of the optical power fluctuation amplitude $\Delta P_{f,B}$ within a specified frequency range f and for bandwidth B, and the square of the average optical power P_{avg}.

$$RIN = \frac{\left\langle \Delta P_{f,B}^{2} \right\rangle}{P_{avg}^{\ 2} \cdot B} \quad \left[\frac{1}{\mathrm{Hz}}\right]$$

RIN, if expressed as "dB/Hz", is calculated by:

$$RIN_{\mathrm{dB/Hz}} = 10 \cdot \log\left(\frac{\Delta P_{f,B}^{2} \cdot 1\,\mathrm{Hz}}{P_{avg}^{\ 2} \cdot B}\right)$$

Conditions: As specified.

Measurement: Using a Lightwave signal analyzer and bandwidth set to 3 MHz.

Relative wavelength accuracy (continuous sweep mode)

When measuring the differences between the actual and Logged wavelength in Continuous sweep mode, the dynamic wavelength accuracy is ± half the span between the maximum and the minimum value of all differences.

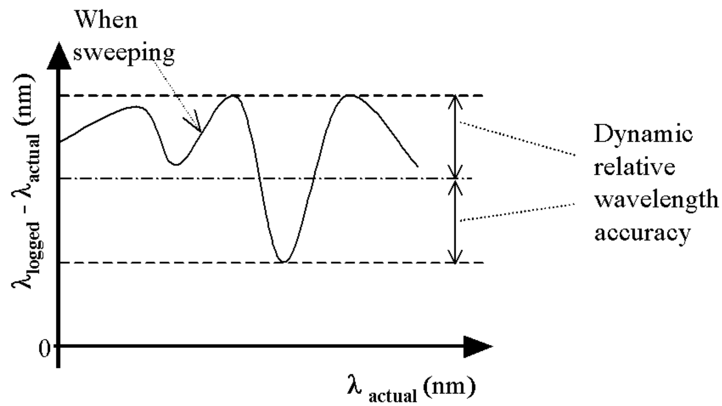


Figure 16 Relative wavelength accuracy (continuous sweep mode).

Conditions: As specified. No mode-hop.

Relative wavelength accuracy (stepped mode)

When randomly changing the wavelength and measuring the differences between the displayed and the actual wavelength, the relative wavelength accuracy is ± half the span between the maximum and the minimum value of all differences.

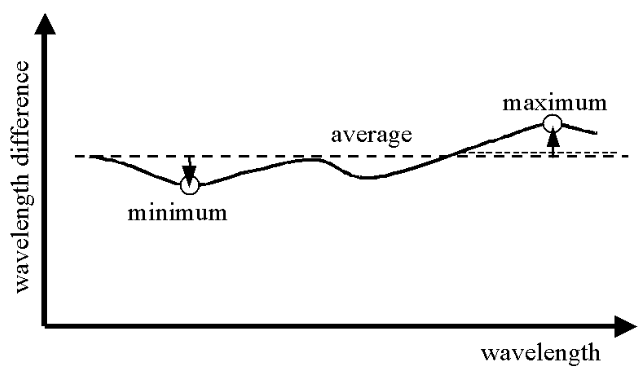


Figure 17 Relative wavelength accuracy.

Conditions: Uninterrupted tunable laser source output power, constant power setting, constant temperature. Other conditions as specified.

Measurement: Using a wavelength meter, averaging time ≥ 1 s.

NOTE The relative wavelength accuracy of the low-SSE output (if applicable) is the same as the relative wavelength accuracy of the high power output (guaranteed by design).

Return loss

Specifies the ratio of the optical power incident to the tunable laser source output port at the wavelength set on the tunable laser source, to the power reflected from the tunable laser source output port.

Conditions: Tunable laser source output off.

Side-mode suppression ratio

The ratio of optical power in the main mode to the optical power of the highest sidemode, expressed in dB:

$$SMSR_{\mathrm{dB}} = 10 \cdot \log\left(\frac{P_{signal}}{P_{highestsidemode}}\right)$$

Conditions: As specified.

Measurement: Using the Lightwave signal analyzer, by analyzing the heterodyning between the main signal and the highest side mode within 0.1 GHz to 6 GHz.

Signal to source spontaneous emission (SSE) ratio

Specifies the ratio between signal power and maximum spontaneous emission (SSE) power. The SSE power is determined in a specified bandwidth within a ±3 nm window around the signal wavelength, where ±1 nm around the signal wavelength are excluded, expressed in dB per specified bandwidth.

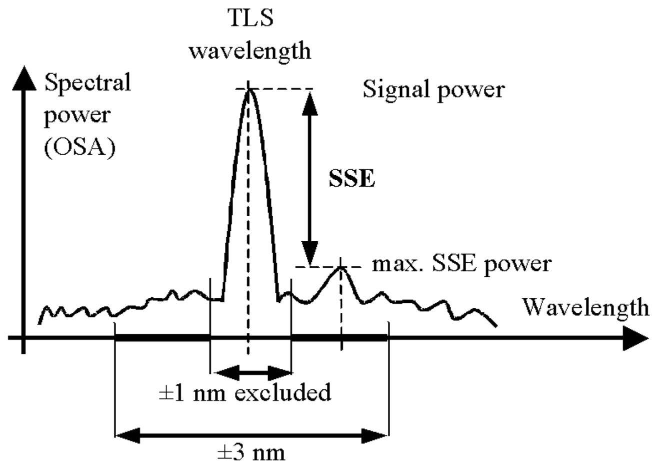


Figure 18 Signal to source spontaneous emission ratio.

Conditions: Output power as specified. Other conditions as specified.

Measurement: Using an optical spectrum analyzer (OSA) at 0.5 nm resolution bandwidth (to address the possibility of higher SSE within a narrower bandwidth), then extrapolated to 1 nm bandwidth. For the low-SSE output, if applicable, with a fiber Bragg grating inserted between the tunable laser source and the OSA to suppress the signal, thereby enhancing the dynamic range of the OSA.

Signal to total source spontaneous emission ratio

The ratio of signal power to total spontaneous emission power within, expressed in dB. The total spontaneous emission power is measured over the specified “Wavelength range.

