Agilent 81600B
Tunable Laser Source Family

User's Guide

Agilent Technologies

Notices

Manual Part Number

81600-90B12

Edition

Fourth edition, January 2005

Third edition, August 2004

Second edition, July 2003

First edition, November 2002

Printed in Germany

Agilent Technologies, Deutschland GmbH
Herrenberger Straße 130
71034 Böblingen, Germany.

Subject Matter

The material in this document is subject to change without notice.

Agilent Technologies *makes no warranty of any kind with regard to this printed material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.*

Agilent Technologies shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

Warranty

The material contained in this document is provided "as is," and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Agilent disclaims all warranties, either express or implied, with regard to this manual and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any information contained herein. Should Agilent and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement shall control.

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

Restricted Rights Legend

If software is for use in the performance of a U.S. Government prime contract or subcontract, Software is delivered and licensed as "Commercial computer software" as defined in DFAR 252.227-7014 (June 1995), or as a "commercial item" as defined in FAR 2.101(a) or as "Restricted computer software" as defined in FAR 52.227-19 (June 1987) or any equivalent agency regulation or contract clause. Use, duplication or disclosure of Software is subject to Agilent Technologies' standard commercial license terms, and non-DOD Departments and Agencies of the U.S. Government will receive no greater than Restricted Rights as defined in FAR 52.227-19(c)(1-2) (June 1987). U.S. Government users will receive no greater than Limited Rights as defined in FAR 52.227-14 (June 1987) or DFAR 252.227-7015 (b)(2) (November 1995), as applicable in any technical data.

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.

Agilent Technologies Sales and Service Offices

For more information about Agilent Technologies test and measurement products, applications, services, and for a current sales office listing, viesit our web site:

http://www.agilent.com/comms/lightwave

You can also contact one of the following centers and ask for a test and measurement sales representative.

United States:	1 800 829 4444 1 800 829 4433 (FAX)
Canada:	1 877 894 4414 1888 900 8921 (FAX)
Europe:	(31 20) 547 2111 (31 20) 547 2190 (FAX)
Japan:	0120 421 345 0120 421 678 (FAX)
Mexico	(52 55) 5081 9469 (52 55) 5081 9467 (FAX)
Australia:	1 800 629 485 1 800 142 134 (FAX)
Asia-Pacific:	800 930 871 800 908 476 (FAX)
Brazil	(55 11) 4197 3600 (55 11) 4197 3800 (FAX)

In This Guide....

This User's Guide contains information about the Agilent 81600B Tunable Laser Source Family.

Table of Contents

List of Figures

1

Getting Started with the Agilent 81600B Tunable Laser Source Family

This chapter describes the Agilent 81600B Tunable Laser Source Family.

General Safety Considerations

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

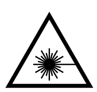
Before operation, review the instrument and manual, including the red safety page, for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

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

An Agilent 81600B Tunable Laser Source Family module operates when installed in the Agilent 8164A/B Lightwave Measurement System.

Operating Environment

The safety information in the Agilent 8164A/B Lightwave Multimeter (and the Agilent 8163A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System) User's Guide summarizes the operating ranges for the Agilent 81600B Tunable Laser Source Family modules. In order for these modules to meet specifications, the operating environment must be within the limits specified for your mainframe.

Input/Output Signals

CAUTION

There are two BNC connectors on the front panel of the 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

These modules 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 Agilent 81600B family modules

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

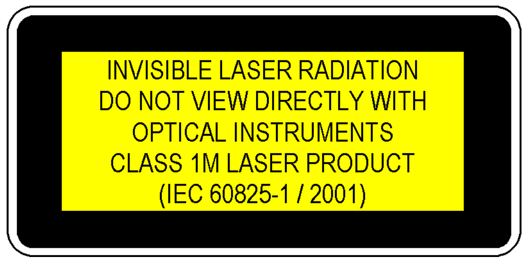
The laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated 2001-July-26.

	81660B #200	81600B #160	81600B #150	81600B #140	81600B #130	81600B #142	81600B #132
Laser Type	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP	EC-Laser InGaAsP
Wavelength range	1440 - 1640 nm	1495 - 1640 nm	1450 - 1590 nm	1370 - 1495 nm	1260 - 1375 nm	1370 - 1495 nm	1260 - 1375 nm
Max. CW output power	<15 mW	<15 mW	<15 mW	<15 mW	<15 mW	<15 mW	<15 mW
Beam waist diameter	9 µm	9 µm	9 µm	9 µm	9 µm	9 µm	9 µm
Numerical apeture	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Laser Class according to IEC 60825-1 (2001)	1M	1M	1M	1M	1M	1M	1M
Max. permissible CW output power	163 mW	163 mW	163 mW	52 mW	52 mW	52 mW	52 mW

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

Laser Safety Labels

Laser class 1M 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 warning:

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 optical instruments with this product will increase eye hazard.

The laser module has a built-in safety circuitry which will disable the optical output in the case of a fault condition

Refer servicing only to qualified and authorised personnel.

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.

Installation

Every Agilent 81600B Tunable Laser Source Family module is backloadable into Slot 0 of an 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.

Front Panels

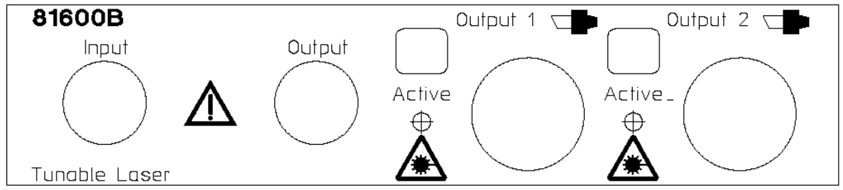


Figure 1 Agilent 81600B Tunable Laser Source Family modules (dual output, angled contact connectors)

Figure 1 illustrates a typical front panel for a dual-output Agilent 81600B Tunable Laser Source Family module, such as options #200, #160, #150, #140 or #130. In this case, angled contact interfaces (81600B-072) are specified.

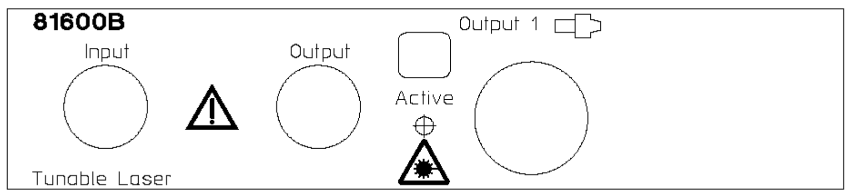


Figure 2 Agilent 81600B Tunable Laser Source Family module (single output, straight contact connectors)

Figure 2 illustrates a typical front panel for a single-output Agilent 81600B Tunable Laser Source Family module, such as options #142 or #132. In this case, straight contact interfaces (81600B#071) are specified.

Front Panel Controls and Indicators

Switch the laser source on or off using the switch on its frontpanel, using the [*State*] parameter in the instrument's Graphical User Interface, or remotely using GP-IB commands. When the Active LED is lit the souce is emitting radiation. When the Active LED is not lit the source is not emitting radiation.

Typical Use Models

The Agilent 81600B Tunable Laser Source Family consists of six modules that fit into the bottom slot of the Agilent 8164B Lightwave Solution Mainframe. The family covers the full wavelength range from 1260 nm to 1640 nm with the minimum number of lasers and no wavelength gaps.

81600B #200

The 81600B option 200 All-band Tunable Laser Source is the flagship module, featuring the widest tuning range of 200 nm with a single laser and a 70 dB/nm signal-to-source spontaneous emission ratio (signal-to-SSE ratio). The excellent low-SSE performance typically allows crosstalk measurements of better than 70 dB for an 8 channel CWDM multiplexer.

81600B #160, 150, 140, 130

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

81600B #142, 132

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

Testing CWDM and DWDM components

The Agilent 81600B Tunable Laser Source Family provides test instrumentation with the flexibility, efficiency and performance required for WDM component tests.

The testing of optical filters is based on a generic principle, namely the stimulus-response test. The state-of-the- art approach is a wavelength resolved stimulus-response measurement utilizing a TLS capable of fast and precise sweeps across the entire wavelength range, and optical power meters.

For Dense Wavelength Division Multiplexer (DWDM) components, high wavelength accuracy and dynamic range are critical. The modules are mode-hop free tunable with continuous output power, so qualify for the test of the most critical DWDM components.

For Coarse Wavelength Division Multiplexer (CWDM) components, a wide wavelength range, dynamic range and tight costing are key targets. If the investment in the test solution can be shared among many different type of filters, the contribution to each individual filter is minimized. In this way, cost targets for CWDM components can be met without sacrificing accuracy.

Swept Measurements

As manufacturing yield expectations becomes more and more stringent, it is important that all instruments deliver optimum performance under all measurement conditions. The Agilent 81600B Tunable Laser Source Family can sweep as fast as
80 nm/s with specified accuracy during the sweep.

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

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

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

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

Precision Every Agilent 81600B Tunable Laser Source Family module includes a built-in real time wavelength meter which realizes an absolute wavelength accuracy of ±10 pm (typ. ±3.6 pm) as a standalone instrument.

Testing Integrated Optical devices The 81600B Tunable Laser Source Family’s PMF output ports provide a well-defined state of polarization to ensure constant measurement conditions for waveguide devices. A PMF cable easily connects to an external optical modulator.

Optical Output

Polarization Maintaining Fiber

All Agilent 81600B Tunable Laser Source Family modules include polarization maintaining fiber (PMF) outputs, 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.

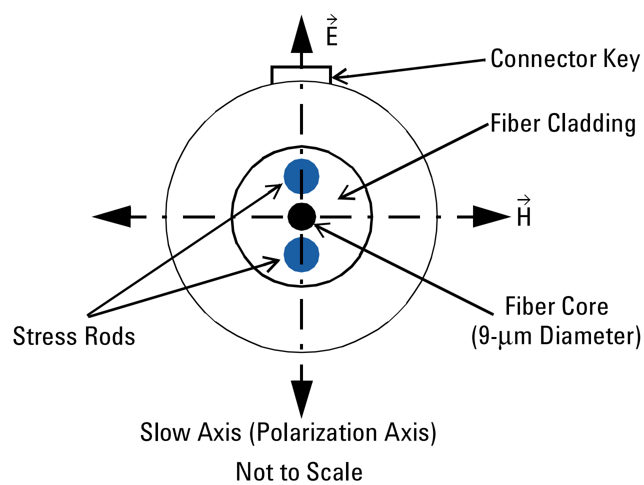


Figure 3 PMF Output Connector

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.

Agilent 81600B Tunable Laser Source Family modules 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 4 Angled and Straight Contact Connector Symbols

Figure 4 shows the symbols that tell you whether the contact connector of your Tunable Laser Source module is angled or straight. The angled contact connector symbol is colored green.

Figure 2 and Figure 5 shows the front panel of the Agilent 81600B Family Tunable Laser Source module with straight and angled contact connectors respectively.

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

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

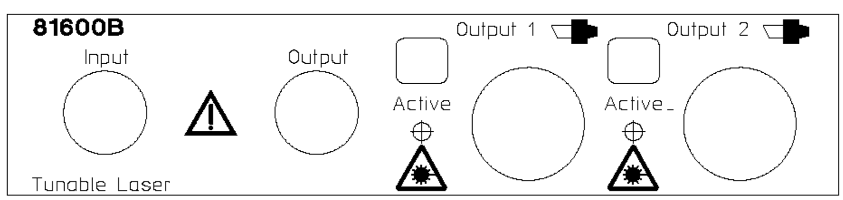


Figure 5 Agilent 81600B Tunable Laser Module (angled contact connector)

See “Accessories” on page 25 for further details on connector interfaces and accessories.

Signal Input and Output

CAUTION

There are two BNC connectors on the front panel of an Agilent 81600B Family Tunable Laser Source module - a BNC input connector and a BNC output connector.

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

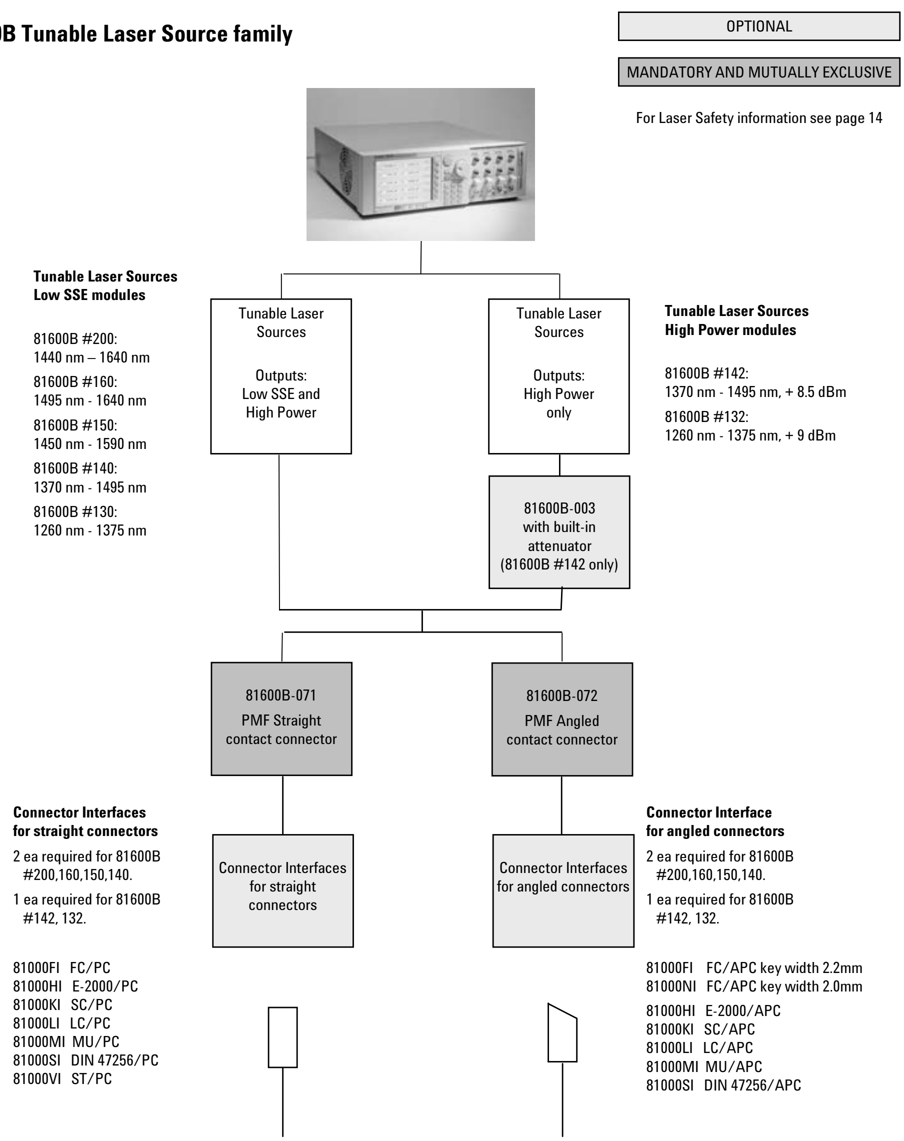
2
Accessories

The Agilent 81600B Family Tunable Laser Source modules are available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

Agilent 81600B Family Tunable Laser Source Modules and Options

81600B Tunable Laser Source family



Note: 81600B - 072 is highly recommended over 81600B - 071 to reduce front-panel reflections, which will greatly reduce interference noise and spectral ripple in the test setup.

Figure 6 Agilent 8164A/B mainframes, Agilent 81600B Family Tunable Laser Source modules, and Options

NOTE

Option 81600B-072 recommended Option 81600B-072 is highly recommended over option 81600B-071 to reduce front panel reflections, which will greatly reduce interference noise and spectral ripple in the test setup.

Module Options

The Agilent 8164A/B Lightwave Measurement System supports one Agilent 81600B Family Tunable Laser Source module.

Table 1

Agilent 81600B Family Tunable Laser Source modules	
Option	**Description**
#200	All-band Tunable Laser Source module for the test of critical DWDM components (1440 nm - 1640 nm).
#130	Low SSE Tunable Laser Source module (1260 nm - 1375 nm).
#140	Low SSE Tunable Laser Source module (1370 nm - 1495 nm).
#150	Low SSE Tunable Laser Source module (1450 nm - 1590 nm).
#160	Low SSE Tunable Laser Source module (1495 nm - 1640 nm).
#132	High Power Tunable Laser Source module (1260 nm - 1375 nm), + 9 dBm.
#142	High Power Tunable Laser Source module (1370 nm - 1495 nm), + 8.5 dBm.

Filler Module

Table 2

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 backloadable Tunable Laser Source module. It is used to help:

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

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

User's Guides

Table 3

User's Guides	
Description	**Part No.**
Agilent 81600B Tunable Laser Source Family User's Guide	81600-90B12
Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System Programming Guide	08164-90B64
Agilent 8163A/B Lightwave Multimeter, Agilent 8164A/B Lightwave Measurement System, & Agilent 8166A/B Lightwave Multichannel System User's Guide	08164-90B15

Options

Option 003 - Agilent 81600B #142 only

Built-in optical attenuator with 60 dB attenuation range.

NOTE

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

Option 071 - All Agilent 81600B Family TLS modules

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

Option 072 - All Agilent 81600B Family TLS modules

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

Connector Interfaces and Other Accessories

The Agilent 81600B Family Tunable Laser Source modules are 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, DIN, SC, ST or E2000) to connect to the instrument, you must do the following:

1. Attach your connector interface to the interface adapter. See Table 4 for a list of the available connector interfaces.
2. Connect your cable (see Table 4)

Table 4 Straight Contact Connector Interfaces

Description	Model No.
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, DIN, E2000 or SC/APC) to connect to the instrument, you must do the following:

1. Attach your connector interface to the interface adapter. See Table 5 for a list of the available connector interfaces.
2. Connect your cable (see Table 5)

Table 5 Angled Contact Connector Interfaces

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

3
Specifications

Agilent 81600B Tunable Laser Source Familys are produced to the ISO 9001 international quality system standard as part of Agilent's commitment to continually increasing customer satisfaction through improved quality control.

Specifications:

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

Definition of Terms

This section defines terms that are used both in this chapter and in Chapter 4, “Performance Tests.

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

General Definitions

Attenuation mode

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

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

Constant Temperature

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

Logged wavelength

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

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

Stepped mode

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

Continuous sweep mode

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

Absolute wavelength accuracy (continuous sweep mode)

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

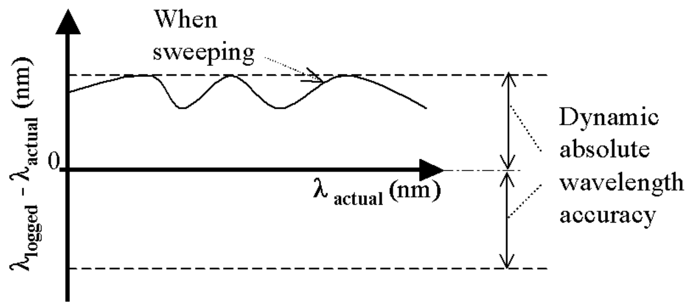


Figure 7 Absolute wavelength accuracy (continuous sweep mode)

Conditions: As specified. No mode-hop.

Absolute wavelength accuracy (stepped mode)

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

Conditions: Constant power level. Other conditions as specified.

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

NOTE

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

Attenuation

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

NOTE

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

Dynamic power reproducibility (continuous sweep mode)

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

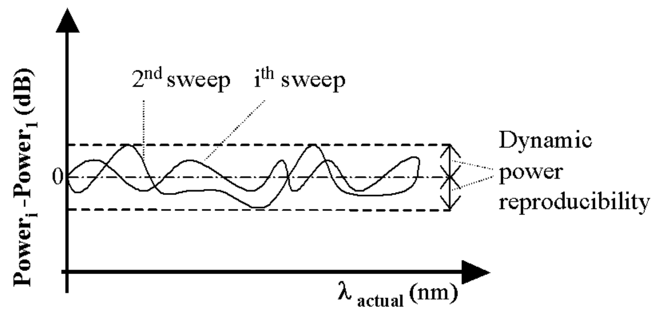


Figure 8 Dynamic power reproducibility (continuous sweep mode)

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

Dynamic relative power flatness (continuous sweep mode)

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

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

Measurement: Reference sweep speed value 0.5 nm/s.

Effective linewidth

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

Conditions: Coherence control on. Other conditions as specified.

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

External analog modulation - modulation depth

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

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

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

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

External digital modulation - delay time

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

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

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

Internal digital modulation - duty cycle

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

Conditions: Modulation frequency as specified.

Linewidth

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

Conditions: Coherence control off. Other conditions as specified.

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

Alternatively, *Using a 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 using an Agilent Lightwave signal analyzer, and the linewidth calculated from the heterodyne spectrum. (Lightwave signal analyzer settings:
resolution bandwidth 1 MHz, video bandwidth 10 kHz,
sweep time 20 ms, single scan).

Maximum output power

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

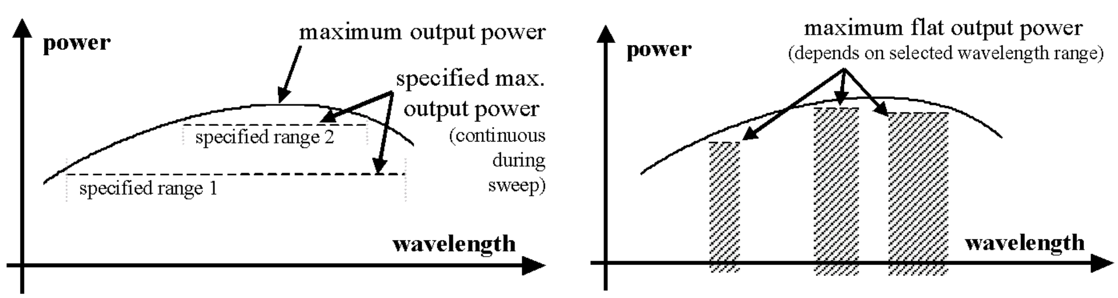


Figure 9 Maximum Output Power vs Wavelength, Maximum Flat Output Power vs Wavelength

Conditions: As specified.

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

Mode-hop free tunability

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

Operating temperature and humidity

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

NOTE

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

Output isolation

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

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

Polarization extinction ratio

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

NOTE

Applicable to tunable laser sources Utilizing polarization maintaining fiber (TE mode in the slow axis and aligned with the connector key).

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

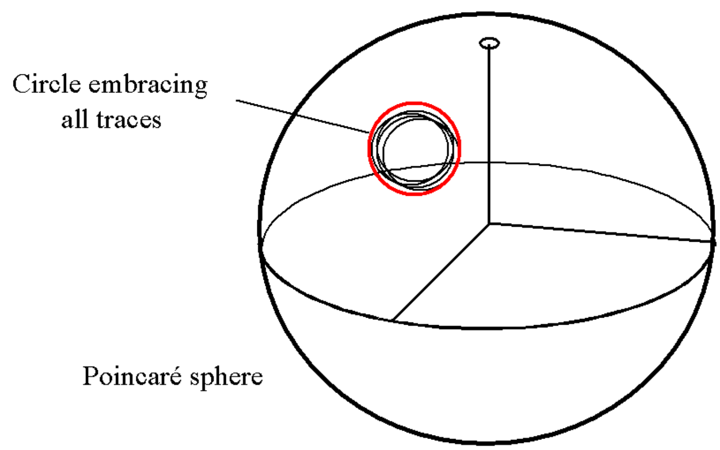


Figure 10 Circular traces on the Poincaré sphere used to calculate polarization extinction ratio.

Power flatness versus wavelength

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

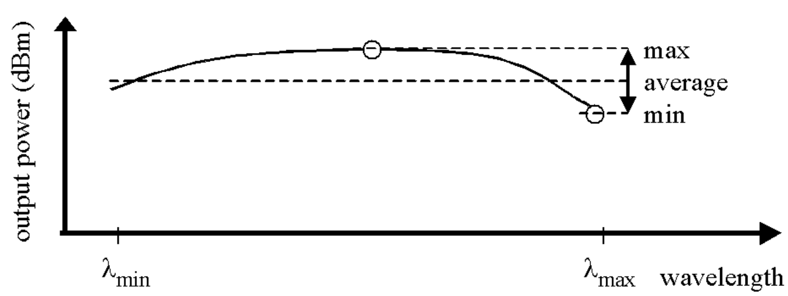


Figure 11 Power flatness vs. wavelength.

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

Power linearity

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

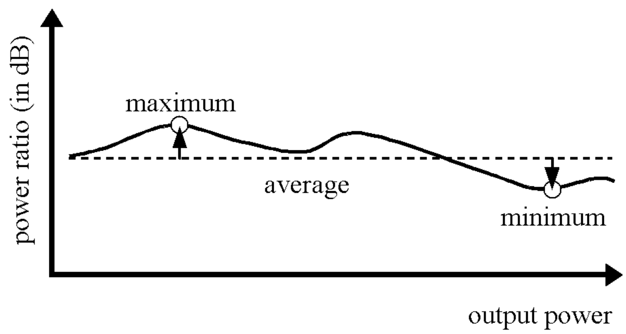


Figure 12 Power linearity.

