Agilent 81600B
Tunable Laser Module

User's Guide

Agilent Technologies

Notices

Manual Part Number

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Safety Notices

CAUTION

A **CAUTION** 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 damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

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.

Safety Considerations

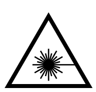
The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies Inc. 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 Agilent 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 an Agilent Technologies Sales/Service Center for repair and calibration.

Line Power Requirements

The Agilent 81600B Tunable Laser Module operates when installed in the Agilent 8164A/B Lightwave Measurement System.

Operating Environment

The safety information in the Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System User's Guide summarizes the operating ranges for the Agilent 81600B Tunable Laser 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 Agilent 81600B; 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

This module can be stored or shipped at temperatures between –40°C and +70°C. Protect the module from temperature extremes that may cause condensation within it.

Initial Safety Information for Tunable Laser Modules

The laser sources specified by this user guide are classified according to IEC 60825-1 (2001).

The laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated 2001-July-26.:

	Agilent 81600B
Laser Type	FP-Laser InGaAsP
Wavelength range	1440-1640 nm
*Max. CW output power**	<15 mW
Beam waist diameter	9 µm
Numerical aperture	0.1
Laser Class according to IEC 60825-1 (2001)- Intl.	1M
Max. permissible CW output power	52 mW/ 163 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

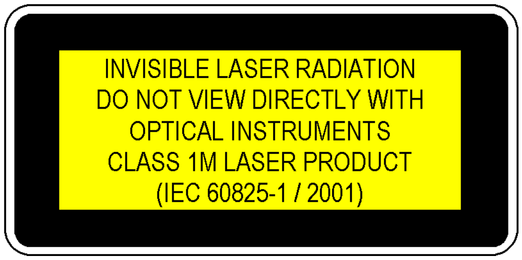


Figure 1 Class 1M Safety Label - Agilent 81600B

Figure 2 FDA Certification Label

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 warnings:

- Under no circumstances look into the end of an optical cable attached to the optical output when the device is operational. The laser radiation can seriously damage your eyesight.
- Do not enable the laser when there is no fiber attached to the optical output connector.
- The laser is enabled by pressing the gray button close to the optical output connector on the front panel of the module. The laser is on when the green LED on the front panel of the instrument is lit.
- The use of the instruments with this product will increase the hazard to your eyes.
- The laser module has built-in safety circuitry which will disable the optical output in the case of a fault condition.

Refer servicing *only* to qualified and authorized personnel.

The Structure of this Manual

This manual is divided into two categories:

- Getting Started
  This section gives an introduction to the Tunable Laser modules. and aims to make these modules familiar to you:
  - “Overview of Tunable Laser Sources" on page 15
- Additional Information
  This is supporting information of a non-operational nature. this contains information concerning accessories, specifications, and performance tests:
  - “Accessories" on page 21,
  - “Specifications" on page 27, and
  - “Performance Tests" on page 45.

Conventions used in this manual

- Hardkeys are indicated by italics, for example, *Config*, or *Channel*.
- Softkeys are indicated by normal text enclosed in square brackets, for example, [Zoom] or [Cancel].
- Parameters are indicated by italics enclosed by square brackets, for example, [*Range Mode*], or [*MinMax Mode*].
- Menu items are indicated by italics enclosed in brackets, for example, <*MinMax*>, or <*Continuous*>.

Contents

List of Figures

1
Overview of Tunable Laser Sources

This chapter describes the Agilent 81600B Tunable Laser module.

What is a Tunable Laser?

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

Output Types

The tunable laser sources are available with a selection of different ouputs to suit your measurement application. There are modules that have different operating wavelength bands, output powers, number of outputs, and different connector types as options.

Agilent 81600B Tunable Laser Module

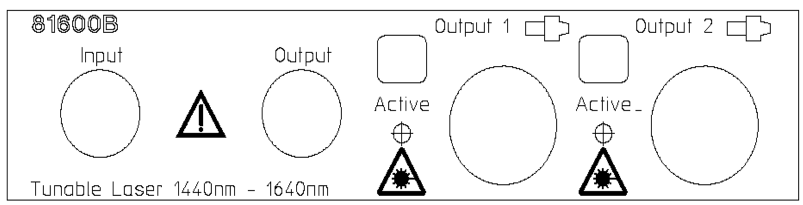


Figure 1 Agilent 81600B Tunable Laser Module (straight contact connectors)

The Agilent 81600B Tunable Laser module is a back-loadable module. To fit this module into the Agilent 8164A/B mainframe see “How to Fit and Remove Modules” in the Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B, Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System User’s Guide.

The Agilent 81600B Tunable Laser module has a built-in wavelength control loop to ensure high wavelength accuracy. As this module is mode-hop free tunable with continuous output power, it qualifies for the test of the most critical dense-Wavelength Division Multiplexer (dWDM) components.

The Agilent 81600B Tunable Laser module is equipped with two optical outputs:

- Output 1, the Low SSE output, delivers a signal with ultra-low source spontaneous emission (SSE). It enables accurate crosstalk measurement of DWDM components with many channels at narrow spacing. You can characterize steep notch filters such as Fiber Bragg Gratings by using this output and a power sensor module.
- Output 2, the High Power output, delivers a signal with high optical power. You can adjust the signal by more than 60 dB by using the built-in optical attenuator.

Optical Output

Polarization Maintaining Fiber

If you have an instrument with a polarization maintaining fiber (PMF), the PMF is aligned to maintain the state of polarization.

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

The Agilent 81600B Tunable Laser module is equipped with PMF outputs as standard.

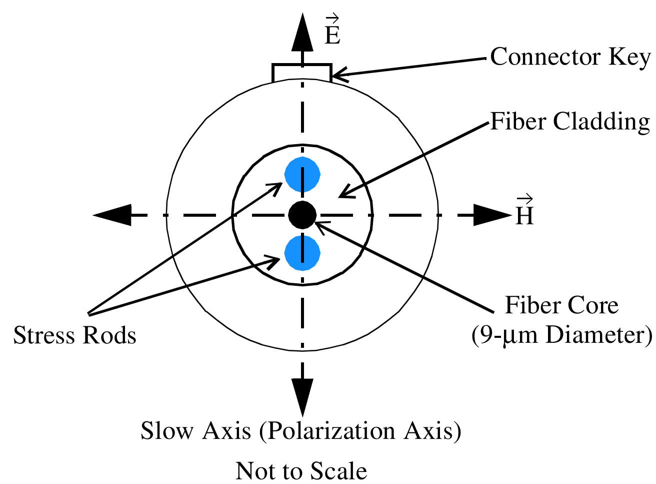


Figure 2 PMF Output Connector

Angled and Straight Contact Connectors

Angled contact connectors help you to control return loss. With angled fiber endfaces, reflected light tends to reflect into the cladding, reducing the amount of light that reflects back to the source.

The Agilent 81600B Tunable Laser module can have the following connector interface options:

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

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

Figure 3 Angled and Straight Contact Connector Symbols

Figure 3 shows the symbols that tell you whether the contact connector of your Tunable Laser module is angled or straight. The angled contact connector symbol is colored green.

Figure 1 and Figure 4 shows the front panel of the Agilent 81600B Tunable Laser 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.

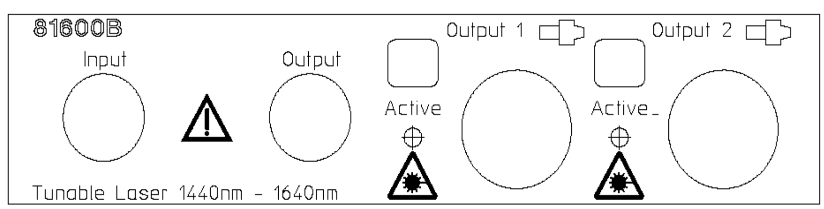


Figure 4 Agilent 81600B Tunable Laser Module (angled contact connector)

See "Accessories" on page 21 for further details on connector interfaces and accessories.

Signal Input and Output

CAUTION

There are two BNC connectors on the front panel of the Agilent 81600B - 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 Agilent 81600B Tunable Laser Source Module is available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

Modules and Options

Figure 5 shows all the options that are available for the 81600B Tunable Laser module and the instruments that support this module.

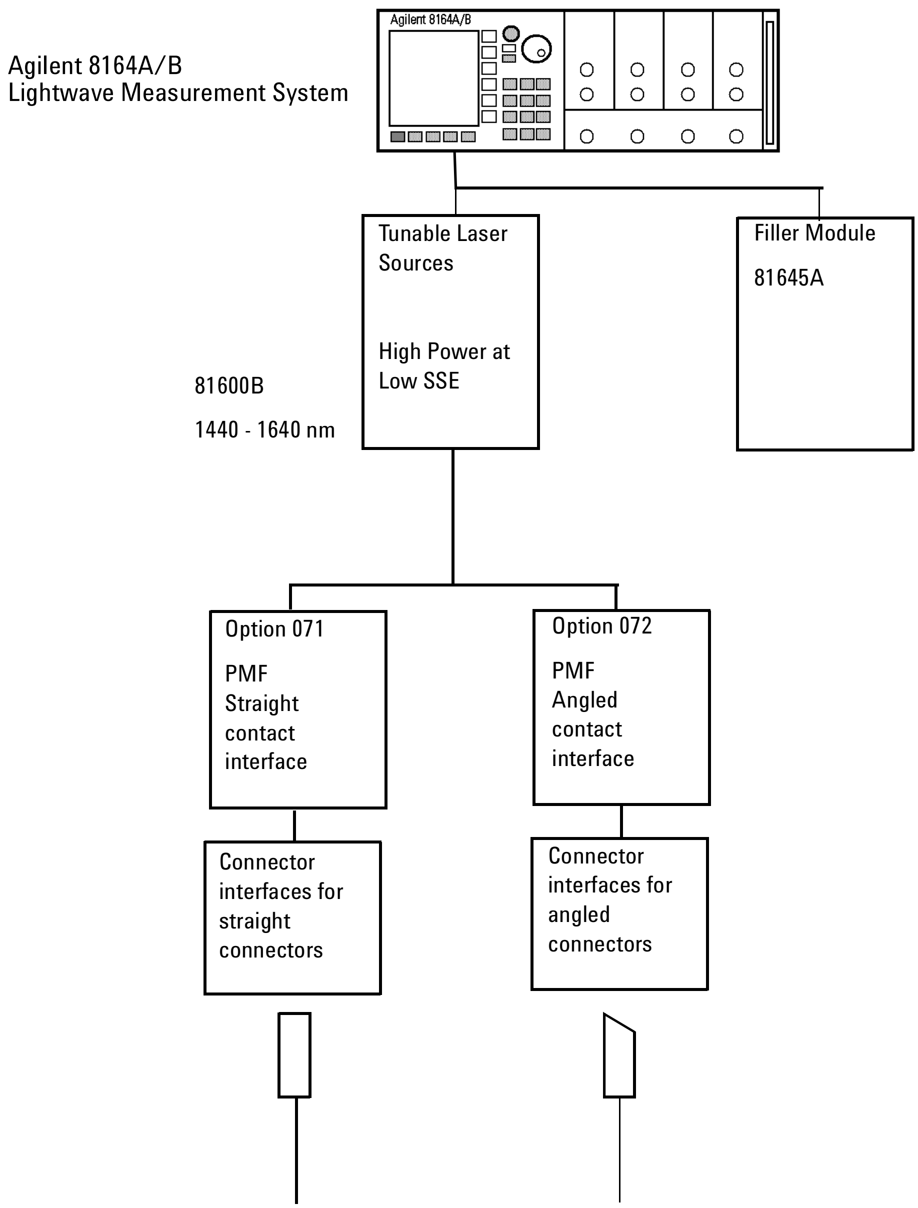


Figure 5 Agilent 8164A/B mainframes, Tunable Laser Module, and Options

Modules

The Agilent 8164A/B Lightwave Measurement System supports the Agilent 81600B Tunable Laser module.

Tunable Laser Modules	
Model No.	**Description**
Agilent 81600B	Tunable Laser for the test of critical dense-WDM components in all-band.

Filler Module

Filler Module	
Model No.	**Description**
Agilent 81645A	Filler Module

The Agilent 81645A Filler Module is required to operate the Agilent 8164A/B mainframe if it is used without a back-loadable Tunable Laser module. It can be used to:

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

See the "Installation and Maintenance" chapter of the Agilent 81600B Tunable Laser Module User's Guide for more details on installing the Agilent 81645A Filler Module.

User's Guides

User's Guides		
Opt	**Description**	**Part No.**
	Agilent 81600B Tunable Laser Module User's Guide	81600-90B11
ABJ	Japanese Agilent 81600B Tunable Laser Module User's Guide	81600-95B11
ABF	French Agilent 81600B Tunable Laser Module User's Guide	81600-92B11
8164A 0B2	Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System Programming Guide	08164-90B63
8164A 0BF	Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System User's Guide	08164-90B14

Options

Option 003 - Agilent 81482B, Agilent 81682B, Agilent 81642B

Built-in optical attenuator with 60 dB attenuation range.

NOTE

The Agilent 81640B, Agilent 81680B, and Agilent 81480B Tunable Laser Modules have a built-in optical attenuator as standard for Output 2, the High Power output.

Option 071 - All Tunable Laser Modules

Polarization-maintaining fiber, Panda-type, for straight contact connectors.

Option 072 - All Tunable Laser Modules

Polarization-maintaining fiber, Panda-type, for angled contact connectors.

Connector Interfaces and Other Accessories

The Agilent 81600B Tunable Laser module is supplied with one of two connector interface options:

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

Option 071: Straight Contact Connector

If you want to use straight connectors (such as FC/PC, Diamond HMS-10, DIN, Biconic, SC, ST or D4) to connect to the instrument, you must do the following:

1. Attach your connector interface to the interface adapter. See Figure 7 for a list of the available connector interfaces.
2. Connect your cable (see Figure 6).

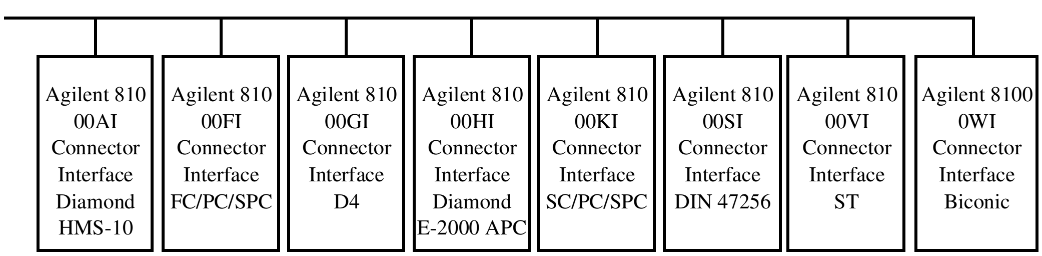


Figure 6 Option 071: PMF with Straight Contact Connectors

Figure 7 Straight Contact Connector Interfaces

Description	Model No.
Biconic	Agilent 81000 WI
D4	Agilent 81000 GI
Diamond HMS-10	Agilent 81000 AI
DIN 47256	Agilent 81000 SI
FC / PC / SPC	Agilent 81000 FI
SC / PC / SCP	Agilent 81000 KI
ST	Agilent 81000 VI
Diamond E-2000 APC	Agilent 81000 HI

Option 072: Angled Contact Connector

If you want to use angled connectors (such as FC/APC, Diamond HRL-10, or SC/APC) to connect to the instrument, you must do the following:

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

2 Connect your cable (see Figure 8).

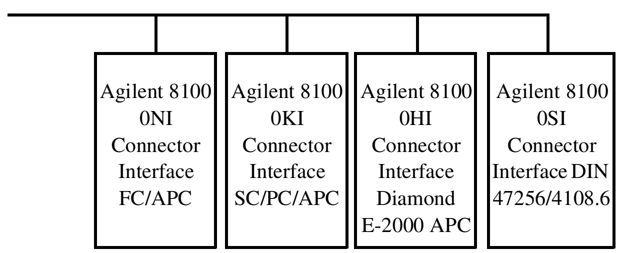


Figure 8 Option 072: PMF with Angled Contact Connector

Table 1 Angled Contact Connector Interfaces

Description	Model No.
DIN 47256-4108.6	Agilent 81000 SI
FC / APC	Agilent 81000 NI
SC / PC / APC	Agilent 81000 KI
Diamond E-2000 APC	Agilent 81000 HI

3
Specifications

The Agilent 81600B Tunable Laser module is produced to the ISO 9001 international quality system standard as part of Agilent Technologies' commitment to continually increasing customer satisfaction through improved quality control.

Specifications describe the modules' warranted performance. Supplementary performance characteristics describe the modules non-warranted typical performance.

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

Definition of Terms

This section defines terms that are used both in this chapter and "Performance Tests" on page 45.