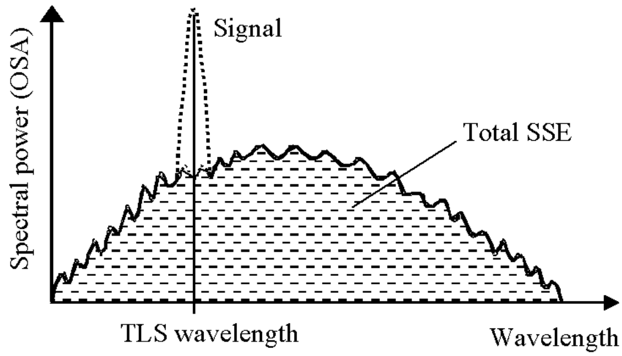


Figure 19 Signal to total source spontaneous emission ratio.

Conditions: Output power as specified. Other conditions as specified.

Measurement: Using an optical spectrum analyzer, by integrating the source spontaneous emission and excluding the remnant signal. For the low-SSE output, if applicable, with a fiber Bragg grating inserted between the tunable laser source and the OSA to suppress the signal, thereby enhancing the dynamic range of the OSA.

Wavelength range

The range of wavelengths for which the specifications apply (if not otherwise stated).

Wavelength repeatability (continuous sweep mode)

The random uncertainty of the nominal wavelength of the tunable laser source at any fixed actual wavelength in repeated sweeps. The nominal wavelength of the tunable laser source is derived from the (discrete) “Logged wavelengths by interpolation. The repeatability is expressed as ± half the span between the maximum and the minimum value of all nominal values.

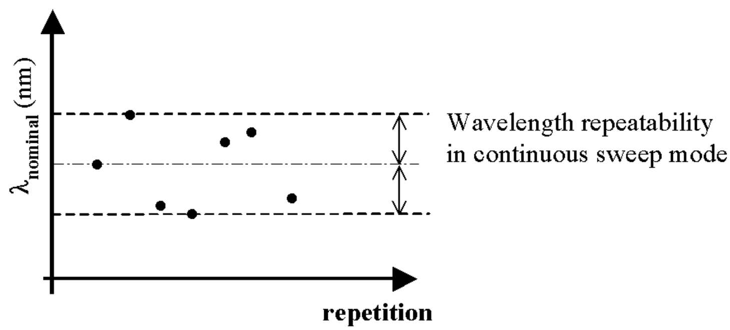


Figure 20 Wavelength repeatability (continuous sweep mode).

Conditions: As specified. No mode-hop.

Measurement: Using an optical power meter and by performing repeated spectral loss measurement on a stable absorption peak from a reference component, then analyzing the variation of the determined (interpolated) wavelength of the peak.

Wavelength repeatability (stepped mode)

The random uncertainty in reproducing a wavelength after changing and re-setting the wavelength. The wavelength repeatability is ± half the span between the maximum and the minimum of all actual values of this wavelength.

Conditions: Uninterrupted tunable laser source output power, constant power level, constant temperature. Other conditions as specified.

Measurement: Using a wavelength meter, averaging time ≥ 1 s.

NOTE The wavelength repeatability of the low-SSE output (if applicable) is the same as the wavelength repeatability of the high power output (guaranteed by design).

NOTE The long-term wavelength repeatability can be obtained by taking the wavelength repeatability and wavelength stability into account.

Wavelength resolution

The smallest selectable wavelength increment or decrement.

Wavelength stability

Specifies the change of the actual wavelength of the tunable laser source over time, expressed as ± half the span between the maximum and minimum of all wavelengths.

Conditions: Time span as specified, uninterrupted tunable laser source output power, constant wavelength and power level settings, constant temperature. Other conditions as specified.

Measurement: Using a wavelength meter, averaging time ≥ 1 s.

Keysight 8160xx Series Tunable Laser Family Specifications

Specifications:

Describe guaranteed product performance that is valid under stated conditions. The confidence level is 95%, as recommended by the ISO standard.

Typical Values and Supplementary Performance Characteristics:

Describe product performance that is usually met but not guaranteed.

Because of the modular nature of the instrument, these performance specifications apply to these modules rather than the mainframe unit.

81602A Extra High Power Tunable Laser Source

Keysight 81602A	**Option 013**
Wavelength range	1250 nm to 1370 nm
Wavelength resolution	0.1 pm, 17.5 MHz at 1310 nm
Continuous sweep range	Full wavelength range [4]
Maximum sweep speed	200 nm/s, bidirectional
Wavelength stability [3] (typ.)	≤ ±0.5 pm, 24 hours
Linewidth (typ.)	< 10 kHz
Maximum output power (continuous power during sweep)	> +18 dBm peak > +16 dBm (1290 nm - 1340 nm) > +12 dBm (1260 nm – 1360 nm) > +10 dBm (1250 nm - 1370 nm)
Signal to source spontaneous emission ratio [2]	≥ 50 dB/nm ≥ 60 dB/0.1 nm
Signal to total source spontaneous emission ratio (typ.) [2]	≥ 40 dB
Side-mode suppression ratio (typ.)	≥ 70 dB [6] ≥ 60 dB (full wavelength range, max. output power)
Relative intensity noise (RIN) (0.1 – 6 GHz)	< –150 dB/Hz [6] (typical)

	Stepped mode	**Continuous sweep mode, both directions (typ.)** [4]
Absolute wavelength accuracy [1]	±2 pm; typ. ±1.5 pm	±1.5 pm
Relative wavelength accuracy [1]	±1.5 pm; typ. ±1 pm	±1 pm
Wavelength repeatability	±0.5 pm; typ. ±0.2 pm	±0.4 pm
Power repeatability (typ.)	±0.002 dB	Not applicable
Power stability [3]	±0.01 dB, 1 hour typ. ±0.025 dB, 24 hours	Not applicable
Power linearity	±0.05 dB	Not applicable
Power flatness versus wavelength	±0.25 dB; typ. ±0.15 dB	Not applicable
Dynamic power reproducibility	Not applicable	±0.01 dB
Dynamic relative power flatness	Not applicable	±0.02 dB [5]

1. Valid for 24 hours after lambda zeroing, within a ±5 K temperature range.
2. At maximum output power, between 1320 nm and 1350 nm.
3. At constant temperature ±1 K.
4. Full wavelength range for sweep speeds ≤ 50 nm/s.
   Full wavelength range reduced by 0.5 nm on both ends for 80 nm/s sweep speed.
   Full wavelength range reduced by 3 nm on both ends for sweep speeds ≥ 100 nm/s and ≤ 150 nm/s.
   Full wavelength range reduced by 5 nm on both ends for ≥160 nm/s sweep speed.
   Mode-hop free tunable across the full wavelength range. Stop wavelength below 1345 nm.
5. Add ±0.01 dB for sweep speeds > 80 nm/s.
6. At maximum output power; within 1290 nm and 1340 nm.