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

Power repeatability

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

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

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

Power stability

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

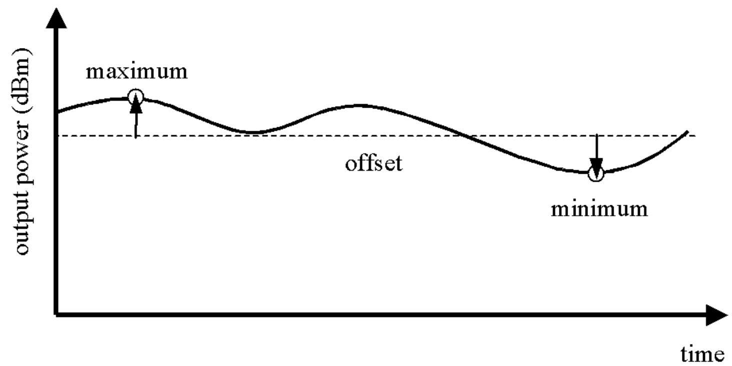


Figure 13 Power stability.

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

Relative intensity noise (RIN)

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

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

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

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

Conditions: As specified.

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

Relative wavelength accuracy (continuous sweep mode)

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

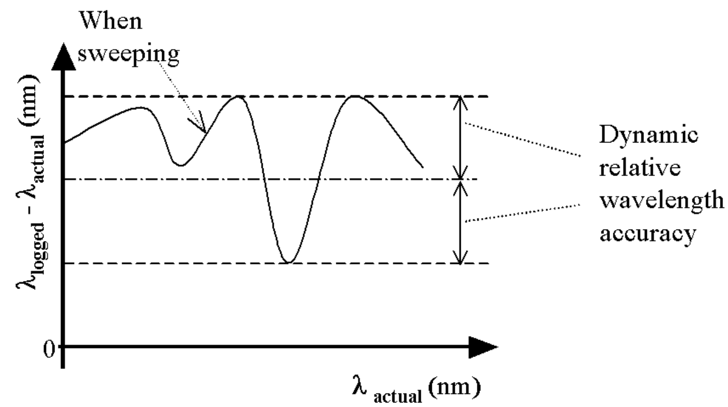


Figure 14 Relative wavelength accuracy (continuous sweep mode).

Conditions: As specified. No mode-hop.

Relative wavelength accuracy (stepped mode)

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

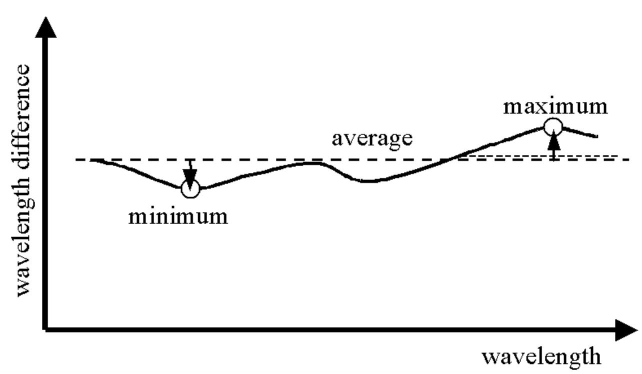


Figure 15 Relative wavelength accuracy.

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

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

NOTE

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

Return loss

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

Conditions: Tunable laser source output off.

Side-mode suppression ratio

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

$$SSR_{\mathrm{dB}} = 10 \cdot \log\left(\frac{P_{signal}}{P_{highest sidemode}}\right)$$

Conditions: As specified.

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

Signal to source spontaneous emission (SSE) ratio

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

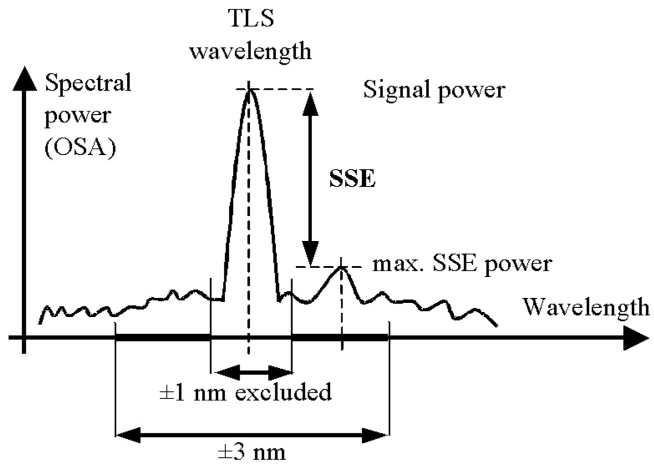


Figure 16 Signal to source spontaneous emission ratio.

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

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

Signal to total source spontaneous emission ratio

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

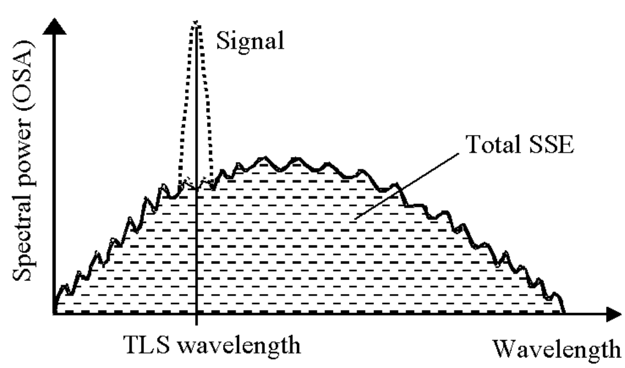


Figure 17 Signal to total source spontaneous emission ratio.

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

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

Wavelength range

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

Wavelength repeatability (continuous sweep mode)

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

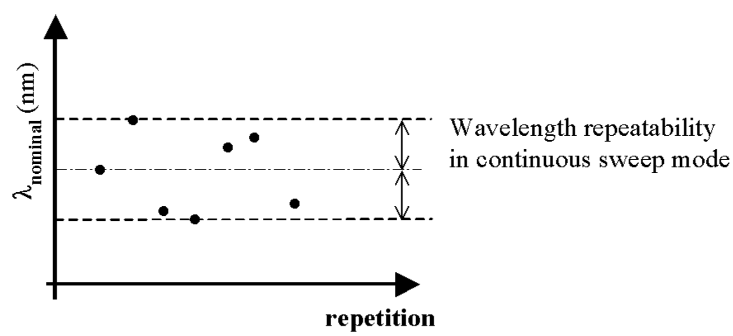


Figure 18 Wavelength repeatability (continuous sweep mode).

Conditions: As specified. No mode-hop.

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

Wavelength repeatability (stepped mode)

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

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

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

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

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

Wavelength resolution

The smallest selectable wavelength increment or decrement.

Wavelength stability

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

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

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

Agilent 81600B Family Tunable Laser Source Module Specifications

Specifications:

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

Typical Values and Supplementary Performance Characteristics:

Describe product performance that is usually met but not guaranteed.

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

81600B opt. 200 All-band TLS module, 1440 nm - 1640 nm, low SSE				
	Agilent 81600B opt.200			**2.3**
Wavelength range	1440 nm to 1640 nm			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [4] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effective linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1475 nm – 1625 nm, at max. constant output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Maximum output power (continuous power during sweep)	≥ +3 dBm peak typ. ≥ +2 dBm (1520 nm – 1610 nm) ≥ -2 dBm (1475 nm – 1625 nm) ≥ -7 dBm (1440 nm – 1640 nm)		≥ +9 dBm peak typ. ≥ +8 dBm (1520 nm – 1610 nm) ≥ +4 dBm (1475 nm – 1625 nm) ≥ -1 dBm (1440 nm – 1640 nm)	
Attenuation			max. 60 dB	
Power repeatability (typ.)	±0.003 dB			
Power stability [4]	±0.01 dB, 1 hour typ. ±0.03 dB, 24 hours			
Power linearity	±0.1 dB		±0.1 dB (±0.3 dB in attenuation mode)	
Power flatness versus wavelength	±0.25 dB [3] typ. ±0.1 dB		±0.3 dB [3] typ. ±0.15 dB	
		Continuous sweep mode		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.02 dB	±0.04 dB
Side-mode suppression ratio (typ.)	≥ 60 dB (1520 nm – 1610 nm)			

	Output 1 (low SSE)	Output 2 (high power)
Signal to source spontaneous emission ratio [2]	≥ 70 dB/nm (1520 nm – 1610 nm) typ. ≥ 80 dB/0.1 nm (1520 nm – 1610 nm) ≥ 66 dB/nm (typ., 1475 nm – 1625 nm) ≥ 60 dB/nm (typ., 1440 nm – 1640 nm)	≥ 48 dB/nm (1520 nm – 1610 nm) typ.≥ 58 dB/0.1nm (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 [2]	≥ 65 dB (1520 nm – 1610 nm) ≥ 57 dB (typ., 1440 nm – 1640 nm)	≥ 30 dB (typ., 1520 nm – 1610 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) (typ.) [2]	-145 dB/Hz (1520 nm – 1610 nm)	

[1] Valid for one month and within a ±4.4 K temperature range after automatic wavelength zeroing.
[2] At maximum output power as specified per wavelength range.
[3] Wavelength range 1440 nm – 1630 nm.
[4] At constant temperature ±1 K

81600B opt. 160 TLS module, 1495 nm - 1640 nm, low SSE				
	Agilent 81600B opt.160			**2.3**
Wavelength range	1495 nm to 1640 nm			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [3] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effective linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1510 nm – 1620 nm, at max. constant output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Maximum output power (continuous power during sweep)	≥ -2 dBm peak typ. ≥ -4 dBm (1520 nm – 1610 nm) ≥ -6 dBm (1510 nm – 1620 nm) ≥ -7 dBm (1495 nm – 1640 nm)		≥ +7 dBm peak typ. ≥ +5 dBm (1520 nm – 1610 nm) ≥ +3 dBm (1510 nm – 1620 nm) ≥ -1 dBm (1495 nm – 1640 nm)	
Attenuation			max. 60 dB	
Power repeatability (typ.)	±0.003 dB			
Power stability [3]	±0.01 dB, 1 hour typ. ±0.03 dB, 24 hours			
Power linearity	±0.1 dB		±0.1 dB (±0.3 dB in attenuation mode)	
Power flatness versus wavelength	±0.25 dB, typ. ±0.1 dB (1495 nm – 1630 nm)		±0.3 dB, typ. ±0.15 dB	
		Continuous sweep mode		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.02 dB	±0.04 dB
Side-mode suppression ratio (typ.) [2]	≥ 40 dB (1520 nm – 1610 nm)			

	Output 1 (low SSE)	Output 2 (high power)
Signal to source spontaneous emission ratio [2]	≥ 64 dB/nm (1520 nm – 1610 nm) typ. ≥ 74 dB/0.1 nm (1520 nm – 1610 nm) ≥ 62 dB/nm (typ., 1510 nm – 1620 nm) ≥ 59 dB/nm (typ., 1495 nm – 1640 nm)	≥ 45 dB/nm (1520 nm – 1610 nm) typ. ≥55 dB/0.1nm (1520 nm – 1610 nm) ≥ 42 dB/nm (1510 nm – 1620 nm) ≥ 37 dB/nm (1495 nm – 1640 nm)
Signal to total source spontaneous emission ratio [2]	≥ 59 dB (1520 nm – 1610 nm) ≥ 56 dB (typ., 1495 nm – 1640 nm)	≥ 27 dB (typ., 1520 nm – 1610 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) (typ.) [2]	-145 dB/Hz (1520 nm – 1610 nm)	

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

81600B opt. 150 TLS module, 1450 nm - 1590 nm, low SSE

	Agilent 81600B opt.150		**2.3**	
Wavelength range	1450 nm to 1590 nm			
Wavelength resolution	0.1 pm, 12.5 MHz at 1550 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [3] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effect. linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1480 nm – 1580 nm, at max. constant output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Maximum output power (continuous power during sweep)	≥ -1 dBm peak typ. ≥ -3 dBm (1520 nm – 1570 nm) ≥ -6 dBm (1480 nm – 1580 nm) ≥ -7 dBm (1450 nm – 1590 nm)		≥ +7 dBm peak typ. ≥ +5 dBm (1520 nm – 1570 nm) ≥ +4 dBm (1480 nm – 1580 nm) ≥ -1 dBm (1450 nm – 1590 nm)	
Attenuation			max. 60 dB	
Power repeatability (typ.)	±0.003 dB			
Power stability [3]	±0.01 dB, 1 hour typ. ±0.03 dB, 24 hours			
Power linearity	±0.1 dB		±0.1 dB (±0.3 dB in attenuation mode)	
Power flatness versus wavelength	±0.2 dB, typ. ±0.1 dB		±0.3 dB, typ. ±0.15 dB	
		Continuous sweep mode		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.02 dB	±0.04 dB
Side-mode suppression ratio (typ.) [2]	≥ 40 dB (1480 nm – 1580 nm)			

	Output 1 (low SSE)	Output 2 (high power)
Signal to source spontaneous emission ratio [2]	≥ 65 dB/nm (1520 nm – 1570 nm) typ. ≥ 75 dB/0.1 nm (1520 nm – 1570 nm) ≥ 61 dB/nm (typ., 1480 nm – 1580 nm) ≥ 59 dB/nm (typ., 1450 nm – 1590 nm)	≥45 dB/nm (1520 nm – 1570 nm) typ. ≥ 55 dB/0.1nm (1520 nm – 1570 nm) ≥ 42 dB/nm (1480 nm – 1580 nm) ≥ 37 dB/nm (1450 nm – 1590 nm)
Signal to total source spontaneous emission ratio [2]	≥ 60 dB (1520 nm – 1570 nm) ≥ 50 dB (typ., 1450 nm – 1590 nm)	≥ 30 dB (typ., 1520 nm – 1570 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) (typ.) [2]	-145 dB/Hz (1480 nm – 1580 nm)	

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

81600B opt. 140 TLS module, 1370 nm - 1495 nm, low SSE				
	Agilent 81600B opt.140			**2.4**
Wavelength range	1370 nm to 1495 nm			
Wavelength resolution	0.1 pm, 15 MHz at 1450 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s (1372 nm – 1495 nm)			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [4] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effective linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1430 nm – 1480 nm, at max. constant output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Maximum output power (continuous power during sweep)	≥ -4.5 dBm peak typ. ≥ -5 dBm (1430 nm – 1480 nm) ≥ -7 dBm (1420 nm – 1480 nm) ≥ -13 dBm (1370 nm – 1495 nm)		≥+5.5 dBm peak typ. ≥ +5 dBm (1430 nm – 1480 nm) ≥ +3 dBm (1420 nm – 1480 nm) ≥ -3 dBm (1370 nm – 1495 nm)	
Attenuation			max. 60 dB	
Power repeatability (typ.)	±0.003 dB			
Power stability [4]	±0.01 dB, 1 hour (1420 nm – 1495 nm) typ. ±0.01 dB, 1 hour (1370 nm – 1420 nm) typ. ±0.03 dB, 24 hours			
Power linearity	±0.1 dB (1420 nm – 1495 nm) typ. ±0.1 dB (1370 nm – 1420 nm)		±0.3 dB (1420 nm – 1495 nm) typ. ±0.3 dB (1370 nm – 1420 nm)	
Power flatness versus wavelength	±0.2 dB, typ. ±0.1 dB (1420 nm – 1495 nm) typ. ±0.2 dB (1370 nm – 1420 nm)		±0.3 dB, typ. ±0.2 dB (1420 nm – 1495 nm) typ. ±0.3 dB (1370 nm – 1420 nm)	
		Continuous sweep mode [3]		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.015dB	±0.03 dB
Side-mode suppression ratio (typ.) [2]	≥ 40 dB (1430 nm – 1480 nm)			

	Output 1 (low SSE)	Output 2 (high power)
Signal to source spontaneous emission ratio [2]	≥ 63 dB/nm (1430 nm – 1480 nm) typ. ≥ 73 dB/0.1 nm (1430 nm – 1480 nm) ≥ 61 dB/nm (typ., 1420 nm – 1480 nm) ≥ 55 dB/nm (typ., 1370 nm – 1495 nm)	≥ 42 dB/nm (1430 nm – 1480 nm) typ. ≥ 52 dB/0.1nm (1430 nm – 1480 nm) ≥ 40 dB/nm (1420 nm – 1480 nm) ≥ 35 dB/nm (1370 nm – 1495 nm)
Signal to total source spontaneous emission ratio [2]	≥ 60 dB (1430 nm – 1480 nm) ≥ 58 dB (1420 nm – 1480 nm) ≥ 53 dB (typ., 1370 nm – 1495 nm)	≥ 28 dB (typ., 1430 nm – 1480 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) [2]	-145 dB/Hz [1] (typ., 1430 nm – 1480 nm)	

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

81600B opt. 130 TLS module, 1260 nm - 1375 nm, low SSE				
	Agilent 81600B opt.130		**1.0**	
Wavelength range	1260 nm to 1375 nm			
Wavelength resolution	0.1 pm, 17.7 MHz at 1300 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [4] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effect. linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1270 nm – 1350 nm, at max. constant output power)			
	Output 1 (low SSE)		**Output 2 (high power)**	
Maximum output power (continuous power during sweep)	≥ -4 dBm peak typ. ≥ -6 dBm (1290 nm – 1370 nm) ≥ -9 dBm (1270 nm – 1375 nm) ≥ -13 dBm (1260 nm – 1375 nm)		≥ +5 dBm peak (typ.) ≥ +4 dBm (1290 nm – 1370 nm) ≥ +1 dBm (1270 nm – 1375 nm) ≥ -3 dBm (1260 nm – 1375 nm)	
Attenuation			max. 60 dB	
Power repeatability (typ.)	±0.003 dB			
Power stability [4]	±0.01 dB, 1 hour (1260 nm – 1350 nm) typ. ±0.01 dB, 1 hour (1350 nm – 1375 nm) typ. ±0.03 dB, 24 hours			
Power linearity	±0.1 dB (1260 nm – 1350 nm) typ. ±0.1 dB (1350 nm – 1375 nm)		±0.3 dB (1260 nm – 1350 nm) typ. ±0.3 dB (1350 nm – 1375 nm)	
Power flatness versus wavelength	±0.2 dB, typ. ±0.1 dB (1260 nm – 1350 nm) typ. ±0.2 dB (1350 nm – 1375 nm)		±0.3 dB, typ. ±0.2 dB (1260 nm – 1350 nm) typ. ±0.3 dB (1350 nm – 1375 nm)	
		Continuous sweep mode [3]		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.02 5dB	±0.04 dB
Side-mode suppression ratio (typ.) [2]	≥ 40 dB (1290 nm – 1370 nm)			

	Output 1 (low SSE)	Output 2 (high power)
Signal to source spontaneous emission ratio (typ.) [2]	≥ 63 dB/nm (1290 nm – 1370 nm) ≥ 61 dB/nm (1270 nm – 1375 nm) ≥ 55 dB/nm (1260 nm – 1375 nm)	≥ 42 dB/nm (1290 nm – 1370 nm) ≥ 40 dB/nm (1270 nm – 1375 nm) ≥ 35 dB/nm (1260 nm – 1375 nm)
Signal to total source spontaneous emission ratio (typ.) [2]	≥ 58 dB (1290 nm – 1370 nm) ≥ 56 dB (1270 nm – 1375 nm) ≥ 51 dB (1260 nm – 1375 nm)	≥ 26 dB (typ., 1290 nm – 1370 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) [2]	-140 dB/Hz (typ., 1270 nm – 1375 nm)	

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

81600B opt.142 TLS module, 1370 nm - 1495 nm, high power				
	Agilent 81600B opt.142		**2.4**	
Wavelength range	1370 nm to 1495 nm			
Wavelength resolution	0.1 pm, 15 MHz at 1450 nm			
Mode-hop free tunability	full wavelength range			
Max. sweep speed	80 nm/s (1372 nm – 1495 nm)			
	Stepped mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Absolute wavelength accuracy [1]	±10 pm, typ. ±3.6 pm	±4.0 pm	±4.6 pm	±6.1 pm
Relative wavelength accuracy [1]	±5 pm, typ. ±2 pm	±2.4 pm	±2.8 pm	±4.0 pm
Wavelength repeatability	±0.8 pm, typ. ±0.5 pm	±0.3 pm	±0.4 pm	±0.7 pm
Wavelength stability [4] (typ.)	≤ ±1 pm, 24 hours			
Linewidth (typ.), coherence control off Effective linewidth (typ.), coherence ctrl. on	100 kHz > 50 MHz (1430 nm – 1480 nm, at max. constant output power)			
Maximum output power (continuous power during sweep) With option 003	≥ +8.5 dBm peak typ. ≥ +7.5 dBm (1430 nm – 1480 nm) ≥ +5 dBm (1420 nm – 1480 nm) ≥ 0 dBm (1370 nm – 1495 nm) Reduced by 1.5 dB.			
Power repeatability (typ.)	±0.003 dB			
Power stability [4]	±0.01 dB, 1 hour (1420 nm – 1495 nm), typ. ±0.01 dB, 1 hour (1370 nm – 1420 nm) typ. ±0.03 dB, 24 hours			
Power linearity With option 003	±0.1 dB (1420 nm – 1495 nm) typ. ±0.1 dB (1370 nm – 1420 nm) Add ±0.2 dB			
Power flatness versus wavelength With option 003	±0.2 dB, typ. ±0.1 dB (1420 nm – 1495 nm) typ. ±0.2 dB (1370 nm – 1420 nm) Add ±0.1 dB			
		Continuous sweep mode [3]		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Dynamic power reproducibility (typ.)		±0.005 mB	±0.01 dB	±0.015 dB
Dynamic relative power flatness (typ.)		±0.01 dB	±0.015dB	±0.03 dB
Side-mode suppression ratio (typ.) [2]	≥ 40 dB (1430 nm – 1480 nm)			

Signal to source spontaneous emission ratio (typ.) [2]	≥ 42 dB/nm (1430 nm – 1480 nm) typ. ≥ 52 dB/0.1 nm (1430 nm – 1480 nm) ≥ 40 dB/nm (1420 nm – 1480 nm) ≥ 35 dB/nm (typ., 1370 nm – 1495 nm)
Signal to total source spontaneous emission ratio (typ.) [2]	≥ 28 dB (1430 nm – 1480 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) (typ.) [2]	-145 dB/Hz (1430 nm – 1480 nm)

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

81600B opt.132 TLS module, 1260 nm - 1375 nm, high power

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

Signal to total source spontaneous emission ratio (typ.) [2]	≥ 28 dB (1290 nm – 1370 nm)
Relative intensity noise (RIN) (0.1 – 6 GHz) (typ.) [2]	-145 dB/Hz (1270 nm – 1375 nm)

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

Conditions

Storage Temperature: -40° C to +70° C

Operating Temperature: +10° C to +35° C

Humidity: < 80% R.H. at 10° C to +35° C non-condensing.

Specifications apply for wavelengths not equal to any water absorption line.

Warm-up time: 1 h ; immediate operation after bootup

Output Power: Specifications are valid at the following output power levels:

81600B option 200, 160, and 150:
≥ -7 dBm (for Output 1)
≥ -1 dBm (for Output 2, attenuation 0 dB).

81600B option 140:
≥ -13 dBm (for Output 1)
≥ -3 dBm (for Output 2).

81600B option 130:
≥ -13 dBm (for Output 1)
≥ -3 dBm (for Output 2).

81600B option 142:
≥ -3 dBm
≥ -4.5 dBm (with option 003).

81600B option 132:
≥ 0 dBm

Continuous sweep mode: Specifications are valid for mode-hop free sweeping.

Maximum 50 nm at constant output power levels as follows:

81600B option 200:
1475 nm - 1620 nm
≥ -2 dBm (for Output 1)
≥ +4 dBm (for Output 2).

81600B option 160:
1510 nm - 1620 nm
≥ -6 dBm (for Output 1)
≥ +3 dBm (for Output 2).

81600B option 150:
1520 nm - 1570 nm
≥ -6 dBm (for Output 1)
≥ +3 dBm (for Output 2).

81600B option 140:
1430 nm - 1480 nm
≥ -9 dBm (for Output 1)
≥ 0 dBm (for Output 2).

81600B option 130:
1300 nm - 1350 nm
≥ -9 dBm (for Output 1)
≥ +1 dBm (for Output 2).

81600B option 142:
1430 nm - 1480 nm
≥ -3 dBm
≥ +1.5 dBm (with option 003).

81600B option 132:
1300 nm - 1350 nm
≥ +3 dBm

Operating temperature within +20° C and +35° C

Supplementary Performance Characteristics

Operating Modes:

Internal digital modulation

50% duty cycle , 200 Hz to 300 Hz.
Displayed wavelength represents average wavelength.

Modulation output (mainframe): TTL reference signal.

External digital modulation

> 45% duty cycle
delay time < 300 ns, 200 Hz to 1 MHz.
Displayed wavelength represents average wavelength.

Modulation input (mainframe): TTL signal.

External analog modulation

≥ ±15% duty cycle
5 kHz to 20 MHz

Modulation input (mainframe): 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 m long patchcords 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.

General

Output Isolation (typ.):

50 dB

Return Loss (typ.):

60 dB (option 072)
40 dB (option 071)

Polarization Maintaining Fiber

(Options 071, 072)

Fiber type: Panda

Orientation: TE mode in slow axis, in line with connector key.

Polarization extinction ratio:

16 dB typ.
14 dB typ. (Option 200).

Recommended recalibration period:

Two years.

4

Performance Tests

The procedures in this chapter test the optical performance of the Agilent 81600B Tunable Laser Source Family. The complete specifications to which each option is tested are given in Chapter 3, “Specifications starting on page 71.

All tests can be performed without access to the interior of the module. The performance tests refer specifically to tests using the listed test equipment and to the associated figures and descriptions of the test setups.

Required Test Equipment

The equipment required for the performance test is listed in Table 6. Any equipment that satisfies the critical specifications of the equipment given in Table 6 may be substituted for the recommended models.