Generally, all specifications apply for the given environmental conditions after the stated warm-up time.

A Typical Value is a characteristic describing the product performance that is usually met but not guaranteed.

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

Static Conditions

The static specifications describe the behavior of the instrument when stepping.

Absolute Wavelength Accuracy

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

Conditions: constant power level, temperature within operating temperature range, coherence control off, measured at high power output.

Validity: within given time span after wavelength zeroing, at a given maximum temperature difference between calibration and measurement.

Measurement with wavelength meter. Averaging time given by wavelength meter, ≥1 s.

NOTE The absolute wavelength accuracy of Output 1, the Low SSE Output, of the Agilent 81600B Tunable Laser module is the same as the absolute wavelength accuracy of Output 2, the High Power Output (guaranteed by design).

Effective Linewidth

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

Conditions: temperature within operating temperature range, coherence control on, power set to specified value.

Measurement with heterodyning technique: the output of the laser under test is mixed with another laser of the same type on a wide bandwidth photodetector. The electrical noise spectrum of the photodetector current is measured with an Agilent Lightwave Signal Analyzer, and the linewidth is calculated from the heterodyne spectrum (Lightwave signal analyzer settings: resolution bandwidth 1 MHz; video bandwidth 10 kHz; sweep time 20 ms; single scan).

Linewidth

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

Conditions: temperature within operating temperature range, coherence control off, power set to maximum flat power (maximum attainable power within given wavelength range).

Measurement with 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 paths is longer than the coherence length of the laser. The electrical noise spectrum of the photodetector current is measured with an Agilent Lightwave Signal Analyzer, and the linewidth is calculated from the heterodyne spectrum (Lightwave signal analyzer settings: resolution bandwidth 1 MHz; video bandwidth 10 kHz; sweep time 20 ms; single scan).

Alternative measurement with heterodyning technique: the output of the laser under test is mixed with another laser beam of the same type on a wide bandwidth photodetector. The electrical noise spectrum of the photodetector current is measured with an Agilent Lightwave Signal Analyzer, and the linewidth is calculated from the heterodyne spectrum.

Lightwave signal analyzer settings: resolution bandwidth 1 MHz; video bandwidth 10 kHz; sweep time 20 ms; single scan.

Minimum Output Power

The minimum output power for which the specifications apply.

Mode-Hop Free Tuning Range

The tuning range for which no abrupt wavelength change occurs during fine wavelength stepping. Abrupt change is defined as change of more than 25 pm.

Conditions: within specified wavelength range, at specified temperature range and output power. Tuning from outside into the mode-hop free tuning range is not allowed.

Modulation Depth

The peak-to-peak optical power change divided by the average optical power for a given sinusoidal input voltage at the analog modulation input, expressed in percent.

Conditions: at a specified output power and wavelength range, temperature within operating temperature range, at a given sinusoidal input voltage.

Measurement: with a photoreceiver and oscilloscope.

Modulation Extinction Ratio

The ratio of total power in on-state to total power in off-state, expressed in dB.

Conditions: Internal or external modulation, tunable laser at highest power setting.

Measurement with optical spectrum analyzer. Tunable laser switched on and off.

Modulation Frequency Range

The range of frequencies for which the modulation index is above –3 dB of the highest modulation index. In this context, modulation index is defined as half of the peak-to-peak AC power amplitude, divided by the average power.

Output Power

The achievable output power for the specified TLS tuning range.

Conditions: temperature within operating temperature range.

Measurement: with power meter at the end of a single-mode fiber patch cord.

Output Isolation

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

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

Peak Power

The highest optical power within specified wavelength range.

Polarization Extinction Ratio

The ratio of optical power in the slow axis of the polarization-maintaining fiber to optical power in the fast axis within a specified wavelength range.

Conditions: only applicable for TLS with polarization maintaining fiber with the TE mode in slow axis and oriented in line with connector key, at constant power level.

Measurement with a polarization analyzer at the end of a polarization-maintaining patch cord, by sweeping the wavelength, thereby creating circular traces on the Poincaré sphere, then calculating the polarization extinction ratio from the circle diameters.

Power Flatness Over Modulation

When changing the modulation frequency, and measuring the differences between actual power level and the displayed power level (in dB), the power flatness is ± half the span between the maximum and the minimum value of all differences.

Conditions: uninterrupted line voltage, constant power setting, temperature variation within ±2 K, external modulation ON, at the given wavelengths.

Measurement with optical power meter.

Power Flatness Versus Wavelength

When changing the wavelength at constant power setting and recording the differences between actual and displayed power levels, the power flatness is ± half the span (in dB) between the maximum and the minimum of the measured power levels.

Conditions: uninterrupted TLS output power, constant power setting, temperature variation within ±1K, coherence control off.

Measurement with optical power meter.

Power Linearity

When changing the power level and measuring the differences (in dB) between actual and displayed power levels, the power linearity is ± half the span (in dB) between the maximum and the minimum value of all differences.

Conditions: power levels from within specified output power range, uninterrupted TLS output power, fixed wavelength settings and constant temperature (power drift effects excluded), coherence control off.

Measurement with optical power meter.

Power Repeatability

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

Conditions: uninterrupted TLS output power, constant wavelength, temperature variation within ±1 K, observation time 10 min., coherence control off.

Measurement with optical power meter.

NOTE

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

Power Stability

The change of the power level during given time span, expressed as ± half the span (in dB) between the highest and lowest actual power.

Conditions: uninterrupted TLS output power, constant wavelength and power level settings, temperature variation within ±1 K, time span as specified, coherence control off.

Measurement with optical power meter.

Relative Intensity Noise (RIN)

The square of the (spectrally resolved) RMS optical power amplitude, P_{RMS}^2, divided by the measurement bandwidth, B_e, and the square of the average optical power, P_{avg}, expressed in dB/Hz.

$$IN = 10\log\left(\frac{P_{RMS}^2}{P_{avg}^2 B_e}\right)\left[\frac{dB}{Hz}\right]$$

Conditions: at specified output power, coherence control off, temperature within operating temperature range, frequency range 0.1 to 6 GHz.

Measurement with Agilent Lightwave Signal Analyzer.

Relative Wavelength Accuracy

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

Conditions: uninterrupted TLS output power, constant power level, temperature within operating temperature range, observation time 10 minutes maximum (constant temperature), coherence control off, measured at high power output.

Measurement with wavelength meter. Averaging time given by wavelength meter, ≥1 s.

NOTE

The relative wavelength accuracy of Output 1, the Low SSE Output, of the Agilent 81600B Tunable Laser module is the same as the relative wavelength accuracy of Output 2, the High Power Output (guaranteed by design).

Return Loss

The ratio of optical power incident to the TLS output port, at the TLS's own wavelength, to the power reflected from the TLS output port.

Conditions: TLS disabled.

Sidemode Suppression Ratio

The ratio of optical power in the main mode to the optical power of the highest sidemode within a distance of 0.1 to 6 GHz to the main signal's optical frequency, expressed in dB.

$$SR = 10\log\left(\frac{P_{signal}}{P_{highestsidemode}}\right)[dB$$

Conditions: at a specified output power and wavelength range, temperature within operating temperature range, coherence control off.

Measurement with the Agilent Lightwave Signal Analyzer, by analyzing the heterodyning between the main signal and the highest sidemode.

Signal-to-Source Spontaneous Emission (SSE) Ratio

The ratio of signal power to maximum spontaneous emission power in 1 nanometer bandwidth within a ±3 nm window around the signal wavelength, where ±1 nm around the signal wavelength is excluded, at the specified output power, expressed in dB/nm.

Conditions: output power set to specified values, at temperatures within operating temperature range, coherence control off.

Measurement with 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. On low-SSE output (if applicable), with fiber Bragg grating inserted between the TLS and the OSA in order to suppress the signal, thereby enhancing the dynamic range of the OSA.

NOTE The specified signal-to-SSE ratio is also applicable to output powers higher than the specified values.

Signal-to-Total-Source Spontaneous Emission

The ratio of signal power to total spontaneous emission power, at the specified achievable output power, expressed in dB.

Conditions: output power set to specified values, at temperatures within operating temperature range, coherence control off.

Measurement with optical spectrum analyzer, by integrating the source spontaneous emission and excluding the remnant signal. On low-SSE output (if applicable), with fiber Bragg grating inserted between the TLS and the OSA in order to suppress the signal, thereby enhancing the dynamic range of the OSA.

NOTE The specified signal-to-total-SSE ratio is also applicable to output powers higher than the specified values.

Wavelength Range

The range of wavelengths for which the specifications apply.

Wavelength Repeatability

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

Conditions: uninterrupted TLS output power, constant power level, temperature within operating temperature range, coherence control off, short time span.

Measurement with wavelength meter at high power output. Averaging time given by wavelength meter, ≥1 s.

NOTE

The wavelength repeatability of Output 1, the Low SSE Output, of the Agilent 81600B Tunable Laser module is the same as the relative wavelength accuracy of Output 2, the High Power Output (guaranteed by design).

NOTE

The long-term wavelength repeatability can be obtained by taken the wavelength re.peatability and wavelength stability into account.

Wavelength Resolution

The smallest selectable wavelength increment/decrement.

Wavelength Stability

The change of wavelength during given time span, expressed as ± half the span between the maximum and the minimum of all actual wavelengths.

Conditions: uninterrupted TLS output power, constant wavelength and power level settings, coherence control off, temperature variation within ±1 K, time span as specified.

Measurement with wavelength meter. Averaging time given by wavelength meter, ≥1 s.

Dynamic Conditions

The dynamic specifications describe the behavior of the instrument when sweeping over the wavelength range.

Add-on Specification Under Dynamic Conditions

These are the values to be arithmetically summed to the corresponding static uncertainties to get the total uncertainties in dynamic operations (swept mode). The total uncertainty is obtainable with the following formula:

$$\text{TotalSpec}_{\text{dynamic}} = \text{Spec}_{\text{static}} + \text{add-on}_{\text{dynamic}}$$

NOTE

This arithmetic sum is used in the data sheet for the convenience of the reader. This has no relationship to the method of measuring and calculating these characteristics. See the Performance Test for further explanations.

Logged Wavelength

The wavelength measured by the internal wavelength meter. This wavelength can be read with the logging function.

Wavelength Accuracy

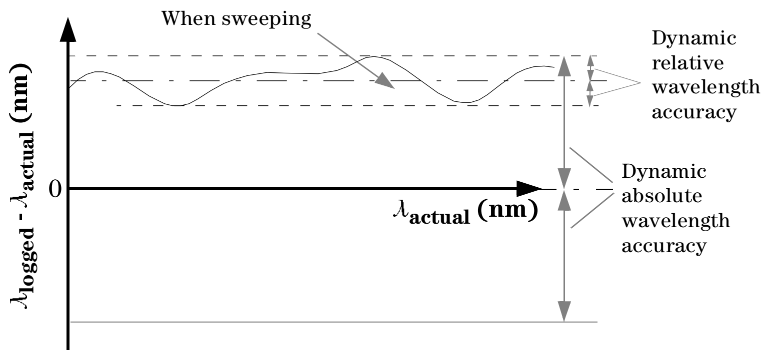


Figure 9 The relationship between the two wavelength accuracy parameters specified.

Dynamic absolute wavelength accuracy

The maximum difference between the *Logged Wavelength* and the actual wavelength in the swept mode. Wavelength is defined as the wavelength in vacuum.

Conditions: same as static, at specified sweep speed, no mode hop.

Measurement: with optical power meter, via IL measurement of reference component exhibiting many stable transmission peaks (Wavelength Reference Unit), relative to the static conditions, with linear interpolation of logged wavelengths. The transmission peaks represent the control points.

Dynamic relative wavelength accuracy

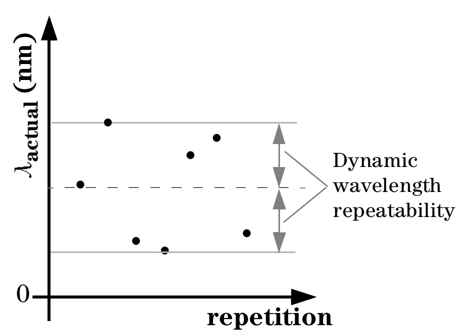
When measuring the differences between the actual and logged wavelength in swept mode, the dynamic relative wavelength accuracy is ±half the span between the maximum and minimum value of all differences.

Conditions: same as static, at specified sweep speed, no mode hop.

Measurement: with optical power meter, via IL measurement of reference component exhibiting many stable transmission peaks (Wavelength Reference Unit), relative to the static conditions, with linear interpolation of logged wavelengths. The transmission peaks represent the control points.

Dynamic wavelength repeatability

The random uncertainty in reproducing the *Logged Wavelength* when sweeping many times is expressed as ±half the span between the maximum and minimum of all values of this Logged Wavelength.

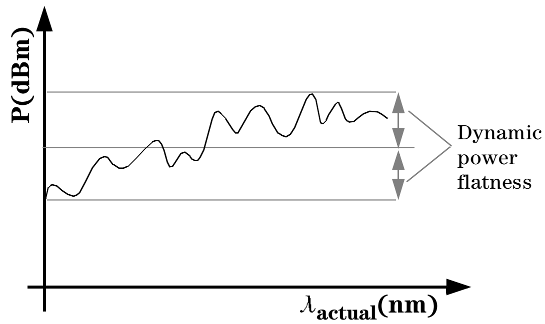


Conditions: same as static, at specified sweep speed, no mode hop.

Measurement: with optical power meter, via IL measurement of reference component exhibiting many stable transmission peaks (Wavelength Reference Unit), with linear interpolation of the logged wavelength. The transmission peaks represent the control points.

Dynamic power flatness

When recording the actual output power of the TLS in swept mode, the dynamic power flatness is ±half the span between the maximum and minimum of the measured power levels.



Dynamic relative power flatness

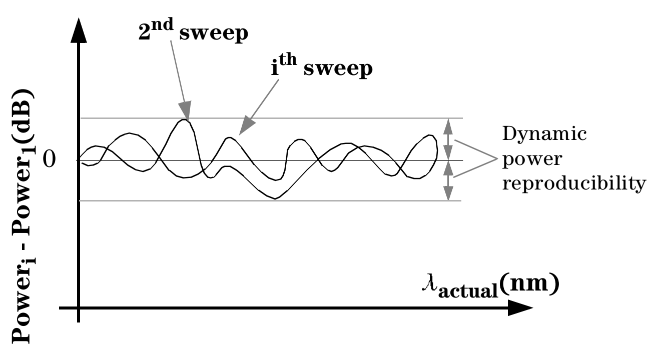
The high frequency part of the *Dynamic power flatness*: obtainable by referencing the power measured at high sweep speed to the power measured at low sweep speed.

Conditions: uninterrupted TLS output power, constant power setting, temperature variation within ±1K, at specified sweep speed, no mode hop.

Measurement: with optical power meter, relative to low sweep speed conditions.

Dynamic power reproducibility

The random uncertainty in reproducing the output power at the same actual wavelength referenced to the first sweep, when sweeping many times. It's expressed as ±half the maximum span over wavelength between the maximum and minimum of all actual values of these differences in power.



Conditions: uninterrupted TLS output power, temperature variation within ±1K, short time span, at specified sweep speed, no mode hop.

Measurement: with optical power meter, power samples linearly interpolated for comparison at the same wavelength.