8160xA Family of Tunable Lasers, Wavelength Options

Wavelength range	81606A, 81608A, 81609A	81607A
	1240 nm to 1380 nm (Option 113) 1340 nm to 1495 nm (Option 114) 1490 nm to 1640 nm (Option 116) 1440 nm to 1640 nm (Option 215) 1450 nm to 1650 nm (Option 216)	1490 nm to 1640 nm (Option 116)
Maximum output power	**81606A, 81608A, 81609A Option 113**	**81607A Option 116**
	> +13 dBm peak > +11 dBm (1290 nm – 1340 nm) > +10 dBm (1260 nm – 1360 nm) > +5 dBm (1240 nm – 1380 nm)	> +8 dBm peak > +7 dBm (1515 nm – 1620 nm) > +4 dBm (1490 nm – 1640 nm)
Maximum output power	**81606A, 81608A, 81609A Option 114**	**81606A, 81608A, 81609A Option 116**
	> +12 dBm peak > +11 dBm (1410 nm – 1470 nm) > +8 dBm (1370 nm – 1490 nm) > +5 dBm (1340 nm – 1495 nm)	> +12 dBm peak > +11 dBm (1515 nm – 1620 nm) > +8 dBm (1490 nm – 1640 nm)
Maximum output power	**81606A, 81608A, 81609A Option 216**	
	> +12 dBm peak > +11 dBm (1515 nm – 1620 nm) > +9 dBm (1480 nm – 1630 nm) > +5 dBm (1450 nm – 1650 nm)	
Minimum output power setting	**81606A, 81607A, 81608A, 81609A**	
	0 dBm	

Wavelength Tuning and Spectral Performance

Wavelength tuning	81606A, 81607A, 81608A	81609A
Wavelength resolution	0.1 pm (17.5 MHz at 1310 nm, 14.3 MHz at 1450 nm, 12.5 MHz at 1550 nm)	
Continuous tuning range	Full wavelength range, mode-hop free	
Tuning time (characteristic) [1]	300 ms (1 nm step, max. output power) 1.5 s (100 nm step, max. output power)	
Continuous sweep range	Full wavelength range [6,7], continuous power during sweep	not applicable
Max. sweep speed	200 nm/s, bidirectional	not applicable

Spectral performance	81606A	81607A	81608A, 81609A
Side-mode suppression ratio (SMSR) (typical) [2]	≥ 70 dB [3] ≥ 60 dB [4]	≥ 65 dB [3] ≥ 55 dB [4]	≥ 70 dB [3] ≥ 60 dB [4]
Relative intensity noise (RIN) (typical, 0.1 to 6 GHz) [2,3]	< -150 dB/Hz	< -135 dB/Hz	< -150 dB/Hz
Signal to source spontaneous emission ratio [2,5]	≥ 80 dB/nm ≥ 90 dB/0.1 nm	≥ 75 dB/nm ≥ 85 dB/0.1 nm	≥ 75 dB/nm ≥ 85 dB/0.1 nm
Signal to total source spontaneous emission ratio [2,5]	≥ 75 dB	≥ 70 dB	≥ 70 dB
Linewidth (typical), coherence control off	< 10 kHz	< 10 kHz	< 10 kHz
Effective linewidth (typical), coherence control on [2,3]	not applicable	not applicable	> 50 MHz

1 Including power stabilization. When “step finished” trigger is received.
2 At maximum output power.
3 1290 nm – 1340 nm (Option 113), 1410 nm – 1470 nm (Option 114), 1515 nm – 1620 nm (Options 116, 216).
4 1250 nm – 1380 nm (Option 113), full wavelength range (Options 114, 116, 216)
5 1320 nm – 1350 nm (Option 113), 1410 nm – 1460 nm (Option 114), 1520 nm – 1580 nm (Options 116, 216).
6 Full wavelength range for sweep speeds ≤ 50 nm/s.
Full wavelength range reduced by 0.5 nm on both ends for 80 nm/s sweep speed.
Full wavelength range reduced by 3 nm on both ends for sweep speeds ≥ 100 nm/s and ≤ 150 nm/s.
Full wavelength range reduced by 5 nm on both ends for ≥ 160 nm/s sweep speed.
7 Mode-hop free tunable across the full wavelength range.
Stop wavelength below 1345 nm (Option 113).
Start wavelength above 1420 nm (Option 114).

81606A Tunable Laser Source, Top Line, High Power with Low SSE

Wavelength accuracy	Stepped mode	Continuous sweep mode, both directions (typical) [3 4]
Absolute wavelength accuracy [1]	± 2 pm typical ± 1.5 pm	± 1.5 pm
Relative wavelength accuracy [1]	± 1.5 pm typical ± 1 pm	± 1 pm
Wavelength repeatability	± 0.5 pm typical ± 0.2 pm	± 0.3 pm
Wavelength stability [2]	≤ ± 0.5 pm, 24 hours (typical)	not applicable
Power repeatability (typical)	± 0.002 dB	not applicable
Power stability [2]	± 0.01 dB, 1 hour typical ± 0.025 dB, 24 hours	not applicable
Power linearity	± 0.05 dB	not applicable
Power flatness versus wavelength	± 0.25 dB typical ± 0.1 dB, Options 116, 216 typical ± 0.15 dB, Options 113, 114	not applicable
Dynamic power reproducibility	not applicable	± 0.01 dB
Dynamic relative power flatness	not applicable	± 0.02 dB [5]

1 Valid for 24 hours and within ± 5 K temperature range after wavelength zeroing.
2 At constant temperature ± 1 K.
3 Full wavelength range for sweep speeds ≤ 50 nm/s.
Full wavelength range reduced by 0.5 nm on both ends for 80 nm/s sweep speed.
Full wavelength range reduced by 3 nm on both ends for sweep speeds ≥ 100 nm/s and ≤ 150 nm/s.
Full wavelength range reduced by 5 nm on both ends for ≥ 160 nm/s sweep speed.
4 Mode-hop free tunable across the full wavelength range.
Stop wavelength below 1345 nm (Option 113).
Start wavelength above 1420 nm (Option 114).
5 Add ± 0.01 dB for sweep speeds > 80 nm/s.