Table 6 Equipment Required

Instrument/Accessory	Description	#071	#072
Agilent 86142B[a]	Optical Spectrum analyser	1	1
Agilent 8164A/B	Lightwave Measurement System	1	1
Agilent 86122A[b]	MultiWavelength meter	1	1
Agilent 81618A or 81619A	Optical Head Interface Module	1	1
Agilent 81624A/B #C01[c]	Standard Optical Head	1	1
Agilent 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[d]	1	1
Equipment for optional tests			
81636B[e]	Fast Power Meter	1	1
N/A	Wavelength Reference Unit (Faby-Perot etalon)[f]	1	1
N/A	Wavelength Reference Unit (Michelson Interferometer) - optional	1	1

[a] You can use the HP 71452B or HP 71450A #100 instead of the Agilent 86142B.
[b] You can use the Burleigh WA-1500 Wavemeter instead of the Agilent 86120C.
[c] You can use the 81623A/B #C01 instead of the 81624A/B #C01
[d] For the 81600B #200, #160 and #150 approximately 1520 nm, 2 nm at 3 dB
For the 81600B #140 approximately 1407 nm, 2 nm at 3 dB
[e] You can use the 81637B instead of the 81636B. Required characteristic: Sample rate ≥ 40 kHz
[f] Required characteristics:
- Optical length 9.35 ± 0.08 mm at 1510 nm
- Reflectivity 50 ± 2 %
- Wavelength range 1250 nm - 1650 nm
- Birefringency DIN 3140-6, that is 20 nm/cm or $2*10^{-6}$
- Linear polarizer with AR-coating at FP-etalon input (~ 30 dB extinction ratio, aligned with the principle state of polarization)
- Temperature Dependency: drift < 0.1 pm over the duration of the test (~ 15 min.).
A reasonable target temperature coefficient is < 0.3 pm/K, which typically requires 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 on 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 executing 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 procedure). 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 an Agilent 81600B Tunable Laser Source Family module fails any performance test, return it to the nearest Agilent Technologies Sales/Service Office for repair.

Instrument Specification

Specifications are the performance characteristics of the instrument that are certified. These specifications, listed in "Agilent 81600B Family Tunable Laser Source Module Specifications" on page 51 are the performance standards or limits against which an Agilent 81600B Tunable Laser Source Family module can be tested.

The specifications also list some "Supplementary Performance Characteristics" of the Agilent 81600B Tunable Laser Source Family on page 68. Supplementary Performance Characteristics should be regarded as additional information.

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

Performance Test Instructions

NOTE

Environment

- Make sure that all fiber connections are clean.
- Ensure that the Device Under Test (DUT) and **all** the test equipment is held within the environmental specfications given in “Agilent 81600B Family Tunable Laser Source Module Specifications” on page 51.

General test Setup

- Insert your Agilent 81600B Tunable Laser Source Family module from the rear into Slot 0 of the Agilent 8164A/B Lightwave Measurememt System.
- Turn the instruments on, enable the laser and allow the instruments to warm up.

Wavelength Tests

NOTE

Zeroing Zero the Tunable Laser Source module before performing wavelength tests.

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

Zeroing takes approximately 4 minutes.

Connect the Tunable Laser Source module to the Wavelength Meter as shown in Figure 19. On the 81600B #130, #140, #150, #160 or #200, connect the Output 2, the high power output.

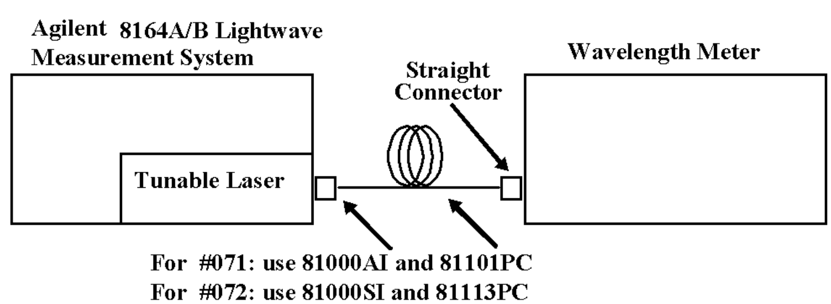


Figure 19 Test Setup for Wavelength Tests

Wavelength Meter Settings for all Wavelength Tests

Set the Wavelength meter:

- Set **Display** to **Wavelength**,
- Set **Medium** to **Vacuum**,
- Set **Resolution** to **Auto**,
- Set **Averaging** to **On**,
- Set **Input Attenuation** to **Auto**.

Wavelength Accuracy

The procedures in this section show how to calculate the Relative Wavelength Accuracy, Absolute Wavelength Accuracy, Mode-hop Free Tuning, and Wavelength Repeatability results.

Absolute and Relative Wavelength Accuracy

For definitions, see:

“Absolute wavelength accuracy (continuous sweep mode)” and “Absolute wavelength accuracy (stepped mode)” on page 37;

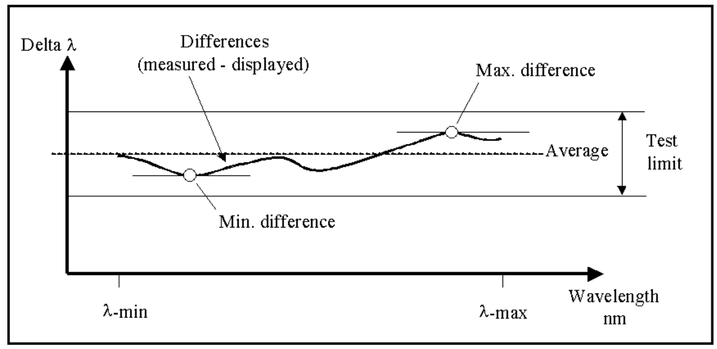
“Relative wavelength accuracy (continuous sweep mode)” and “Relative wavelength accuracy (stepped mode)” on page 45.

Measurement Principle

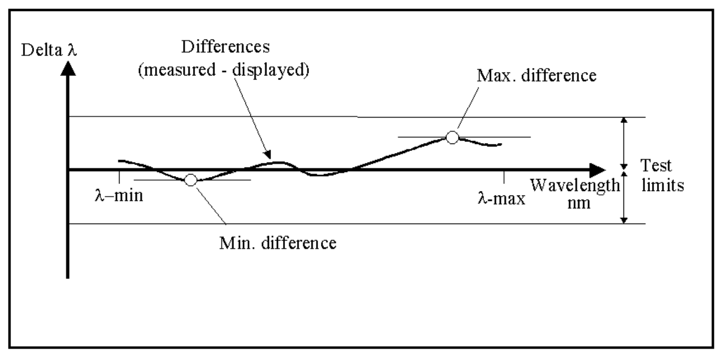
The TLS is set to certain wavelengths and the actual wavelength is measured using a well-calibrated wavelength meter. Ideally, the displayed and measured wavelengths should coincide. The difference between the displayed and measured (actual) wavelength is the Absolute Wavelength Accuracy.

Relative Wavelength Accuracy describes the instrument's ability to generate precise wavelength steps. For example, if the wavelength setting is changed by 1 nm, the actual wavelength should change by 1 nm. To test for deviations from this ideal, the tunable laser source is set to various wavelengths, and the actual wavelength is measured using a wavelength meter.

The measurement of the relative wavelength accuracy includes the measurement of absolute wavelength accuracy. The absolute wavelength accuracy measurement program generates all the results needed for the calculation of the relative wavelength accuracy.



Relative Wavelength Accuracy



Absolute Wavelength Accuracy

Figure 20 Absoute and Relative Wavelength Accuracy.

At the start of the test the TLS is set:

- To its lowest specified wavelength,
- To the highest power the TLS can deliver over the full wavelength range,

NOTE

Attenuate the Power Output from the TLS Reduce the output power delivered by the TLS to a level compatible with the capabilities of the wavelength meter.

Use the TLS module's built-in attenuator, or an external attenuator.

- Such that any modulation is off.

At the end of the test, the TLS is set to its maximum specified wavelength.

Test Procedure

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #130 (Output 2, High Power)
Agilent 81600B #132

It measures the absolute and relative wavelength accuracy of the module at the outputs indicated.

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

2 Set the menu parameters to:

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

3 Connect the fiber to the optical output.
If you are using the Agilent 81600B #200, #160, #150, #140 or #130, connect the fiber to Output 2, the High Power output.
That is, set *<Optical Output>* to *<High Power (2)>*.

4 Set the inital wavelength and power of the TLS to:

TLS module	Wavelength [λ]	Power [*P*]
Agilent 81600B #200	1440.000 nm	- 1.00 dBm
Agilent 81600B #160	1495.000 nm	- 1.00 dBm
Agilent 81600B #150	1450.000 nm	- 1.00 dBm
Agilent 81600B #140	1370.200 nm	- 3.00 dBm
Agilent 81600B #130	1260.000 nm	- 3.00 dBm
Agilent 81600B #142 #003	1370.200 nm	- 1.50 dBm
Agilent 81600B #142	1370.200 nm	0.00 dBm
Agilent 81600B #132	1260.000 nm	0.00 dBm

NOTE

Water absorption lines For 81600B #130, #132, #140 and #142, some wavelengths are set to odd values to avoid conflict with water absorption lines.

5 Switch on the TLS output.

6 Wait until the wavelength meter has settled then note the wavelength displayed by the wavelength meter in the Test Record.

7 Set the TLS module to the next wavelength given in the Test Record.

8 Repeat step 6 and step 7 to the maximum wavelength value for the TLS module:

TLS module	Maximum Wavelength Value
Agilent 81600B #200	1640 nm
Agilent 81600B #160	1640 nm
Agilent 81600B #150	1590 nm
Agilent 81600B #140	1495 nm
Agilent 81600B #130	1375 nm
Agilent 81600B #142 #003	1495 nm
Agilent 81600B #142	1495 nm
Agilent 81600B #132	1375 nm

9 Repeat step 4 to step 8 another four times.

10 Select the maximum and minum deviations from each repetition of the measurements, and note these values in the Test Record.

11 Determine the *Relative Wavelength Accuracy* and *Summary of all Repetitions*.

  a Take the *Largest Maximum Deviation* and note it in the Test Record,

  b Take the *Smallest Minimum Deviation* and note it in the Test Record.

NOTE

Determining the Maximum and the Minimum Deviations

- The *Largest Maximum Deviation* is the most positive value (or the least negative, if all values are negative).
- The *Smallest Minimum Deviation* is the most negative value (or the least positive, if all values are positive).

12 Determine, and note in the Test Record, the *Relative Wavelength Accuracy*, which is the

Smallest Minimum Deviation subracted from the *Largest Maximum Deviation.*

13 Determine, and note in the Test Record, the *Absolute Wavelength Accuracy*, which is the largest deviation (of either the *Smallest Minimum Deviation* or the *Largest Maximum Deviation*).

Mode-Hop Free Tuning

For definition, see “Mode-hop free tunability” on page 41.

Measurement Principle

The mode-hop free sweeping range (= mode-hop free span) is defined for the sweep mode. The sweep mode operates without TCFS. A mode-hop is an abrupt change of the laser wavelength during tuning, when the laser changes to another longitudinal mode. In the mode-hop free sweeping range, abrupt changes of the wavelength larger than 25 pm are not allowed. To test this, the wavelength of the TLS is continuously swept over the tuning range and the wavelengths are measured by the TCFS. The difference between two successive wavelengths should not deviate more than 25 pm from the ratio of the scan range to the number of wavelength reading points. The test of the mode-hop free sweeping range requires dedicated software and cannot be done manually. Agilent Technologies service centers use this software to test the TLS for mode-hop free sweeping.

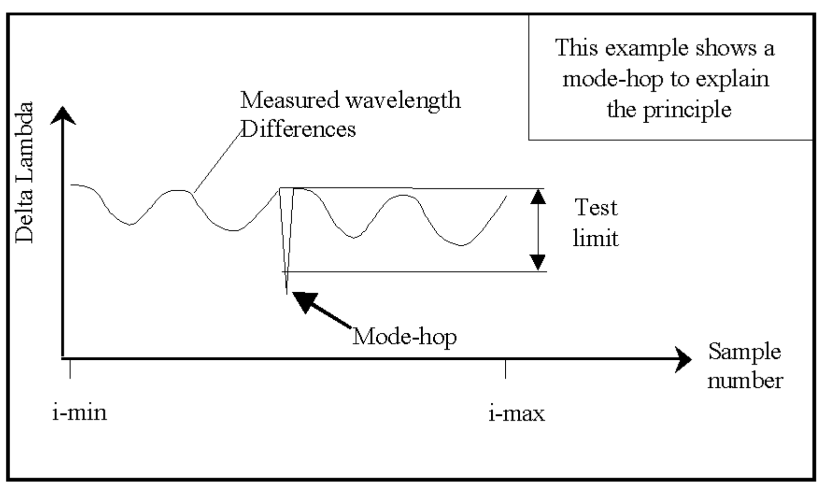


Figure 21 Mode-hop free Tuning Range.

The mode-hop free tuning range is defined for the stepped mode. It is automatically ensured by the wavelength regulation performed by the TCFS, because the relative wavelength accuracy is better than half of a mode-hop. The mode-hop free tuning range can be tested manually in the same way as wavelength accuracy but with a higher wavelength resolution, as described in the following test sequence. The test is focussed to the beginning and the end of the tuning range where the probability of possible mode-hops is much higher.

At the start of the test the TLS is set:

- To (a) its lowest specified wavelength, then
  (b) 10 nm below its maximum specified wavelength,
- To the highest power the TLS can deliver over the 10 nm wavelength range at the beginning and the end of the tuning range,

NOTE

Attenuate the Power Output from the TLS Reduce the output power delivered by the TLS to a level compatible with the capabilities of the wavelength meter.

Use the TLS module’s built-in attenuator, or an external attenuator.

- Such that any modulation is off,
- To tune over 10 steps with 1 nm increments.

Test Procedure

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #130 (Output 2, High Power)
Agilent 81600B #132

It measures mode-hop free tuning range of the module at the outputs indicated.

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

2 Set the menu parameters to:

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

3 Connect the fiber to the optical output.
If you are using the Agilent 81600B #200, #160, #150 or #140, connect the fiber to Output 2, the High Power output.
That is, set <*Optical Output*> to <*High Power (2)*>.

4 Set the inital wavelength and power of your TLS to:

TLS module	Wavelength [λ]	Power [*P*]
Agilent 81600B #200	1440.000 nm	- 1.00 dBm
Agilent 81600B #160	1495.000 nm	- 1.00 dBm
Agilent 81600B #150	1450.000 nm	- 1.00 dBm
Agilent 81600B #140	1370.200 nm	- 3.00 dBm
Agilent 81600B #130	1260.000 nm	- 3.00 dBm
Agilent 81600B #142 #003	1370.200 nm	- 1.50 dBm
Agilent 81600B #142	1370.200 nm	0.00 dBm
Agilent 81600B #132	1260.000 nm	0.00 dBm

NOTE

Water absorption lines For 81600B #140 and #142, some wavelengths are set to odd values to avoid conflict with water absorption lines.

5 Switch on the TLS output.

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

7 Set the TLS module to the next wavelength given in the Test record.

8 Repeat step 6 and step 7 to the maximum wavelength value for the TLS module:

TLS module	Maximum Wavelength Value [λ]
Agilent 81600B #200	1640 nm
Agilent 81600B #160	1640 nm
Agilent 81600B #150	1590 nm
Agilent 81600B #140	1495 nm
Agilent 81600B #130	1375 nm
Agilent 81600B #142 #003	1495 nm
Agilent 81600B #142	1495 nm
Agilent 81600B #132	1375 nm

9 Note the maximum deviation and the minimum deviation in the Test Record.

10 The Mode-Hope Free Tuning result is the larger of either the maximum deviation or the minimum deviation in the Test Record

It is not necessary to repeat the Mode-Hop Free Tuning Test.

Wavelength Repeatability

For definitions, see "Wavelength repeatability (continuous sweep mode)" and "Wavelength repeatability (stepped mode)" on page 48.

Measurement Principle

The TLS is set to any wavelength (an initial reference wavelength) within the specified wavelength range and the actual wavelength measured. Then the TLS is set to another wavelength (generally chosen at random), re-set to the initial wavelength and the actual wavelength measured again. This sequence is repeated several times. The maximum deviation of the measured wavelength after being reset to the reference is calculated and compared to the test limits.

Then the TLS is set to a second (initial reference) wavelength, and the sequence repeated.

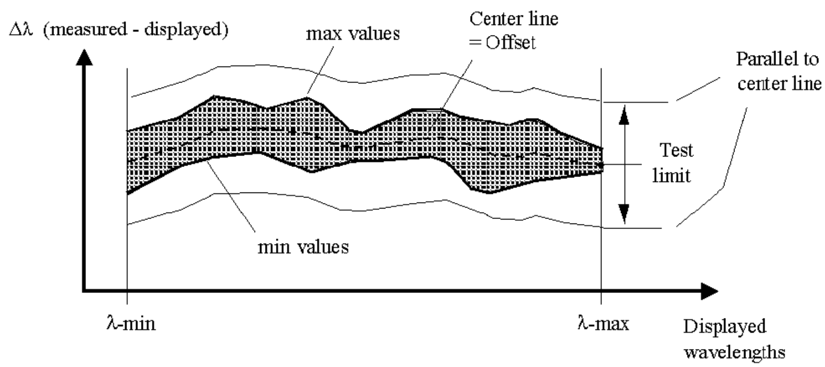


Figure 22 Wavelength Repeatability.

At the start of the test the TLS is set:

- To its lowest specified wavelength,
- To the highest power the TLS can deliver over the full wavelength range,

NOTE

Attenuate the Power Output from the TLS Reduce the output power delivered by the TLS to a level compatible with the capabilities of the wavelength meter.

Use the TLS module’s built-in attenuator, or an external attenuator.

- Such that any modulation is off,

At the end of the test, the TLS is set to its maximum specified wavelength.

Test Procedure

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #130 (Output 2, High Power)
Agilent 81600B #132

It measures the wavelength repeatability of the module at the outputs indicated.

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

2 Set the menu parameters to:

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

3 Connect the fiber to the optical output.
If you are using the Agilent 81600B #200, #160, #150, #140 or #130, connect the fiber to Output 2, the High Power output.
That is, set <*Optical Output*> to <*High Power (2)*>.

4 Set the wavelength and power of your TLS module to:

TLS module	**Wavelength** [λ]	**Power** [*P*]
Agilent 81600B #200	1440.000 nm	- 1.00 dBm
Agilent 81600B #160	1495.000 nm	- 1.00 dBm
Agilent 81600B #150	1450.000 nm	- 1.00 dBm
Agilent 81600B #140	1370.200 nm	- 3.00 dBm
Agilent 81600B #130	1260.000 nm	- 3.00 dBm
Agilent 81600B #142 #003	1370.200 nm	- 1.50 dBm
Agilent 81600B #142	1370.200 nm	0.00 dBm
Agilent 81600B #132	1260.000 nm	0.00 dBm

NOTE

Water absorption lines For 81600B #140 and #142, some wavelengths are set to odd values to avoid conflict with water absorption lines.

5 Switch on the TLS output.

6 Wait until the wavelength meter has settled then note the wavelength displayed by the wavelength meter in the Test Record as the Initial Setting, the reference wavelength "REF".

7 Set the TLS module to any wavelength in its range. In the Test Record, this is given in the "from wavelength" column.

8 Set the wavelength of your TLS module back to the reference wavelength and wait until the wavelength meter has settled.

9 Measure the wavelength using the Wavelength Meter and note the result in the Test Record.

10 Repeat step 7 to step 9 for all the 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 smallest measured value from the largest measured value.

Power Tests

The procedures in this section show how to measure the Maximum Output Power, Power Linearity, Power Flatness versus Wavelength, and Power Stability.

Maximum Output Power

For definition, see “Maximum output power” on page 40.

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

Measurement Principle

The TLS' output power is set to excessive power (indicated on the display by "ExP") to get the highest achievable power. For each wavelength within the specified wavelength range, the actual output power is measured and compared against (wavelength-dependent) test limits.

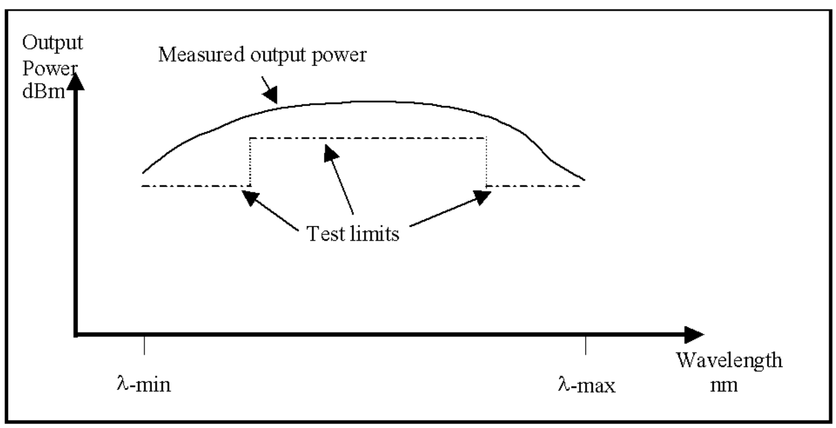


Figure 23 Maximum Output Power.

NOTE

- Absolute power *accuracy* is not specified.
- The result of the measurement is greatly influenced by the quality and matching of the interconnections used.

At the start of the test the TLS is set:

- To its lowest specified wavelength,
- To an output power larger than the specified output power,
- Such that any modulation is off.

At the end of the test, the TLS is set to its maximum specified wavelength.

Test Procedure

This test procedure is applicable to the:

Agilent 81600B #200 (Output 1, Low SSE), (Output 2, High Power)
Agilent 81600B #160 (Output 1, Low SSE), (Output 2, High Power)
Agilent 81600B #150 (Output 1, Low SSE), (Output 2, High Power)
Agilent 81600B #140 (Output 1, Low SSE), (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #130 (Output 1, Low SSE), (Output 2, High Power)
Agilent 81600B #132

It measures the maximum output power of the module at the outputs indicated.

Set up the equipment as shown in Figure 24:

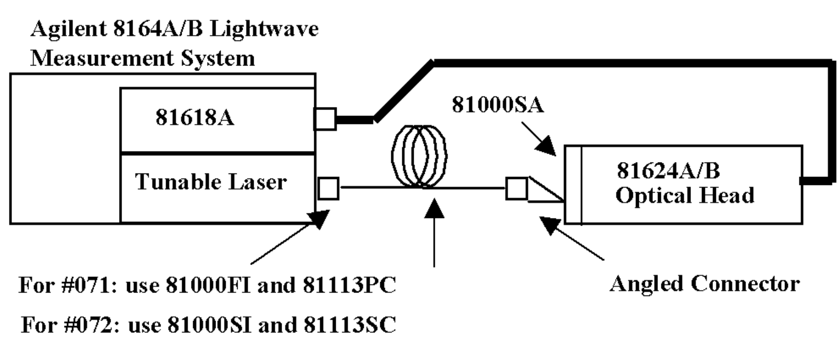


Figure 24 Test Setup for Maximum Output Power Tests

1 Move to the power meter channel:

- Select **Automatic** ranging (this is the default setting),
- Set the **Averaging Time** to **500 ms**,
- Select <*dBm*> as the power units,
- While the laser is **Off**, Zero the power meter. Select <*Menu*> then <*Zero*>.

2 Move to the TLS channel. Set the menu parameters to:

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

3 Connect the fiber to the optical output.
If you are using the Agilent 81600B #200, #160, #150, #140 or #130, connect the fiber to Output 1, the Low SSE output.
That is, set <*Optical Output*> to <*Low SSE(1)*>.

4 Set the wavelength and power of your TLS module to:

TLS module	Wavelength [λ]	Power [*P*]
Agilent 81600B #200	1440.000 nm	+ 12.00 dBm
Agilent 81600B #160	1495.000 nm	+ 12.00 dBm
Agilent 81600B #150	1450.000 nm	+ 12.00 dBm
Agilent 81600B #140	1370.200 nm	+ 12.00 dBm
Agilent 81600B #130	1260.000 nm	+ 12.00 dBm
Agilent 81600B #142 #003	1370.200 nm	+ 12.00 dBm
Agilent 81600B #142	1370.200 nm	+ 12.00 dBm
Agilent 81600B #132	1260.000 nm	+ 12.00 dBm

NOTE

Water absorption lines For 81600B #130, #132, #140 and #142, some wavelengths are set to odd values to avoid conflict with water absorption lines.

NOTE

ExP •Excessive power indicator.

The laser output is limited to its maximum possible value at this wavelength.

The display will probably show ExP (Excessive Power).

5 Switch on the TLS output.

6 Set the wavelength of the 81624A/B to the same as the TLS module, as given in step 4.

7 Measure the output power using the 81624A/B and note the result for this wavelength in the Test Record.

8 Increase λ, the output wavelength, of the TLS module to the next value given in the Test Record.

9 Increase the wavelength of the 81624A/B to the same value.

10 Note the measured power for the wavelength in the Test Record.

11 Repeat step 8 to step 10 for the full wavelength range.

12 If you are using the Agilent 81600B #200, #160, #150, #140 or #130, connect the fiber to Output 2, the High Power output.
That is, set <*Optical Output*> to <*High Power (2)*>.

13 Repeat step 5 to step 11 for the full wavelength range.

Power Linearity

For definition, see “Power linearity” on page 43.

Measurement Principle

Power linearity describes the TLS' ability to generate precise power steps. For example, if the power setting is changed by
3 dB, the actual power should change by 3 dB. The deviations from this ideal are tested by setting defined power steps and measuring them using the power meter.