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Tunable Laser Module Specifications

Agilent 81600B				1.5
Wavelength range	1440 nm to 1640 nm			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tuning range	full wavelength range			
Max. Tuning speed	80 nm/s			
	Specification under static condition	Add-on specification under dynamic condition (typ.) [10]		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1, 2, 11]	±10 pm	±0.4 pm	±1.0 pm	±2.5 pm
Relative wavelength accuracy [1, 2, 11]	±5 pm, typ. ±2 pm	±0.4 pm	±0.8 pm	±2.0 pm
Wavelength repeatability [2, 11]	±0.8 pm, typ. ±0.5 pm			
		Specification under dynamic condition (typ.)		
Dynamic wavelength repeatability [2, 10]		±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [2] (typ., 24 hours at constant temperature)	≤ ±1 pm			
Linewidth (typ.), coherence control off Effective linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1460 – 1625 nm, at flat output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Output power [3] (continuous power during tuning)	≥ +3 dBm peak typ. ≥ +2 dBm (1520 – 1610 nm) ≥ -2 dBm (1475 – 1625 nm) ≥ -7 dBm (1440 – 1640 nm)		≥ +9 dBm peak typ. ≥ +8 dBm (1520 – 1610 nm) ≥ +4 dBm (1475 – 1625 nm) ≥ -1 dBm (1440 – 1640 nm)	
Minimum output power [3]	-7 dBm		-1 dBm (-60 dBm in attenuation mode)	
Power linearity [3]	±0.1 dB		±0.1 dB (±0.3 dB in attenuation mode)	
Power stability [3, 9]	±0.01 dB, 1 hour typ. ±0.03 dB, 24 hours			
	Specifications under static condition	Dynamic relative power flatness (typ.) [10]		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Power flatness versus wavelength Output 1 (low SSE) [3]	±0.2 dB typ. ±0.1 dB	±10 mdB	±15 mdB	±30 mdB
Power flatness versus wavelength Output 2 (high power) [3]	±0.3 dB typ. ±0.15 dB	±10 mdB	±15 mdB	±30 mdB
Dynamic power reproducibility (typ.) [3, 9,10]		±5 mdB	±10 mdB	±15 mdB
Power repeatability (typ.) [3, 9]	±3 mdB			
Side-mode suppression ratio (typ.) [4, 8]	≥ 60 dB (1520 nm – 1610 nm)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Signal to source spontaneous emission ratio [5, 6, 8]	≥ 70 dB/nm [7] (1520 nm – 1610 nm) ≥ 66 dB/nm [7] (typ.,1475 nm – 1625 nm) ≥ 60 dB/nm [7] (typ.,1440 nm – 1640 nm)		≥ 48 dB/nm (1520 nm – 1610 nm) ≥ 43 dB/nm (1475 nm – 1625 nm) ≥ 37 dB/nm (1440 nm – 1640 nm)	

Signal to total source spontaneous emission ratio [6, 8]	≥ 65 dB (1520 nm – 1610 nm)[7] ≥ 57 dB (typ., 1440 nm – 1640 nm)[7]	≥ 30 dB (typ., 1520 - 1610 nm)
Relative intensity noise (RIN, typ.) [8]	-155 dB/Hz (1520 – 1610 nm)	

1. Valid for one month and within a ±4.4 K temperature range after automatic wavelength zeroing. Wavelength zeroing is an internal function that performs an automatic self-adjustment.
2. At CW operation. Measured with wavelength meter based on wavelength in vacuum.
3. Applies to the selected output.
4. Measured by heterodyne method.
5. Value for 1 nm resolution bandwidth.
6. Measured with optical spectrum analyzer.
7. Measured with Fiber Bragg grating to suppress the signal.
8. Output power as specified per wavelength range and output port.
9. Warm-up time 1 hour.
10. Conditions: Any 50 nm between 1475 nm - 1620 nm for:
    - Output 1 when flat output power is set to ≥ -2 dBm
    - Output 2 when flat output power is set to ≥ 4 dBm.
11. Specification typical for:
    - Output 1 when *both* wavelength is set to > 1620 nm *and* output power is set to ≥ -7 dBm
    - Output 2 when *both* wavelength is set to > 1620 nm *and* output power is set to ≥ -1 dBm.

Supplementary Performance Characteristics

Operating Modes

Internal Digital Modulation [1]

50% duty cycle, 200 Hz to 300 kHz. Modulation output: TTL reference signal.

[1] Agilent 81600B: displayed wavelength represents average wavelength while digital modulation is active.

External Digital Modulation [1]

> 45% duty cycle, fall time < 300 ns, 200 Hz to 1 MHz. Modulation input: TTL signal.

External Analog Modulation [1]

≤ 15% modulation depth, 5 kHz to 20 MHz.
Modulation input: 5 Vp-p.

External Wavelength Locking

> ±70 pm at 10 Hz
> ±7 pm at 100 Hz
Modulation input: ±5 V

Coherence Control

For measurements on components with 2-meter 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 drastically reducing interference effects in the test setup.

Continuous Sweep Mode

Tuning speed adjustable up to: 80 nm/s.

Mode-hop free span:

Any 50 nm between 1475 nm - 1620 nm for:

- Output 1 when flat output power is set to ≥ -2 dBm
- Output 2 when flat output power is set to ≥ 4 dBm.

Ambient temperature between +20°C and +35°C.

Stepped Mode

Full instrument performance.

General

Output Isolation (typ.):

50 dB

Return loss (typ.):

60 dB (options 022, 072);
40 dB (options 021, 071).

Polarization Maintaining Fiber (Options 071, 072):

Fiber type: Panda.
Orientation: TE mode in slow axis, in line with connector key.
Extinction Ratio: 16 dB typ.

Laser Class:

The laser sources used in this equipment are classified as class 1M according to IEC 60825-1 (2001).

The laser sources comply with FDA 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated 2001-July-26.

Recalibration Period:

2 years.

Warm-up Time:

< 20 min, immediate operation after boot-up.

Environmental

Storage Temperature:

–40°C to +70°C.

Operating Temperature:

+10°C to +35°C .

Humidity:

< 80% R. H. at +10°C to +35°C.
Specifications are valid in non-condensing conditions.

4
Performance Tests

The procedures in this section tests the optical performance of the instrument. The complete specifications to which the Agilent 81600B are tested are given in “Specifications" on page 27. All tests can be performed without access to the interior of the instrument. The performance tests refer specifically to tests using the Diamond HMS-10/Agilent connector.

Required Test Equipment

The equipment required for the Performance Test is listed in Table 2. Any equipment that satisfies the critical specifications of the equipment given in Table 2, may be substituted for the recommended models.

Table 2 Equipment Required

Instrument	Description of Instrument/Accessory	#071	#072
Agilent 86142B[1]	Optical Spectrum Analyzer	1	1
Agilent 8164A/B	Lightwave Measurement System	1	1
WA-1500	Burleigh Wavemeter	1	1
81618A or 81619A	Optical Head Interface Module	1	1
81626B #CO 1	Standard Optical Head	1	1
81634A/B	Power Sensor	1	1
Agilent 81000SA	DIN 47256/4108 Connector Adapter	1	1
Agilent 81000AI	HMS-10 Connector Interface	1	
Agilent 81000SI	DIN 47256/4108 Connector Interface	2	2
Agilent 81000FI	FC/PC Connector Interface	1	1
Agilent 81101AC	Diamond HMS-10/Diamond HMS-10 Patchcord	1	
Agilent 81101PC	Diamond HMS-10/Agilent FC/PC Patchcord	1	
Agilent 81113PC	Diamond HMS-10/Agilent FC/Super PC Patchcord	1	1
Agilent 81113SC	Diamond HMS-10/Agilent DIN 47256/4108 Patchcord		1
1005-0255	Adapter DIN-DIN	1	
N/A	Fiber Bragg Grating[2]	1	1
Equipment for optional tests:			
81637B[3]	Fast Power Meter	1	1
N/A	Wavelength Reference unit (Fabry-Perot etalon)[4]	1	1
N/A	Wavelength Reference unit (Michelson Interferometer) - optional	1	1

[1] You can use the HP 71452B or HP 71450A #100 instead of the Agilent 86142B.
[2] approximately 1520nm, 2nm @ 3dB.
[3] You can use the 81636B instead of the 81637B. Required characteristic: Sample rate ≥ 40 kHz.
[4] Required characteristics:

- Optical length: 9.35 ± 0.08 mm at 1510 nm;
- Reflectivity: 50 ± 2%;
- Wavelength range: 1250 - 1650 nm;
- Birefringence: DIN 3140-6 / 20 (i.e. 20 nm/1 cm or $2*10^{-6}$)

- Linear polarizer with AR-coating at FP-etalon input (~ 30 dB extinction ratio, aligned with principal state of polarization)
- Temperature dependency: drift < 0.1 pm over the test duration (~15 min). A reasonable target temperature coefficient is < 0.3 pm/K (typically required active temperature regulation)
- Insertion loss (minimum value over the specified wavelength range): < 3.5 dB.
- Fiber connections: angled PM fiber at input (requires DUT-independent patchcord) and angled SM fiber at output.

Test Record

Results of the performance test may be tabulated in the Test Record provided at the end of the test procedures. It is recommended that you fill out the Test Record and refer to it while doing the test. Since the test limits and setup information are printed on the Test Record for easy reference, the record can also be used as an abbreviated test procedure (if you are already familiar with the test procedures). The Test Record can also be used as a permanent record and may be reproduced without written permission from Agilent Technologies.

Test Failure

Always ensure that you use the correct cables and adapters, and that all connectors are undamaged and extremely clean.

If the Agilent 81600B Tunable Laser module fails any performance test, return the instrument to the nearest Agilent Technologies Sales/Service Office for repair.

Instrument Specification

Specifications are the performance characteristics of the instrument which are certified. These specifications, listed in “Specifications" on page 27, are the performance standards or limits against which the Agilent 81600B Tunable Laser module can be tested.

The specifications also list some supplemental characteristics of the Agilent 81600B Tunable Laser module. Supplemental characteristics should be considered as additional information.

Any changes in the specifications due to manufacturing changes, design, or traceability to the National Institute of Standards and Technology (NIST), will be covered in a manual change supplement, or revised manual. Such specifications supersede any that were previously published.

Performance Test Instructions

NOTE

- Make sure that all fiber connectors are clean. clean
- Turn the instruments on, enable the laser and allow the instruments to warm up.
- Ensure that the Device Under Test (DUT) and all the test equipment is held within the environmental specifications given in "Specifications" on page 27

General Test Setup

Insert your Tunable Laser module from the rear into slot 0 of the Agilent 8164A/B Lightwave Measurement System.

Wavelength Tests

NOTE

When performing wavelength tests, zero the Tunable Laser first.

Move to Channel 0, press [Menu], select <λ *Zeroing*>.

Zeroing takes approximately 2 minutes.

Connect the Tunable Laser module to the Wavelength Meter as shown in Figure 10.

On the Agilent 81600B Tunable Laser Module, connect the Output 2, the high power output.

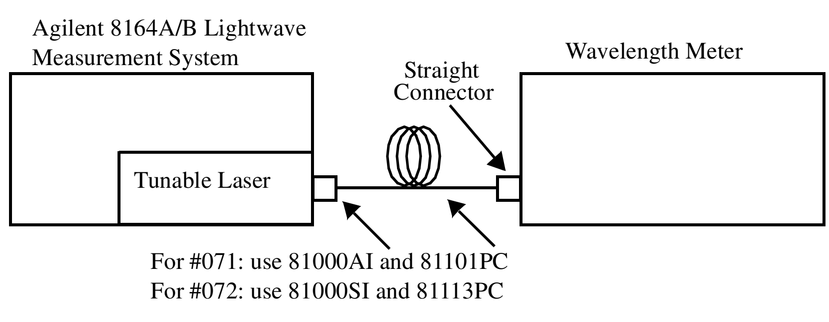


Figure 10 Test Setup for Wavelength Tests

General Settings of Wavelength Meters for all Wavelength Tests

Set the Burleigh WA-1500 to the following settings:

- Set *Display* to Wavelength.
- Set *Medium* to Vacuum.

- Set *Resolution* to Auto.
- Set *Averaging* to On.
- Set *Input Attenuator* to Auto.

Wavelength Accuracy

The steps below explain how to calculate the Relative Wavelength Accuracy, Absolute Wavelength Accuracy, and the Mode Hop Free Tuning Result.

Relative Wavelength Accuracy

1 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

2 Set the menu parameters to the values shown in Table 3.

Table 3 Tunable Laser Channel Settings

Tunable Laser Channel Menu Parameters	Values
<Wavelength Mode>	<λ>
<Source State>	*<Off>*
<Power Unit>	*<dBm>*
<Power Mode>	*<Automatic>*
Modulation <Mod src>	<off>

3 On the Agilent 81600B Tunable Laser module:
Connect the fiber output to Output 2, the High Power output.
Set *<Optical Output>* to *<High Power (2)>*.

4 Set the wavelength and power of your Tunable Laser module to the values given in Table 4.

Table 4 Initial Wavelength and Power Settings for Relative Wavelength Accuracy Tests

Module	Wavelength [λ]	Power [*P*]
Agilent 81600B	1440.000 nm	–1.00 dBm

5 Press the key beside the laser output to switch on the laser output.

6 Wait until the wavelength meter has settled, then, note the wavelength displayed on the wavelength meter in the test record.

7 Increase the wavelength setting of the Tunable Laser module by the steps shown in the test record.

8 Repeat steps 6 and 7 up to the maximum wavelength values shown in Table 5.

Table 5 Maximum Wavelength for Relative Wavelength Accuracy Tests

Tunable Laser Module	Maximum Wavelength Value
Agilent 81600B	1640 nm

9 Repeat steps 4 through 8 another 4 times.

10 From each repetition of the measurements, choose the maximum and minimum deviations, and note these values in the test record.

11 Determine the **Relative Wavelength Accuracy Summary** of all repetitions:

a Take the largest Maximum Deviation, and note it as the Largest Maximum Deviation in the test record.

b Take the smallest Minimum Deviation, and note it as the Smallest Minimum Deviation in the test record.

NOTE The largest Maximum Deviation is the largest positive value and the smallest Minimum Deviation is the largest negative value (largest deviation above and below zero respectively).

12 Determine the **Relative Wavelength Accuracy Result**:

Subtract the Smallest Minimum Deviation from the Largest Maximum Deviation. Record this value as the Relative Wavelength Accuracy Result.

13 Determine the **Absolute Wavelength Accuracy**:

From the measurements taken in the Relative Wavelength Accuracy test, take the largest absolute value from either the Largest Maximum Deviation or the Smallest Minimum Deviation taken in step 12 and note this value as Absolute Wavelength Accuracy.

Mode Hop Free Tuning

14 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

15 Set the menu parameters to the values shown in Table 3.

16 On the Agilent 81600B Tunable Laser module: Connect the output fiber to Output 2, the High Power output.
Set <*Optical Output*> to <*High Power (2)*>.

17 Set the wavelength and power of your Tunable Laser module to the values given in Table 6.

Table 6 Initial Wavelength and Power Settings for Mode Hop Free Tuning Tests

Module	Wavelength [λ]	Power [*P*]
Agilent 81600B	1440.000 nm	–1.00 dBm

18 Press the key beside the laser output to switch on the laser output.

19 Then perform steps 4 through 8 once.

20 Note the wavelength displayed by the wavelength meter in the test record.

21 Increase wavelength setting on Tunable Laser by the steps shown in the test record.

22 Repeat steps 6 and 7 up to the maximum wavelength values shown in Table 5.

23 Determine the maximum and minimum deviations, and note these values in the test record.

24 Take the largest value of either the maximum or minimum deviation. Record this value as the **Mode Hop Free Tuning Result.**

25 You do not need to repeat the Mode Hop Free Tuning test.

Wavelength Repeatability

1 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

2 Set the menu parameters to the values shown in Table 3.

3 On the Agilent 81600B Tunable Laser module:
Connect the output fiber to Output 2, the High Power output.
Set <*Optical Output*> to <*High Power (2)*>.

4 Set the wavelength and power for each Tunable Laser module to the values given in Table 7.

.

Table 7 Reference Wavelength and Power Settings for Wavelength Repeatability Tests

Module	Wavelength [λ]	Power [*P*]
Agilent 81600B	1440.000 nm	–1.00 dBm

5 Press the key beside the laser output to switch on the laser output.

6 Wait until the wavelength meter has settled. Then measure the wavelength with the wavelength meter and note the result in test record as the reference wavelength, "REF".
7 Set the wavelength of your Tunable Laser module to any wavelength in its range (in the test record, this is given in column “from wavelength”).
8 Set the wavelength of your Tunable Laser module back to the Reference Wavelength and wait until the wavelength meter has settled.
9 Measure the wavelength with the Wavelength Meter and note the result in test record.
10 Repeat steps 7 through 9 with all wavelength settings given in the “from wavelength” column of the test record.
11 From all wavelength measurements pick the largest measured value and the smallest measured value.
12 Calculate the wavelength repeatability by subtracting the largest measured value from the smallest measured value.

Power Tests

Maximum Output Power

Make sure the instruments have warmed up before starting the measurement.

NOTE

- Absolute Power Accuracy is not specified.
- The result of the measurement below is greatly influenced by the quality and the matching of the interconnections used.

1 Set up the equipment as shown in Figure 11.

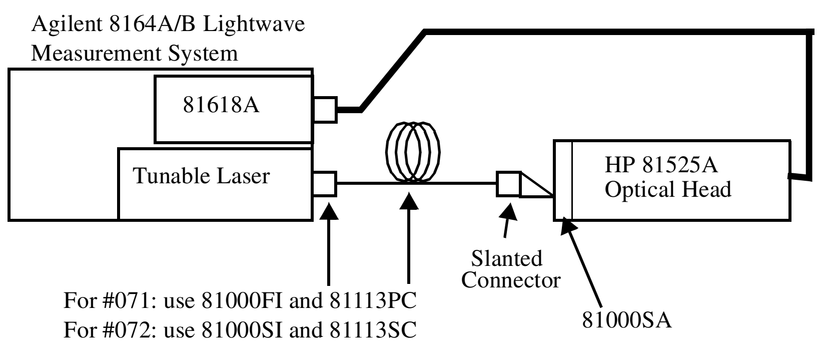


Figure 11 Test Setup for the Maximum Output Power Tests

2 Set the Power Meter to the following settings:
   a Select automatic ranging; press *Auto* as required.
   b Set T, the averaging time, to 500 ms.
   c Select *dBm* as the power units.
   d While the laser is switched off, zero the power meter. Press *Zero* from the *Menu*.