81607A Tunable Laser Source, Value Line, Low SSE

Wavelength accuracy	Stepped mode	Continuous sweep mode, both directions (typical) [3 4]
Absolute wavelength accuracy [1]	± 5 pm typical ± 3 pm	± 3 pm
Relative wavelength accuracy [1]	± 3 pm typical ± 2 pm	± 2 pm
Wavelength repeatability	± 1.5 pm typical ± 1 pm	± 1 pm
Wavelength stability [2]	≤ ± 1 pm, 24 hours (typical)	not applicable
Power repeatability (typical)	± 0.005 dB	not applicable
Power stability [2]	± 0.01 dB, 1 hour typical ± 0.025 dB, 24 hours	not applicable
Power linearity	± 0.05 dB	not applicable
Power flatness versus wavelength	± 0.25 dB typical ± 0.1 dB	not applicable
Dynamic power reproducibility	not applicable	± 0.01 dB
Dynamic relative power flatness	not applicable	± 0.02 dB [5]

1 Valid for 24 hours and within ± 5 K temperature range after wavelength zeroing.
2 At constant temperature ± 1 K.
3 Full wavelength range for sweep speeds ≤ 50 nm/s.
Full wavelength range reduced by 0.5 nm on both ends for 80 nm/s sweep speed.
Full wavelength range reduced by 3 nm on both ends for sweep speeds ≥ 100 nm/s and ≤ 150 nm/s.
Full wavelength range reduced by 5 nm on both ends for ≥ 160 nm/s sweep speed.
4 Mode-hop free tunable across the full wavelength range.
5 Add ± 0.01 dB for sweep speeds > 80 nm/s.

81608A Tunable Laser Source, Value Line, High Power with Low SSE

Wavelength accuracy	Stepped mode	Continuous sweep mode, both directions (typical) [3 4]
Absolute wavelength accuracy [1]	± 20 pm typical ± 5 pm	± 10 pm
Relative wavelength accuracy [1]	± 10 pm typical ± 3 pm	± 5 pm
Wavelength repeatability	± 2.5 pm typical ± 1 pm	± 1.5 pm
Wavelength stability [2]	≤ ± 2.5 pm, 24 hours (typical)	not applicable
Power repeatability (typical)	± 0.01 dB	not applicable
Power stability [2]	± 0.01 dB, 1 hour typical ± 0.03 dB, 24 hours	not applicable
Power linearity	± 0.1 dB	not applicable
Power flatness versus wavelength	± 0.25 dB typical ± 0.1 dB, Options 116, 216 typical ± 0.15 dB, Options 113, 114	not applicable
Dynamic power reproducibility	not applicable	± 0.01 dB
Dynamic relative power flatness	not applicable	± 0.02 dB [5]

1 Valid for 24 hours and within ± 5 K temperature range after wavelength zeroing.
2 At constant temperature ± 1 K.
3 Full wavelength range for sweep speeds ≤ 50 nm/s.
Full wavelength range reduced by 0.5 nm on both ends for 80 nm/s sweep speed.
Full wavelength range reduced by 3 nm on both ends for sweep speeds ≥ 100 nm/s and ≤ 150 nm/s.
Full wavelength range reduced by 5 nm on both ends for ≥ 160 nm/s sweep speed.
4 Mode-hop free tunable across the full wavelength range.
Stop wavelength below 1345 nm (Option 113).
Start wavelength above 1420 nm (Option 114).
5 Add ± 0.01 dB for sweep speeds > 80 nm/s.

81609A Step-Tunable Laser Source, Basic Line, High Power with Low SSE

Wavelength accuracy	
Absolute wavelength accuracy [1]	± 30 pm; typical ± 10 pm
Relative wavelength accuracy [1]	± 15 pm; typical ± 5 pm
Wavelength repeatability	± 5 pm; typical ± 3 pm
Wavelength stability [2]	≤ ± 5 pm, 24 hours (typical)
Power repeatability (typical)	± 0.01 dB
Power stability [2]	± 0.01 dB, 1 hour typical ± 0.03 dB, 24 hours
Power linearity	± 0.1 dB
Power flatness versus wavelength	± 0.25 dB typical ± 0.1 dB, Options 116, 216 typical ± 0.15 dB, Options 113, 114

1 Valid for 24 hours and within ± 5 K temperature range after wavelength zeroing.
2 At constant temperature ± 1 K.

81600B Option 201 Tunable Laser, 1455 nm to 1640 nm, Low SSE
81600B Option 200 Tunable Laser, 1440 nm to 1640 nm, Low SSE