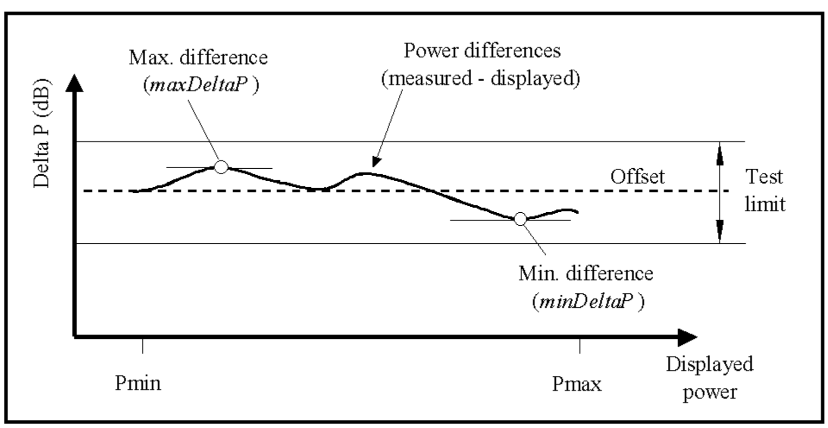


Figure 25 Power Linearity.

At the start of the test the TLS is set:

- To any fixed wavelength, preferably to a wavelength where the highest specified output power can be achieved,
- To the maximum output power specified for this wavelength or, if a built-in attenuator is used, to 0 dBm.
- Such that any modulation is off.

The output power is measured and compared to the displayed power value. For simplicity, the start value is defined as a reference, and all subsequent differences between the measured and displayed power values are compared to this reference.

Output power is decremented in 1 dB steps.

At the end of the test, the TLS is set to its minimum output power.

Test Procedure - Low SSE output

This test procedure is applicable to the:

Agilent 81600B #200 (Output 1, Low SSE)
Agilent 81600B #160 (Output 1, Low SSE)
Agilent 81600B #150 (Output 1, Low SSE)
Agilent 81600B #140 (Output 1, Low SSE)
Agilent 81600B #130 (Output 1, Low SSE)

It measures the power linearity of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 26:

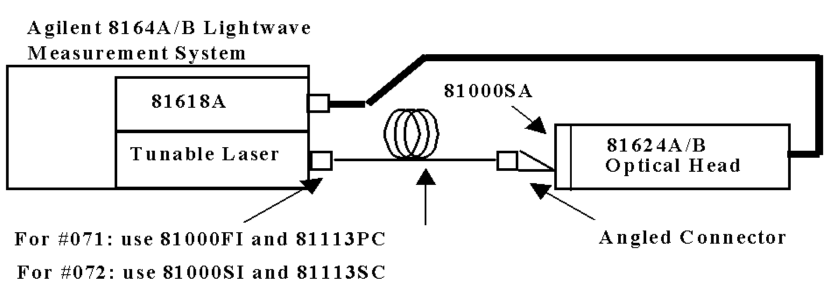


Figure 26 Test Setup for Power Linearity Tests

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

3 Set the inital wavelength and power of the TLS to:

Tunable Laser Channel [Menu] Parameters[a]	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
Modulation: <*mod src*>	<*Off*>

[a] When using the low SSE output <*Power Mode*> is not applicable.

TLS module - low SSE output	Wavelength [λ]	Power [*P*]
Agilent 81600B #200 - Output 1	1570.000 nm	+ 2.00 dBm
Agilent 81600B #160 - Output 1	1570.000 nm	- 4.00 dBm
Agilent 81600B #150 - Output 1	1550.000 nm	- 3.00 dBm
Agilent 81600B #140 - Output 1	1460.000 nm	- 5.00 dBm
Agilent 81600B #130 - Output 1	1350.000 nm	-6.00 dBm

4 Connect the fiber to the low SSE oupout, Output 1.
Set <*Optical Output*> to <*Low SSE (1)*>.

5 Make sure the optical output is switched **off**.

6 At the 81624A/B:

- **a** Zero the 81624A/B. Select <*Menu*> then <*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 the TLS module, as given in step 3.

7 Switch on the LowSSE output of the TLS.

8 Note the power value displayed by the 81624A/B in the Test Record.

9 At the 81624A/B, select <*Menu*> then <*Disp → Ref*>

10 Change the power setting of the TLS to the next value given in the Test Record.

11 Note the (relative) power displayed by the 81624A/B as the “Measured Relative Power from start”.

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

13 Repeat step 10 to step 12 for all power levels listed in the Test Record.

14 Determine the maximum value and the minimum value of the calculated Power Linearity at the various settings and record them in the Test Record as "Maximum Power Linearity at current setting", and "Minimum Power Linearity at current setting", respectively.

15 Subtract the minimum power linearity value from the maximum power linearity value and record the result as the **Total Power Linearity**.

Example: Agilent 81600B #200 Power Linearity, Output 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 dBm	+	0.00 dBm	=	0.00 dBm
	+ 1.0 dBm	- 1.02 dBm	+	1.00 dBm	=	- 0.02 dBm
	0.0 dBm	- 1.92 dBm	+	2.00 dBm	=	+ 0.08 dBm
	- 1.0 dBm	- 2.95 dBm	+	3.00 dBm	=	+ 0.05 dBm
	- 2.0 dBm	- 4.07 dBm	+	4.00 dBm	=	- 0.07 dBm
	- 3.0 dBm	- 4.96 dBm	+	5.00 dBm	=	+ 0.04 dBm
	- 4.0 dBm	- 5.97 dBm	+	6.00 dBm	=	+ 0.03 dBm
	- 5.0 dBm	- 6.98 dBm	+	7.00 dBm	=	+ 0.02 dBm
	- 6.0 dBm	- 7.97 dBm	+	8.00 dBm	=	+ 0.03 dBm
	- 7.0 dBm	- 8.98 dBm	+	9.00 dBm	=	+ 0.02 dBm

Maximum Power Linearity at current setting:	+ 0.08 dBm
Minimum Power Linearity at current setting:	- 0.07 dBm
Total Linearity	
= Max. Power Linearity - Min. Power Linearity	**0.15 dBpp**

Test Procedure - High Power output, no attenuation

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #160 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #150 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #140 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #130 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #142 #003, built-in attenuator not used.
Agilent 81600B #142
Agilent 81600B #132

It measures the power linearity of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 26 on page 92.

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>[a]	<*Manual Att*>
Modulation: <*mod src*>	<*Off*>

[a] For the 81600B #200, #160, #150, #140, and #142 #003 (that is, where a built-in attenuator is fitted).

3 Set the inital wavelength and power of the TLS to:

TLS module - High Power output, no attenuation	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B #200 - Output 2	1570.000 nm	+ 8.000 dBm	0.000 dB
Agilent 81600B #160 - Output 2	1570.000 nm	+ 5.000 dBm	0.000 dB
Agilent 81600B #150 - Output 2	1550.000 nm	+ 5.000 dBm	0.000 dB
Agilent 81600B #140 - Output 2	1460.000 nm	+ 5.000 dBm	0.000 dB
Agilent 81600B #130 - Output 2	1350.000 nm	+ 4.000 dBm	0.000 dB
Agilent 81600B #142 #003	1460.000 nm	+ 6.000 dBm	0.000 dB
Agilent 81600B #142	1460.000 nm	+ 7.500 dBm	not applicable
Agilent 81600B #132	1460.000 nm	+ 7.000 dBm	not applicable

4 For the 81600B #200, #160, #150, #140 and #130, connect the fiber to the High Power output, Output 2.

Set <*Optical Output*> to <*High Power (2)*>.

5 Make sure the optical output is switched **off**.

6 At the 81624A/B:

  a Zero the 81624A/B. Select <*Menu*> then <*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 the TLS module, as given in step 3.

7. Switch on the High Power output of the TLS.

8. Note the power value displayed by the 81624A/B in the Test Record.

   [For the 81600B #200, #160, #150, #140 and #130 use the Test Record table “Power Linearity Output 2, High Power Upper Power Levels”.

   For the 81600B #142 #003 use the Test Record table “Power Linearity 81600B #142 #003, High Power Upper Power Levels”.]

9. At the 81624A/B, select <*Menu*> then <*Disp* → *Ref*>

10. Change the power setting of the TLS to the next value given in the Test Record.

11. Note the (relative) power displayed by the 81624A/B as the “Measured Relative Power from start”.

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

13. Repeat step 10 to step 12 for all power levels listed in the Test Record.

14. Determine the maximum value and the minimum value of the calculated Power Linearity at the various settings and record them in the Test Record as "Maximum Power Linearity at current setting", and "Minimum Power Linearity at current setting", respectively.

15. Subtract the minimum power linearity value from the maximum power linearity value and record the result as the **Total Power Linearity**.

    [For example, refer to Table .]

Test Procedure - High Power output, using the built-in attenuator

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #130 (Output 2, High Power)
Agilent 81600B #142 #003

It measures the power linearity of the module at the outputs indicated and the built-in attenuator is used.

1 Set up the equipment as shown in Figure 27 on page 97.

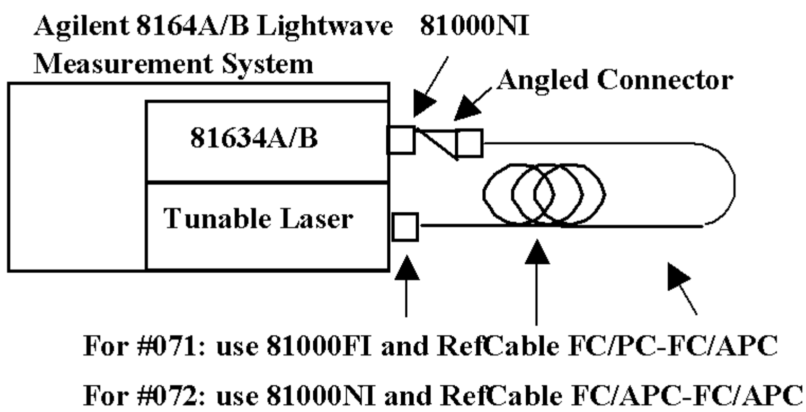


Figure 27 Test Setup for Power Linearity Tests using built-in attenuator

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<Wavelength Mode>	<λ>
<Source State>	*<Off>*
<Power Unit>	*<dBm>*
<Power Mode>	*<Manual Att>*
Modulation: *<mod src>*	*<Off>*

3 Set the inital wavelength and power of the TLS to:

TLS module - High Power output, no attenuation	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B #200 - Output 2	1570.000 nm	+ 0.000 dBm	0.000 dB
Agilent 81600B #160 - Output 2	1570.000 nm	+ 0.000 dBm	0.000 dB
Agilent 81600B #150 - Output 2	1550.000 nm	+ 0.000 dBm	0.000 dB
Agilent 81600B #140 - Output 2	1460.000 nm	+ 0.000 dBm	0.000 dB
Agilent 81600B #130 - Output 2	1350.000 nm	+ 0.000 dBm	0.000 dB
Agilent 81600B #142 #003	1460.000 nm	+ 0.000 dBm	0.000 dB

4 4For the Agilent 81600B #130, #140, #150, #160 and #200 TLS modules, connect the output fiber to Output 2, the High Power output

Set <*Optical Output*> to <*High Power (2)*>.

5 Make sure the optical output is switched **off**.

6 At the 81624A/B:

- **a** Zero the 81624A/B. Select <*Menu*> then <*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 the TLS module, as given in step 3.

7 Switch on the High Power output of the TLS.

8 Note the power value displayed by the 81624A/B in the Test Record.

[For the 81600B #200, #160, #150, #140 and #130 use the Test Record table “Power Linearity Output 2, High Power by attenuator”.

For the 81600B #142 #003 use the Test Record table “Power Linearity 81600B #142 #003, High Power by attenuator”.]

9 At the 81624A/B, select <*Menu*> then <*Disp* → *Ref*>

10 Change the power setting of the TLS to the next value given in the Test Record.

11 Note the (relative) power displayed by the 81624A/B as the “Measured Relative Power from start”.

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

13 Repeat step 10 to step 12 for all power levels listed in the Test Record.

14 Determine the maximum value and the minimum value of the calculated Power Linearity at the various settings and record them in the Test Record as "Maximum Power Linearity at current setting", and "Minimum Power Linearity at current setting", respectively.

15 Subtract the minimum power linearity value from the maximum power linearity value and record the result as the **Total Power Linearity**.

[For example, refer to Table .]

Power Flatness versus Wavelength

For definition, see “Power flatness versus wavelength” on page 42.

Measurement Principle

At a fixed power level, the wavelength is tuned over a given wavelength span. At each wavelength, the power is measured. Ideally, all power levels would be identical. Any deviation is expressed as power flatness.

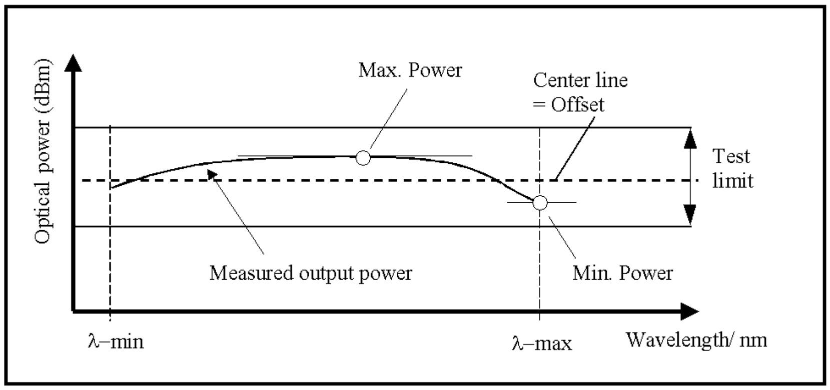


Figure 28 Power Flatness.

At the start of the test the TLS is set:

- To its lowest specified wavelength,
- To the highest power the TLS can deliver over the full wavelength range,
- Such that any modulation is off.

The wavelength is increased in 5 nm increments and the difference between the measured and the displayed power is recorded.

At the end of the test, the TLS is set to its maximum specified wavelength.

NOTE

81600B #140, #142 To avoid conflicts with water absorption lines, the power flatness measurement begins at 1420.2 nm.

Test Procedure - Low SSE output

This test procedure is applicable to the:

Agilent 81600B #200 (Output 1, Low SSE)
Agilent 81600B #160 (Output 1, Low SSE)
Agilent 81600B #150 (Output 1, Low SSE)
Agilent 81600B #140 (Output 1, Low SSE)
Agilent 81600B #130 (Output 1, Low SSE)

It measures the power flatness of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 29:

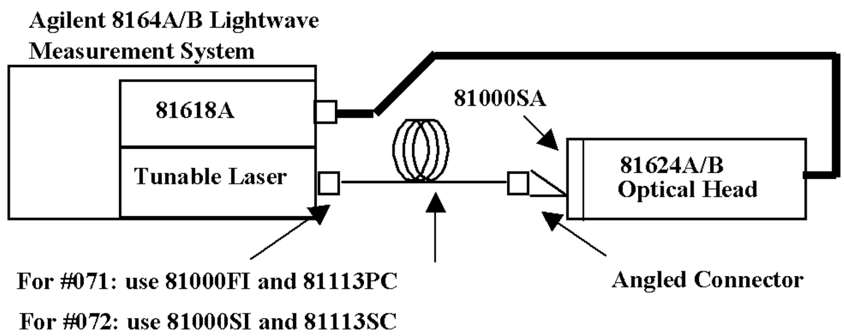


Figure 29 Test Setup for Power Flatness Tests - Low SSE output

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters[a]	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
Modulation: <*mod src*>	<*Off*>

[a] When using the low SSE output <*Power Mode*> is not applicable.

3 Set the inital wavelength and power of the TLS to:

TLS module - low SSE output	Wavelength [λ]	Power [*P*]
Agilent 81600B #200 - Output 1	1440.000 nm	- 7.00 dBm
Agilent 81600B #160 - Output 1	1495.000 nm	- 7.00 dBm
Agilent 81600B #150 - Output 1	1450.000 nm	- 7.00 dBm
Agilent 81600B #140 - Output 1[a]	1420.000 nm	- 13.00 dBm
Agilent 81600B #130 - Output 1	1260.000 nm	- 13.00 dBm

[a] For the 81600B #140, some wavelengths are set to odd values to avoid conflict with water absorption lines.

4 Connect the fiber to the low SSE output, Output 1.
Set <*Optical Output*> to <*Low SSE (1)*>.

5 Make sure the optical output is switched **off**.

6 For the 81624A/B power meter channel:

- Zero the 81624A/B. Select <*Menu*> then <*Zero*>,
- Set the **power range** manually to **+0 dBm**,
- Set the **Averaging Time** to **500 ms**,
- Select <*dB*> as the power units,
- Set λ, the wavelength, to the same as the TLS module, as given in step 3.

7 Switch on the TLS output.

8 At the 81624A/B, select <*Menu*> then <*Disp → Ref*>

9 Increase λ, the output wavelength, of the TLS module and of the power meter to the next value listed in the Test Record.

For the 81600B #140, some wavelengths are set to odd values to avoid conflict with water absorption lines.

10 Measure the change in output power (in dB) and note this value in the Test Record.

11 Repeat step 9 to step 10 for all wavelength settings listed in the Test Record.

12 Determine the maximum deviation and the minimum deviation from REF and record them in the Test Record.

13 Subtract the minimum deviation from the maximum deviation and record the result as the **Flatness**.

Test Procedure - High Power output, no attenuation

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #160 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #150 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #140 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #130 (Output 2, High Power), built-in attenuator not used.
Agilent 81600B #142 #003, built-in attenuator not used.
Agilent 81600B #142
Agilent 81600B #132

It measures the power flatness of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 30:

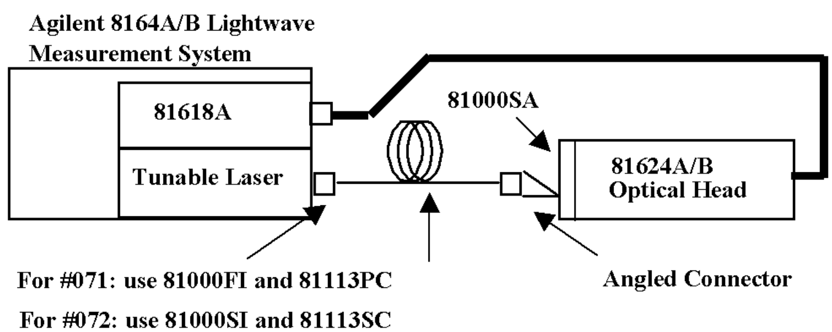


Figure 30 Test Setup for Power Flatness Tests - High Power output, without using attenuator

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>[a]	<*Manual Att*>
Modulation: <*mod src*>	<*Off*>

[a] For the 81600B #200, #160, #150, #140, and #142 #003 (that is, where a built-in attenuator is fitted).

3 Set the inital wavelength and power of the TLS to:

TLS module - High Power output, no attenuation	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B #200 - Output 2	1440.000 nm	- 1.000 dBm	0.000 dB
Agilent 81600B #160 - Output 2	1495.000 nm	- 1.000 dBm	0.000 dB
Agilent 81600B #150 - Output 2	1450.000 nm	- 1.000 dBm	0.000 dB
Agilent 81600B #142[*]	1420.000 nm	0.000 dBm	not applicable
Agilent 81600B #142 #003[*]	1420.000 nm	- 1.500 dBm	0.000 dB
Agilent 81600B #140 - Output 2[a]	1420.200 nm	- 3.000 dBm	0.000 dB
Agilent 81600B #130 - Output 2	1260.000 nm	- 3.000 dBm	0.000 dB
Agilent 81600B #132	1260.000 nm	0.000 dBm	not applicable

a For the 81600B #140, #142, and #142 #003, some wavelengths are set to odd values to avoid conflict with water absorption lines.

4 Connect the fiber to the High Power output, Output 2.
Set <*Optical Output*> to <*High Power(2)*>.

5 Make sure the optical output is switched **off**.

6 For the 81624A/B power meter channel:

- Zero the 81624A/B. Select <*Menu*> then <*Zero*>,
- Set the **power range** manually to **+0 dBm**,
- Set the **Averaging Time** to **500 ms**,
- Select <*dB*> as the power units,
- Set λ, the wavelength, to the same as the TLS module, as given in step 3.

7 Switch on the TLS output.

8 At the 81624A/B, select <*Menu*> then <*Disp* → *Ref*>

9 Increase λ, the output wavelength, of the TLS module and of the power meter to the next value listed in the Test Record.

For the 81600B #140 and #142 some wavelengths are set to odd values to avoid conflict with water absorption lines.

10 Measure the change in output power (in dB) and note this value in the Test Record.

11 Repeat step 9 to step 10 for all wavelength settings listed in the Test Record.

12 Determine the maximum deviation and the minimum deviation from REF and record them in the Test Record.

13 Subtract the minimum deviation from the maximum deviation and record the result as the **Flatness**.

Test Procedure - High Power output, using the built-in attenuator

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #130 (Output 2, High Power)

It measures the power flatness of the module at the outputs indicated and when the built-in attenuator is used.

1 Set up the equipment as shown in Figure 31:

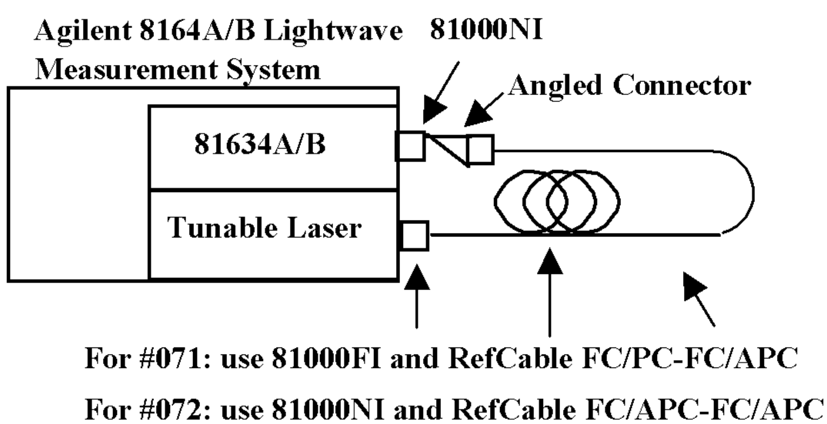


Figure 31 Test Setup for Power Flatness Tests - High Power output, using the built-in attenuator

2 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Manual Att*>
Modulation: <*mod src*>	<*Off*>

3 For the 81600B #200, #160, #150, #140 and #130, set <*Optical Output*> to <*High Power(2)*>.

4 Set the inital wavelength and power of the TLS to:

TLS module - High Power output, no attenuation	Wavelength [λ]	Power [*P*]	Attenuation [*Atten*]
Agilent 81600B #200 - Output 2	1440.000 nm	- 1.000 dBm	59.000 dB
Agilent 81600B #160 - Output 2	1495.000 nm	- 1.000 dBm	59.000 dB
Agilent 81600B #150 - Output 2	1450.000 nm	- 1.000 dBm	59.000 dB
Agilent 81600B #140 - Output 2[a]	1420.200 nm	- 3.000 dBm	57.000 dB
Agilent 81600B #142 #003*	1420.200 nm	- 1.500 dBm	58.000 dB
Agilent 81600B #130 - Output 2	1260.200 nm	- 3.000 dBm	57.000 dB

[a] For the 81600B #140 and #142 #003, some wavelengths are set to odd values to avoid conflict with water absorption lines.

5 Connect the fiber to the optical output.

6 Make sure the optical output is switched **off**.

7 For the 81624A/B power meter channel:

- Zero the 81624A/B. Select <*Menu*> then <*Zero*>,
- Set the **power range** manually to **- 50 dBm**,
- Set the **Averaging Time** to **500 ms**,
- Select <*dB*> as the power units,
- Set λ, the wavelength, to the same as the TLS module, as given in step 4.

8 Switch on the TLS output.

9 At the 81624A/B, select <*Menu*> then <*Disp* → *Ref*>

10 Increase λ, the output wavelength, of the TLS module and of the power meter to the next value listed in the Test Record.

For the 81600B #140, #142, and #142 #003, some wavelengths are set to odd values to avoid conflict with water absorption lines.

11 Measure the change in output power (in dB) and note this value in the Test Record.

12 Repeat step 10 to step 11 for all wavelength settings listed in the Test Record.

13 Determine the maximum deviation and the minimum deviation from REF and record them in the Test Record.

14 Subtract the minimum deviation from the maximum deviation and record the result as the **Flatness**.

Power Stability

For definition, see "Power stability" on page 44.

Measurement Principle

The TLS module's output is measured over a given time span at constant temperature.

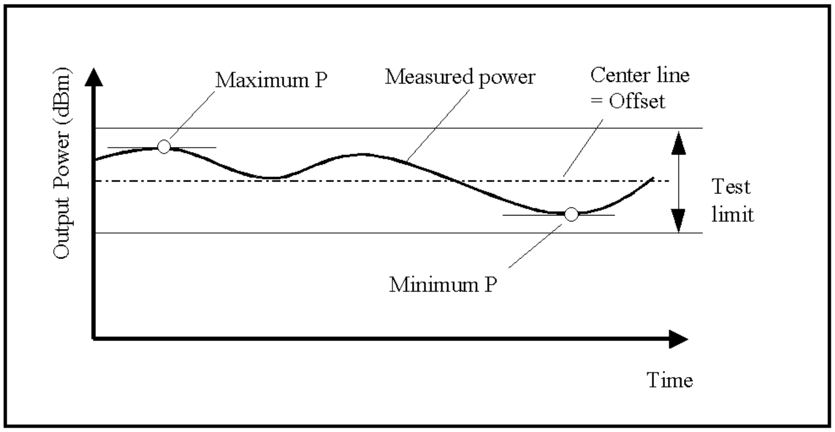


Figure 32 Stability of Power Output versus Time.