3 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

4 Set the menu parameters to the values shown in Table 3.

5 On the Agilent 81600B Tunable Laser module:
Connect the output fiber to Output 1, the Low SSE output, remember to calibrate the Agilent 81001FF Attenuation Filter.
Set <*Optical Output*> to <*Low SSE (1)*>.

6 Set the wavelength and power for each Tunable Laser module to the values given in Table 8

Table 8 Reference Wavelength and Power Values for Maximum Output Power Tests

Module	**Wavelength** [λ]	**Power** [*P*]
Agilent 81600B - Output 1	1440.000 nm	+12.00 dBm

NOTE The laser output is limited to its maximum possible value at this wavelength, the display will probably show `ExP`.

7 Press the key beside the laser output to switch on the laser output.

8 Set the wavelength of the 81626B to the same as your Tunable Laser module, as given in Table 8.

9 Measure the output power with the 81626B and note the result for this wavelength in the test record.

10 Increase the λ, output wavelength, of the Tunable Laser module to the next value given in the test record.

11 Increase the wavelength of the 81626B to the same value.

12 Note the measured power in the test record for each wavelength

13 Repeat step 10 to step 12 for the full wavelength range

14 On the Agilent 81600B Tunable Laser module:
Connect the output fiber to Output 2, the High Power output, remember to calibrate the Agilent 81001FF Attenuation Filter and set <*Optical Output*> to <*High Power (2)*>.
Then, perform step 6 through step 13 for the full wavelength range.

Power Linearity

Power Linearity - Low Power Test

To measure the power linearity of the Low SSE output, Output 1, of the Agilent 81600B:

1. Set up the equipment as shown in Figure 11.
2. Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].
3. Set the menu parameters to the values shown in Table 3. <*Power Mode*> does not apply.
4. Set the wavelength and power for each Tunable Laser module to the values given in Table 9.

Table 9 Wavelength and Power Settings for Low Power Linearity Tests

Module	Wavelength [λ]	Power [*P*]
Agilent 81600B - Output 1	1580.000 nm	+2.00 dBm

5. On the Agilent 81600B Tunable Laser module:
   Connect the output fiber to Output 1, the Low SSE output.
   Set <*Optical Output*> to <*Low SSE (1)*>.
6. Make sure the optical output is switched off.
7. Set the 81626B to the following settings:
   a. Zero the 81626B; from *Menu*, select *Zero*.
   b. Automatic ranging is set by default.
   c. Set the Averaging Time, to 500 ms.
   d. Select dB as the power units.
   e. Set λ, the wavelength, to the same as your Tunable Laser module, as given in Table 9.
8. Press the key beside the laser output to switch on the laser. On the Agilent 81600B, press the key beside Output 1, the Low SSE output.
9. Record the power displayed by the 81626B.
10. Press *Disp–>Ref* on the 81626B.
11. Change the power setting of your Tunable Laser module to the next value listed in the test record and record the power displayed by the 81626B again.
12. Record the (relative) power displayed by the 81626B as the "Measured Relative Power from start".

13 Calculate the "Power Linearity at current setting” as the sum of "Measured Relative Power from start" and "Power Reduction from start".

14 Repeat step 11 to step 13 for all power levels listed in the test record.

15 Note the maximum and minimum values of the calculated Power Linearity values for the various settings and record these in the test record.

16 Subtract the minimum values from the maximum values of the Power Linearity for the various settings. Record these as the **Total Power Linearity** for the various settings.

Example (Agilent 81600B Output 1)

Power LinearityOutput 1

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+2.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+1.0 dBm	–1.02 dB	+	1.00 dB	=	–0.02 dB
	+0.0 dBm	–1.92 dB	+	2.00 dB	=	+0.08 dB
	–1.0 dBm	–2.95 dB	+	3.00 dB	=	+0.05 dB
	– 2.0 dBm	–4.07 dB	+	4.00 dB	=	–0.07 dB
	– 3.0 dBm	–4.96 dB	+	5.00 dB	=	+0.04 dB
	– 4.0 dBm	–5.97 dB	+	6.00 dB	=	+0.03 dB
	– 5.0 dBm	–6.98 dB	+	7.00 dB	=	+0.02 dB
	– 6.0 dBm	–7.97 dB	+	8.00 dB	=	+0.03 dB
	– 7.0 dBm	–8.98 dB	+	9.00 dB	=	+0.02 dB

Maximum Power Linearity at current setting:	+0.08 dB
Minimum Power Linearity at current setting:	–0.07 dB
Total Power Linearity: (Max Power Linearity – Min Power Linearity)	0.15 dBpp

Power Linearity - High Power Test

Follow the steps below to measure the power linearity (without using attenuation) of the Output2, the High Power output, of the Agilent 81600B

1. Set up the equipment as shown in Figure 11.
2. Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].
3. Set the menu parameters to the values shown in Table 3.
   On the Agilent 81600B Tunable laser module:
   Set <*Power Mode*> to <*Manual Att*>.
4. Set the wavelength and power for each Tunable Laser module to the values given in Table 10.

Table 10 Wavelength and Power Settings for High Power Linearity Tests without Attenuation

Module	**Wavelength** [λ]	**Power** [*P*]	**Attenuation** [*Atten*]
Agilent 81600B - Output 2	1580.000 nm	+8.000 dBm	0.000 dB

NOTE If you use the Agilent 81600B Output 2 without attenuation, refer to the table “Power Linearity Output 2, High Power Upper Power Levels” in the related test record.

5 On the Agilent 81600B Tunable laser module:
Connect the output fiber to Output 2, the High Power output.
Set <*Optical Output*> to <*High Power(2)*>.

6 Peform the steps 6 to 17 of the “Power Linearity - Low Power Test" on page 55.

Power Linearity - Test Using Attenuation

Follow the steps below to measure the power linearity (while using attenuation) for Output 2, the High Power output, of the Agilent 81600B:

1 Set up the equipment as shown in Figure 12.

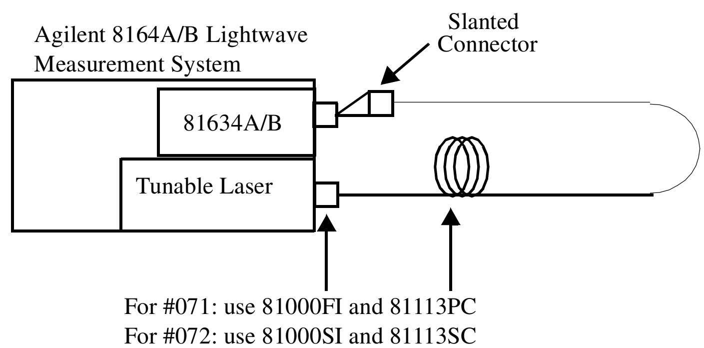


Figure 12 Test Setup for Low Power Linearity Tests

2 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

3 Set the menu parameters to the values shown in Table 3.
On the Agilent 81600B:
Set <*Power Mode*> to <*Manual Att*>.

4 Set the wavelength and power for each Tunable Laser module to the values given in Table 11.

Table 11 Wavelength and Power Settings for High Power Linearity Tests with Attenuation

Module	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B - Output 2	1580.000 nm	+0.000 dBm	0.000 dB

NOTE

If you use the Agilent 81600B Output 2, with attenuation, use the table “Power Linearity Output 2, High Power by attenuator" on page 101

5 On the Agilent 81600B Tunable laser module:
Connect the output fiber to Output 2, the High Power output.
Set <*Optical Output*> to <*High Power(2)*>.

6 Perform the steps 5 to 17 of the “Power Linearity Output 2, High Power by attenuator" on page 101.

Power Flatness over Wavelength

Power Flatness over Wavelength - Without Attenuation

1 Set up the equipment as shown in Figure 11.

Low SSE Output

2 On the Agilent 81600B Tunable Laser module: Connect the output fiber to Output 1, the Low SSE output.

3 Move to the Tunable Laser Channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu]

4 Set the menu parameters to the values shown in Table 3.
On the Agilent 81600B:
Set <*Optical Output*> to <*Low SSE (1)*>.

5 Set the wavelength and power for the Tunable Laser module to the values given in Table 12, Output 1.

Table 12 Wavelength and Power Settings for Power Flatness over Wavelength Tests without Attenuation

Module	Wavelength [λ]	Power [P]	Attenuation [ATTEN]
Agilent 81600B - Output 1	1440.000 nm	–7.000 dBm	Not applicable
Agilent 81600B - Output 2	1440.000 nm	–1.000 dBm	ATT = 0 dB

6 Set the power meter channel of the 81626B to the following settings:

  a With the laser still switched off, zero the power meter. Select [Zero] from [Menu].

  b Autoranging is set by default.

  c Set the averaging time, to 500 ms.

  d Set λ, the wavelength, to the same as your Tunable Laser module, as given in Table 12.

  e Select dB as the power units.

7 Press the key beside the laser output to switch on the laser.

8 Press the *DISP->REF* hardkey on the channel menu of the 81626B.

9 Increase the wavelength of the Tunable Laser module and of the Power Meter to the next value listed in the test record.

10 Measure the change in output power (the value is in dB). Note the result in the test record.

11 Repeat steps 7 and 8 for the wavelength settings given in the test record.

12 From the measurement results calculate the difference between the maximum and minimum deviation from REF and note the result as the Flatness.

High Power Output

13 On the Agilent 81600B Tunable Laser module:
Connect the output fiber to Output 2, the High Power output.
Set <*Optical Output*> to <*High Power (2)*> Set <*Power Mode*> to <*Manual Att*>

14 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu]

15 Set the menu parameters to the vaues shown in Table X.

16 Set the wavelength and power for each Tunable Laser module to the values given in Table 12, Output 2.

17 Repeat steps 7 to 13.

Power Flatness over Wavelength - Using Attenuation

Follow the steps below to measure the power flatness over wavelength (while using attenuation) of the Agilent 81600B, Output 2:

1 Set up the equipment as shown in Figure 12.

2 On the Agilent 81600B Tunable Laser module: Connect the output fiber to Output 2, the High Power output.

3 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

4 Set the menu parameters to the values shown in Table 3 on page 49.
Set <*Optical Output*> to <*High Power(2)*>. Set <*Power Mode*> to <*Manual Att*>.

Table 13 Wavelength and Power Settings for Power Flatness over Wavelength Tests with Attenuation

Module	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B - Output 2	1440.000 nm	0.000 dBm	60.000 dB

5 Set the wavelength and power for the Tunable Laser module to the values given in Table 13.

6 Set the power meter channel of the 81634A/B to the following settings:

a Still having the laser swithed off, zero ther power meter. From the {*Menu*}, select {*Zero*}

b Autoranging is set by default.

c Set the Averaging time, to 500 ms.

d Set the λ, the wavelength, to the same as your Tunable Laser module, as given in Table 12.

e Select dB as the power units.

7 Press the key beside the laser output to switch on the laser.

8 Press the *DISP->REF* key on the channel menu of the 81634A/B.

9 Increase the wavelength of the Tunable Laser module and of the Power Meter to the next value listed in the test record.

10 Measure the change in the output power, value is in dB. Note the result in the test record

11 Repeat steps 9 and 10 for the wavelength settings given in the test record unit the relative power level of all listed wavelengths are measured.

12 From the measurement results calculate the difference between the maximum and minimum deviation from REF and note the result as the Flatness.

Power Stability

Follow the steps below to measure the power stability:

1 Set up the equipment as shown in Figure 11.

Low SEE Output:

2 On the Agilent 81600B Tunable Laser module: Connect the output fiber to Output 1, the low SSE output.

3 Move to the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System and press [Menu].

4 Set the menu parameters to the values shown in Table 3.

5 On the Agilent 81600B:
Set <*Optical Output*> to <*Low SSE (1)*>.

6 Set the wavelength and power for each Tunable Laser module to the values given in Table 14, Output 1

Table 14 Wavelength and Power Settings for Power Stability Tests

Module	Wavelength [λ]	Power [P]
Agilent 81600B - Output 1	1580.000 nm	–7.000 dBm
Agilent 81600B - Output 2	1580.000 nm	–1.000 dBm

7 Ensure that the optical output is switched off.

8 Zero the power meter. Select [Zero] from the [Menu].

9 Press the key beside the laser output to switch on the laser and wait 1 minute.

10 Select the logging application. Press [Appl], select [Logging].

11 Within the logging application, set the power meter as follows:

  a Module selection 2.1 (assumes the use of 81619A in slot 2, 81626B is connected to “Head 1”)

  b Set λ, the wavelength, to the same as your Tunable Laser module, as given in Table 14.

  c Set range to 0 dBm

  d Set Ref mode to Value

  e Set Samples to 4000

  f Set the Average Time to 200ms

  g Set Range mode to Common

  h Set Power unit to dB.

  i Set Ref to the value given in Table 14

12 Start the Logging application by pressing {Measure}. The progress of the measurement is displayed.

13 When the measurement has finished, select {Analysis}

14 From the Statistics window, note

  a the “max” value in the Maximum Deviation field of the test record

  b the “min” value in the Minimum Deviation field of the test record

  c the “ΔP” value in the Power Stability field of the test record

High Power Output:

15 On the Agilent 81600B Tunable Laser module:
Connect the output fiber to Output 2, the high power output.
Set <*Optical Output*> to <*High Power (2)*>. Set <*Power Mode*> to <*Manual Att*>
Then set the wavelength and power to the value given in Table 14, Output 2

16 Repeat item list 6 to 13.

NOTE To test power stability, it is sufficient to do it for approximately 15 minutes rather than 1 hour, to ensure that the power control loop works correctly.

Signal-to-Source Spontaneous Emission

See chapter “Specifications”, “Definition of Terms” for a definition of Signal-to-Source Spontaneous Emission.

Signal-to-Source Spontaneous Emission Tests - High Power Outputs

Follow this procedure to test the Agilent 81600B, Output 2, High Power:

1 Connect the Tunable Laser module to the Optical Spectrum Analyzer as shown in Figure 13.

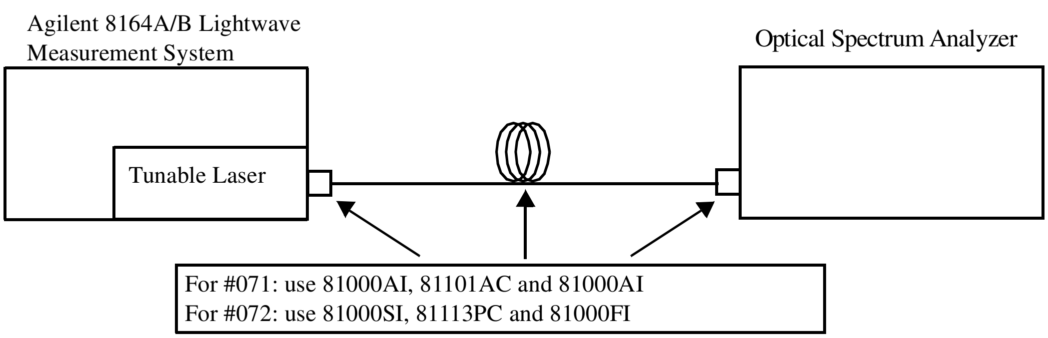


Figure 13 Test Setup for the Source Spontaneous Emission Test - High Power Outputs

2 On the Agilent 81600B Tunable Laser module:
Connect one end of the fiber to Output 2, the High Power output, and the other to the Optical Spectrum Analyzer. On the 8164A/B, set <Optical Output> to <High Power (2)>.

3 At the Tunable Laser channel of the Agilent 8164A/B Lightwave Measurement System, press [Menu].

4 Set the menu parameters to the values shown in Table 3.

5 Ensure the optical output is switched off.

6 Set the wavelength of your Tunable Laser module to the value given in Table 15.

Table 15 Wavelength Settings for Source Spontaneous Emission Tests

Module	Wavelength [λ]
Agilent 81600B - Output 2	1580.000 nm

7 Set the power for each Tunable Laser module to the maximum specified output power as given in the Test Record.

8 Press the key beside the laser output to switch on the laser output.

9 Initialize the Optical Spectrum Analyzer: press *Preset,* the green hardkey, and *Auto Meas*.

10 Set the following on the Optical Spectrum Analyzer:

   a Set Span to 4 nm. Press Span, enter the value.

   b Set the resolution Bandwidth to 0.5 nm. Press [AMPL], press [BW Swp], and enter the value.

   c Set the Sensitivity to -60 dBm. Press [AMPL], press [SENS], and enter the value.

   d Set the wavelength to the value given for your Tunable laser module in Table 15.