Keysight 81600B Option 201, 200				
Wavelength range	1455 nm to 1640 nm (81600B Option 201)			
	1440 nm to 1640 nm (81600B Option 200)			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [4] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1475 nm to 1625 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ +3 dBm peak (typical)		≥ +9 dBm peak (typical)	
	≥ +2 dBm (1520 nm to 1610 nm)		≥ +8 dBm (1520 nm to1610 nm)	
	≥ −2 dBm (1475 nm to 1625 nm)		≥ +4 dBm (1475 nm to 1625 nm)	
	≥ −7 dBm [5]		≥ −1 dBm [5]	
Attenuation			Max. 60 dB	
Power repeatability (typical)	± 0.003 dB			
Power stability [4]	± 0.01 dB, 1 hour			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB		± 0.1 dB (± 0.3 dB in attenuation mode)	
Power flatness versus wavelength	± 0.25 dB [3], typical ± 0.1 dB		± 0.3 dB [3], typical ± 0.15 dB	
	Continuous sweep mode			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.02 dB	± 0.04 dB	
Side-mode suppression ratio (typical)	≥ 60 dB (1520 nm to 1610 nm)			
Signal to source spontaneous emission ratio [2]	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ 70 dB/nm (1520 nm to 1610 nm)		≥ 48 dB/nm (1520 nm to 1610 nm)	
	≥ 80 dB/0.1 nm (typical, 1520 nm to 1610 nm)		≥ 58 dB/0.1 nm (typical, 1520 nm to 1610 nm)	
	≥ 66 dB/nm (typical, 1475 nm to 1625 nm)		≥ 43 dB/nm (1475 nm to 1625 nm)	
	≥ 60 dB/nm (typical) [5]		≥ 37 dB/nm [5]	
Signal to total source spontaneous emission ratio [2]	≥ 65 dB (1520 nm to 1610 nm)		≥ 30 dB (typical, 1520 nm to 1610 nm)	
	≥ 57 dB (typical) [5]			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typ.) [2]	−145 dB/Hz (1520 nm to 1610 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. Wavelength range 1455 nm to 1640 nm (81600B Option 201); 1440 nm to 1630 nm (81600B Option 200).
4. At constant temperature ± 1 K.
5. Wavelength range 1455 nm to 1640 nm (81600B Option 201); 1440 nm to 1640 nm (81600B Option 200).

81600B Option 160 Tunable Laser Source, 1495 nm to 1640 nm, Low SSE

Keysight 81600B Option 160				
Wavelength range	1495 nm to 1640 nm			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability full	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [3] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1510 nm to 1620 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ –2 dBm peak (typical)		≥ +7 dBm peak (typical)	
	≥ –4 dBm (1520 nm to 1610 nm)		≥ +5 dBm (1520 nm to 1610 nm)	
	≥ –6 dBm (1510 nm to 1620 nm)		≥ +3 dBm (1510 nm to 1620 nm)	
	≥ –7 dBm (1495 nm to1640 nm)		≥ –1 dBm (1495 nm to 1640 nm)	
Attenuation			Max. 60 dB	
Power repeatability (typical)	± 0.003 dB			
Power stability [3]	± 0.01 dB, 1 hour			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB		± 0.1 dB (± 0.3 dB in attenuation mode)	
Power flatness versus wavelength	± 0.25 dB, typical ± 0.1 dB (1495 nm to 1630 nm)		± 0.3 dB, typical ± 0.15 dB	
	Continuous sweep mode			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.02 dB	± 0.04 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1520 nm to 1610 nm)			
Signal to source spontaneous emission ratio [2]	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ 64 dB/nm (1520 nm to1610 nm)		≥ 45 dB/nm (1520 nm to 1610 nm)	
	≥ 74 dB/0.1 nm (typical, 1520 nm to 1610 nm)		≥ 55 dB/0.1 nm (typical, 1520 nm to 1610 nm)	
	≥ 62 dB/nm (typical, 1510 nm to 1620 nm)		≥ 42 dB/nm (1510 nm to 1620 nm)	
	≥ 59 dB/nm (typical, 1495 nm to 1640 nm)		≥ 37 dB/nm (1495 nm to 1640 nm)	
Signal to total source spontaneous emission ratio [2]	≥ 59 dB (1520 nm to 1610 nm)		≥ 27 dB (typical, 1520 nm to 1610 nm)	
	≥ 56 dB (typical, 1495 nm to 1640 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	–145 dB/Hz (1520 nm to 1610 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. At constant temperature ± 1 K.

81600B Option 150 Tunable Laser Source, 1450 nm to 1590 nm, Low SSE

Keysight 81600B Option 150				
Wavelength range	1450 nm to 1590 nm			
Wavelength resolution	Wavelength resolution 0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [3] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1480 nm to 1580 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ –1 dBm peak (typical)		≥ +7 dBm peak (typical)	
	≥ –3 dBm (1520 nm to 1570 nm)		≥ +5 dBm (1520 nm to 1570 nm)	
	≥ –6 dBm (1480 nm to 1580 nm)		≥ +4 dBm (1480 nm to 1580 nm)	
	≥ –7 dBm (1450 nm to 1590 nm)		≥ –1 dBm (1450 nm to 1590 nm)	
Attenuation			Max 60 dB	
Power repeatability (typical)	± 0.003 dB			
Power stability [3]	± 0.01 dB, 1 hour			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB		± 0.1 dB (± 0.3 dB in attenuation mode)	
Power flatness versus wavelength	± 0.2 dB, typical ± 0.1 dB		± 0.3 dB, typical ± 0.15 dB	
	Continuous sweep mode			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.02 dB	± 0.04 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1480 nm to 1580 nm)			
Signal to source spontaneous emission ratio [2]	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ 65 dB/nm (1520 nm to 1570 nm)		≥ 45 dB/nm (1520 nm to 1570 nm)	
	≥ 75 dB/0.1 nm (typical, 1520 nm to 1570 nm)		≥ 55 dB/0.1 nm (typical, 1520 nm to 1570 nm)	
	≥ 61 dB/nm (typical, 1480 nm to 1580 nm)		≥ 42 dB/nm (1480 nm to 1580 nm)	
	≥ 59 dB/nm (typical, 1450 nm to 1590 nm)		≥ 37 dB/nm (1450 nm to 1590 nm)	
Signal to total source spontaneous emission ratio [2]	≥ 60 dB (1520 nm to 1570 nm)		≥ 30 dB (typical, 1520 nm to 1570 nm)	
	≥ 50 dB (typical, 1450 nm to 1590 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	–145 dB/Hz (1480 nm to 1580 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. At constant temperature ± 1 K.