NOTE

When testing Power Stability: A test duration of approximately 15 minutes (rather than 1 hour) is sufficient to demonstrate whether or not the power control loop is working correctly.

At the start of the test the TLS module is set:

- To any wavelength within its specified wavelength range,
- To any power specified for the TLS module at this wavelength.

  The lower limit is the mininimum output power specified; the upper limit by the maximum output power specified.
- Such that any modulation is off.

At the start of the test, a reference power value is taken.

At any time during the measurement, the actual output power is compared to the reference and recorded.

The end of the test is defined by the specified stability time.

Test Equipment - Power Stability Tests

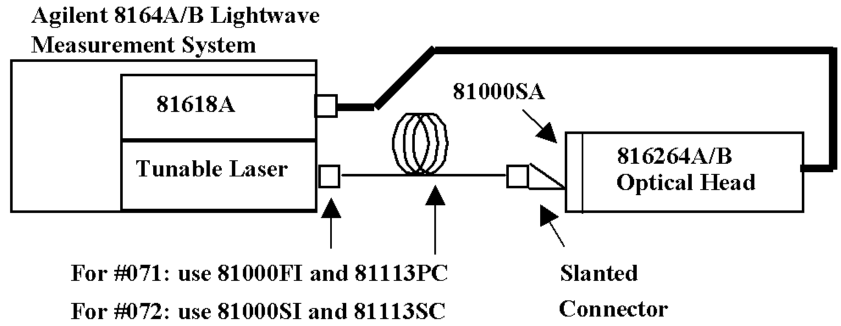


Figure 33 Test Setup for Power Stability Tests

Test Procedure, Low SSE output

This test procedure is applicable to the:

Agilent 81600B #200 (Output 1, Low SSE)
Agilent 81600B #160 (Output 1, Low SSE)
Agilent 81600B #150 (Output 1, Low SSE)
Agilent 81600B #140 (Output 1, Low SSE)
Agilent 81600B #130 (Output 1, Low SSE)

It measures the power stability of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 23.

2 Connect the fiber to the low SSE output, Output 1.
Set <*Optical Output*> to <*Low SSE (1)*>.

3 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<*λ*>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Manual Att*>
Modulation: <*mod src*>	<*Off*>

4 Set the inital wavelength and power of the TLS to:

TLS module - low SSE output	**Wavelength [λ]**	**Power [*P*]**
Agilent 81600B #200 - Output 1	1570.000 nm	- 7.00 dBm
Agilent 81600B #160 - Output 1	1570.000 nm	- 7.00 dBm
Agilent 81600B #150 - Output 1	1550.000 nm	- 7.00 dBm
Agilent 81600B #140 - Output 1	1460.000 nm	- 13.00 dBm
Agilent 81600B #130 - Output 1	1350.000 nm	- 13.00 dBm

5 Make sure the optical output is switched **off**.

6 Zero the power meter. Press [*Menu*] then select <*Zero*>.

7 Switch on the TLS output, then wait for 1 minute.

8 Select the logging application.
Press [*Appl*] then select <*Logging*>.

9 Within the logging application, set the power meter:

- Select module **2.1**
(if 81619A is in slot 2, the 81626B connected to “Head 1”)
- Set λ, the wavelength, to the same as the TLS module, as given in step 4,
- Set **Range** to **0 dBm**,
- Set **Ref mode** to **Value**,
- Set **Samples** to **4000**,
- Set the **Averaging Time** to **200 ms**,
- Set **Range mode** to **common**,
- Set **Power unit** to **dB**,
- Set **Ref** to the value given at step 4.

10 Select [*Measure*] to start the logging application. A progress indicator is displayed.

11 When the measurement has finished, select [*Analysis*]

12 From the Statistics window, note the following results in the Test Record:

- The “max” value as the *Maximum Deviation*,
- The “min” value as the *Minimum Deviation*,
- The “ΔP” value as the *Power Stability*.

Test Procedure - High Power output

This test procedure is applicable to the:

Agilent 81600B #200 (Output 2, High Power)
Agilent 81600B #160 (Output 2, High Power)
Agilent 81600B #150 (Output 2, High Power)
Agilent 81600B #140 (Output 2, High Power)
Agilent 81600B #130 (Output 2, High Power)
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #132

It measures the power stability of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 33.

2 Connect the fiber to the optical output.

   For Agilent 81600B #200, #160, #150, #140 and #130 modules, connect to the High Power output, Output 2.
   Set <*Optical Output*> to <*High Power (2)*>.

3 Move to the TLS channel of the Agilent 8164A/B Lightwave Measurement System and set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<*λ*>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Manual Att*>
Modulation: <*mod src*>	<*Off*>

4 Set the inital wavelength and power of the TLS to:

TLS module - High Power output	Wavelength [λ]	Power [*P*]
Agilent 81600B #200 - Output 2	1580.000 nm	- 1.000 dBm (ATT=0 dB)
Agilent 81600B #160 - Output 2	1550.000 nm	- 1.000 dBm (ATT=0 dB)
Agilent 81600B #150 - Output 2	1550.000 nm	- 1.000 dBm (ATT=0 dB)
Agilent 81600B #140 - Output 2	1460.000 nm	- 3.000 dBm (ATT=0 dB)
Agilent 81600B #130 - Output 2	1350.000 nm	- 3.000 dBm (ATT=0 dB)
Agilent 81600B #142 #003	1460.000 nm	- 1.500 dBm (ATT=0 dB
Agilent 81600B #142	1460.000 nm	0.000 dBm
Agilent 81600B #132	1350.000 nm	0.000 dBm

5 Make sure the optical output is switched **off**.

6 Zero the power meter. Press [*Menu*] then select <*Zero*>.

7 Switch on the TLS output, then wait for 1 minute.

8 Select the logging application.
Press [*Appl*] then select <*Logging*>.

9 Within the logging application, set the power meter:

- Select module **2.1**
(if 81619A is in slot 2, the 81626B connected to “Head 1”)
- Set λ, the wavelength, to the same as the TLS module, as given in step 4,
- Set **Range** to **0 dBm**,
- Set **Ref mode** to **Value**,
- Set **Samples** to **4000**,
- Set the **Averaging Time** to **200 ms**,
- Set **Range mode** to **common**,
- Set **Power unit** to **dB**,
- Set **Ref** to the value given at step 4,.

10 Select [*Measure*] to start the logging application. A progress indicator is displayed.

11 When the measurement has finished, select [*Analysis*]

12 From the Statistics window, note the following results in the Test Record:

- The “max” value as the *Maximum Deviation*,
- The “min” value as the *Minimum Deviation*,
- The “ΔP” value as the *Power Stability*.

Signal-to-Source Spontaneous Emission Ratio

For definition, see “Signal to source spontaneous emission (SSE) ratio” on page 46.

Measurement Principle

The TLS is set to a number of wavelengths. For each wavelength, the Signal-to-Source Spontaneous Emission Ratio (SSE) spectrum is measured for a ±3 nm window around the set wavelength using an Optical Spectrum Analyzer (OSA). The SSE spectrum within ±1 nm of the set wavelength is excluded because of the limited dynamic range of the OSA. The OSA resolution bandwidth is set to 0.5 nm to catch the peaks of the SSE ripple caused by the chip modes of the laser chip. An extrapolation to 1 nm is done by adding 3 dB to the SSE measurement result.

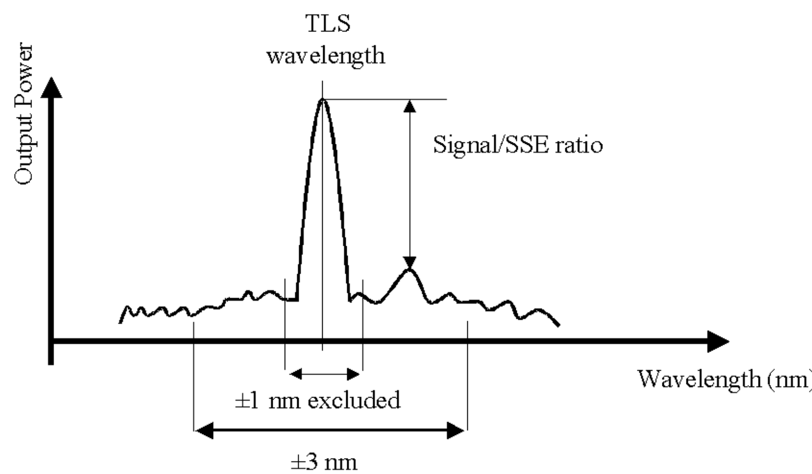


Figure 34 Signal-to-Source Spontaneous Emission Ratio.

At the start of the test the TLS is set:

- To its lowest specified wavelength,
- To the output power specified for the TLS at this wavelength,
- Such that any modulation is off.

With a resolution bandwidth of 0.5 nm, SSE is measured directly using the OSA, then the measurement result is extrapolated for a bandwidth resolution of 1 nm (a factor of 2 relates to 3 dB). This value is recorded as the test result.

The wavelength is increased, preferably in 10 nm increments. For each wavelength the associated SSE value is measured, extrapolated to 1 nm bandwidth resolution and recorded.

At the end of the test, the TLS is set to its maximum specified wavelength.

Test Procedure - High Power output

Note: This test does not apply to 81600B #130

This test procedure is applicable to the:

Agilent 81600B #200, Output 2, High Power
Agilent 81600B #160, Output 2, High Power
Agilent 81600B #150, Output 2, High Power
Agilent 81600B #140, Output 2, High Power
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #132

It measures the SSE of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 35:

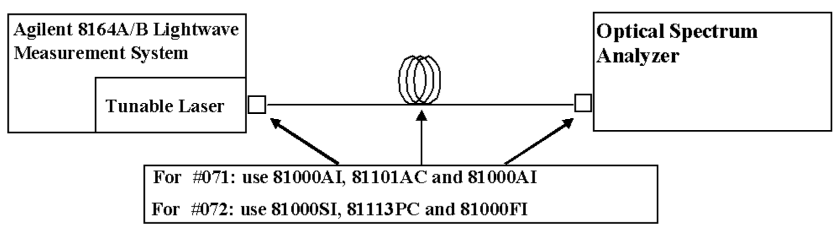


Figure 35 Test Setup for Signal-to-Source Spontaneous Emission Test - High Power Output

2 If you are using the Agilent 81600B #200, #160, #150 or #140, connect the fiber to the High Power output, Output 2. On the 8164A/B, set <*Optical Output*> to <*High Power (2)*>.

3 Move to the TLS channel of the 8164A/B mainframe. Set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Automatic*>
Modulation: <*mod src*>	<*Off*>

4 Make sure the optical output is switched **off**.

5 Set the wavelength of the TLS module to

TLS module - High Power output	Wavelength [λ]
Agilent 81600B #200 - Output 2	1440.000 nm
Agilent 81600B #160 - Output 2	1495.000 nm
Agilent 81600B #150 - Output 2	1450.000 nm
Agilent 81600B #140 - Output 2	1370.000 nm
Agilent 81600B #142 #003	1370.000 nm
Agilent 81600B #142	1370.000 nm
Agilent 81600B #132	1260.000 nm

6 Set the power of the TLS to its maximum specified output power (as given in the Test Record).

7 Switch on the TLS output.

8 Initialize the OSA. Press [*Preset*] then select <*Auto Meas.*>.

9 Set the OSA:

- Set **Span** to **4 nm**,
  Press [*Span*] then enter the value.
- Set **Resolution Bandwidth (RBW)** to **0.5 nm**,
  Press [*Ampl*], press [*BW Sup*], then enter the value.
- Set **Sensitivity** to **- 60 dBm**,
  Press [*Ampl*], press [*Sens*], then enter the value.
- Set **Wavelength** to the value given at step 5.

NOTE

Extrapolation to an RBW of 1 nm: Although an RBW of 0.5 nm is used for the measurement, this is extrapolated to an RBW of 1.0 nm by subtracting 3 dB from the absolute value since this factor of 2 in the RBW gives 2 x power = 3 dB.

For example:

RBW=0.5 nm results in $|SSE_{0.5\ nm}|$ = 55.5 dB measured.

RBW=1.0 nm extrapolates to $|SSE_{1\ nm}| = |SSE_{0.5\ nm}|$ - 3 dB

= 55.5 dB - 3 dB = 52.5 dB.

---

10 At the OSA, set the **marker** to the highest peak then select *delta*.
[*Marker*] → [*Highest Peak*] → [*DELTA*]

11 Use the [Modify] knob to move the **second marker** to the highest peak of the displayed side modes.

12 Extrapolate the measurement result, the difference *delta* between the two markers, to 1 nm bandwidth by adding 3 dB to the absolute value of the measurement result.

13 Note the extrapolated value in the Test Record.

14 Increase the wavelength of the TLS by 10 nm, as specified in the Test Record.

15 Repeat step 10 to step 14 for all wavelength settings listed in the Test Record.

Signal-to-Source Spontaneous Emission Ratio - Low SSE Output

The setup described by “Signal-to-Source Spontaneous Emission Ratio” on page 112 is limited by the dynamic range of the Optical Spectrum Analyzer. This can be improved by reducing the power of the spectral line of the TLS module using a filter, namely a Fiber Bragg Grating. However, this approach limits the measurement to a single wavelength, that of the the peak attenuation of the Fiber Bragg Grating.

NOTE

Wavelength measurement mismatch between TLS and OSA

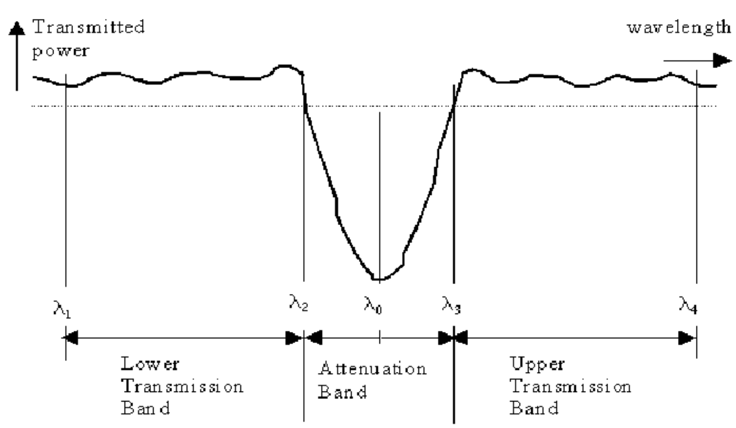
Because the Tunable Laser channel displays the wavelength in air and the Optical Spectrum Analyzer displays the wavelength in vacuum there is a mismatch between the values displayed by the two instruments.

A good approximation in this wavelength range is:

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

Use λ_{TLS} as the primary reference because the specified wavelength accuracy of the TLS module is better than that of the OSA.

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



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

Figure 36 Transmission Characteristics of Fiber Bragg Grating

Test Procedure - Low SSE output

Note: This test does not apply to 81600B #130

This test procedure is applicable to:

Agilent 81600B #200, Output 1, Low SSE
Agilent 81600B #160, Output 1, Low SSE
Agilent 81600B #150, Output 1, Low SSE
Agilent 81600B #140, Output 1, Low SSE

It measures the SSE of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 35:

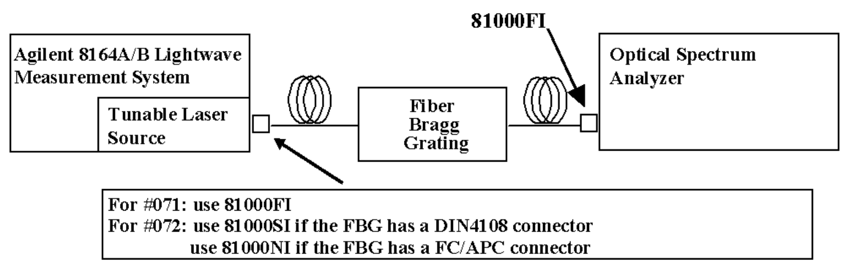


Figure 37 Test Setup for Signal-to-Source Spontaneous Emission Test - Low SSE Output.

NOTE

Use the correct connector for the Fiber Bragg Grating The Fiber Bragg Grating must be connected to the TLS module using:

- a straight connector, if you are testing a TLS module with option #071
- an angled connector, if you are testing a TLS module with option #072

NOTE

Fiber Bragg Grating Wavelength

- For Agilent 81600B #200, #160 or #150 use an FBG of: $\lambda_{FBG} \cong 1520$ nm
- For Agilent 81600B #140, use an FBG of: $\lambda_{FBG} \cong 1407$ nm

2 Move to the TLS channel of the 8164A/B mainframe. Set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<Wavelength Mode>	*<λ>*
<Source State>	*<Off>*
<Power Unit>	*<dBm>*
<Power Mode>	*<Automatic>*
Modulation: *<mod src>*	*<Off>*

3 Determine the filter transmission characteristics

NOTE

There is no need to perform this procedure prior to each use of the FBG Use this procedure prior to the first application of the FBG, and then every 12 months.

NOTE

λ_{FBG} and λ_0 for a Fiber Bragg Grating

- λ_{FBG} is the nominal center wavelength of the FBG, printed on its label
- λ_0 is its measured, actual value.

Both are measured in vacuum with reference to the TLS. In practice, both values are the same, although you may find a difference of some pm.

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

b Set the OSA:

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

c Set the TLS module:

- Set [λ], the wavelength, to λ_{FBG} - 1 nm.
  For example, 1520.5 nm - 1 nm = 1519 nm.
- Set [P], the output power to:

Table 7 Output Power setting - Low SSE Output:

Tunable Laser Source module	Power (P)
Agilent 81600B #200, Output 1	+ 2.000 dBm*
Agilent 81600B #160, Output 1	- 4.000 dBm*
Agilent 81600B #150, Output 1	- 3.000 dBm*
Agilent 81600B #140, Output 1	-13.000 dBm

* The laser output is limited to its maximum possible value at this wavelength. The display will probably show *Exp*

d Switch on the TLS output.

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

f For all wavelengths within a ±1 nm window around each 0.1 nm step, check and note the power level displayed by the OSA. Fill out this table:

Table 8 Filter Transmission Characteristic

TLS module Output Wavelength relative to λ_{FBG}	Peak Power Level	Assosciated Wavelength displayed by OSA
-1.0 nm	_______ dBm	_______ nm
-0.9 nm	_______ dBm	_______ nm
-0.8 nm	_______ dBm	_______ nm
-0.7nm	_______ 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

Table 8 Filter Transmission Characteristic

TLS module Output Wavelength relative to λ_{FBG}	Peak Power Level	Assosciated Wavelength displayed by OSA
0.0 nm	_______ 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

4 Determine the minimum value of the filter transmission, that is the actual Fiber bragg Grating center wavelength λ_0.

a Check for the minimum transmitted peak power in the table.

b Mark the associated wavelength set on the Tunable Laser, TLS_λ_0, and note the value in the Test Record.

c Mark the associated displayed on the Optical Spectrum Analyser, OSA_λ_0, and note the value in the Test Record.

5 Set the TLS to the wavelength of the minimum transmission, TLS_λ_0

6 Record the spectrum at minimum filter transmission.
Set the OSA:

- Set the sensitivity to -90 dBm
- Set the resolution bandwidth to 0.5 nm
- Set the center wavelength to OSA_λ_0
- Set the span to 6 nm
- Set the reference level to -40 dBm

7 Determine the limits of the transmission and attenuation ranges:

a Lower Transmission Band: λ_1 ... λ_2

- TLS_λ_1 = TLS_λ_0 - 3 nm
- TLS_λ_2 = TLS_λ_0 - 0.5 x Attenuation Band
  = TLS_λ_0 - 1 nm

b Upper Transmission Band: λ_3 ... λ_4

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

8 Determine the maximum transmitted power value inside the transmission band.

a Record Spectrum.

b Using the marker, find the maximum transmitted power (max_SSE_power) within the Lower and Upper Transmission Bands. Change λ by using the RPG and note the maximum power value within both the Lower and Upper Transmission Bands (this is a single value). Note this value in the Test Record. Check the associated wavelength from the Optical Specrum Analyzer, OSA@max_SSE_power, and note this value in the Test Record.

9 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]

10 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.

11 Within the total spectrum, determine peak power, power@SSE_peak, and note the absolute value, |power@SSE_peak| in the Test Record.

NOTE

Wavelength Specific These results are at the wavelength the TLS is set to for this measurement, and the OSA measurements, respectively.

12 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

Extrapolation to an RBW of 1 nm: The measurements were performed at a resolution bandwidth of 0.5 nm. Adding 3 dB takes the resolution to 1 nm, so giving the SSE in [dB/nm]
(A factor of 2 in the RBW gives 2 x power = 3 dB).

For example:

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

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

Signal-to-Total-Source Spontaneous Emission Ratio - Low SSE Ouptput

For definition, see “Signal to total source spontaneous emission ratio” on page 47.

NOTE

Qualified Agilent Service Center recommended: Although the following description should allow users to verify their products' performance, due to the high complexity of this test Agilent recommends that it be performed in a qualified Agilent Service Center.

Measurement Principle

The TLS module is set to a number of wavelengths. For each wavelength, the Signal-to-Source Spontaneous Emission Ratio (SSE) spectrum is measured in the specified wavelength range using an OSA resolution bandwidth of 1 nm. One sample per nm is taken and summed to the total SSE. The SSE spectrum near the signal (within a ±3 nm window) is substituted by the average SSE based on the last sample on the left, at -3 nm, and the first sample on the right, at +3 nm.

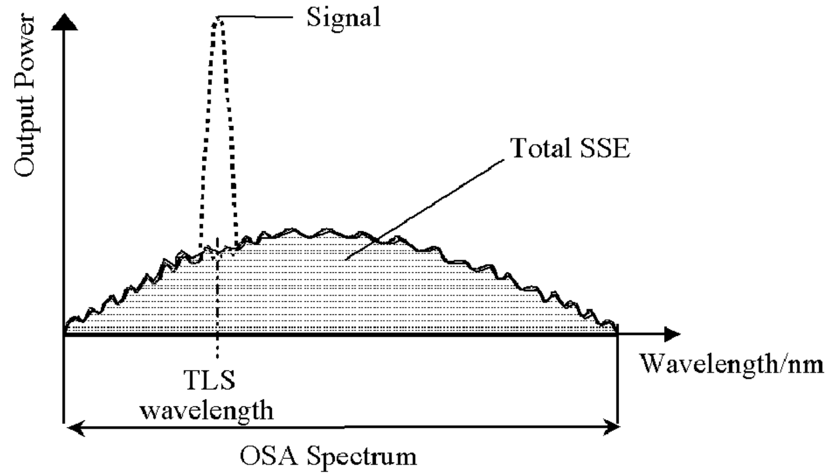


Figure 38 Total SSE Measurement.

Test Procedure

Note: This test does not apply to 81600B #130

This test procedure is applicable to:

Agilent 81600B #200, Output 1, Low SSE
Agilent 81600B #160, Output 1, Low SSE
Agilent 81600B #150, Output 1, Low SSE
Agilent 81600B #140, Output 1, Low SSE

It measures the Total SSE of the module at the outputs indicated.

1 Set up the equipment as shown in Figure 39:

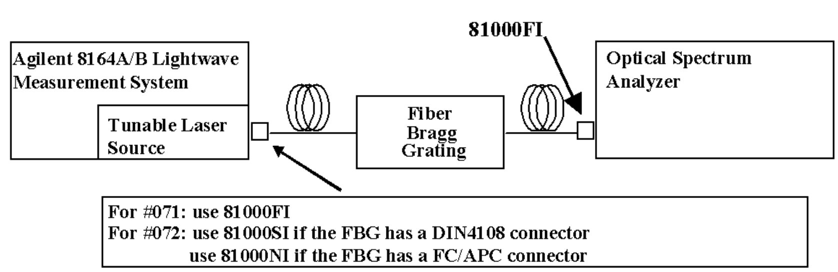


Figure 39 Test Setup for Total Source Spontaneous Emission Test - Low SSE output

NOTE

Fiber Bragg Grating Wavelength

- For Agilent 81600B #200, #160 or #150 use an FBG of: $\lambda_{FBG} \cong 1520$ nm
- For Agilent 81600B #140, use an FBG of: $\lambda_{FBG} \cong 1407$ nm

2 Determine OSA noise, that is the noise of the 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 this 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 this value.
- Set the Sensitivity to -90 dBm.
  Press [AMPL], press [SENS AUTO MAN], and enter this value.
- Set the resolution bandwidth to 1 nm.
  Press [BW Swp], and enter this value.

c Record the noise spectrum for a single sweep.

d Measure the 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.

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

For example:

Table 9 Signal to Total SSE - Low SSE output

Wavelength, Reative 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

Table 9 Signal to Total SSE - Low SSE output

Wavelength, Reative to OSA_λ_center	**Partial Noise Power Levels**
+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
= __________ pW

f Note the OSA_noise value in the test record.

3 Connect the Tunable Laser module to the Optical Spectrum Analyzer as shown in Figure 39 on page 123. Connect one end of the Fiber Bragg Grating to Output 1, the Low SSE output of the TLS and the other to the Optical Spectrum Analyzer.

