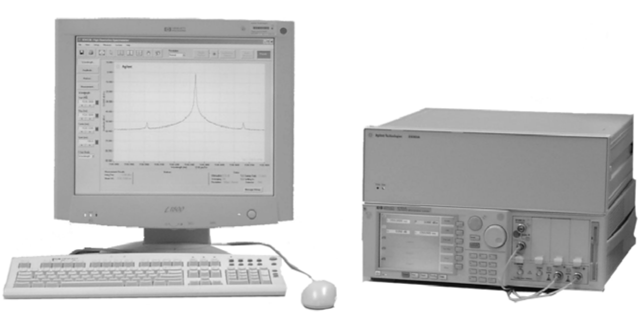
Agilent 83453B
High-Resolution Spectrometer

Technical Specifications

February 2005



The Agilent 83453B high-resolution spectrometer (HRS) provides spectral measurements over the 1440 to 1640 nm communication range. This revolutionary, high resolution spectrometer displays resolution hundreds of times better than conventional grating-based optical spectrum analyzers (OSA). Utilizing groundbreaking technology, the HRS allows measurements with sub-pico meter spectral resolution on tunable lasers, transmitters, and systems. Designers and researchers now have an integrated solution to find, measure, and improve the spectral characteristics of lasers and transmitters for the next generation DWDM networks.

Agilent Technologies

Laser trends and challenges

The growing need for bandwidth in transmission networks drives the demand for increased information-carrying capacity of optical fiber. Close DWDM channel spacing requires control of laser spectral characteristics such as close-in spurious sidebands and modulated linewidth. Higher bandwidth and complex modulation formats, such as single-sideband (SSB) and sub-carrier modulation (SCM), also require close scrutiny of the modulation spectra. Greater fidelity and verification of performance of optical modulation is required.

Many equipment manufacturers are replacing fixed distributed feedback (DFB) lasers in transmission systems with more configurable tunable lasers. Tunable lasers often have cavity modes that generate sidebands close to their primary mode and modulation sidebands. The interaction between these sidebands, the primary mode, and the modulation sidebands can have a negative impact on the optical system performance.

Stability can also be an issue. Tunable lasers can jitter or jump from a few megahertz to over a gigahertz, disrupting the system by causing dispersion and receiver errors not easily seen with conventional OSAs. The problem is hidden until the errors show up at a much higher system level. The 83453B provides the resolution researchers and designers need to see these effects and to obtain insights into the spectral behavior of the communication lasers, transmitters, and optical systems.

Measurement capabilities

With its high resolution, the 83453B characterizes tunable laser, modulator, and transmitter spectral features.

- Modulation and spectral content
- DWDM channel separation, spacing, and interaction
- Sub-carrier modulation parameters
- Laser spectral symmetry
- Linewidth of modulated and unmodulated sources
- Chirp of direct and EML sources
- DFB relaxation oscillation resonance
- Crosstalk in DWDM systems

Calibrated and integrated system

The 83453B HRS is the first calibrated and integrated measurement system based on heterodyne techniques. With a friendly operating interface, all the components necessary to build a heterodyne system are conveniently set up as a desktop rack&stack solution. This also allows for standalone usage of the individual instruments! The HRS system includes the following:

- Optical receiver test set
- Agilent tunable laser
- Agilent variable attenuator
- System controller
- Keyboard, mouse, and monitor

Variable resolution, and span

The HRS operates over the 1440 to 1640 nm wavelength range with flexible resolution and span settings to allow you to view a variety of spectrums. Three resolution settings of wide, normal, and high enable you to select different measurement aspects. Choose wide for fast speeds and large spectral views, normal for best accuracy, or high resolution for very fine detail over spans of 5 GHz (40 pm) or less. Fully variable span settings allow you to zoom in on any part of the signal or spectrum.

Heterodyne analysis

The 83453B utilizes a heterodyne technique to detect and measure optical signals. Signals from the laser-under-test and the swept local oscillator (an Agilent tunable laser) are combined optically in a balanced receiver. This design allows the separation of the coherent (desired), and common mode (noise) of a signal. By subtracting the currents generated by the balanced receiver (common mode), direct detection components are reduced relative to the desired heterodyne signal (Figure 1). This common mode rejection reduces noise and improves dynamic range. Polarization independence is improved by depolarizing the local oscillator. The local oscillator's tuning range determines the spectral coverage.