NOTE

Using RBW = 0.5 nm for measurement, you can extrapolate to the result RBW = 1 nm by subtracting 3 dB (factor of 10 in the RBW gives 2 x power = 3 dB)

Example: RBW = 0.5 nm results in: $|SSE_{0.5\ nm}|$ = 55.3dB measured

RBW = 1 nm extrapolates to $|SSE_{1\ nm}| = |SSE_{0.5\ nm}|$ - 3dB = 55.3 dB - 3 dB = 52.3 dB

---

11 On the spectrum analyzer, set the Marker to the highest peak and select delta.
(Marker –> HIGHEST PEAK –> DELTA)

12 Using the MODIFY knob move the second marker to the highest peak of the displayed side modes and note the difference, delta, between the two markers in the Test Record.

13 Increase the wavelength of the Tunable Laser by 10 nm as specified in the Test Record.

14 Repeat steps 11 to 13 within the wavelength range of the Tunable Laser.

Signal-to-Source Spontaneous Emission Tests - Low SSE Outputs

Follow this procedure to test the Agilent 81600B, Output 1, Low SSE

The previous setup is limited by the dynamic range of the Optical Spectrum Analyzer. An improvement can be done by reducing the power of the spectral line of the Tunable Laser module by a filter, a Fiber Bragg Grating. However, by this approach, the measurement is limited to a single wavelength (that of the peak attenuation of the Fiber Bragg Grating):

Depending on the output connector option of your Tunable Laser module, the Device Under Test (DUT), the Fiber Bragg Grating should be connected with:

- a straight connector, if you use a TLS with option #071, or
- an angled connector, if you use a TLS with option #072.

NOTE Because the Tunable Laser channel displays the wavelength in air and the Optical Spectrum Analyzer displays the wavelength in a vacuum there is a mismatch between the values displayed by the two instruments.

A good approximation in this wavelength range is:

$\lambda_{OSA} = \lambda_{TLS} - 0.5$ nm

Use λ_{TLS} as primary reference because the specified wavelength accuracy of the Tunable Laser modules is better than the OSA.

The accuracy of the offset value in this equation does not influence the measurement accuracy of spectral and total SSE measurements.

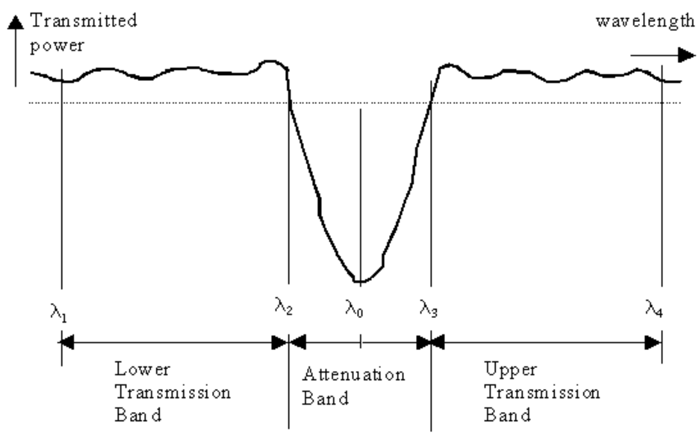


Figure 14 Transmission Characteristic of Fiber Bragg Grating

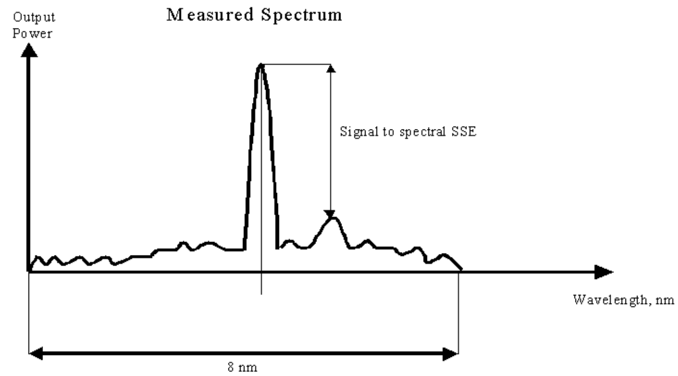


Figure 15 Signal-to-Spectral SSE Measurement

Lower Transmission Band	$\lambda_1 \ldots \lambda_2$	
Upper Transmission Band	$\lambda_3 \ldots \lambda_4$	
Attenuation Band	$\lambda_2 \ldots \lambda_3$	< 2 nm

1 Connect the Tunable Laser module (DUT) to the Optical Spectrum Analyzer as shown in Figure 16. Connect one end of the Fiber Bragg Grating (FBG)[1] to Output 1, the Low SSE output, and the other to the Optical Spectrum Analyzer.
[1]**81600B:** $\lambda_{FBG} \approx 1520$ nm

Set the menu parameters to the values shown in Table 3, "Tunable Laser Channel Settings," on page 49.

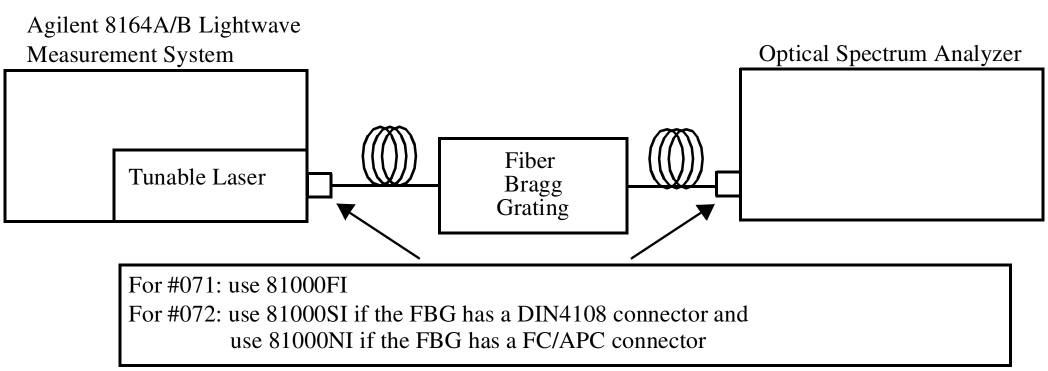


Figure 16 Test Setup for Source Spontaneous Emission Test

2 Determine the filter transmission characteristics:

NOTE λ_{FBG} is the nominal center wavelength of the FBG which is printed on it, while λ_0 is the true measured value. Both are measured in vacuum (reference is the TLS). In practise both values are the same, but you may find a difference of some pm.

a Check center wavelength, λ_{FBG}, of the Fiber Bragg Grating. This wavelength is printed on its label, for example, 1520.5 nm. This value relates to measurements performed in a vacuum.

b Set the Optical Spectrum Analyzer:

- Set the Span to 8 nm. Press *Span* and enter the value.
- Set the center wavelength to λ_{FBG} – 0.5 nm. Press *Center* and enter the value.
- Set the reference level to 0 dBm. Press [AMPL], press [Ref LVL], and enter the value.
- Set the Sensitivity to -68 dBm. Press [AMPL], press [SENS AUTO MAN], and enter the value.
- Set the resolution bandwidth to 0.1 nm. Press [BW Swp], and enter the value.

c Set the Tunable Laser module

- Set [λ], the wavelength, to λ_{FBG} – 1 nm, for example, 1520.5 nm – 1 nm = 1519.5 nm.
- Set [P], the output power, to the value in Table 16.

Table 16 Output Power Setting - Low SSE Output

Tunable Laser Module	Power [P]
Agilent 81600B - Output 1	+2.00 dBm

d Press the key beside the laser output to switch on the laser output.

e Check and note the peak power level displayed by the OSA and the wavelength at the peak power. Press *Peak Search* in the Marker field.

f For λ_{FBG} ± 1 nm, check and note the power level displayed by the OSA at every 0.1 nm interval. That is, fill out the table shown in Table 17.

Table 17 Filter Transmission Characteristic

Tunable Laser Module Output Wavelength Relative to λ_{FBG}	Peak Power Level	Associated Wavelength Displayed on OSA
–1.0 nm	dBm	nm
–0.9 nm	dBm	nm
–0.8 nm	dBm	nm
–0.7 nm	dBm	nm
–0.6 nm	dBm	nm
–0.5 nm	dBm	nm
–0.4 nm	dBm	nm
–0.3 nm	dBm	nm
–0.2 nm	dBm	nm
–0.1 nm	dBm	nm
±0 nm = λ_{FBG}	dBm	nm
+0.1 nm	dBm	nm
+0.2 nm	dBm	nm
+0.3 nm	dBm	nm
+0.4 nm	dBm	nm
+0.5 nm	dBm	nm
+0.6 nm	dBm	nm
+0.7 nm	dBm	nm
+0.8 nm	dBm	nm
+0.9 nm	dBm	nm
+1.0 nm	dBm	nm

3 Determine minimum value of filter transmission and actual Fiber-Bragg-Grating center wavelength, λ_0.

   a Check for minimum transmitted peak power in Table 17.

   b Mark the associated wavelength set on the Tunable Laser, TLS_λ0, and note the value in the test record.

   c Mark the associated wavelength displayed on the OSA, *OSA*_λ0, and note the value in the test record.

4 Set TLS to the wavelength of minimum transmission, TLS_λ0.

5 Record spectrum at minimum filter transmission. Set the Optical Spectrum Analyzer:

  a Set the Sensitivity to -90 dBm.

  b Set the resolution bandwidth to 0.5 nm.

  c Set the center wavelength to OSA_λ_0.

  d Set the reference level to -40 dBm.

  e Set the span to 6 nm.

6 Determine limits of transmission and attenuation ranges by performing the following calculations:

  a Lower Transmission Band: λ_1 ... λ_2

  - TLS_λ1 = TLS_λ0 – 3 nm
  - TLS_λ2 = TLS_λ_0 – 0.5 × Attenuation Band
    = TLS_λ_0 – 1 nm

  b Upper Transmission Band: λ_3 ... λ_4

  - TLS_λ_3 = TLS_λ0 + 0.5 × Attenuation Band
    = TLS_λ0 + 1 nm
  - TLS_λ_4 = TLS_λ_0 + 0.5 × Upper Transmission Band
    = TLS_λ_0 + 3 nm

7 Determine maximum transmitted power value inside transmission band:

  Record spectrum:
  Check for the maximum transmitted power (max_SSE_power) within Lower and Upper Transmission Bands. Do this by using the marker. Change λ by using the RPG and note the maximum power value within the Lower and Upper Transmission Bands (this is one value for these bands together). Note this value in the test record. Check the associated wavelength on OSA (OSA@max_SSE_power) and note the value in the test record.

8 Set the marker of the OSA to OSA@max_SSE_power.
  Change [λ], the output wavelength of the TLS, so that the peak wavelength of the spectrum is at the OSA marker
  Change [λ], *the output wavelength of the TLS, to the wavelength of highest SSE (TLS@max_SSE_power) using the approximation:*

  TLS@max_SSE_power = OSA@max_SSE_power + 0.5 nm

9 Determine TLS@max_SSE_power as follows:
Set the Optical Spectrum Analyzer:

a Set the Sensitivity to -68 dBm.

b Set the resolution bandwidth to 0.5 nm.

c Set the center wavelength to OSA@max_SSE_power.

d Set the reference level to 0 dBm.

e Set the span to 6 nm.

f Record the spectrum.

10 Within the total spectrum, determine peak power, power@SSE_peak, and note the absolute value |power@SSE_peak| in the test record.

NOTE This is at the wavelength the TLS is set to for this measurement and the OSA measures, respectively.

---

11 Calculate spectral SSE by using the following equation:

Spectral SSE = |power@SSE_peak| – | max_SSE_power| + 3 [dB/nm])

Note the value in the test record.

NOTE The measurements were made with a resolution bandwidth of 0.5 nm. The additional value of 3 dB takes care of a resolution of 1 nm, and so gives the SSE in [dB/nm]. (Factor of 10 in the RBW gives 2 x power = 3 dB).

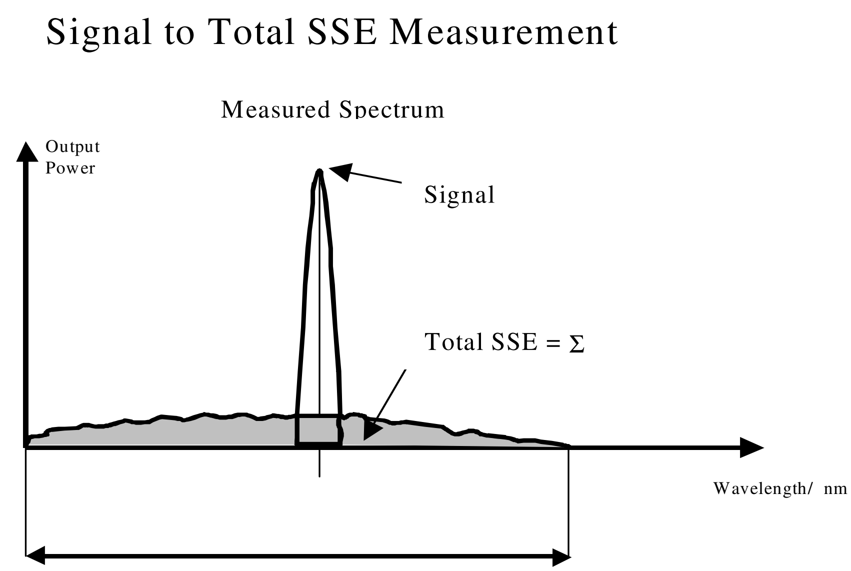
Example:

RBW = 0.5 nm results in: $|SSE_{0.5\ nm}|$ = 44.3dB measured

RBW = 1 nm extrapolates to $|SSE_{1\ nm}|$ = $|SSE_{0.5\ nm}|$ - 3dB = 44.3 dB - 3 dB = 41.3 dB

Signal-to-Total-Source Spontaneous Emission

NOTE Although the following description will allow you to verify your products performance by yourself, due to the high complexity of this test Agilent recommends that you have this test performed by an Agilent service center.



Signal to Total SSE Tests - Low SSE Outputs

Follow this procedure to test modules the Agilent 81600B, Output 1, the Low SSE output:

1 Check center wavelength of the Fiber Bragg Grating, FBG (λ_FBG) which is printed on its label (for example, 1520.5 nm). This value relates to vacuum conditions.

2 Determine OSA noise, that is, the noise of OSA alone without applying the Tunable Laser signal:

   a Switch off the laser output of the Tunable Laser.

   b Set the OSA

      - Set the Span to 30 nm. Press *Span* and enter the value.
      - Set the center wavelength, OSA_λ_center, to λ_{FBG} – 0.5 nm. Press *Center* and enter the value.
      - Set the reference level to –40 dBm. Press [AMPL], press [Ref LVL], and enter the value.
      - Set the Sensitivity to –90 dBm. Press [AMPL], press [SENS AUTO MAN], and enter the value.

- Set the resolution bandwidth to 1 nm. Press [BW Swp], and enter the value.

c Record noise spectrum for a single sweep.

d Measure partial noise of the spectrum.
With a sampling step of 1 nm on the OSA, check all 201 power levels within the recorded spectrum, starting at OSA_λ_center – 15 nm and finishing at OSA_λ_center + 15 nm.

NOTE Note the “partial noise power level” values in a table in [pW], where
1 pW = 10^{-12} W.

Example:

Table 18 Signal to Total SSE Tests - Low SSE Outputs

Wavelength, Relative to OSA_λ_center	**Partial Noise Power levels**
–15 nm	pW
–14 nm	pW
–13nm	pW
....	pW
....	pW
–2 nm	pW
–1 nm	pW
±0 nm (= OSA_λ_center)	pW
+1 nm	pW
+ 2 nm	pW
....	pW
....	pW
+ 13 nm	pW
+ 14 nm	pW
+ 15 nm	pW
Sum of all partial noise power levels	pW

e Determine total noise power by adding up all 31 partial noise power levels:
OSA_noise = Sum of all partial noise power levels

OSA_noise = _________ pW

f Note the OSA_noise value in the test record.

3 Connect the Tunable Laser (DUT) to the Optical Spectrum Analyzer as shown in Figure 16. Connect one end of the Fiber Bragg Grating to Output 1, the Low SSE output of the TLS and the other end to the Optical Spectrum Analyzer.

4 Set the TLS menu parameters to the values shown in Table 3.

5 Set the power for each Tunable Laser module to the values given in Table 19.

NOTE For the Agilent 81480B and Agilent 81640B, the laser output power is limited to its maximum possible value at this wavelength. The display will probably show `ExP`.