4 Move to the TLS channel of the 8164A/B mainframe. Set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	**Values**
<Wavelength Mode>	*<λ>*
<Source State>	*<Off>*
<Power Unit>	*<dBm>*
<Power Mode>	*<Automatic>*
Modulation: *<mod src>*	*<Off>*

5 Set the output power of the TLS module to:

Output Power setting for Total SSE - Low SSE Output:	
Tunable Laser Source module	**Power (P)**
Agilent 81600B #200, Output 1	+ 2.000 dBm*
Agilent 81600B #160, Output 1	- 4.000 dBm*
Agilent 81600B #150, Output 1	- 3.000 dBm*
Agilent 81600B #140, Output 1	-13.000 dBm

* The laser output is limited to its maximum possible value at this wavelength. The display will probably show *Exp*

6 Determine filter transmission characteristic, as described in step 3 on page 118. You may skip this step if the characteristic has already been determined. This value relates to measurements performed in vacuum.

7 Determine the minimum value of the filter transmission, that is the actual Fiber bragg Grating center wavelength λ_0.

a Check for the minimum transmitted peak power in the table.

b Mark the associated wavelength set on the Tunable Laser, TLS_λ_0, and note the value in the Test Record.

c Mark the associated displayed on the Optical Spectrum Analyser, OSA_λ_0, and note the value in the Test Record.

8 Record the spectrum at minimum filter transmission:

Set the TLS to the wavelength of minimum transmission (TLS_λ_0). Check that the laser output is activated.

9 Set the Optical Spectrum Analyzer:

a Set span to 30 nm.
Press [*Span*] then enter this value.

b Set the resolution bandwidth (RBW) to 1 nm.
Press [AMPL], press [BW Swp] then enter this value.

c Set the sensitivity to -90 dBm.
Press [AMPL], press [SENS] then enter this value.

d Set the center wavelength to OSA_λ_0.
Press [*Center*] then enter this value.

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

10 Determine the limits of the transmission and attenuation ranges:

a Lower Transmission Band: λ_1 ... λ_2

- OSA_λ_1 = OSA_λ_0 - 15 nm
- OSA_λ_2 = OSA_λ_0 - 0.5 x Attenuation Band
  = OSA_λ_0 - 1 nm

b Upper Transmission Band: λ_3 ... λ_4

- OSA_λ_3 = OSA_λ_0 + 0.5 x Attenuation Band
  = OSA_λ_0 + 1 nm
- OSA_λ_4 = OSA_λ_0 + 0.5 x Upper Transmission Band
  = OSA_λ_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

11 Determine the SSE power values inside the transmission bands:

a Ensure the TLS is set to TLS_λ_0 and is not changed.

b Set the OSA marker to OSA_λ_1

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

d Increase the OSA marker wavelength by 1 nm

e Repeat step c and step d until the wavelength is equal to OSA_λ_2

f Set the OSA to OSA_λ_3

g g Repeat step c and step d until the wavelength is equal to OSA_λ_4.

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

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

For example:

Lower Transmission Band, OSA_λ_1 to OSA_λ_2		Upper Transmission Band, OSA_λ_3 to OSA_λ_4	
Relative Wavelength, Increments from λ_1	**SSE_power measured**	**Relative Wavelength, Increments from λ_3**	**SSE_power measured**
0 (relates to OSA_λ_1	pW	0 (relates to OSA_λ_3	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
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
Lower Transmission Band, OSA_λ_1 to OSA_λ_2		**Upper Transmission Band, OSA_λ_3 to OSA_λ_4**	
Relative Wavelength, Increments from λ_1	**SSE_power measured**	**Relative Wavelength, Increments from λ_3**	**SSE_power measured**
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
+11 nm	pW	+11 nm	pW
+22 nm	pW	+12 nm	pW
+13 nm	pW	+13 nm	pW
+14 nm	pW	+14 nm	pW
0 (relates to OSA_λ_2	pW	0 (relates to OSA_λ_4	pW

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 (1) + (2)

power_trans = _______ pW

12 Determine the SSE power inside the attenuation band by interpolation:

a Check the power measured at OSA_λ_2 and OSA_λ_3

b Mark the larger of OSA_λ_2 and OSA_$\lambda_{3,}$ and record its value as power_ OSA_$\lambda_{2,3}$_max

c Calculate the power inside the attenuation band using:

power_att = 0.5 x power_ OSA_$\lambda_{2,3}$_max

= ___________ 10^{-12} W = ___________ pW

All power values are in [pW], where 1 pW = 10^{-12} W.

Determine the total noise power, power_total_noise.
Add the value of 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 this value.
- Set the center wavelength to OSA_λ_0.
  Press *Center* and enter this value.
- Set the reference level to 0 dBm.
  Press [AMPL], press [Ref LVL] then enter this value.
- Set the Sensitivity to -68 dBm.
  Press [AMPL], press [SENS AUTO MAN] then enter this value.
- Set the resolution bandwidth to 1 nm.
  Press [BW Swp] then enter this value.

b Set the TLS:

- Set the wavelength to a value outside the attenuation band. That is, set it to TLS_λ_0 + 5 nm.
- Set the output power to the value in ??
- Ensure the laser output is activated.

c Record the spectrum for a single sweep.

All power values are 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 expressed in decibels, [dB].

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

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 Performance Tests

These tests refer to some typical characterics of the TLS that are not guaranteed, and which are not part of the standard re-calibration. However, the tests can be performed in qualified Agilent Service Centers on special request.

Signal-to-Total-Source Spontaneous Emission Ratio - High Power Output

Note: This test does not apply to 81600B #130

For definition, see “Signal to total source spontaneous emission ratio” on page 47.

Test Procedure

This optional test procedure is applicable to:

Agilent 81600B #200, Output 2, High Power
Agilent 81600B #160, Output 2, High Power
Agilent 81600B #150, Output 2, High Power
Agilent 81600B #140, Output 2, High Power
Agilent 81600B #142 #003
Agilent 81600B #142
Agilent 81600B #132

It measures the Total SSE of the module at the outputs indicated.

1 Connect the Tunable Laser module (DUT) to the Optical Spectrum Analyzer as shown in Figure 40:

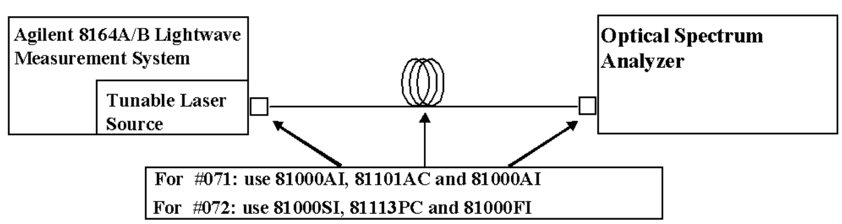


Figure 40 Test Setup for Total Source Spontaneous Emission Test - High Power output

2 On the Agilent 81600B #140, #150, #160 and #200, make sure that Output 2, the High Power output, is connected to the Optical Spectrum Analyzer.

3 Move to the TLS channel of the 8164A/B mainframe. Set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Automatic*>
Modulation: <*mod src*>	<*Off*>

4 Set the output power of the TLS module to:

Table 10 Output Power setting for Total SSE - High Power Output:

Tunable Laser Source module	Power (P)	Wavelength
Agilent 81600B #200, Output 2	+ 8.00 dBm	1570 nm
Agilent 81600B #160, Output 2	+ 5.00 dBm	1570 nm
Agilent 81600B #150, Output 2	+ 5.00 dBm	1550 nm
Agilent 81600B #140, Output 2	+ 5.00 dBm	1460 nm
Agilent 81600B #142 #003	+ 6.00 dBm	1460 nm
Agilent 81600B #142	+ 7.50 dBm	1460 nm
Agilent 81600B #132	+ 7.00 dBm	1330 nm

5 Set the Optical Spectrum Analyzer:

a Set span to 30 nm.
Press Span, and enter this value.

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

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

6 Record the spectrum (run a single sweep):

a Press *Peak Search* in the Marker field.

b Set the Marker to Center Wavelength and note its displayed wavelength as:

OSA_λ_center = ________________ nm

7 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

8 Measure the 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.

Record the "partial noise power level" values in the table in [pW], where 1 pW = 10^{-12} W.

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

For example:

Table 11 Signal to Total SSE - Low SSE output

Wavelength, Reative 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)	
+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

9 Determine total noise power by adding up all 30 partial noise power levels:

OSA_noise = Sum of all partial noise power levels
= __________ pW

10 Note the OSA_noise value in the test record.

11 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.

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

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

12 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

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

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

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.

14 Note the result in the Test Record:

Total SSE = ________________ dB

Dynamic Wavelength Accuracy

NOTE

Software control required The performance verification of 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 detail and gives hints to the calculations that 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 Source Family 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 41. The sections that follow provide more detailed explanation.

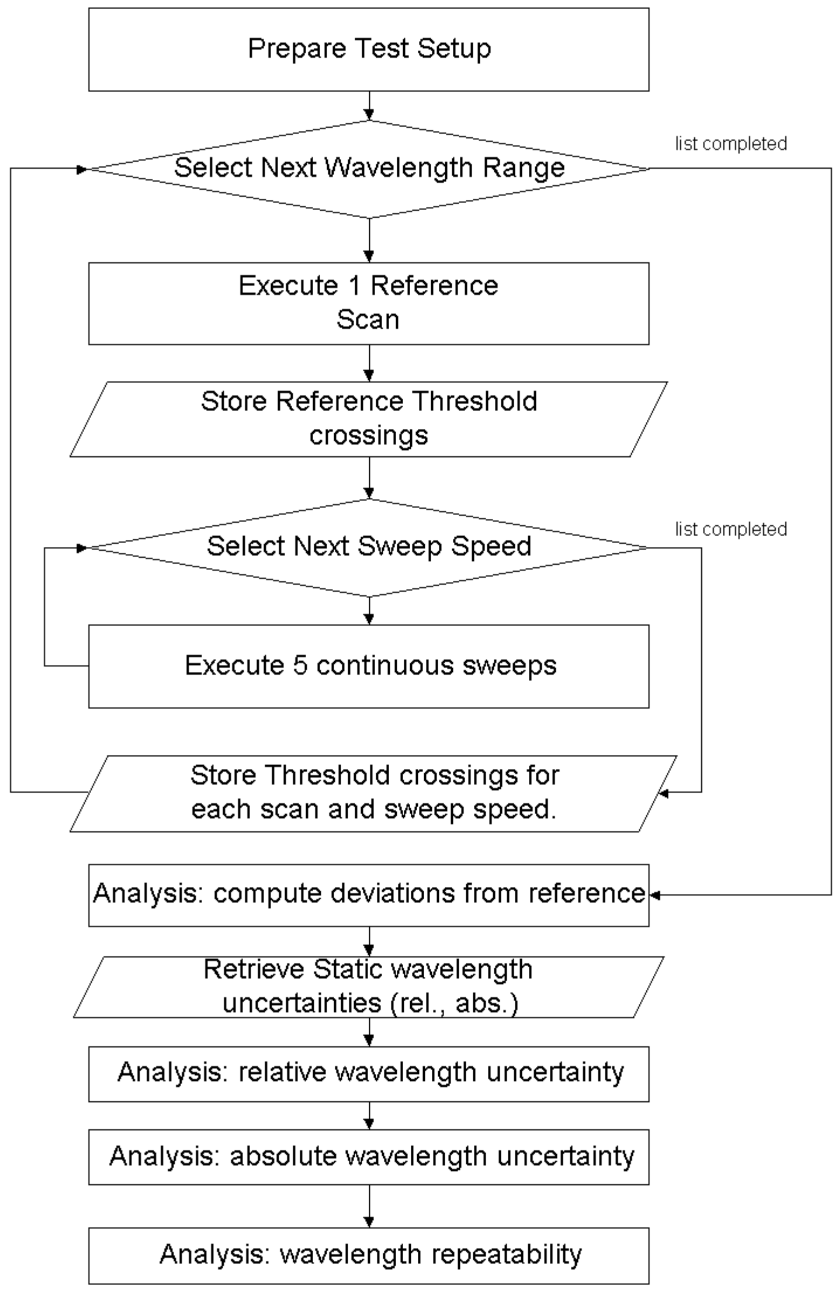


Figure 41 Test Flow - Dynamic Wavelength Accuracy Measurements

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 measurement

Measurement Sequence

1 Make sure that cable connectors, detectors and adapters are clean.

2 Connect the equipment as shown in Figure 42.

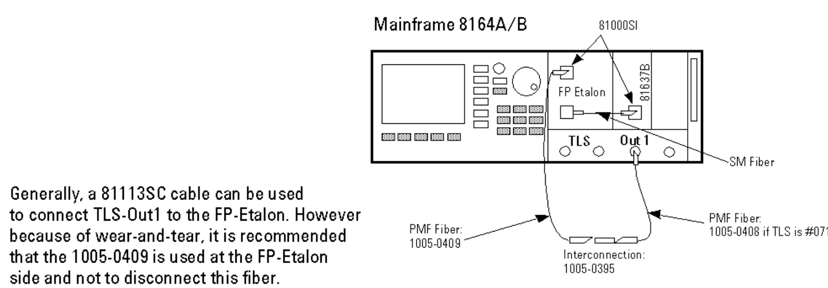


Figure 42 Setup for wavelength uncertainty verification in swept mode

3 Turn the instruments on and allow the instruments to warm up for at least 60 minutes.

4 Move to the TLS channel of the 8164A/B mainframe. Set the [Menu] parameters to:

Tunable Laser Channel [Menu] Parameters	Values
<*Wavelength Mode*>	<λ>
<*Source State*>	<*Off*>
<*Power Unit*>	<*dBm*>
<*Power Mode*>	<*Automatic*>
Modulation: <*mod src*>	<*Off*>

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 Set the power and sweep settings:

Table 12 Power and Sweep settings for dynamic accuracy tests

	81600B #200	81600B #160	81600B #150	81600B #140	81600B #130	81600B #142 #003	81600B #142	81600B #132
TLS output port	Low SSE, Output 1	Low SSE, Output 1	Low SSE, Output 1	Low SSE, Output 1	Low SSE, Output 1	High Power, Output 2	High Power, Output 2	High Power, Output 2
TLS output power	- 2 dBm	- 6 dBm	- 3 dBm	- 7 dBm	- 9 dBm	+3.5 dBm	+5 dBm	0 dBm
PM range	0 dBm	0 dBm	0 dBm	0 dBm	0 dBm	+10 dBm	+10 dBm	0 dBm
Wavelength step	2.0 pm	2.0 pm	2.0 pm	2.0 pm	2.0 pm	2.0 pm	2.0 pm	2.0 pm
Wavelength range 1	1475-1485 nm	1510-1514 nm	1520-1524 nm	1420-1424 nm	1270-1274 nm	1420-1424 nm	1420-1424 nm	1260-1264 nm
Wavelength range 2	1610-1620 nm	1165-1620 nm	1566-1570 nm	1476-1480 nm	1371-1375 nm	1476-1480 nm	1476-1480 nm	1270-1280 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 at step 6, but only windows of ±25 pm (or approx. 25 points) centered around each transmission peak, as shown in Figure 43 on page 140. 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

Do not disturb the test setup. 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 specified at step 6 “Power and Sweep settings for dynamic accuracy tests”

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 step 6 “Power and Sweep settings for dynamic accuracy tests”) 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 (that is: wavelength range):

$P_{th}\,dBm\,(j)$
$= 10{*}\log10(\max(Pmeas\,mW(\lambda))) - 2 \quad (j = 1, 2, \ldots 30) \qquad [dBm]$

representing the threshold level (2 dB below the maximum transmitted power at each peak).

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

Find the corresponding 60 crossings of the thresholds
Pth dBm (j)
(via linear interpolation of the two closest measurements):
$\lambda_{ref}(i) \qquad (j = 1, 2, \ldots 60)$

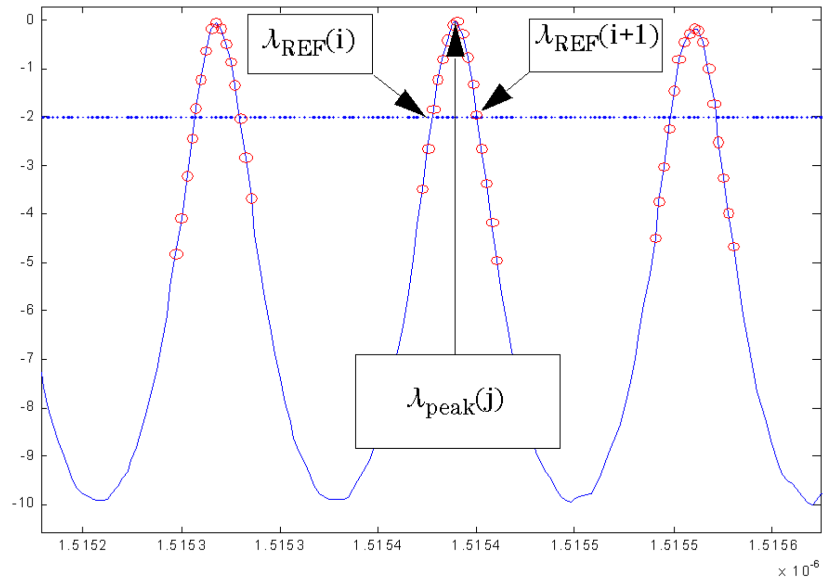


Figure 43 Optimization of reference scans. Sampling points as circled, threshold in dashed line.

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:
5 nm/s, 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,
that is: *100 µs, 100 µs, 25 µs, 25 µs* respectively.

For each sweep speed and each repetition the detailed operations are:

15 Set the TLS and PWM to the power settings specified at step 6;

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

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

18 Select 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 (that is, set *hp816x_returnEquidistantData()* to false);

20 Set the sweep parameters according to settings specified at step 6 (*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 -2 dB 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 that 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:

$\Delta\lambda_{LOGGED}(i, n) = \lambda_{LOGGED}(i, n) - \lambda_{REF}(i, n)$

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:

$\lambda_{LOGGED}(i, n)$ $i = 1, 2, \ldots 60 \times 2$, $n = 1, \ldots 5$ (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 $\lambda_{LOGGED}(i, n)$ corresponding to the sweep speed of interest;

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

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 using:

$$R(n) = sqrt[\ (\lambda_{REL\ STATIC})^2 + (\Delta\lambda_{REL}(n))^2\ ]$$

33 Compute a Dynamic Absolute Wavelength Uncertainty (see Definition of Terms) *A(n)* for each scan, by combining static and dynamic uncertainties using:

$$A(n) = R(n) + |\ (\lambda_{ABS\ STATIC} - \lambda_{REL\ STATIC}) + \Delta\lambda_{OFFSET}(n)\ |$$

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 $\pm A_{AVG}$

Test limits: Dynamic Absolute and Relative Wavelength Uncertainty are not guaranteed specifications but charactereristics with typical performance. Nevertheless, the test would ask for test limits within which the product can be assumed to perform well.

The test limits of the mentioned parameters use the add-on difference between the dynamic parameters and the static parameters, and add this add-on value to the guaranteed specification of the static parameter.

For Example, Absolute Wavelength Accuracy 81600B #200:

Dynamic characteristic (at 5nm/s): ±4.0 pm (typical)

Static characteristic: ±3.6 pm (typical)

Add-on value (dynamic - static characteristic): ± 0.4 pm (typical)

Static specification: ±10 pm

Test limits: ±10.4 pm

Dynamic Wavelength Repeatability

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:

$\lambda_{LOGGED}(i, n)$ $\quad i = 1, 2, \dots 60 \times 2,$ $\quad$ 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 $\sigma^2(i)$ among the repeated scans:
$\sigma^2(i) = 1/(5-1)*\{\Sigma_{j=1\dots5}[\lambda_{LOGGED}(i,j)]^2 - 5*\{\Sigma_{j=1\dots5}[\lambda_{LOGGED}(i,j)/5]^2\}\}$

$i = 1,2, \dots 60 * 2$

and its average over all control points σ^2

$\sigma^2 = 1/120 * \Sigma_{i=1\dots120}[\sigma^2(i)]$

2 Calculate the Dynamic Wavelength Repeatability (see Definition of Terms), given as ±REP, using:

REP = +/- 2.663 * sqrt(σ^2)
or
peak-to-peak deviation: $REP_{peak\text{-}to\text{-}peak} = 2 * 2.663 * sqrt(\sigma^2)$

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:

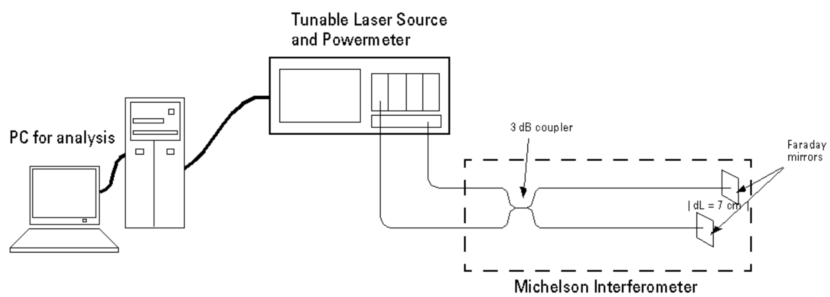


Figure 44 Measurement Setup to Determine the Sweep Speed

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 Records

This section contains Test Records for Agilent 81600B Tunable Laser Source Family.

Results of the performance test may be tabulated on the Test Records. It is recommended that you fill out the Test Record and refer to it while executing 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 procedure). The Test Record can also be used as a permanent record and may be reproduced without written permission from Agilent Technologies.

- This page deliberately blank -

Test Record

Agilent 81600B #200 Performance Test

Page 1 of 14

Test Facility:

______________________________ Report No. ______________________________

______________________________ Date ______________________________

______________________________ Customer ______________________________

______________________________ Tested By ______________________________

Model Agilent 81600B #200 Tunable Laser Module All Band

Serial No. __________________ Ambient temperature _______ °C

Options __________________ Relative humidity _______ %

Firmware Rev. __________________ Line frequency _______ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #200 Performance Test | Page 2 of 14
Model Agilent 81600B #200 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.				

Agilent 81600B #200 Performance Test | Page 3 of 14

Model Agilent 81600B #200 Tunable Laser | Report No. ________ | Date________

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 = Wave length Measured - Wavelength Setting

Agilent 81600B #200 Performance Test Page 4 of 14

Model Agilent 81600B #200 Tunable Laser Report No. ________ Date_______

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 0.010 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 0.01 nm Measurement Uncertainty: ±0.6 pm

Agilent 81600B #200 Performance Test | Page 5 of 14

Model Agilent 81600B #200 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

Agilent 81600B #200 Performance Test — Page 6 of 14

Model Agilent 81600B #200 Tunable Laser — Report No. ________ — Date________

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 wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
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 wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
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 wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #200 Performance Test Page 7 of 14

Model Agilent 81600B #200 Tunable Laser Report No. ________ Date________

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:

- Using 81624A/B #C01 ±2.8%
- Using 81623A/B #C01 ±3.5% (up to 8 dBm)

Agilent 81600B #200 Performance Test — Page 8 of 14

Model Agilent 81600B #200 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.025	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	Using 81624A/B #C01	± 0.02	dB
		Using 81623A/B #C01	± 0.045	dB

Agilent 81600B #200 Performance Test Page 9 of 14

Model Agilent 81600B #200 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 dB	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 Using 81634A/B #C01 ± 0.015 dB

Agilent 81600B #200 Performance Test Page 10 of 14

Model Agilent 81600B #200 Tunable Laser Report No. ________ Date________

Power Flatness

Wavelength		Low SSE Output 1	High Power Output 2	
		P = –7.00 dBm	P = –1.00 dBm ATT = 0 dB	P = 0.00 dBm ATT = 59 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
	Maximum deviation	dB	dB	dB
	Minimum deviation	dB	dB	dB
Flatness = Maximum – Minimum Deviation		dB	dB	dB
	Upper Test Limit	0.50 dBpp	0.60 dBpp	0.60 dBpp
	Measurement Uncertainty: using 81624A/B #C01 using 81623A/B #C01	 ± 1.6% ± 1.6%	 ± 1.6% ± 1.6%	 ± 1.6% ± 1.8%

Agilent 81600B #200 Performance Test Page 11 of 14

Model Agilent 81600B #200 Tunable Laser Report No. ________ Date________

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

Agilent 81600B #200 Performance Test Page 12 of 14

Model Agilent 81600B #200 Tunable Laser Report No. _________ Date________

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

Agilent 81600B #200 Performance Test Page 13 of 14

Model Agilent 81600B #200 Tunable Laser Report No. ________ Date________

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_l$_0$ = 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 - 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_l$_0$ = 1520 nm - 1610 nm)

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #200 Performance Test | Page 14 of 14

Model Agilent 81600B #200 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				

Test Record

Agilent 81600B #160 Performance Test

Page 1 of 14

Test Facility:

____________________________ Report No. ____________________________

____________________________ Date ____________________________

____________________________ Customer ____________________________

____________________________ Tested By ____________________________

Model Agilent 81600B #160 Tunable Laser Module 1600 nm

Serial No. ________________ Ambient temperature _______ °C

Options ________________ Relative humidity _______ %

Firmware Rev. ________________ Line frequency _______ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #160 Performance Test Page 2 of 14
Model Agilent 81600B #160 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.	________	________	________	________

Agilent 81600B #160 Performance Test Page 3 of 14

Model Agilent 81600B #160 Tunable Laser Report No. ________ Date________

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]**
1495.000 nm	nm	nm	nm	nm	nm	nm
1510.000 nm	nm	nm	nm	nm	nm	nm
1525.000 nm	nm	nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm	nm	nm
1550.000 nm	nm	nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm	nm	nm
1575.000 nm	nm	nm	nm	nm	nm	nm
1590.000 nm	nm	nm	nm	nm	nm	nm
1600.000 nm	nm	nm	nm	nm	nm	nm
1615.000 nm	nm	nm	nm	nm	nm	nm
1630.000 nm	nm	nm	nm	nm	nm	nm
1640.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1495.000 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]**
1495.000 nm	nm	nm	nm	nm
1510.000 nm	nm	nm	nm	nm
1525.000 nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm
1550.000 nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm
1575.000 nm	nm	nm	nm	nm
1590.000 nm	nm	nm	nm	nm
1600.000 nm	nm	nm	nm	nm
1615.000 nm	nm	nm	nm	nm
1630.000 nm	nm	nm	nm	nm
1640.000 nm	nm	nm	nm	nm
Within full Tuning Range 1495.000 nm to1640.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Agilent 81600B #160 Performance Test | Page 4 of 14