81600B Option 140 Tunable Laser Source, 1370 nm to 1495 nm, Low SSE

Keysight 81600B Option 140				
Wavelength range	1370 nm to 1495 nm			
Wavelength resolution	0.1 pm, 15 MHz at 1450 nm			
Mode-hop free tunability full	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s (1372 nm to 1495 nm)			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [4] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1430 nm to 1480 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ −4.5 dBm peak (typical)		≥ +5.5 dBm peak (typical)	
	≥ −5 dBm (1430 nm to 1480 nm)		≥ +5 dBm (1430 nm to 1480 nm)	
	≥ −7 dBm (1420 nm to 1480 nm)		≥ +3 dBm (1420 nm to 1480 nm)	
	≥ −13 dBm (1370 nm to 1495 nm)		≥ −3 dBm (1370 nm to 1495 nm)	
Attenuation			Max 60 dB	
Power repeatability (typical)	± 0.003 dB			
Power stability [4]	± 0.01 dB, 1 hour (1420 nm to 1495 nm)			
	Typical ± 0.01 dB, 1 hour (1370 nm to 1420 nm)			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB (1420 nm to 1495 nm)		± 0.3 dB (1420 nm to 1495 nm)	
	Typical ± 0.1 dB (1370 nm to 1420 nm)		Typical ± 0.3 dB (1370 nm to 1420 nm)	
Power flatness versus wavelength	± 0.2 dB		± 0.3 dB	
	Typical ± 0.1 dB (1420 nm to 1495 nm)		Typical ± 0.2 dB (1420 nm to 1495 nm)	
	Typical ± 0.2 dB (1370 nm to 1420 nm)		Typical ± 0.3 dB (1370 nm to 1420 nm)	
	Continuous sweep mode [3]			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.015 dB	± 0.03 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1430 nm to 1480 nm)			
Signal to source spontaneous emission ratio [2]	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ 63 dB/nm (1430 nm to 1480 nm)		≥ 42 dB/nm (1430 nm to 1480 nm)	
	≥ 73 dB/0.1 nm (typical, 1430 nm to 1480 nm)		≥ 52 dB/0.1 nm (typical, 1430 nm to 1480 nm)	
	≥ 61 dB/nm (1420 nm to 1480 nm)		≥ 40 dB/nm (1420 nm to 1480 nm)	
	≥ 55 dB/nm (typical, 1370 nm to 1495 nm)		≥ 35 dB/nm (typical, 1370 nm to 1495 nm)	
Signal to total source spontaneous emission ratio [2]	≥ 60 dB (1430 nm to 1480 nm)			
	≥ 58 dB (1420 nm to 1480 nm)		≥ 28 dB (typical, 1430 nm to 1480 nm)	
	≥ 53 dB (typical, 1370 nm to 1495 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	−145 dB/Hz (1430 nm to 1480 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. Valid for absolute humidity of 11.5 g/m3 (For example, equivalent to 50% relative humidity at 25 °C).
4. At constant temperature ± 1 K.

81600B Option 130 Tunable Laser Source, 1260 nm to 1375 nm, Low SSE

Keysight 81600B Option 130				
Wavelength range	1260 nm to 1375 nm			
Wavelength resolution	0.1 pm, 17.7 MHz at 1300 nm			
Mode-hop free tunability	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [4] (typical)	≤ ±1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1270 nm to 1350 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ –4 dBm peak (typical)		≥ +5 dBm peak (typical)	
	≥ –6 dBm (1290 nm to 1370 nm)		≥ +4 dBm (1290 nm to 1370 nm)	
	≥ –9 dBm (1270 nm to 1375 nm)		≥ +1 dBm (1270 nm to 1375 nm)	
	≥ –13 dBm (1260 nm to 1375 nm)		≥ –3 dBm (1260 nm to 1375 nm)	
Attenuation			Max 60 dB	
Power repeatability (typical)	± 0.003 dB			
Power stability [4]	± 0.01 dB, 1 hour (1260 nm to 1350 nm)			
	Typical ± 0.01 dB, 1 hour (1350 nm to 1375 nm)			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB (1260 nm to 1350 nm)		±0.3 dB (1260 nm to 1350 nm)	
	Typical ± 0.1 dB (1350 nm to 1375 nm)		Typical ± 0.3 dB (1350 nm to 1375 nm)	
Power flatness versus wavelength	± 0.2 dB		± 0.3 dB	
	Typical ± 0.1 dB (1260 nm to 1350 nm)		Typical ± 0.15 dB (1260 nm to 1350 nm)	
	Typical ± 0.2 dB (1350 nm to 1375 nm)		Typical ± 0.3 dB (1350 nm to 1375 nm)	
	Continuous sweep mode [3]			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.02 dB	± 0.04 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1290 nm to 1370 nm)			
Signal to source spontaneous emission ratio (typical) [2]	**Output 1 (low SSE)**		**Output 2 (high power)**	
	≥ 63 dB/nm (1290 nm to 1370 nm)		≥ 42 dB/nm (1290 nm to 1370 nm)	
	≥ 61 dB/nm (1270 nm to 1375 nm)		≥ 40 dB/nm (1270 nm to 1375 nm)	
	≥ 55 dB/nm (1260 nm to 1375 nm)		≥ 35 dB/nm (1260 nm to 1375 nm)	
Signal to total source spontaneous emission ratio (typical) [2]	≥ 58 dB (1290 nm to 1370 nm)		≥ 26 dB (1290 nm to 1370 nm)	
	≥ 56 dB (1270 nm to 1375 nm)			
	≥ 51 dB (1260 nm to 1375 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	–140 dB/Hz (1270 nm to 1375 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. Valid for absolute humidity of 11.5 g/m3 (For example, equivalent to 50% relative humidity at 25 °C).
4. At constant temperature ± 1 K.

81600B Option 142 Tunable Laser Source, 1370 nm to 1495 nm, High Power

Keysight 81600B Option 142				
Wavelength range	1370 nm to 1495 nm			
Wavelength resolution	0.1 pm, 15 MHz at 1450 nm			
Mode-hop free tunability	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s (1372 nm to 1495 nm)			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [4] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1430 nm to 1480 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	≥ +8.5 dBm peak (typical)			
	≥ +7.5 dBm (1430 nm to 1480 nm)			
	≥ +5 dBm (1420 nm to 1480 nm)			
	≥ 0 dBm (1370 nm to 1495 nm)			
With option 003	Reduced by 1.5 dB			
Power repeatability (typical)	± 0.003 dB			
Power stability [4]	± 0.01 dB, 1 hour (1420 nm to 1495 nm)			
	Typical ± 0.01 dB, 1 hour (1370 nm to 1420 nm)			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB (1420 nm to 1495 nm)			
	Typical ± 0.1 dB (1370 nm to 1420 nm)			
With option 003	Add ± 0.2 dB			
Power flatness versus wavelength	± 0.2 dB			
	Typical ± 0.1 dB (1420 nm to 1495 nm)			
	Typical ± 0.2 dB (1370 nm to 1420 nm)			
With option 003	Add ± 0.1 dB			
	Continuous sweep mode [3]			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.015 dB	± 0.03 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1430 nm to 1480 nm)			
Signal to source spontaneous emission ratio [2]	≥ 42 dB/nm (1430 nm to 1480 nm)			
	≥ 52 dB/0.1 nm (typical, 1430 nm to 1480 nm)			
	≥ 40 dB/nm (1420 nm to 1480 nm)			
	≥ 35 dB/nm (typical, 1370 nm to 1495 nm)			
Signal to total source spontaneous emission ratio (typical) [2]	≥ 28 dB (1430 nm to 1480 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	–145 dB/Hz (1430 nm to 1480 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. Valid for absolute humidity of 11.5 g/m3 (For example, equivalent to 50% relative humidity at 25 °C).
4. At constant temperature ± 1 K.