Table 19 Power Settings for Signal to Total SSE Tests - Low SSE Outputs

Module	Power [*P*]
Agilent 81600B - Output 1	+2.000 dBm

6 Determine filter transmission characteristic (see Signal-to-Source Spontaneous Emission Tests - Low SSE Outputs on page 65). You may skip this step if the characteristic has already been determined.

a Determine minimum value of filter transmission and actual FBG center wavelength λ_0 (see step 3 on page 69). You may skip this step if the characteristic has already been determined.

b Note the wavelength of minimum transmitted peak power the TLS is set to in the test record
TLS_λ0 = ________ nm

c Mark the associated wavelength displayed on the OSA (OSA_λ0) and note the value in the test record
OSA_λ0 = ________ nm

7 Record spectrum at minimum filter transmission:
Set TLS to the wavelength of minimum transmission (TLS_λ0)Check that the laser output is activated.

8 Set the Optical Spectrum Analyzer:

a Set Span to 30 nm. Press *Span*, enter the value.

b Set the Resolution Bandwidth to 1 nm. Press [AMPL], press [BW Swp], and enter the value.

c Set the Sensitivity to -90 dBm. Press [AMPL], press [SENS], and enter the value.

d Set the center wavelength to OSA_λ0. Press *Center* and enter the value.

e Set the reference level to -40 dBm. Press [AMPL], press [Ref LVL], and enter the value.

9 Determine limits of SSE range by performing the following calculations:

a Lower Transmission Band: λ_1 ... λ_2

- $OSA\_\lambda_1 = OSA\_\lambda_0 - 15$ nm

- $OSA\_\lambda_2 = OSA\_\lambda_0 - 1/2 \times$ Attenuation Band
  $= OSA\_\lambda_0 - 1$ nm

b Upper Transmission Band: $\lambda_3 \ldots \lambda_4$

- $OSA\_\lambda_3 = OSA\_\lambda_0 + 1/2 \times$ Attenuation Band
  $= OSA\_\lambda_0 + 1$ nm
- $OSA\_\lambda_4 = OSA\_\lambda_0 +$ Upper Transmission Band
  $= OSA\_\lambda_0 + 15$ nm

c Note the values of OSA_λ_1, OSA_λ_2, OSA_λ_3, OSA_λ_4 in the test record:

- OSA_λ_1 = ___________ nm
- OSA_λ_2 = ___________ nm
- OSA_λ_3 = ___________ nm
- OSA_λ_4 = ___________ nm

10 Determine SSE power values inside the transmission bands:

a Ensure the TLS is set to TLS_λ0 and *is not* changed.

b On OSA, set marker to OSA_λ1.

c Check the OSA and note SSE power value in [pW] in the table below as SSE_power.

d Increase OSA marker wavelength by 1 nm.

e Repeat previous two steps until the wavelength is equal to OSA_λ2.

f Set OSA to OSA_λ3.

g Repeat the same two steps until the wavelength is equal to OSA_λ4.

h Add up all power values inside the transmissions bands to get the value of power_trans.

NOTE Note all the power values in the table in [pW], where 1 pW = 10^{-12} W.

Example:

Lower transmission band OSA_λ1 to OSA_λ2		Upper transmission band OSA_λ3 to OSA_λ4	
Relative Wavelength, Increments from _λ1	**SSE_power measured**	**Relative Wavelength, Increments from _λ3**	**SSE_power measured**
0 (relates to OSA_λ1)	pW	0 (relates to _λ3)	pW
+1 nm	pW	+ 1 nm	pW
+2 nm	pW	+ 2 nm	pW
+3 nm	pW	+ 3 nm	pW
+4 nm	pW	+ 4 nm	pW
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
+11 nm	pW	+11 nm	pW
+12 nm	pW	+12 nm	pW
+13 nm	pW	+13 nm	pW
+14 nm	pW	+14 nm	pW
(relates to OSA_λ2)		(relates to OSA_λ4)	

Sum of all SSE power levels:

- in lower transmission band ________ pW (1)
- in upper transmission band ________ pW (2)

Sum of all SSE power levels in transmission bands, add results in (1) and (2)
power_trans = ___________ pW

11 Determine SSE power inside the attenuation band by interpolation:

a Check the power measured at OSA_λ2 and OSA_λ3.

b Mark that power value which is the largest of both and note it as power_ OSA_λ2,3_max

c Calculate the power inside the attenuation band by using power_att =1/2 × power_ OSA_λ2,3_max
= ___________ 10^{-12} W = ___________ pW

NOTE Note all the power values in [pW], where 1 pW = 10^{-12} W.

12 Determine total noise power, power_total_noise. Add the value of the power_trans and the value of power_att:
power_total_noise = power_trans + power_att
= ___________ 10^{-12} W = ___________ pW

13 Determine Peak power:

a Set the OSA:

- Set the Span to 30 nm. Press *Span* and enter the value.
- Set the center wavelength to OSA_λ0. Press *Center* and enter the value.
- Set the reference level to 0 dBm. Press [AMPL], press [Ref LVL], and enter the value.
- Set the Sensitivity to –68 dBm. Press [AMPL], press [SENS AUTO MAN], and enter the value.
- Set the resolution bandwidth to 1 nm. Press [BW Swp], and enter the value.

b Set the TLS:

- Set the wavelength to a value outside attenuation band. That is, set it to TLS_λ0 + 5 nm.
- Set the output power to the value in Table 19.
- Ensure the laser output is activated.

c Record the spectrum for a single sweep.

NOTE Note all the power values in [pW], where 1 pW = 10^{-12} W.

d Find the maximum power level for the whole spectrum, power_SSE_peak, and enter the result in the test record in [pW]:
Peak_power = ___________ 10^{-12} W = ___________ pW

14 Calculate total SSE and express in decibels, [dB].

$$Total\_SSE = 10 \times \log \frac{peak\_power}{power\_total\_noise - OSA\_noise}$$

NOTE Make sure that all power values are entered in the same units, for example Watts, W, or picowatts, pW. This ensures that the equation will give Total SSE in decibels, dB.

15 Note the result in the test record:

Total SSE = _______________ dB

Optional Tests

These tests refer to some of the instruments typical characteristics that are not guaranteed. They are not subject to the standard re-calibration but can be performed in qualified Agilent service centers on special request

Signal to Total SSE Tests - High Power Outputs

Follow this optional procedure to test the Agilent 81600B, Output 2, the High Power output

1. Connect the Tunable Laser module (DUT) to the Optical Spectrum Analyzer as shown in Figure 13. On the Agilent 81600B, make sure to connect Output 2, the High Power output, to the Optical Spectrum Analyzer.
2. Set the TLS menu parameters to the values shown in Table 3.
3. Set the wavelength and power for each Tunable Laser module to the values given in Table 20.

Table 20 TLS Settings for Signal to Total SSE Tests - High Power Outputs

Module	Power [*P*]	Wavelength [λ]
Agilent 81600B - Output 2	+ 8.00 dBm	1580 nm

4. Set the Optical Spectrum Analyzer:
   a. Set Span to 30 nm. Press *Span*, enter the value.
   b. Set the Resolution Bandwidth to 1 nm. Press [AMPL], press [BW Swp], and enter the value.
   c. Set the Sensitivity to -60 dBm. Press [AMPL], press [SENS], and enter the value.
5. Record Spectrum (run a single sweep):
   a. Press *Peak Search* in the Marker field.
   b. Set Marker to Center Wavelength and note its displayed wavelength as:
      OSA_λ_center = ________________ nm
6. Find the maximum power level at OSA_λ_center, peak_power, and enter the result in the test record in [pW]:
   Peak_power = ___________ 10^{-12} W = ___________ pW
7. Measure partial noise of the spectrum.
   With a sampling step of 1 nm on the OSA, check all 30 power levels within the recorded spectrum, starting at OSA_λ_center – 15 nm and finishing at OSA_λ_center + 15 nm without recording a value at OSA_λ_center.

NOTE Note the “partial noise power level” values in the table in [pW], where
1 pW = 10^{-12} W.

Example:

Wavelength, Relative to OSA_λ_center	Partial Noise Power levels
–15 nm	pW
–14 nm	pW
–13 nm	pW
....	pW
....	pW
–2 nm	pW
–1 nm	pW
+/– 0 nm (= OSA_λ_center)	pW
+1 nm	pW
+ 2 nm	pW
....	pW
....	pW
+13 nm	pW
+14 nm	pW
+15 nm	pW
Sum of all partial noise power levels:	pW

8 Determine total noise power by adding up all 30 partial noise power levels:
OSA_noise = Sum of all partial noise power levels

OSA_noise = __________ pW

9 Note the OSA_noise value in the test record.

10 Determine SSE of the Tunable-Laser output signal by using the maximum value at its border:

a Note the power measured at:
OSA_λ_center - 1 nm

b Note the power measured at:
OSA_λ_center + 1 nm

c Determine the larger of these two power values and note it as SSE_power_λTLS_max.

NOTE Note all the power values in [pW], where 1 pW = 10^{-12} W.

d SSE_power_λTLS_max= ________ 10^{-12} W = _______ pW

11 Determine the Total SSE power, power_total_SSE.
Add the values of OSA_noise and SSE_power_λTLS_max:

power_total_SSE = OSA_noise + SSE_power_λTLS_max
= ___________ 10^{-12} W = ___________ pW

12 Calculate the Total SSE in [dB] by using the following formula:

$$Total\_SSE = 10 \times \log \frac{peak\_power}{power\_total\_SSE}$$

NOTE Make sure that you enter all power values are entered in the same units, for example Watts, W, or picowatts, pW. This ensures that the equation will give Total SSE in decibels, dB.

13 Note the result in the test record:

Total_SSE = _____________________ dB

Dynamic Wavelength Accuracy

NOTE The performance verification of the dynamic parameters is extremely complex and needs to be done within a short time frame under software control. The following describes the steps to be taken in details and gives hints to calculations which need to be done by user defined software. Due to the complexity of this test, it is strongly recommended to have the related performance verification done in a dedicated Agilent service center.

Introduction

The procedures in this section test the wavelength accuracy of the Agilent 81600B Tunable Laser during a continuous sweep. The test setup and the measurement phases are common to absolute and relative wavelength accuracy, as well as wavelength repeatability; but the computations are different. This is reflected in the structure of this description.

Required Equipment

This test requires the 81637B Fast Power Meter and the Wavelength Reference Unit (Fabry-Perot etalon). In addition, PnP drivers of version 3.5 or higher are required.

Test Overview

A short overview of the test procedure is shown as a flow chart in Figure 11. Details are explained in the sections that follow.

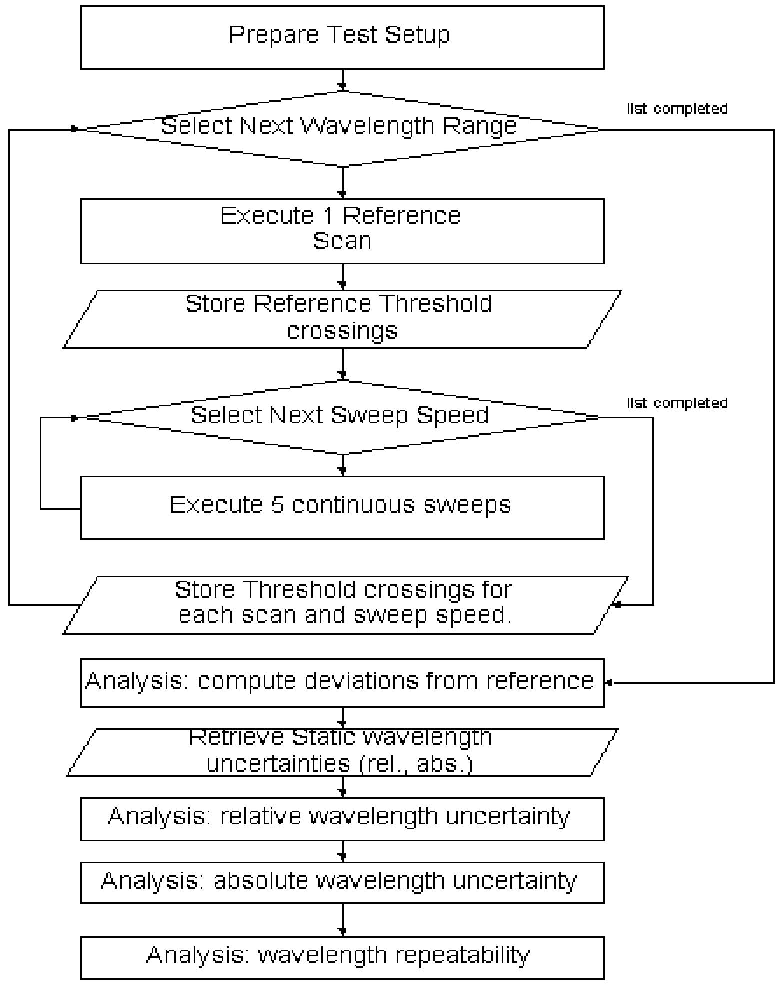


Figure 17 Test Flow - Dynamic Wavelength Accuracy Measurements

Test Setup and Measurement Procedure

General Remarks

The idea behind the measurement procedure described in this section is to characterize only the performance penalty in the wavelength measurements of the tunable laser when replacing the traditional stepped operation with continuous sweeps. The derivation of the *total* wavelength uncertainty under swept operation (as described in the Definition of Terms) is described later, in the corresponding *Analysis* sections of each term.

The transmission peaks of a stable Fabry-Perot etalon are used as control points to compare the measurement performance of the TLS in the two operating conditions; in particular, the wavelength at which a relative threshold is crossed. The threshold is positioned at 2 dB below the maximum transmitted power of each peak, to ensure a local slope of ~ 0.33 dB / pm.

For this reason, the measurements described here should not last more than approximately 15 minutes, timed from the reference measurement to the last of the verification measurements. This relaxes the stability requirements on the etalon used as a relative reference. It also avoids unnecessary characterization of long-term drifts that are already accounted for in the specifications given for stepped mode. This requirement is easily satisfied when executing the measurements using the Plug and Play drivers, which are anyway required also for other reasons; however it imposes particular optimizations in the execution of the reference measurement.

It is also crucial to connect all cables ***only once***: avoid repeating or (un)tightening the connections during or between these measurements.

Generally, a 81113SC cable can also be used to connect TLS-Out 1 to the FP-Etalon. However because of wear-and-tear, it is recommended that you use the 1005-0409 at the FP-Etalon side and do not disconnect the fiber.

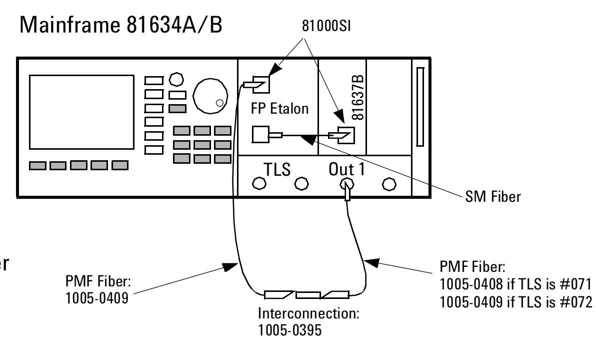


Figure 18 Setup for wavelength uncertainty verification in swept mode

Measurement Sequence

1 Make sure that cable connectors, detectors and adapters are clean.
2 Connect the equipment as shown in figure 2.
3 Turn the instruments on and allow the instruments to warm up for at least 60 minutes.
4 Set the TLS parameters to the values shown in Table 3, “Tunable Laser Channel Settings,” on page 49
5 Fix the optical fiber at the input of the FP-Etalon; allow the FP-Etalon to stabilize for at least 5 minutes.

6 To configure the instruments in all of the subsequent measurements follow the settings reported below - except if otherwise specified:

a ensure the modulation of the source is turned off

b select the power settings according to table 7:

Table 21 Power settings during dynamic wavelength accuracy tests

	81600B
TLS output port	Low – SSE (Output 1)
TLS output power	-2.00 dBm
PM range	0 dBm

c select the sweep settings according to Table 9

Table 22 Sweep settings during dynamic wavelength accuracy tests

	81600B
Wavelength step	2.0 pm
Wavelength range 1	1475-1485 nm
Wavelength range 2	1610-1620 nm

7 Before taking the measurement

a perform a lambda zero (via menu) on the TLS module

b zero the power-meter (make sure the TLS output is disabled)

Reference Scans

These scans are executed in *stepped mode*, one per wavelength range, and will provide the reference wavelength measurements (once the threshold-crossing analysis is performed).