Model Agilent 81600B #160 Tunable Laser | Report No. _________ | Date________

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 0.010 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 0.01 nm

Measurement Uncertainty: ±0.6 pm

Agilent 81600B #160 Performance Test Page 5 of 14

Model Agilent 81600B #160 Tunable Laser Report No. _________ Date________

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1495.000 nm	nm	nm
1496.000 nm	nm	nm
1497.000 nm	nm	nm
1498.000 nm	nm	nm
1499.000 nm	nm	nm
1500.000 nm	nm	nm
1501.000 nm	nm	nm
1502.000 nm	nm	nm
1503.000 nm	nm	nm
1504.000 nm	nm	nm
1505.000 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

Agilent 81600B #160 Performance Test Page 6 of 14

Model Agilent 81600B #160 Tunable Laser Report No. ________ Date________

Wavelength Repeatability

Repeatability of 1495.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1520.000 nm to REF	nm
from 1550.000 nm to REF	nm
from 1580.000 nm to REF	nm
from 1610.000 nm to REF	nm
from 1640.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1580.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1495.000 nm to REF	nm
from 1520.000 nm to REF	nm
from 1550.000 nm to REF	nm
from 1610.000 nm to REF	nm
from 1640.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
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 1495.000 nm to REF	nm
from 1520.000 nm to REF	nm
from 1550.000 nm to REF	nm
from 1580.000 nm to REF	nm
from 1610.000 nm to REF	nm
from 1615.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #160 Performance Test Page 7 of 14

Model Agilent 81600B #160 Tunable Laser Report No. ________ Date________

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
1495.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm
1510.000 nm	dBm	– 6.00 dBm	dBm	+ 3.00 dBm
1520.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1530.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1540.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1550.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1560.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1570.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1580.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1590.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1600.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1610.000 nm	dBm	– 4.00 dBm	dBm	+ 5.00 dBm
1620.000 nm	dBm	– 6.00 dBm	dBm	+ 3.00 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

Agilent 81600B #160 Performance Test | Page 8 of 14

Model Agilent 81600B #160 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	– 4.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	– 5.0 dBm	dB	+	1.00 dB	=	dB
	– 6.0 dBm	dB	+	2.00 dB	=	dB
	– 7.0 dBm	dB	+	3.00 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	+ 5.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 4.0 dBm	dB	+	1.00 dB	=	dB
	+ 3.0 dBm	dB	+	2.00 dB	=	dB
	+ 2.0 dBm	dB	+	3.00 dB	=	dB
	+ 1.0 dBm	dB	+	4.00 dB	=	dB
	0.0 dBm	dB	+	5.00 dB	=	dB
	– 1.0 dBm	dB	+	6.00 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

Agilent 81600B #160 Performance Test Page 9 of 14

Model Agilent 81600B #160 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 dB	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

Agilent 81600B #160 Performance Test | Page 10 of 14

Model Agilent 81600B #160 Tunable Laser | Report No. ________ | Date________

Power Flatness

Wavelength		Low SSE Output 1	High Power Output 2	
		P = –7.00 dBm	P = –1 dBm ATT = 0 dB	P = –1 dBm ATT = 59.000 dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1495 nm	0.00 dB	0.00 dB	0.00 dB
	1510 nm	dB	dB	dB
	1520 nm	dB	dB	dB
	1530 nm	dB	dB	dB
	1540 nm	dB	dB	dB
	1550 nm	dB	dB	dB
	1560 nm	dB	dB	dB
	1570 nm	dB	dB	dB
	1580 nm	dB	dB	dB
	1585 nm	dB	dB	dB
	1590 nm	dB	dB	dB
	1595 nm	dB	dB	dB
	1600 nm	dB	dB	dB
	1610 nm	dB	dB	dB
	1620 nm	dB	dB	dB
	1630 nm	dB	dB	dB
	Maximum deviation	dB	dB	dB
	Minimum deviation	dB	dB	dB
Flatness = Maximum – Minimum Deviation		dB	dB	dB
	Upper Test Limit	0.50 dBpp	0.60 dBpp	0.60 dBpp
	Measurement Uncertainty:	± 0.10 dB	± 0.10 dB	± 0.10 dB

Agilent 81600B #160 Performance Test — Page 11 of 14

Model Agilent 81600B #160 Tunable Laser — Report No. ________ — Date________

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
1495.000 nm	– 1.00 dBm	dB	37 dB
1510.000 nm	+ 3.00 dBm	dB	42 dB
1520.000 nm	+ 5.00 dBm	dB	45 dB
1530.000 nm	+ 5.00 dBm	dB	45 dB
1540.000 nm	+ 5.00 dBm	dB	45 dB
1550.000 nm	+ 5.00 dBm	dB	45 dB
1560.000 nm	+ 5.00 dBm	dB	45 dB
1570.000 nm	+ 5.00 dBm	dB	45 dB
1580.000 nm	+ 5.00 dBm	dB	45 dB
1590.000 nm	+ 5.00 dBm	dB	45 dB
1600.000 nm	+ 5.00 dBm	dB	45 dB
1610.000 nm	+ 5.00 dBm	dB	45 dB
1620.000 nm	+ 3.00 dBm	dB	42 dB
1630.000 nm	– 1.00 dBm	dB	37 dB
1640.000 nm	– 1.00 dBm	dB	37 dB

Measurement Uncertainty: ± 0.20 dB

Agilent 81600B #160 Performance Test | Page 12 of 14

Model Agilent 81600B #160 Tunable Laser | Report No. ________ | Date________

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:		64 dB/nm	
Measurement Uncertainty:		± 1.2 dB	

Agilent 81600B #160 Performance Test Page 13 of 14

Model Agilent 81600B #160 Tunable Laser Report No. _________ Date________

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:			59 dB

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

Measurement Uncertainty: ± 2.00 dB

Optional Test: Signal-to-Total-Source Spontaneous Emission - 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
Specification		22 dB (27 dB typical)

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #160 Performance Test Page 14 of 14

Model Agilent 81600B #160 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				
Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

Test Record

Agilent 81600B #150 Performance Test

Page 1 of 14

Test Facility:

____________________ Report No. ____________________

____________________ Date ____________________

____________________ Customer ____________________

____________________ Tested By ____________________

Model Agilent 81600B #150 Tunable Laser Module 1550 nm

Serial No. ____________ Ambient temperature ______ C

Options ____________ Relative humidity ______ %

Firmware Rev. ____________ Line frequency ______ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #150 Performance Test | Page 2 of 14
Model Agilent 81600B #150 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.				

Agilent 81600B #150 Performance Test Page 3 of 14

Model Agilent 81600B #150 Tunable Laser Report No. ________ Date________

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]**
1450.000 nm	nm	nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm	nm	nm
1475.000 nm	nm	nm	nm	nm	nm	nm
1490.000 nm	nm	nm	nm	nm	nm	nm
1500.000 nm	nm	nm	nm	nm	nm	nm
1510.000 nm	nm	nm	nm	nm	nm	nm
1520.000 nm	nm	nm	nm	nm	nm	nm
1530.000 nm	nm	nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm	nm	nm
1550.000 nm	nm	nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm	nm	nm
1575.000 nm	nm	nm	nm	nm	nm	nm
1590.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1450.000 nm to1590.000 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]**
1450.000 nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm
1475.000 nm	nm	nm	nm	nm
1490.000 nm	nm	nm	nm	nm
1500.000 nm	nm	nm	nm	nm
1510.000 nm	nm	nm	nm	nm
1520.000 nm	nm	nm	nm	nm
1530.000 nm	nm	nm	nm	nm
1540.000 nm	nm	nm	nm	nm
1550.000 nm	nm	nm	nm	nm
1560.000 nm	nm	nm	nm	nm
1575.000 nm	nm	nm	nm	nm
1590.000 nm	nm	nm	nm	nm
Within full Tuning Range 1450.000 nm to1590.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wave length Measured - Wavelength Setting

Agilent 81600B #150 Performance Test Page 4 of 14

Model Agilent 81600B #150 Tunable Laser Report No. _________ Date________

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 0.010 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 0.01 nm Measurement Uncertainty: ±0.6 pm

Agilent 81600B #150 Performance Test | Page 5 of 14

Model Agilent 81600B #150 Tunable Laser | Report No. ________ | Date_______

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1450.000 nm	nm	nm
1451.000 nm	nm	nm
1452.000 nm	nm	nm
1453.000 nm	nm	nm
1454.000 nm	nm	nm
1455.000 nm	nm	nm
1456.000 nm	nm	nm
1457.000 nm	nm	nm
1458.000 nm	nm	nm
1459.000 nm	nm	nm
1460.000 nm	nm	nm
1580.000 nm	nm	nm
1581.000 nm	nm	nm
1582.000 nm	nm	nm
1583.000 nm	nm	nm
1584.000 nm	nm	nm
1585.000 nm	nm	nm
1586.000 nm	nm	nm
1587.000 nm	nm	nm
1588.000 nm	nm	nm
1589.000 nm	nm	nm
1590.000 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

Agilent 81600B #150 Performance Test Page 6 of 14

Model Agilent 81600B #150 Tunable Laser Report No. ________ Date_______

Wavelength Repeatability

Repeatability of 1450.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1490.000 nm to REF	nm
from 1520.000 nm to REF	nm
from 1550.000 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 wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1520.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1450.000 nm to REF	nm
from 1490.000 nm to REF	nm
from 1550.000 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 wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1590.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1450.000 nm to REF	nm
from 1490.000 nm to REF	nm
from 1520.000 nm to REF	nm
from 1550.000 nm to REF	nm
largest measured wavelength	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #150 Performance Test — Page 7 of 14

Model Agilent 81600B #150 Tunable Laser — Report No. ________ — Date________

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
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
1480.000 nm	dBm	– 6.00 dBm	dBm	+ 4.00 dBm
1490.000 nm	dBm	– 6.00 dBm	dBm	+ 4.00 dBm
1500.000 nm	dBm	– 6.00 dBm	dBm	+ 4.00 dBm
1510.000 nm	dBm	– 6.00 dBm	dBm	+ 4.00 dBm
1520.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1530.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1540.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1550.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1560.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1570.000 nm	dBm	– 3.00 dBm	dBm	+ 5.00 dBm
1580.000 nm	dBm	– 6.00 dBm	dBm	+ 4.00 dBm
1590.000 nm	dBm	– 7.00 dBm	dBm	– 1.00 dBm

Measurement Uncertainty: ± 0.10 dB

Agilent 81600B #150 Performance Test Page 8 of 14

Model Agilent 81600B #150 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	– 3.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	– 4.0 dBm	dB	+	1.00 dB	=	dB
	– 5.0 dBm	dB	+	2.00 dB	=	dB
	– 6.0 dBm	dB	+	3.00 dB	=	dB
	– 7.0 dBm	dB	+	4.00 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	+ 5.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 4.0 dBm	dB	+	1.00 dB	=	dB
	+ 3.0 dBm	dB	+	2.00 dB	=	dB
	+ 2.0 dBm	dB	+	3.00 dB	=	dB
	+ 1.0 dBm	dB	+	4.00 dB	=	dB
	0.0 dBm	dB	+	5.00 dB	=	dB
	– 1.0 dBm	dB	+	6.00 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

Agilent 81600B #150 Performance Test | Page 9 of 14

Model Agilent 81600B #150 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 dB	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

Agilent 81600B #150 Performance Test | Page 10 of 14

Model Agilent 81600B #150 Tunable Laser | Report No. ________ | Date________

Power Flatness

Wavelength		Low SSE Output 1	High Power Output 2	
		P = –7.00 dBm	P = –1 dBm ATT = 0 dB	P = –1 dBm ATT = 59 dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1450 nm	0.00 dB	0.00 dB	0.00 dB
	1455 nm	dB	dB	dB
	1460 nm	dB	dB	dB
	1465 nm	dB	dB	dB
	1470 nm	dB	dB	dB
	1475 nm	dB	dB	dB
	1480 nm	dB	dB	dB
	1490 nm	dB	dB	dB
	1495 nm	dB	dB	dB
	1500 nm	dB	dB	dB
	1505 nm	dB	dB	dB
	1510 nm	dB	dB	dB
	1515 nm	dB	dB	dB
	1520 nm	dB	dB	dB
	1525 nm	dB	dB	dB
	1530 nm	dB	dB	dB
	1535 nm	dB	dB	dB
	1540 nm	dB	dB	dB
	1545 nm	dB	dB	dB
	1550 nm	dB	dB	dB
	1555 nm	dB	dB	dB
	1560 nm	dB	dB	dB
	1565 nm	dB	dB	dB
	1570 nm	dB	dB	dB
	1575 nm	dB	dB	dB
	1580 nm	dB	dB	dB
	1589 nm	dB	dB	dB
	1590 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:	± 0.10 dB	± 0.10 dB	± 0.10 dB

Agilent 81600B #150 Performance Test Page 11 of 14

Model Agilent 81600B #150 Tunable Laser Report No. ________ Date________

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
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
1480.000 nm	+ 4.00 dBm	dB	42 dB
1490.000 nm	+ 4.00 dBm	dB	42 dB
1500.000 nm	+ 4.00 dBm	dB	42 dB
1510.000 nm	+ 4.00 dBm	dB	42 dB
1520.000 nm	+ 5.00 dBm	dB	45 dB
1530.000 nm	+ 5.00 dBm	dB	45 dB
1540.000 nm	+ 5.00 dBm	dB	45 dB
1550.000 nm	+ 5.00 dBm	dB	45 dB
1560.000 nm	+ 5.00 dBm	dB	45 dB
1570.000 nm	+ 5.00 dBm	dB	45 dB
1580.000 nm	- 4.00 dBm	dB	42 dB
1590.000 nm	- 1.00 dBm	dB	37 dB

Measurement Uncertainty: ± 0.20 dB

Agilent 81600B #150 Performance Test | Page 12 of 14

Model Agilent 81600B #150 Tunable Laser | Report No. _________ | Date________

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	
Test Limit:		65 dB/nm	
Measurement Uncertainty:		± 1.2 dB	

Agilent 81600B #150 Performance Test Page 13 of 14

Model Agilent 81600B #150 Tunable Laser Report No. _________ Date________

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:			60 dB

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

Measurement Uncertainty: ± 2.00 dB

Optional Test: Signal-to-Total-Source Spontaneous Emission - 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
Lower Test Limit		25 dB (30 dB typical)

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #150 Performance Test Page 14 of 14

Model Agilent 81600B #150 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				
Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

Test Record

Agilent 81600B #140 Performance Test

Page 1 of 14

Test Facility:

________________________ Report No. ________________________

________________________ Date ________________________

________________________ Customer ________________________

________________________ Tested By ________________________

Model Agilent 81600B #140 Tunable Laser Module 1400 nm

Serial No. ________________ Ambient temperature ______ °C

Options ________________ Relative humidity ______ %

Firmware Rev. ________________ Line frequency ______ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #140 Performance Test | Page 2 of 14
Model Agilent 81600B #140 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.				

Agilent 81600B #140 Performance Test Page 3 of 14

Model Agilent 81600B #140 Tunable Laser Report No. _________ Date________

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]**
1370.200 nm	nm	nm	nm	nm	nm	nm
1380.000 nm	nm	nm	nm	nm	nm	nm
1390.200 nm	nm	nm	nm	nm	nm	nm
1400.200 nm	nm	nm	nm	nm	nm	nm
1410.000 nm	nm	nm	nm	nm	nm	nm
1420.200 nm	nm	nm	nm	nm	nm	nm
1430.200 nm	nm	nm	nm	nm	nm	nm
1440.000 nm	nm	nm	nm	nm	nm	nm
1450.000 nm	nm	nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm	nm	nm
1470.000 nm	nm	nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm	nm	nm
1495.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1370.000 nm to1495.000 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]**
1370.200 nm	nm	nm	nm	nm
1380.000 nm	nm	nm	nm	nm
1390.200 nm	nm	nm	nm	nm
1400.200 nm	nm	nm	nm	nm
1410.000 nm	nm	nm	nm	nm
1420.200 nm	nm	nm	nm	nm
1430.200 nm	nm	nm	nm	nm
1440.000 nm	nm	nm	nm	nm
1450.000 nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm
1470.000 nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm
1495.000 nm	nm	nm	nm	nm
Within full Tuning Range 1370.000 nm to1495.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wave length Measured - Wavelength Setting

Agilent 81600B #140 Performance Test | Page 4 of 14

Model Agilent 81600B #140 Tunable Laser | Report No. ________ | Date________

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 0.010 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 0.01 nm

Measurement Uncertainty: ±0.6 pm

Agilent 81600B #140 Performance Test Page 5 of 14

Model Agilent 81600B #140 Tunable Laser Report No. ________ Date_______

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1420.000 nm	nm	nm
1421.000 nm	nm	nm
1422.000 nm	nm	nm
1423.000 nm	nm	nm
1424.000 nm	nm	nm
1425.000 nm	nm	nm
1426.000 nm	nm	nm
1427.000 nm	nm	nm
1428.000 nm	nm	nm
1429.000 nm	nm	nm
1430.000 nm	nm	nm
1460.000 nm	nm	nm
1461.000 nm	nm	nm
1462.000 nm	nm	nm
1463.000 nm	nm	nm
1464.000 nm	nm	nm
1465.000 nm	nm	nm
1466.000 nm	nm	nm
1467.000 nm	nm	nm
1468.000 nm	nm	nm
1469.000 nm	nm	nm
1470.000 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

Agilent 81600B #140 Performance Test Page 6 of 14

Model Agilent 81600B #140 Tunable Laser Report No. ________ Date________

Wavelength Repeatability

Repeatability of 1370.200 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1390.200 nm to REF	nm
from 1430.200 nm to REF	nm
from 1460.000 nm to REF	nm
from 1495.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1430.200 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1370.200 nm to REF	nm
from 1390.200 nm to REF	nm
from 1460.000 nm to REF	nm
from 1495.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1495.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1370.200 nm to REF	nm
from 1390.200 nm to REF	nm
from 1430.200 nm to REF	nm
from 1460.000 nm to REF	nm
largest measured wavelength	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #140 Performance Test Page 7 of 14

Model Agilent 81600B #140 Tunable Laser Report No. ________ Date________

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
1370.200 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm
1380.000 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm
1390.200 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm
1400.200 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm
1410.000 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm
1420.200 nm	dBm	- 7.00 dBm	dBm	+ 3.00 dBm
1430.200 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1440.000 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1450.000 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1460.000 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1470.000 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1480.000 nm	dBm	- 5.00 dBm	dBm	+ 5.00 dBm
1495.000 nm	dBm	- 13.00 dBm	dBm	- 3.00 dBm

Measurement Uncertainty:

- Using 81624A/B #C01 ±2.8%
- Using 81623A/B #C01 ±3.5% (up to 8 dBm)

Agilent 81600B #140 Performance Test Page 8 of 14

Model Agilent 81600B #140 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	– 5.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	– 6.0 dBm	dB	+	1.00 dB	=	dB
	– 7.0 dBm	dB	+	2.00 dB	=	dB
	– 8.0 dBm	dB	+	3.00 dB	=	dB
	– 9.0 dBm	dB	+	4.00 dB	=	dB
	– 10.0 dBm	dB	+	5.00 dB	=	dB
	– 11.0 dBm	dB	+	6.00 dB	=	dB
	– 12.0 dBm	dB	+	7.00 dB	=	dB
	– 13.0 dBm	dB	+	8.00 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.025	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	+ 5.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 4.0 dBm	dB	+	1.00 dB	=	dB
	+ 3.0 dBm	dB	+	2.00 dB	=	dB
	+ 2.0 dBm	dB	+	3.00 dB	=	dB
	+ 1.0 dBm	dB	+	4.00 dB	=	dB
	0.0 dBm	dB	+	5.00 dB	=	dB
	– 1.0 dBm	dB	+	6.00 dB	=	dB
	– 2.0 dBm	dB	+	7.00 dB	=	dB
	– 3.0 dBm	dB	+	8.00 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.045	dB

Agilent 81600B #140 Performance Test | Page 9 of 14

Model Agilent 81600B #140 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 dB	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 Using 81634A/B ± 0.05 dB

Agilent 81600B #140 Performance Test Page 10 of 14

Model Agilent 81600B #140 Tunable Laser Report No. ________ Date________

Power Flatness

Wavelength		Low SSE Output 1	High Power Output 2	
		P = –13.00 dBm	P = –3 dBm ATT = 0 dB	P = –3 dBm ATT = 57 dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1420.200 nm	0.00 dB	0.00 dB	0.00 dB
	1425.000 nm	dB	dB	dB
	1430.200 nm	dB	dB	dB
	1435.000 nm	dB	dB	dB
	1440.000 nm	dB	dB	dB
	1445.000 nm	dB	dB	dB
	1450.000 nm	dB	dB	dB
	1455.000 nm	dB	dB	dB
	1460.000 nm	dB	dB	dB
	1465.000 nm	dB	dB	dB
	1470.000 nm	dB	dB	dB
	1480.000 nm	dB	dB	dB
	1495.000 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:			
	Using 81624A/B #C01	± 1.6%	± 1.6%	± 1.6%
	Using 81623A/B #C01	± 1.6%	± 1.6%	± 1.6%

Agilent 81600B #140 Performance Test Page 11 of 14

Model Agilent 81600B #140 Tunable Laser Report No. ________ Date________

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
1370.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)
1380.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)
1390.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)
1400.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)
1410.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)
1420.000 nm	+ 3.00 dBm	dB	40 dB
1430.000 nm	+ 5.00 dBm	dB	42 dB
1440.000 nm	+ 5.00 dBm	dB	42 dB
1450.000 nm	+ 5.00 dBm	dB	42 dB
1460.000 nm	+ 5.00 dBm	dB	42 dB
1470.000 nm	+ 5.00 dBm	dB	42 dB
1480.000 nm	+ 5.00 dBm	dB	42 dB
1495.000 nm	- 3.00 dBm	dB	30 dB(typ. 35 dB)

Measurement Uncertainty: ± 0.20 dB

Agilent 81600B #140 Performance Test | Page 12 of 14

Model Agilent 81600B #140 Tunable Laser | Report No. _________ | Date________

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	
Test Limit:		50 dB/nm (typ. 55 dB/nm) (for TLS_λ_0 = 1370.. <1420 nm)	
Measurement Uncertainty:		± 1.2 dB	

Agilent 81600B #140 Performance Test | Page 13 of 14

Model Agilent 81600B #140 Tunable Laser | Report No. ________ | Date________

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
Test Limit:			50 dB (typ. 53 dB)*

* for TLS_l0 = 1370... < 1420 nm

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

Measurement Uncertainty: ± 2.00 dB

Optional Test: Signal-to-Total-Source Spontaneous Emission - 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
Test Limit		23 dB (28 dB typical)*

* for TLS_l0 = 1370... < 1420 nm

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #140 Performance Test | Page 14 of 14

Model Agilent 81600B #140 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				
Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

Test Record

Agilent 81600B #130 Performance Test

Page 1 of 12

Test Facility:

____________________ Report No. ____________________

____________________ Date ____________________

____________________ Customer ____________________

____________________ Tested By ____________________

Model Agilent 81600B #130 Tunable Laser Module 1300 nm

Serial No. ________________ Ambient temperature ________ °C

Options ________________ Relative humidity ________ %

Firmware Rev. ________________ Line frequency ________ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #130 Performance Test | Page 2 of 12
Model Agilent 81600B #130 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.				