81600B Option 132 Tunable Laser Source, 1260 nm to 1375 nm, High Power

Keysight 81600B Option 132				
Wavelength range	1260 nm to 1375 nm			
Wavelength resolution	0.1 pm, 17.7 MHz at 1300 nm			
Mode-hop free tunability	Full wavelength range; see page 10 for conditions to assure mode-hop free continuous sweeps			
Maximum sweep speed	80 nm/s			
	Stepped mode	**Continuous sweep mode (typical)**		
		At 5 nm/s	At 40 nm/s	At 80 nm/s
Absolute wavelength accuracy [1]	± 10 pm, typical ± 3.6 pm	± 4.0 pm	± 4.6 pm	± 6.1 pm
Relative wavelength accuracy [1]	± 5 pm, typical ± 2 pm	± 2.4 pm	± 2.8 pm	± 4.0 pm
Wavelength repeatability	± 0.8 pm, typical ± 0.5 pm	± 0.3 pm	± 0.4 pm	± 0.7 pm
Wavelength stability [2] (typical)	≤ ± 1 pm, 24 hours			
Linewidth (typical), coherence control off	100 kHz			
Effective linewidth (typical), coherence control on	> 50 MHz (1270 nm to 1350 nm, at max. constant output power)			
Maximum output power (continuous power during sweep)	≥ +9 dBm peak (typical)			
	≥ +7 dBm (1290 nm to 1370 nm)			
	≥ +3 dBm (1270 nm to 1375 nm)			
	≥ 0 dBm (1260 nm to 1375 nm)			
Power repeatability (typical)	± 0.003 dB			
Power stability [4]	± 0.01 dB, 1 hour (1260 nm to 1350 nm)			
	Typical ± 0.01 dB, 1 hour (1350 nm to 1375 nm)			
	Typical ± 0.03 dB, 24 hours			
Power linearity	± 0.1 dB (1260 nm to 1350 nm)			
	Typical ± 0.1 dB (1350 nm to 1375 nm)			
Power flatness versus wavelength	± 0.2 dB			
	Typical ± 0.1 dB (1260 nm to 1350 nm)			
	Typical ± 0.2 dB (1350 nm to 1375 nm)			
	Continuous sweep mode [3]			
	At 5 nm/s	At 40 nm/s	At 80 nm/s	
Dynamic power reproducibility (typical)	± 0.005 dB	± 0.01 dB	± 0.015 dB	
Dynamic relative power flatness (typical)	± 0.01 dB	± 0.015 dB	± 0.03 dB	
Side-mode suppression ratio (typical) [2]	≥ 40 dB (1270 nm to 1375 nm)			
Signal to source spontaneous emission ratio [2]	≥ 45 dB/nm (1290 nm to 1370 nm)			
	≥ 55 dB/0.1 nm (typical, 1290 nm to 1370 nm)			
	≥ 40 dB/nm (1270 nm to 1375 nm)			
	≥ 35 dB/nm (typical, 1260 nm to 1375 nm)			
Signal to total source spontaneous emission ratio (typical) [2]	≥ 28 dB (1290 nm to 1370 nm)			
Relative intensity noise (RIN) (0.1 to 6 GHz) (typical) [2]	–145 dB/Hz (1270 nm to 1375 nm)			

1. Valid for one month and within a ± 4.4 K temperature range after automatic wavelength zeroing.
2. At maximum output power as specified per wavelength range.
3. Valid for absolute humidity of 11.5 g/m3 (For example, equivalent to 50% relative humidity at 25 °C).
4. At constant temperature ± 1 K.

Conditions

Storage temperature	−40 °C to +70 °C	
Operating temperature	+10 °C to +35 °C	
Humidity	< 80% R.H. at +10 °C to +35 °C, non-condensing	
Specifications apply for wavelengths not equal to any water absorption line. Note: if the laser is operated in a dry box filled with dry air or nitrogen, specifications also apply at water absorption lines.		
All specifications are typical at wavelengths < 1250 nm.		
Warm-up time	60 minutes; immediate operation after boot up	
	81602A, 81606A, 81607A, 81608A, 81609A: 30 minutes if previously stored at the same temperature	
Output power		
Specifications are valid at the following output power levels:		
81600B Options 201, 200, 160 and 150	≥ −7 dBm (for Output 1); ≥ −1 dBm (for Output 2, −60 dB in attenuation mode)	
81600B Option 140 and 130	≥ −13 dBm (for Output 1); ≥ −3 dBm (for Output 2, −60 dB in attenuation mode)	
81600B Option 142	≥ −3 dBm; ≥ −4.5 dBm (with Option 003: −60 dB in attenuation mode)	
81600B Option 132	≥ 0 dBm	
Continuous sweep range	**Sweep speed**	**Continuous sweep range**
81602A, 81606A, 81607A, 81608A	≤ 50 nm/s	Full wavelength range
	80 nm/s	Full wavelength range reduced by 0.5 nm on both ends
	≥ 100 nm/s and ≤ 150 nm/s	Full wavelength range reduced by 3 nm on both ends
	≥160 nm/s	Full wavelength range reduced by 5 nm on both ends
81600B	Specifications are valid for mode-hop free sweeping. Maximum 50 nm at constant output power levels as follows:	
– 81600B Option 200, 201	1475 nm to 1620 nm; ≥ −2 dBm (for Output 1); ≥ +4 dBm (for Output 2)	
– 81600B Option 160	1510 nm to 1620 nm; ≥ −6 dBm (for Output 1); ≥ +3 dBm (for Output 2)	
– 81600B Option 150	1520 nm to 1570 nm; ≥ −6 dBm (for Output 1); ≥ +3 dBm (for Output 2)	
– 81600B Option 140	1430 nm to 1480 nm; ≥ −9 dBm (for Output 1); ≥ 0 dBm (for Output 2)	
– 81600B Option 130	1300 nm to 1350 nm; ≥ −9 dBm (for Output 1); ≥ +1 dBm (for Output 2)	
– 81600B Option 142	1430 nm to 1480 nm; ≥ −3 dBm; ≥ +1.5 dBm (with Option 003)	
– 81600B Option 132	1300 nm to 1350 nm; ≥ +3 dBm	
– Operating temperature within	+20 °C and +35 °C	