In order to keep the measurement time to a minimum, it is not necessary to scan the whole of the wavelength ranges specified in Table 22, but only windows of ± 25 pm (or approx. 25 points) centered around each transmission peak, as shown in Figure 19. The value is indicative as it may depend on the exact free spectral range of the Fabry-Perot etalon (which is also a function of the wavelength).

A preliminary measurement (not described here) of the Fabry-Perot etalon is necessary in order to determine the positions of such windows.

NOTE After beginning the first of the following measurements it is extremely important not to disturb the experimental setup, in particular the connections, and the fiber from the TLS to the etalon.

8 Set the TLS and PWM to the power settings described in Table 21, “Power settings during dynamic wavelength accuracy tests,” on page 85

9 Set the Power-Meter wavelength to 1500 nm (*hp816x_set_PWM_wavelength*);

10 Set the Power-Meter averaging time to 5 ms or higher (*hp816x_set_PWM_averaging_time*);

11 Set the TLS to the current wavelength (*hp816x_set_TLS_wavelength*);

12 Take the corresponding power-measurement (*hp816x_set_PWM_readValue*)

13 Update the current wavelength (add one wavelength step, see Table 22) and move to the next wavelength window if necessary; return to step 10 and proceed when finished.

14 Compute the following results from each reference scan (i.e., wavelength range):

a $P_{th\ dBm}$ (j) = $10*\log10(\max(P_{meas\ mW}(\lambda))) - 2$ $(j=1,2,...30)$ $[dBm]$
representing the threshold level (2 dB below the maximum transmitted power at each peak)

b Select the 30 central transmission peaks, with positions $\lambda_{peak}(j)$ j = 1,2...30

c Find the corresponding 60 crossings of the thresholds $P_{th\ dBm}$ (j) (via linear interpolation of the two closest measurements).
$\lambda_{REF}(i)$ i = 1,2...60

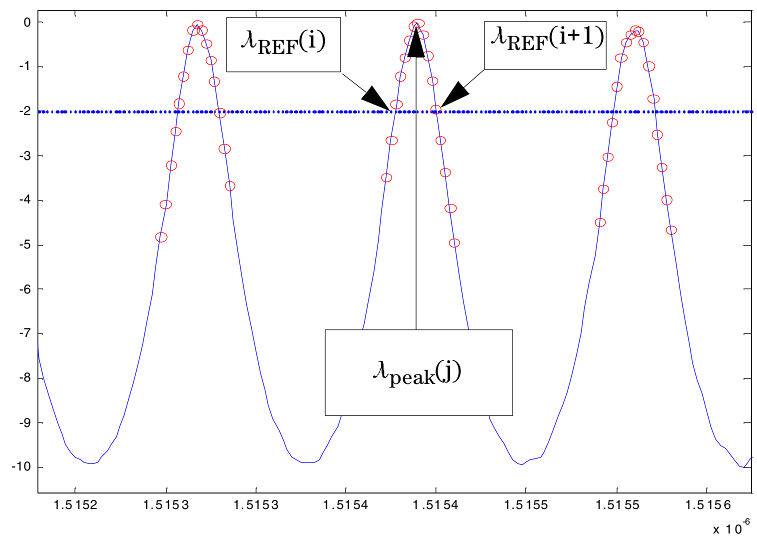


Figure 19 Optimization of reference scans. Sampling points as circled, threshold in dashed line.

Verification Measurements (Continuous Sweeps)

These measurements are performed in each wavelength range in continuous sweep mode, and require 5 consecutive scans at each speed under test. The current list of sweep speeds to be tested is:
20 nm/s, 40 nm/s, 80 nm/s.

The corresponding averaging times of the power-meters should be set to the maximum values compatible with the required sweep speed and wavelength step, i.e. *100* μs, *25* μs , *25* μs respectively.

For each sweep speed and each repetition the detailed operations are described below.

15 Set the TLS and PWM to the power settings described in Table 21;

16 Set the power-meter wavelength to 1500 nm (*hp816x_set_LambdaScan_wavelength*);

17 Enable selection of all sweep speeds (*hp816x_enableHighSweepSpeed*);

18 Select from following list the current sweep speed (*hp816x_setSweepSpeed);*

Sweep Speed	5 nm/s	10 nm/s	20 nm/s	40 nm/s	80 nm/s
Delay	4%	10%	20%	40%	80%

19 Disable automatic re-interpolation of power-wavelength pairs (i.e., set *hp816x_returnEquidistantData()* to false);

20 Set the sweep parameters according to Table 9 on page 55 (*hp816x_prepareMfLambdaScan* with *numberofScans* = *hp816x_NO_OF_SCANS_1;* this call also automatically programs the averaging times of the power-meter as required*);*

21 Execute the wavelength sweep (*hp816x_prepareMfLambdaScan*) and read out the wavelength data (logged wavelength);

22 Read out the logged power data (*hp816x_getLambdaScanResult*);

23 To compensate for the group-delay of the receivers in the power-meters models, delay the logged wavelength values by the following fractions of the sampling steps using linear interpolation (lever rule) between wavelength samples:

Sweep Speed	5 nm/s	10 nm/s	20 nm/s	40 nm/s	80 nm/s
Delay	4 %	10 %	20 %	40 %	80 %

24 Retrieve the following results from the reference scan performed in the same wavelength range: positions $\lambda_{peak}(j)$ of the reference transmission peaks and threshold crossings $\lambda ref(i)$;

25 Use the corrected wavelength values and the power values of the current scan to find the positions of the -2dB threshold crossings for the same transmission peaks $\lambda peak(j)$ (linear interpolation between the two closest wavelength-power points):
$\lambda_{LOGGED}(i,n)$i = 1,2...60 n = 1, ... 5 (scan repetition)

NOTE The threshold position is relative to the maximum power of the transmission peak, as in the reference sum, hence it is slightly wavelength dependent.

26 Compute the deviations of these positions (computed with the logged wavelengths) from the reference ones:
$\Delta\lambda_{LOGGED}(i, n) = \lambda_{LOGGED}(i, n) - \lambda_{REF}(i)$

27 Repeat these steps for each required value of sweep speed. Store the results separately for later analysis.

Dynamic Absolute and Relative Wavelength Uncertainty

This section describes the analysis steps leading to dynamic absolute and relative wavelength uncertainty with reference to a single sweep speed.

Repeat them until all the sweep speeds of interest have been covered.

The only measurement results to be considered here are the deviations from the reference sweep:
$\lambda_{LOGGED}(i, n)$ *i = 1,2...60 * 2 n = 1, ... 5 (scan repetition)*
Their intuitive meaning is the additional error in the TLS wavelength measurements caused by the continuous-sweep mode (at the speed of interest). Such additional error is evaluated at fixed control points, positioned in different wavelength intervals.

The results from all intervals should here be merged in a single array, since the final specification must hold for the whole TLS wavelength range.

Analysis

28 Select the data $\Delta\lambda_{LOGGED}(i, n)$ corresponding to the sweep speed of interest;

29 Compute (for each scan) the half of the peak-to-peak value over wavelength:
$\Delta\lambda_{REL}(n) = ½ * \{ max[\Delta\lambda_{LOGGED}(i , n)] – min[\Delta\lambda_{LOGGED}(i, n)] \}$

30 Compute the average offset over wavelength for each scan:
$\Delta\lambda_{OFFSET}(n) = avg [\Delta\lambda_{LOGGED}(i , n)]$

31 Retrieve the results of the static (stepped mode) wavelength accuracy tests:
let $\lambda_{REL\ STATIC}$ be the value to be compared with the test limit for relative wavelength accuracy; let $\lambda_{ABS\ STATIC}$ be the value to be compared with the test limit for absolute wavelength accuracy .

32 Compute a Dynamic Relative Wavelength Uncertainty (see Definition of Terms) $R(n)$ for each scan, by combining static and dynamic uncertainties with the following formula:
$R(n) = sqrt[(\lambda_{REL\ STATIC})^2 + (\Delta\lambda_{REL}(n))^2]$

33 Compute a Dynamic Absolute Wavelength Uncertainty (see Definition of Terms) $A(n)$ for each scan, by combining static and dynamic uncertainties with the following formula:
$A(n) = R(n) + | (\lambda_{ABS\ STATIC} - \lambda_{REL\ STATIC}) + \Delta\lambda_{OFFSET}(n) |$

34 Compute the average of the previous results over all scans:
$A_{AVG} = sum[A(*)] / n$
$R_{AVG} = sum[R(*)] / n$

35 The Dynamic Relative Wavelength Uncertainty (see Definition of Terms) is given as $\pm R_{AVG}$

36 The Dynamic Absolute Wavelength Uncertainty (see Definition of Terms) is given as $\pm A_{AVG}$

Dynamic Wavelength Repeatability

NOTE This section describes the analysis steps leading to wavelength repeatability with reference to a single sweep speed.

Repeat them until all sweep speeds of interest are covered.

The only measurement results to be considered here are the results of the threshold-crossing analysis in the continuous sweep measurements:

$\lambda_{\mathrm{LOGGED}}(\mathrm{i, n})$ i = 1,2...60* 2 n = 1, ... 5 (scan repetition)

The results from all the tested wavelength intervals should here be merged in a single array, since the final results must hold for the specification of the whole TLS wavelength range.

Analysis

1 Estimate the local repeatability for each control wavelength as the sample variances $\sigma^2(\mathrm{i})$ among the repeated scans:
$\sigma^2(\mathrm{i})$ =
$1/(5-1)^*\{\Sigma_{\mathrm{j}=1...5}[\lambda_{LOGGED}(i,j)]^2\text{-}5^*\{\Sigma_{\mathrm{j}=1...5}[\lambda_{LOGGED}(i,j)/5]^2\}\ \}$

- $i = 1,2...60{*}2$
  and its average over all control points σ^2
- $\sigma^2 = 1/120 * \Sigma_{\mathrm{i}=1...120}[\sigma^2(\mathrm{i})]$

2 Calculate the **Dynamic Wavelength Repeatability** (see Definition of Terms), given as ±REP, using the following formula:
REP = +/- 2.663 * sqrt(σ^2)
or
peak-to-peak deviation: $\mathrm{REP}_{\text{peak-to-peak}} = 2 * 2.663 * \mathrm{sqrt}(\sigma^2)$

Normalized Sweep Acceleration

The determination of this parameter is extremely complex and cannot be done manually. It requires Fourier and Hilbert Transformation that can only be done by means of sophisticated mathematics. The associated test can only be done by use of specific software tools which are available in dedicated Agilent service centers.

Principal Measurement Setup:

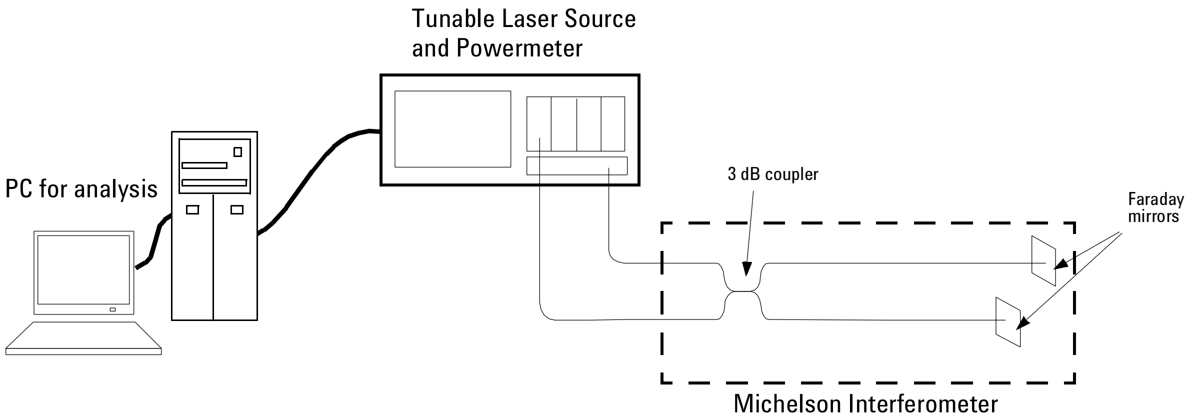


Figure 20 Measurement Setup to Determine the Sweep Speed

The measurement of the sweep speed is performed in the following manner:

The TLS performs a continuous sweep with a constant output power. The laser signal enters a Michelson Interferometer, which splits the beam into two equal parts. These travel over different paths and are reflected from Faraday mirrors (thus inverting the polarization). The reflected rays interfere at the coupler and produce an interferogram at the powermeter depending on destructive or additive interference. Afterwards, all data is transferred to the host PC, which starts the analysis of the interferogram from which the parameter Normalized Sweep Acceleration is determined.

Test Record

Agilent 81600B Performance Test

Test Facility:

________________________________ Report No. ________________________________

________________________________ Date ________________________________

________________________________ Customer ________________________________

________________________________ Tested By ________________________________

Model Agilent 81600B Tunable Laser Module 1400 nm

Serial No. ____________________ Ambient temperature ________°C

Options ____________________ Relative humidity ________ %

Firmware Rev. ____________________ Line frequency ________ Hz

Special Notes:

____

____

____

____

____

____

____

Page 2 of 14
Model Agilent 81600B Tunable Laser
Report No. ________Date_______

Test Equipment Used

	Description	Model No.	Trace No.	Cal. Due Date
1.	Standard Optical Head			
2.	Power Sensor			
3.	Optical Spectrum Analyzer			
4.	Wavelength Meter			
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				

Relative Wavelength Accuracy

	Repetition 1		Repetition 2		Repetition 3	
Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]	Wavelength Measured	Wavelength Deviation [1]	Wavelength Measured	Wavelength Deviation [1]
1440.000 nm	nm	nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm	nm	nm
1500.000 nm	nm	nm	nm	nm	nm	nm
1520.000 nm	nm	nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm	nm	nm
1580.000 nm	nm	nm	nm	nm	nm	nm
1600.000 nm	nm	nm	nm	nm	nm	nm
1620.000 nm	nm	nm	nm	nm	nm	nm
1640.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1440.000 nm to1640.000 nm						
Maximum Deviation		nm		nm		nm
Minimum Deviation		nm		nm		nm

	Repetition 4		Repetition 5	
Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]	Wavelength Measured	Wavelength Deviation [1]
1440.000 nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm
1500.000 nm	nm	nm	nm	nm
1520.000 nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm
1580.000 nm	nm	nm	nm	nm
1600.000 nm	nm	nm	nm	nm
1620.000 nm	nm	nm	nm	nm
1640.000 nm	nm	nm	nm	nm
Within full Tuning Range 1440.000 nm to1640.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Relative Wavelength Accuracy Summary of all Repetitions

Largest Maximum Deviation_______nm

Smallest Minimum Deviation________nm

Relative Wavelength Accuracy Result

(= Largest Maximum Deviation – Smallest Minimum Deviation)

Relative Wavelength Accuracy ________nm

Upper Test Limit	0.01 nm
Measurement Uncertainty:	±0.2 pm

Absolute Wavelength Accuracy Result

Largest Value of Deviation (= largest value of either Largest Maximum Deviation or Smallest Minimum Deviation)

Absolute Wavelength Accuracy_______nm

Upper Test Limit	0.02 nm
Measurement Uncertainty:	±0.6 pm

Model Agilent 81600B Tunable Laser Report No. ________ Date_______

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1440.000 nm	nm	nm
1441.000 nm	nm	nm
1442.000 nm	nm	nm
1443.000 nm	nm	nm
1444.000 nm	nm	nm
1445.000 nm	nm	nm
1446.000 nm	nm	nm
1447.000 nm	nm	nm
1448.000 nm	nm	nm
1449.000 nm	nm	nm
1450.000 nm	nm	nm
1630.000 nm	nm	nm
1631.000 nm	nm	nm
1632.000 nm	nm	nm
1633.000 nm	nm	nm
1634.000 nm	nm	nm
1635.000 nm	nm	nm
1636.000 nm	nm	nm
1637.000 nm	nm	nm
1638.000 nm	nm	nm
1639.000 nm	nm	nm
1640.000 nm	nm	nm
	Maximum Deviation:	nm
	Minimum Deviation:	nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Mode Hop Free Tuning Result (= Largest value of either the Maximum or Minimum Deviation)

Mode Hop Free Tuning Result________ nm

Test Limit ±0.025 nm

Measurement Uncertainty ±0.2 pm

Wavelength Repeatability

Repeatability of 1440.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1490.000 nm to REF	nm
from 1540.000 nm to REF	nm
from 1590.000 nm to REF	nm
from 1640.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wave-length	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wave-length	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1540.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1440.000 nm to REF	nm
from 1490.000 nm to REF	nm
from 1590.000 nm to REF	nm
from 1640.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wave-length	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wave-length	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1640.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1440.000 nm to REF	nm
from 1490.000 nm to REF	nm
from 1540.000 nm to REF	nm
from 1590.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wave-length	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ±0.1 pm