Agilent 81600B #130 Performance Test Page 3 of 12

Model Agilent 81600B #130 Tunable Laser Report No. _________ Date________

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]**
1260.000 nm	nm	nm	nm	nm	nm	nm
1270.000 nm	nm	nm	nm	nm	nm	nm
1280.000 nm	nm	nm	nm	nm	nm	nm
1290.000 nm	nm	nm	nm	nm	nm	nm
1300.000 nm	nm	nm	nm	nm	nm	nm
1310.000 nm	nm	nm	nm	nm	nm	nm
1320.000 nm	nm	nm	nm	nm	nm	nm
1330.000 nm	nm	nm	nm	nm	nm	nm
1340.000 nm	nm	nm	nm	nm	nm	nm
1350.000 nm	nm	nm	nm	nm	nm	nm
1360.000 nm	nm	nm	nm	nm	nm	nm
1369.500nm	nm	nm	nm	nm	nm	nm
1375.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1260.000 nm to1375.000 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]**
1260.000 nm	nm	nm	nm	nm
1270.000 nm	nm	nm	nm	nm
1280.000 nm	nm	nm	nm	nm
1290.000 nm	nm	nm	nm	nm
1300.000 nm	nm	nm	nm	nm
1310.000 nm	nm	nm	nm	nm
1320.000 nm	nm	nm	nm	nm
1330.000 nm	nm	nm	nm	nm
1340.000 nm	nm	nm	nm	nm
1350.000 nm	nm	nm	nm	nm
1360.000 nm	nm	nm	nm	nm
1369.500nm	nm	nm	nm	nm
1375.000 nm	nm	nm	nm	nm
Within full Tuning Range 1260.000 nm to1375.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Agilent 81600B #130 Performance Test | Page 4 of 12

Model Agilent 81600B #130 Tunable Laser | Report No. ________ | Date_______

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 0.010 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

Test Limit ±0.01 nm

Measurement Uncertainty: ±0.6 pm

Agilent 81600B #130 Performance Test Page 5 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1260.000 nm	nm	nm
1261.000 nm	nm	nm
1262.000 nm	nm	nm
1263.000 nm	nm	nm
1264.000 nm	nm	nm
1265.000 nm	nm	nm
1266.000 nm	nm	nm
1267.000 nm	nm	nm
1268.000 nm	nm	nm
1269.000 nm	nm	nm
1270.000 nm	nm	nm
1365.000 nm	nm	nm
1366.000 nm	nm	nm
1367.000 nm	nm	nm
1368.000 nm	nm	nm
1369.000 nm	nm	nm
1370.000 nm	nm	nm
1371.000 nm	nm	nm
1372.000 nm	nm	nm
1373.000 nm	nm	nm
1374.000 nm	nm	nm
1375.000 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

Agilent 81600B #130 Performance Test Page 6 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

Wavelength Repeatability

Repeatability of 1260.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1280.00 nm to REF	nm
from 1310.000 nm to REF	nm
from 1350.000 nm to REF	nm
from 1375.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1310.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1260.000 nm to REF	nm
from 1280.000 nm to REF	nm
from 1350.000 nm to REF	nm
from 1375.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1375.000 nm (= reference)	**Measurement Result**
Initial Setting	REF = nm
from 1260.000 nm to REF	nm
from 1280.000 nm to REF	nm
from 1310.000 nm to REF	nm
from 1350.000 nm to REF	nm
largest measured wavelength	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #130 Performance Test Page 7 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
1260.000 nm	dBm	-13.00 dBm	dBm	- 3.00 dBm
1270.000 nm	dBm	-9.00 dBm	dBm	+ 1.00 dBm
1280.000 nm	dBm	-9.00 dBm	dBm	+ 1.00 dBm
1290.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1300.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1310.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1320.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1330.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1340.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1350.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1360.000 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1369.500 nm	dBm	-6.00 dBm	dBm	+ 4.00 dBm
1375.000 nm	dBm	-9.00 dBm	dBm	+ 1.00 dBm

Measurement Uncertainty:

- Using 81624A/B #C01 ±2.8%
- Using 81623A/B #C01 ±3.5% (up to 8 dBm)

Agilent 81600B #130 Performance Test | Page 8 of 12

Model Agilent 81600B #130 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	- 6.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	- 7.0 dBm	dB	+	1.00 dB	=	dB
	- 8.0 dBm	dB	+	2.00 dB	=	dB
	- 9.0 dBm	dB	+	3.00 dB	=	dB
	- 10.0 dBm	dB	+	4.00 dB	=	dB
	- 11.0 dBm	dB	+	5.00 dB	=	dB
	- 12.0 dBm	dB	+	6.00 dB	=	dB
	- 13.0 dBm	dB	+	7.00 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.025	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	+ 4.0 dBm	0.00 dB	+	0.00 dB	=	dB
	+ 3.0 dBm	dB	+	1.00 dB	=	dB
	+ 2.0 dBm	dB	+	2.00 dB	=	dB
	+ 1.0 dBm	dB	+	3.00 dB	=	dB
	0.0 dBm	dB	+	4.00 dB	=	dB
	- 1.0 dBm	dB	+	5.00 dB	=	dB
	- 2.0 dBm	dB	+	6.00 dB	=	dB
	- 3.0 dBm	dB	+	7.00 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.045	dB

Agilent 81600B #130 Performance Test Page 9 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

Power Linearity Output 2, High Power

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	0.0 dB	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 Using 81634A/B ± 0.05 dB

Agilent 81600B #130 Performance Test Page 10 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

Power Flatness

Wavelength		Low SSE Output 1	High-Power Output 2	
		P = - 13 dBm	P = -3 dBm ATT = 0 dB	P = -3 dBm ATT = 57dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1260.000 nm	0.00 dB	0.00 dB	0.00 dB
	1270.000 nm	dB	dB	dB
	1280.000 nm	dB	dB	dB
	1290.000 nm	dB	dB	dB
	1300.000 nm	dB	dB	dB
	1310.000 nm	dB	dB	dB
	1320.000 nm	dB	dB	dB
	1330.000 nm	dB	dB	dB
	1340.000 nm	dB	dB	dB
	1350.000 nm	dB	dB	dB
	1360.000 nm	dB	dB	dB
	1370.000 nm	dB	dB	dB
	1375.000 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			
	Using 81624A/B #C01	± 1.6%	± 1.6%	± 1.6%
	Using 81623A/B #C01	± 1.6%	± 1.6%	± 1.6%

Agilent 81600B #130 Performance Test Page 11 of 12

Model Agilent 81600B #130 Tunable Laser Report No. ________ Date________

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

Agilent 81600B #130 Performance Test Page 12 of 12

Model Agilent 81600B #130 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				
Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

Test Record

Agilent 81600B #142 Performance Test

Page 1 of 13

Test Facility:

_______________________ Report No. _______________________

_______________________ Date _______________________

_______________________ Customer _______________________

_______________________ Tested By _______________________

Model Agilent 81600B #142 Tunable Laser Module 1400 nm

Serial No. _______________ Ambient temperature ________ °C

Options _______________ Relative humidity ________ %

Firmware Rev. _______________ Line frequency ________ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #142 Performance Test Page 2 of 13
Model Agilent 81600B #142 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.				

Agilent 81600B #142 Performance Test — Page 3 of 13

Model Agilent 81600B #142 Tunable Laser — Report No. _________ — Date________

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]**
1370.200 nm	nm	nm	nm	nm	nm	nm
1380.000 nm	nm	nm	nm	nm	nm	nm
1390.200 nm	nm	nm	nm	nm	nm	nm
1400.200 nm	nm	nm	nm	nm	nm	nm
1410.000 nm	nm	nm	nm	nm	nm	nm
1420.200 nm	nm	nm	nm	nm	nm	nm
1430.200 nm	nm	nm	nm	nm	nm	nm
1440.000 nm	nm	nm	nm	nm	nm	nm
1450.000 nm	nm	nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm	nm	nm
1470.000 nm	nm	nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm	nm	nm
1495.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1370.000 nm to1495.000 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]**
1370.200 nm	nm	nm	nm	nm
1380.000 nm	nm	nm	nm	nm
1390.200 nm	nm	nm	nm	nm
1400.200 nm	nm	nm	nm	nm
1410.000 nm	nm	nm	nm	nm
1420.200 nm	nm	nm	nm	nm
1430.200 nm	nm	nm	nm	nm
1440.000 nm	nm	nm	nm	nm
1450.000 nm	nm	nm	nm	nm
1460.000 nm	nm	nm	nm	nm
1470.000 nm	nm	nm	nm	nm
1480.000 nm	nm	nm	nm	nm
1495.000 nm	nm	nm	nm	nm
Within full Tuning Range 1370.000 nm to1495.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Agilent 81600B #142 Performance Test Page 4 of 13

Model Agilent 81600B #142 Tunable Laser Report No. _________ Date________

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 0.010 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 0.01 nm Measurement Uncertainty: ±0.6 pm

Agilent 81600B #142 Performance Test Page 5 of 13

Model Agilent 81600B #142 Tunable Laser Report No. _________ Date________

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1420.000 nm	nm	nm
1421.000 nm	nm	nm
1422.000 nm	nm	nm
1423.000 nm	nm	nm
1424.000 nm	nm	nm
1425.000 nm	nm	nm
1426.000 nm	nm	nm
1427.000 nm	nm	nm
1428.000 nm	nm	nm
1429.000 nm	nm	nm
1430.000 nm	nm	nm
1460.000 nm	nm	nm
1461.000 nm	nm	nm
1462.000 nm	nm	nm
1463.000 nm	nm	nm
1464.000 nm	nm	nm
1465.000 nm	nm	nm
1466.000 nm	nm	nm
1467.000 nm	nm	nm
1468.000 nm	nm	nm
1469.000 nm	nm	nm
1470.000 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

Agilent 81600B #142 Performance Test Page 6 of 13

Model Agilent 81600B #142 Tunable Laser Report No. ________ Date________

Wavelength Repeatability

Repeatability of 1370.200 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1390.200 nm to REF	nm
from 1420.200 nm to REF	nm
from 1450.000 nm to REF	nm
from 1495.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1430.200 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1370.200 nm to REF	nm
from 1390.200 nm to REF	nm
from 1450.000 nm to REF	nm
from 1495.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Repeatability of 1495.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1370.200 nm to REF	nm
from 1390.200 nm to REF	nm
from 1420.200 nm to REF	nm
from 1450.000 nm to REF	nm
largest measured wavelength	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm
Performance Characteristic	0.0010 nm typical

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #142 Performance Test Page 7 of 13

Model Agilent 81600B #142 Tunable Laser Report No. ________ Date________

Maximum Power Test

	Output 1		Output 2	
Wavelength Setting	**Power Measured**	**Lower Test Limit**	**Power Measured**	**Lower Test Limit**
1370.200 nm	dBm	0.00 dBm	dBm	- 1.50 dBm
1380.000 nm	dBm	0.00 dBm	dBm	- 1.50 dBm
1390.200 nm	dBm	0.00 dBm	dBm	- 1.50 dBm
1400.200 nm	dBm	0.00 dBm	dBm	- 1.50 dBm
1410.000 nm	dBm	0.00 dBm	dBm	- 1.50 dBm
1420.200 nm	dBm	+ 5.00 dBm	dBm	+ 3.50 dBm
1430.200 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1440.000 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1450.000 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1460.000 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1470.000 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1480.000 nm	dBm	+ 7.50 dBm	dBm	+ 6.00 dBm
1495.000 nm	dBm	0.00 dBm	dBm	- 1.50 dBm

Measurement Uncertainty:

- Using 81624A/B #C01 ±2.8%
- Using 81623A/B #C01 ±3.5% (up to 8 dBm)

Agilent 81600B #142 Performance Test Page 8 of 13

Model Agilent 81600B #142 Tunable Laser Report No. ________ Date________

Power Linearity Output 1, Low SSE Option #003

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+ 7.5 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 7.0 dBm	dB	+	0.50 dB	=	dB
	+ 6.0 dBm	dB	+	1.50 dB	=	dB
	+ 5.0 dBm	dB	+	2.50 dB	=	dB
	+ 4.0 dBm	dB	+	3.50 dB	=	dB
	+ 3.0 dBm	dB	+	4.50 dB	=	dB
	+ 2.0 dBm	dB	+	5.50 dB	=	dB
	+ 1.0 dBm	dB	+	6.50 dB	=	dB
	0.0 dBm	dB	+	7.50 dB	=	dB
	- 1.0 dBm	dB	+	8.50 dB	=	dB
	- 2.0 dBm	dB	+	8.50 dB	=	dB
	- 3.0 dBm	dB	+	9.50 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	Using 81624A/B #C01	± 0.02	dB
	Using 81623A/B #C01	± 0.045	dB

Power Linearity Output 1, Low SSE Option #003 Upper Power Levels

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+ 6.0 dBm	0.00 dB	+	0.00 dB	=	dB
	+ 5.0 dBm	dB	+	1.00 dB	=	dB
	+ 4.0 dBm	dB	+	2.00 dB	=	dB
	+ 3.0 dBm	dB	+	3.00 dB	=	dB
	+ 2.0 dBm	dB	+	4.00 dB	=	dB
	+ 1.0 dBm	dB	+	5.00 dB	=	dB
	0.0 dBm	dB	+	6.00 dB	=	dB
	- 1.0 dBm	dB	+	7.00 dB	=	dB
	- 2.0 dBm	dB	+	8.00 dB	=	dB
	- 3.0 dBm	dB	+	9.00 dB	=	dB
	- 4.0 dBm	dB		10.00 dB		dB
	- 4.5 dBm	dB		10.50 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	Using 81624A/B #C01	± 0.05	dB

Agilent 81600B #142 Performance Test | Page 9 of 13

Model Agilent 81600B #142 Tunable Laser | Report No. ________ | Date_______

Power Linearity Option #003 by attenuator

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	0.0 dB	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 Using 81634A/B ± 0.05 dB

Agilent 81600B #142 Performance Test — Page 10 of 13

Model Agilent 81600B #142 Tunable Laser — Report No. ________ Date________

Power Flatness

Wavelength		#142	#142 #003	
		P = 0 dBm	P = -1.5 dBm ATT = 0 dB	P = -1.5 dBm ATT = 58.5 dB
		Power Deviation	Power Deviation	Power Deviation
Start = REF	1420.200 nm	0.00 dB	0.00 dB	0.00 dB
	1425.000 nm	dB	dB	dB
	1430.200 nm	dB	dB	dB
	1435.000 nm	dB	dB	dB
	1440.000 nm	dB	dB	dB
	1445.000 nm	dB	dB	dB
	1450.000 nm	dB	dB	dB
	1455.000 nm	dB	dB	dB
	1460.000 nm	dB	dB	dB
	1465.000 nm	dB	dB	dB
	1470.000 nm	dB	dB	dB
	1480.000 nm	dB	dB	dB
	1495.000 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	± 0.1 dB	± 0.1 dB

Agilent 81600B #142 Performance Test   Page 11 of 13

Model Agilent 81600B #142 Tunable Laser   Report No. ________   Date________

Power Stability

	#142	#142 #003
		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

	Agilent 81600B #142 Standard (without #003)			Agilent 81600B #142 with #003		
Wavelength	Output Power	Results	Lower Test Limit	Output Power	Results	Lower Test Limit
1370.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)
1380.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)
1390.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)
1400.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)
1410.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)
1420.000 nm	+ 5.00 dBm	dB	40 dB	+ 3.50 dBm	dB	40 dB
1430.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1440.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1450.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1460.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1470.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1480.000 nm	+ 7.50 dBm	dB	42 dB	+ 6.00 dBm	dB	42 dB
1495.000 nm	0.00 dBm	dB	30 dB(typ. 35 dB)	- 1.50 dBm	dB	30 dB(typ. 35 dB)

Measurement Uncertainty: ± 0.20 dB

Agilent 81600B #142 Performance Test | Page 12 of 13

Model Agilent 81600B #142 Tunable Laser | Report No. ________ | Date________

Optional Test: Signal-to-Total-Source Spontaneous Emission - 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
Lower Test Limit		28 dB

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #142 Performance Test Page 13 of 13

Model Agilent 81600B #142 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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				
Test Limit (peak to peak)	0.6 pm					0.8 pm					1.4 pm				

- This page deliberately blank -

Test Record

Agilent 81600B #132 Performance Test

Page 1 of 11

Test Facility:

______________________	Report No.	______________________
______________________	Date	______________________
______________________	Customer	______________________
______________________	Tested By	______________________

Model Agilent 81600B #132 Tunable Laser Module 1400 nm

Serial No.	______________	Ambient temperature	______ °C
Options	______________	Relative humidity	______ %
Firmware Rev.	______________	Line frequency	______ Hz

Special Notes:

____

____

____

____

____

____

____

Agilent 81600B #132 Performance Test | Page 2 of 11
Model Agilent 81600B #132 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.				

Agilent 81600B #132 Performance Test Page 3 of 11

Model Agilent 81600B #132 Tunable Laser Report No. _________ Date________

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]**
1260.000 nm	nm	nm	nm	nm	nm	nm
1270.000 nm	nm	nm	nm	nm	nm	nm
1280.000 nm	nm	nm	nm	nm	nm	nm
1290.000 nm	nm	nm	nm	nm	nm	nm
1300.000 nm	nm	nm	nm	nm	nm	nm
1310.000 nm	nm	nm	nm	nm	nm	nm
1320.000 nm	nm	nm	nm	nm	nm	nm
1330.000 nm	nm	nm	nm	nm	nm	nm
1340.000 nm	nm	nm	nm	nm	nm	nm
1350.000 nm	nm	nm	nm	nm	nm	nm
1360.000 nm	nm	nm	nm	nm	nm	nm
1369.500 nm	nm	nm	nm	nm	nm	nm
1375.000 nm	nm	nm	nm	nm	nm	nm
Within full Tuning Range 1260.000 nm to1375.000 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]**
1260.000 nm	nm	nm	nm	nm
1270.000 nm	nm	nm	nm	nm
1280.000 nm	nm	nm	nm	nm
1290.000 nm	nm	nm	nm	nm
1300.000 nm	nm	nm	nm	nm
1310.000 nm	nm	nm	nm	nm
1320.000 nm	nm	nm	nm	nm
1330.000 nm	nm	nm	nm	nm
1340.000 nm	nm	nm	nm	nm
1350.000 nm	nm	nm	nm	nm
1360.000 nm	nm	nm	nm	nm
1369.500 nm	nm	nm	nm	nm
1375.000 nm	nm	nm	nm	nm
Within full Tuning Range 1260.000 nm to1375.000 nm				
Maximum Deviation		nm		nm
Minimum Deviation		nm		nm

[1] Wavelength Deviation = Wavelength Measured - Wavelength Setting

Agilent 81600B #132 Performance Test | Page 4 of 11

Model Agilent 81600B #132 Tunable Laser | Report No. ________ | Date________

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 0.010 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
	Test Limits 0.01 nm
	Measurement Uncertainty: ±0.6 pm

Agilent 81600B #132 Performance Test Page 5 of 11

Model Agilent 81600B #132 Tunable Laser Report No. ________ Date________

Mode Hop Free Tuning

Wavelength Setting	Wavelength Measured	Wavelength Deviation [1]
1260.000 nm	nm	nm
1261.000 nm	nm	nm
1262.000 nm	nm	nm
1263.000 nm	nm	nm
1264.000 nm	nm	nm
1265.000 nm	nm	nm
1266.000 nm	nm	nm
1267.000 nm	nm	nm
1268.000 nm	nm	nm
1269.000 nm	nm	nm
1270.000 nm	nm	nm
1365.000 nm	nm	nm
1366.000 nm	nm	nm
1367.000 nm	nm	nm
1368.000 nm	nm	nm
1369.000 nm	nm	nm
1370.000 nm	nm	nm
1371.000 nm	nm	nm
1372.000 nm	nm	nm
1373.000 nm	nm	nm
1374.000 nm	nm	nm
1375.000 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

Agilent 81600B #132 Performance Test Page 6 of 11

Model Agilent 81600B #132 Tunable Laser Report No. ________ Date________

Wavelength Repeatability

Repeatability of 1260.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1280.000 nm to REF	nm
from 1310.000 nm to REF	nm
from 1350.000 nm to REF	nm
from 1375.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm

Repeatability of 1310.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1260.000 nm to REF	nm
from 1280.000 nm to REF	nm
from 1350.000 nm to REF	nm
from 1375.000 nm to REF	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm

Repeatability of 1375.000 nm (= reference)	Measurement Result
Initial Setting	REF = nm
from 1260.000 nm to REF	nm
from 1280.000 nm to REF	nm
from 1310.000 nm to REF	nm
from 1350.000 nm to REF	nm
largest measured wavelength	nm
largest measured wavelength	nm
smallest measured wavelength	nm
Wavelength Repeatability	nm
= largest measured wavelength - smallest measured wavelength	
Upper Test Limit	0.0016 nm

Measurement Uncertainty: ± 0.1 pm

Agilent 81600B #132 Performance Test | Page 7 of 11

Model Agilent 81600B #132 Tunable Laser | Report No. ________ | Date________

Maximum Power Test

Wavelength Setting	Power Measured	Lower Test Limit
1260.000 nm	dBm	0.00 dBm
1270.000 nm	dBm	+ 3.00 dBm
1280.000 nm	dBm	+ 3.00 dBm
1290.000 nm	dBm	+ 7.00 dBm
1300.000 nm	dBm	+ 7.00 dBm
1310.000 nm	dBm	+ 7.00 dBm
1320.000 nm	dBm	+ 7.00 dBm
1330.000 nm	dBm	+ 7.00 dBm
1340.000 nm	dBm	+ 7.00 dBm
1350.000 nm	dBm	+ 7.00 dBm
1360.000 nm	dBm	+ 7.00 dBm
1369.500 nm	dBm	+ 7.00 dBm
1375.000 nm	dBm	+ 3.00 dBm

Measurement Uncertainty:

- Using 81624A/B #C01 ±2.8%
- Using 81623A/B #C01 ±3.5% (up to 8 dBm)

Power Linearity

	Power Setting from start	Measured Relative Power from start		Power reduction from start		Power Linearity at current setting
Start = REF	+ 7.0 dBm	0.00 dB	+	0.00 dB	=	0.00 dB
	+ 6.0 dBm	dB	+	1.00 dB	=	dB
	+ 5.0 dBm	dB	+	2.00 dB	=	dB
	+ 4.0 dBm	dB	+	3.00 dB	=	dB
	+ 3.0 dBm	dB	+	4.00 dB	=	dB
	+ 2.0 dBm	dB	+	5.00 dB	=	dB
	+ 1.0 dBm	dB	+	6.00 dB	=	dB
	0.0 dBm	dB	+	7.00 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 Using 81624A/B #C01 ± 0.02 dB

Using 81623A/B #C01	± 0.025 dB

Agilent 81600B #132 Performance Test Page 8 of 11

Model Agilent 81600B #132 Tunable Laser Report No. ________ Date________

Power Flatness

Wavelength		**#132**
		P = 0 dBm
		Power Deviation
Start = REF	1260.000 nm	0.00 dB
	1265.000 nm	dB
	1270.000 nm	dB
	1275.000 nm	dB
	1280.000 nm	dB
	1285.000 nm	dB
	1290.000 nm	dB
	1295.000 nm	dB
	1300.000 nm	dB
	1305.000 nm	dB
	1310.000 nm	dB
	1315.000 nm	dB
	1320.000 nm	dB
	1325.000 nm	dB
	1330.000 nm	dB
	1335.000 nm	dB
	1340.000 nm	dB
	1345.000 nm	dB
	1350.000 nm	dB
	1355.000 nm	dB
	1360.000 nm	dB
	1365.000 nm	dB
	1370.000 nm	dB
	1375.000 nm	dB
	Maximum deviation	dB
	Minimum deviation	dB
Flatness = Maximum – Minimum Deviation		dB
	Upper Test Limit	0.40 dBpp
Measurement Uncertainty:		
	Using 81624A/B #C01	± 1.6%
	Using 81623A/B #C01	± 1.6%

Agilent 81600B #132 Performance Test Page 9 of 11

Model Agilent 81600B #132 Tunable Laser Report No. ________ Date________

Power Stability

	Agilent 81600B #132
Maximum Deviation	dB
Minimum Deviation	dB
Power Stability [1]	dB
Upper Test Limit	0.02 dBpp
Measurement Uncertainty	±0.005 dB

[1] Power Stability = Maximum Deviation – Minimum Deviation

Signal-to-Source Spontaneous Emission

	Agilent 81600B #132		
Wavelength	**Output Power**	**Results**	**Lower Test Limit**
1260 nm	0.00 dBm	dB	30 dB(typ. 35 dB)
1270 nm	+ 3.00 dBm	dB	40 dB
1280 nm	+ 3.00 dBm	dB	40 dB
1290 nm	+ 7.00 dBm	dB	45 dB
1300 nm	+ 7.00 dBm	dB	45 dB
1310 nm	+ 7.00 dBm	dB	45 dB
1320 nm	+ 7.00 dBm	dB	45 dB
1330 nm	+ 7.00 dBm	dB	45 dB
1340 nm	+ 7.00 dBm	dB	45 dB
1350 nm	+ 7.00 dBm	dB	45 dB
1360 nm	+ 7.00 dBm	dB	45 dB
1370 nm	+ 7.00 dBm	dB	45 dB
1375 nm	+ 3.00 dBm	dB	40 dB

Measurement Uncertainty: ± 0.20 dB

Agilent 81600B #132 Performance Test Page 10 of 11

Model Agilent 81600B #132 Tunable Laser Report No. ________ Date________

Optional Test: Signal-to-Total-Source Spontaneous Emission - 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
Lower Test Limit		25 dB
Performance Characteristic		(28 dB typical)

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

Measurement Uncertainty: ± 2.00 dB

Agilent 81600B #132 Performance Test | Page 11 of 11

Model Agilent 81600B #132 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 (from page 4)															
Relative static wavelength accuracy (from page 4)															
$\Delta\lambda_{REL}$ (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)	± 10.3 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				
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/m^2). If this happens, measurements become inaccurate and non-repeatable.

Cleaning is, therefore, an essential yet difficult task. Unfortunately, when comparing most published cleaning recommendations, you will discover that they contain several inconsistencies. In this 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 cleaner slowly as you do this.

CAUTION

Be careful when using pipe cleaners, as the core and the bristles of the pipe cleaner are hard and can damage the adapter.

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

3 Blow away any remaining lint with compressed air.

How to clean lenses and instruments with an optical glass plate

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings. Some instruments, for example, 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 series 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.

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

Preferred Procedure

Use the following procedure on most occasions.

1 Clean the lens by rubbing a new, dry cotton swab over the surface using a small circular movement.
2 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure when there is greasy dirt on the lens.

1 Moisten a new cotton swab with isopropyl alcohol.
2 Clean the lens by rubbing the cotton swab over the surface using a small circular movement.
3 Using a new, dry cotton swab remove the alcohol, any dissolved sediment and dust.
4 Blow away any remaining lint with compressed air.

How to clean instruments with a fixed connector interface

You should only clean instruments with a fixed connector interface when it is absolutely necessary. This is because it is difficult to remove any used alcohol or filaments from the input of the optical block.

It is important, therefore, to keep dust caps on the 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 Blowaway 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

U

www.agilent.com

Printed in Germany January 2005
Fourth edition, January 2005

81600-90B12

Agilent Technologies