General Specifications and Supplementary Characteristics

Supplementary performance characteristics		
Internal digital modulation (81600B only)		
	Duty cycle	50%
	Frequency range	200 Hz to 300 kHz
	Displayed wavelength represents average wavelength.	
Modulation output	TTL reference signal	
External digital modulation (81600B only)		
	Duty cycle	> 45%
	Delay time	< 300 ns
	Frequency range	200 Hz to 1 MHz
	Displayed wavelength represents average wavelength.	
Modulation input	TTL signal	
External analog modulation (81600B only)		
	Modulation depth	> ± 15%
	Frequency range	5 kHz to 20 MHz
Modulation input	5 Vp-p	
External wavelength locking (81602A, 81606A, 81600B)		
	Modulation depth	> ± 70 pm at 10 Hz
		> ± 7 pm at 100 Hz
Modulation input	± 5 V	
Coherence control (81602A, 81608A,81609A, 81600B)		
For measurements on components with 2 m long patch cords and connectors with 14 dB return loss, the effective linewidth results in a typical power stability of < ± 0.025 dB over 1 minute by significantly reducing interference effects in the test setup. For 81608A and 81609A, available at max. output power, at wavelength range 1290 nm – 1340 nm (Option 113), 1420 nm – 1470 nm (Option 114), 1515 nm – 1620 nm (Options 116, 216).		
Output isolation		
	Built-in optical isolator	
General specifications		
Return loss (typical)		
81602A, 81606A, 81607A, 81608A, 81609A	60 dB	
81600B Option 072	60 dB	
81600B Option 071	40 dB	
Polarization maintaining fiber		
Fiber type	Panda	
Orientation	Electrical field is oriented in slow axis, in line with the connector key	
Polarization extinction ratio		
81602A, 81606A, 81607A, 81608A, 81609A	16 dB typical	
81600B Options 130, 132, 140, 142, 150, 160	16 dB typical	
81600B Options 200, 201	14 dB typical	
Recommended re-calibration period		
	2 years	

4 Cleaning Instructions

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 9 lists the sections that are relevant to the various modules that can be installed in this instrument.

Table 9 Cleaning Instructions for Modules

Modules	Instruction
Optical Heads	How to clean instruments with a physical contact interface on page 93
Laser Source Modules	How to clean instruments with a physical contact interface on page 93
Tunable Laser Modules	How to clean instruments with a physical contact interface on page 93
Return Loss Modules	How to clean instruments with a physical contact interface on page 93
LED Source Modules	How to clean instruments with a physical contact interface on page 93
Power Sensor Modules	How to clean instruments with a recessed lens interface on page 95

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.

Why is it important to clean optical devices?

In transmission links optical fiber cores are about 9 mm (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 materials do I need for proper cleaning?

Some <Cross Reference Color>Standard Cleaning Equipment is necessary for cleaning your instrument. For certain cleaning procedures, you may also require certain <Cross Reference Color>Additional Cleaning Equipment.

Standard Cleaning Equipment

Before you can start your cleaning procedure you need the following standard equipment:

- Dust and shutter caps on page 77
- Isopropyl alcohol on page 77
- Cotton swabs on page 78
- Soft tissues on page 78
- Pipe cleaner on page 79
- Compressed air on page 79

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 80
- Ultrasonic bath on page 80
- Warm water and liquid soap on page 80
- Premoistened cleaning wipes on page 81
- Polymer film on page 81
- Infrared Sensor Card on page 81

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.

General Cleaning Procedure

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 How to clean connectors on page 85 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.

Alternative Procedure

Use the following procedure if an Optical Connector Cleaner is not available.

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 optical head adapters

CAUTION Do not use pipe cleaners on optical head adapters, as the hard core of normal pipe cleaners can damage the bottom of an adapter.

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.

When using optical head adapters, periodically inspect the optical head's front window. Dust and metal particles can be propelled through the adapter's pinhole while inserting the connector ferrule into the receptacle. These dirt particles collect on the head's front window, which can lead to incorrect results if not removed.

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.**

Preferred Procedure

Use the following procedure on most occasions.

1. Clean the interface, when no lens is connected, by pushing and pulling a new, dry pipe cleaner into the opening. Rotate the pipe cleaner slowly as you do this.
2. Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure 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. Using a new, dry pipe-cleaner, and 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 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 and instruments with an optical glass plate

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings. Some instruments, for example, Keysight optical heads have an optical glass plate to protect the sensor.

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.

If you are cleaning an Keysight series 8162xx optical head, periodically inspect the optical head's front window for dust and other particles. Dust and particles can be propelled through the optical head adapter's pinhole while inserting a connector ferrule to the receptacle. Particles on the optical head's front window can significantly impair measurement results.

CAUTION **Do not dry the lens by rubbing with cloth or other material, which may scratch the lens surface.**

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 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

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.

NOTE

Both the surface and the jacket of the attached connector should be completely dry and clean.

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 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 N7747A, N7748A, 81630B and 81634B Power Sensors) do NOT follow ths 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 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 mesh filters

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

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.

Preferred Procedure

There is an easy method for removing dust from bare fiber ends

1 Touch the bare fiber end with adhesive tape. Any dust will be removed.

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 there is no other way of cleaning your optical device without causing 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.

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 chapter 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 the 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.

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