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
1440.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1450.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1460.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1470.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1475.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1480.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1490.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1500.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1510.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1520.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1530.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1540.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1550.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1560.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1570.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1580.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1590.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1600.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1610.000 nm	dBm	+ 2.00 dBm	dBm	+ 8.00 dBm
1620.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1625.000 nm	dBm	– 2.00 dBm	dBm	+ 4.00 dBm
1630.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1640.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm

Measurement Uncertainty: ±0.10 dB

Model Agilent 81600B Tunable Laser Report No. ________ Date________

Power Linearity Output 1, Low SSE

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+ 2.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 1.0 dBm	dB	+	1.00 dB	=	dB
	+ 0.0 dBm	dB	+	2.00 dB	=	dB
	– 1.0 dBm	dB	+	3.00 dB	=	dB
	– 2.0 dBm	dB	+	4.00 dB	=	dB
	– 3.0 dBm	dB	+	5.00 dB	=	dB
	– 4.0 dBm	dB	+	6.00 dB	=	dB
	– 5.0 dBm	dB	+	7.00 dB	=	dB
	– 6.0 dBm	dB	+	8.00 dB	=	dB
	– 7.0 dBm	dB	+	9.00 dB	=	dB

Maximum Power Linearity at current setting ______ dB

Minimum Power Linearity at current setting ______ dB

Total Power Linearity = (Max Power Linearity – Min Power Linearity) ______ dBpp

Upper Test Limit 0.2 dBpp

Measurement Uncertainty ± 0.05 dB

Power Linearity Output 2, High Power Upper Power Levels

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+ 8.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 7.0 dBm	dB	+	1.00 dB	=	dB
	+ 6.0 dBm	dB	+	2.00 dB	=	dB
	+ 5.0 dBm	dB	+	3.00 dB	=	dB
	+ 4.0 dBm	dB	+	4.00 dB	=	dB
	+ 3.0 dBm	dB	+	5.00 dB	=	dB
	+ 2.0 dBm	dB	+	6.00 dB	=	dB
	+ 1.0 dBm	dB	+	7.00 dB	=	dB
	0.0 dBm	dB	+	8.00 dB	=	dB
	– 1.0 dBm	dB	+	9.00 dB	=	dB

Maximum Power Linearity at current setting ______ dB

Minimum Power Linearity at current setting ______ dB

Total Power Linearity = (Max Power Linearity – Min Power Linearity) ______ dBpp

Upper Test Limit (automatic mode) 0.2 dBpp

Measurement Uncertainty ± 0.05 dB

Model Agilent 81600B Tunable Laser Report No. ________ Date_______

Power Linearity Output 2, High Power by attenuator

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	0.0 dBm	dB	+	0.00 dB	=	dB
	– 1.0 dBm	dB	+	1.00 dB	=	dB
	– 2.0 dBm	dB	+	2.00 dB	=	dB
	– 3.0 dBm	dB	+	3.00 dB	=	dB
	– 4.0 dBm	dB	+	4.00 dB	=	dB
	– 5.0 dBm	dB	+	5.00 dB	=	dB
	– 10.0 dBm	dB	+	10.00 dB	=	dB
	– 15.0 dBm	dB	+	15.00 dB	=	dB
	– 20.0 dBm	dB	+	20.00 dB	=	dB
	– 25.0 dBm	dB	+	25.00 dB	=	dB
	– 30.0 dBm	dB	+	30.00 dB	=	dB
	– 35.0 dBm	dB	+	35.00 dB	=	dB
	– 40.0 dBm	dB	+	40.00 dB	=	dB
	– 45.0 dBm	dB	+	45.00 dB	=	dB
	– 50.0 dBm	dB	+	50.00 dB	=	dB
	– 55.0 dBm	dB	+	55.00 dB	=	dB
	– 60.0 dBm	dB	+	60.00 dB	=	dB

Maximum Power Linearity at current setting ______dB

Minimum Power Linearity at current setting ______dB

Total Power Linearity = (Max Power Linearity – Min Power Linearity) ______dBpp

Upper Test Limit 0.6 dBpp

Measurement Uncertainty ± 0.05 dB

Model Agilent 81600B Tunable Laser Report No. ________ Date________

Power Flatness

Wavelength		Low SSE Output 1	High Power Output 2	
		P = –7.000 dBm	P = –1.000 dBm ATT = 0 dB	P = 0.000 dBm ATT = 60 dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1440.000 nm	0.00 dB	0.00 dB	0.00 dB
	1450.000 nm	dB	dB	dB
	1460.000 nm	dB	dB	dB
	1470.000 nm	dB	dB	dB
	1480.000 nm	dB	dB	dB
	1490.000 nm	dB	dB	dB
	1500.000 nm	dB	dB	dB
	1510.000 nm	dB	dB	dB
	1520.000 nm	dB	dB	dB
	1530.000 nm	dB	dB	dB
	1540.000 nm	dB	dB	dB
	1550.000 nm	dB	dB	dB
	1560.000 nm	dB	dB	dB
	1570.000 nm	dB	dB	dB
	1580.000 nm	dB	dB	dB
	1590.000 nm	dB	dB	dB
	1600.000 nm	dB	dB	dB
	1610.000 nm	dB	dB	dB
	1620.000 nm	dB	dB	dB
	1630.000 nm	dB	dB	dB
	1640.000 nm	dB	dB	dB
	Maximum deviation	dB	dB	dB
	Minimum deviation	dB	dB	dB
Flatness = Maximum – Minimum Deviation		dB	dB	dB
	Upper Test Limit	0.40 dBpp	0.60 dBpp	0.60 dBpp
	Measurement Uncertainty	± 0.1 dB	± 0.15 dB	± 0.15 dB

Power Stability

	Low SSE Output 1	High Power Output 2
		Att = 0 dB
Maximum Deviation	dB	dB
Minimum Deviation	dB	dB
Power Stability [1]	dB	dB
Upper Test Limit	0.02 dBpp	0.02 dBpp
Measurement Uncertainty	±0.005 dB	±0.005 dB

[1] Power Stability = Maximum Deviation – Minimum Deviation

Signal-to-Source Spontaneous Emission - Output 2, High Power

Wavelength	Output Power	Results	Lower Test Limit
1440.000 nm	– 1.00 dBm	dB	37 dB
1450.000 nm	– 1.00 dBm	dB	37 dB
1460.000 nm	– 1.00 dBm	dB	37 dB
1470.000 nm	– 1.00 dBm	dB	37 dB
1475.000 nm	+ 4.00 dBm	dB	43 dB
1480.000 nm	+ 4.00 dBm	dB	43 dB
1490.000 nm	+ 4.00 dBm	dB	43 dB
1500.000 nm	+ 4.00 dBm	dB	43 dB
1510.000 nm	+ 4.00 dBm	dB	43 dB
1520.000 nm	+ 8.00 dBm	dB	48 dB
1530.000 nm	+ 8.00 dBm	dB	48 dB
1540.000 nm	+ 8.00 dBm	dB	48 dB
1550.000 nm	+ 8.00 dBm	dB	48 dB
1560.000 nm	+ 8.00 dBm	dB	48 dB
1570.000 nm	+ 8.00 dBm	dB	48 dB
1580.000 nm	+ 8.00 dBm	dB	48 dB
1590.000 nm	+ 8.00 dBm	dB	48 dB
1600.000 nm	+ 8.00 dBm	dB	48 dB
1610.000 nm	+ 8.00 dBm	dB	48 dB
1620.000 nm	+ 4.00 dBm	dB	43 dB
1625.000 nm	+ 4.00 dBm	dB	43 dB
1630.000 nm	– 1.00 dBm	dB	37 dB
1640.000 nm	– 1.00 dBm	dB	37 dB

Measurement Uncertainty: ± 0.20 dB

Signal-to-Source Spontaneous Emission - 81600B Output 1, Low SSE

Center Wavelength of Fiber Bragg Grating:		TLS_λ_0	= ________ nm
		OSA_λ_0	= ________ nm
Maximum Transmitted Power:		max_SSE_power	= _________ dBm
		OSA@max_SSE_power	= _________ nm
Peak Power:		power@SSE_peak	= _________ dBm
Test result:	Spectral SSE	= |power@SSE_peak| – | max_SSE_power| - 3 dB	
		= ___________ dB / nm	
Lower test Limit:		70 dB / nm (for TLS_λ_0 = 1520 nm - 1610 nm)	
Measurement Uncertainty:		± 1.2 dB	

Signal-to-Total-Source Spontaneous Emission - Output 1, Low SSE

Center Wavelength of Fiber Bragg Grating:	TLS_λ_0	= ________ nm
	OSA_λ_0	= ________ nm
Transmission Band Limits:	OSA_λ_1	= ________ nm
	OSA_λ_2	= ________ nm
	OSA_λ_3	= ________ nm
	OSA_λ_4	= ________ nm

	Output 1, Low SSE		
OSA_noise			________ pW
Sum of all SSE power levels in lower transmission band	________ pW		
Sum of all SSE power levels in upper transmission band	________ pW		
power_trans = Sum of all SSE power levels in transmission bands		________ pW	
power_att		________ pW	
power_total_noise= power_trans + power_att			________ pW
peak_power			________ pW
Measurement Result - Total SSE			________ dB
Lower Test Limit:			65 dB*

* (for TLS_λ_0 = 1520 nm - 1610 nm)

$$Total\_SSE = 10 \times \log \frac{peak\_power}{power\_total\_noise - OSA\_noise}$$

Measurement Uncertainty: ± 2.0 dB

Optional Test: Signal-to-Total-Source Spontaneous Emission - 81600B Output 2, High Power

	Output 2, High Power	
OSA_noise	________ pW	
SSE_power_λTLS_max	________ pW	
Power_total_noise = OSA_noise + SSE_power_λTLS_max		________ pW
Peak_power		________ pW
Measurement Result - Total SSE		________ dB
Testlimit		27 dB *
Performance Characteristic		30 dB typical

* (for TLS_λ_0 = 1520 - 1610 nm)

$$Total\_SSE = 10 \times \log \frac{peak\_power}{power\_total\_SSE}$$

Measurement Uncertainty: ± 2.00 dB

Model Agilent 81600B Tunable Laser Report No. ________ Date________

Optional Tests:
Dynamic Wavelength Accuracy and Repeatability

Sweep speed	5 nm/s					40 nm/s					80 nm/s				
Scan #	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Absolute static wavelength accuracy															
Relative static wavelength accuracy															
$\Delta\lambda_{REL}$ (n)															
$\Delta\lambda_{OFFSET}$ (n)															
Dynamic relative wavelength accuracy per scan, R(n)															
Dynamic absolute wavelength accuracy per scan, A(n)															
Average dynamic absolute wavelength accuracy, A_{AVG}	____________ pm					____________ pm					____________ pm				
Testlimits (static + dynamic add-on)	± 10.4 pm					± 11 pm					± 12.5 pm				
Average dynamic relative wavelength accuracy, R_{AVG}	____________ pm					____________ pm					____________ pm				
Testlimits (static + dynamic add-on)	± 5.4 pm					± 5.8 pm					± 7 pm				
Sweep speed	20 nm/s					40 nm/s					80 nm/s				
Dynamic Wavelength Repeatability, $REP_{peak\ to\ peak}$	____________ pm					____________ pm					____________ pm				
Lower Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

5
Cleaning Procedures for Lightwave Test and Measurement Equipment

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.
Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.

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.
- Use of controls or adjustments or performance of procedures other than those specified may result in hazardous radiation exposure.
- Make sure that you disable all sources when you are cleaning any optical interfaces.
- Under no circumstances look into the end of an optical device attached to optical outputs when the device is operational. The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.
- 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.
- Do not install parts or perform any unauthorized modification to optical devices.
- Refer servicing only to qualified and authorized personnel.

Why is it important to clean optical devices ?

In transmission links optical fiber cores are about 9 µm (0.00035”) in diameter. Dust and other particles, however, can range from tenths to hundredths of microns in diameter. Their comparative size means that they can cover a part of the end of a fiber core, and thus degrade the transmission quality. This 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/m2). 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 chapter, 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 Standard Cleaning Equipment is necessary for cleaning your instrument. For certain cleaning procedures, you may also require certain Additional Cleaning Equipment.

Standard Cleaning Equipment

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

- Dust and shutter caps
- Isopropyl alcohol
- Cotton swabs
- Soft tissues
- Pipe cleaner
- Compressed air

Dust and shutter caps

All Agilent 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 protective 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 Agilent Technologies sales office.

Isopropyl alcohol

This solvent is usually available from any local pharmaceutical supplier or chemist's shop. Results will vary depending on the purity of the alcohol.

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 some of the dust and the dirt has dissolved in the alcohol and will leave behind filmy deposits after the alcohol has 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 drink this alcohol, as it may seriously damage 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. Some 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 produce scratches.

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 feedthrough 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
- Ultrasonic bath
- Warm water and liquid soap
- Premoistened cleaning wipes

- Polymer film
- Infrared Sensor Card

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 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 cause 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 causing corrosion or damage. Do not use water that is too hot or too cold, 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 the help of this card you are able to inspect the shape of the laser light beam emitted. The invisible laser beam is projected onto the sensor card. The light beam's infrared wavelengths are reflected at visible wavelengths, so becoming visible to the 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 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.

Always keep the caps on the equipment when it is not in use.

All Agilent 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 Agilent Technologies Sales/Service Office.

Immersion Oil and Other Index Matching Compounds

Wherever 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 invalidated.

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 filaments left by the swab.

Heavy dirt

If the previous procedure is not enough to clean your instrument, use one of the following procedures outlined in this chapter.

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 9um. This generally means you cannot see streaks or scratches on its 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 a skilled person, and as a last resort, as it wears out your connector.

WARNING Never look into the end of an optical cable that is connected to an active source.

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 projected onto the card and becomes visible as a small circular spot.

Preferred Procedure

An Optical Connector Cleaner, which ressembles a VCR cleaning tape, is a device that can be used to clean grease from the surface of a connector.

1. Blow away any surface dust with compressed air.
2. Press the button on the side of the Optical Connector Cleaner device to ensure that a fresh strip of tape is ready.
3. Position the connector interface on the tape.
4. Holding the connector interface against the tape, rotate the interface about 180 degrees, then slide it across the surface of the tape.

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 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 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, dis-solved 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;
- deposit dissolved dirt in the groove, which can then contaminate the surface of an inserted fiber.

Preferred Procedure

Use the following procedure on most occasions.

- Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure 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 cleanerslowly 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, Agilent's optical heads have an optical glass plate to protect the sensor.

CAUTION Do not attempt to access the internal parts of an Agilent N3988A video microscope for cleaning or for any other purpose.

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 Agilent 8162*A 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.

NOTE 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 equip-ment 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 oil in the connector, please refer the instrument to the skilled personnel of the Agilent 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 become misaligned.

NOTE

Both the surface and the jacket of the attached connector interface 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 begin the cleaning procedure. Cleaning interfaces is difficult as the core diameter of a single-mode fiber is only about 9µm. 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 Never look into an optical output, because this can seriously damage your eyesight.

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 projected onto the card and becomes visible as a small circular spot.

Preferred Procedure

Use the following procedure on most occasions.

1 Clean the interface by rubbing a new, dry cotton swabover 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 inter-face.

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

For instruments with a *deeply* recessed lens interface (for example the Agilent 81633A and 81634A Power Sensors) do NOT follow this procedure. Alcohol and compressed air could damage your lens even further.

Keep your dust and shutter caps on when your instrument is not in use. This should prevent it from getting too dirty.

If you must clean such instruments, please refer the instrument to the skilled personnel of the Agilent'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:

   a Clean the interface by rubbing a new, dry cotton swab over the surface using a small circular movement.

   b 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 that are sensitive to mechanical stress and pressure

Some optical devices, such as the Agilent 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.

- 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 ultra-sonic bath if you are sure that it won't cause any damage to any part of 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 attenuating mesh filters

This kind of device is extremely fragile. A misalignment of the filter leads to inaccurate measurements. Never touch the surface of the metal filter or attenuating mesh filter.

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.

- 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 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

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

How to clean large area lenses and mirrors

Some mirrors, such 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.

- Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure 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 clea-ning, please contact the manufacturer or your sales distri-butor.

1 Moisten the lens or the mirror with water.
2 Put a little liquid soap on the surface and gently spreadthe 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 straight movement.
5 Blow away remaining lint with compressed air.

Alternative Procedure A

To clean lenses that are extremely sensitive to mechani cal 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, dis-solved 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 Agilent Technologies representative.

Making the connection

Before you make any connection you must ensure that all lightwave cables and connectors are clean. If not, then use appropriate cleaning methods.

When you insert the ferrule of a patchcord into a connector or an adapter, ensure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise, the fiber end will rub up against something which could scratch it and leave deposits.

Lens cleaning papers

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.

Index

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