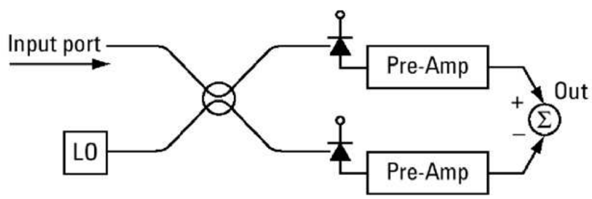


Figure 1. HRS simplified block diagram.

Easy to use graphical user interface

All the individual instruments as well as the whole system fit seamlessly into Agilent's complete optical test portfolio. The Agilent 86146B grating-based OSA, with filter mode, is an excellent example of such hardware. The 86146B with its channel drop capability allows the HRS system to select a specific channel of your DWDM signal for further analysis. In this configuration, the OSA acts as a preselector to the 83453B. The 83453B graphical user interface is easy to use (Figure 2). Measurement controls are easily accessible on the touch screen display. You do not have to search through layers of menus to access measurement control. Features such as variable horizontal, vertical, and full zoom; normal, bandwidth, and delta markers; frequency or wavelength trace display; trace averaging, data exporting; trace and state save; and built in measurements such as linewidth, spectral bandwidths, and integrated spectral power are all built into the HRS system.

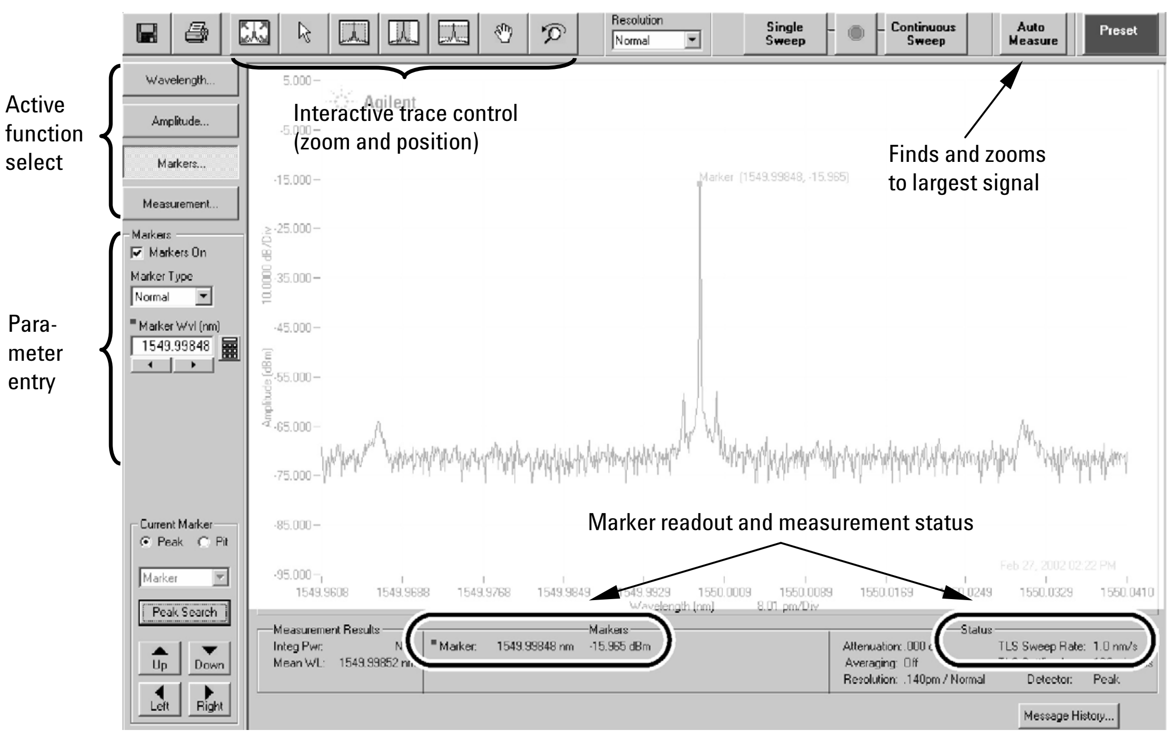


Figure 2. The 83453B graphical user interface is easy to use.

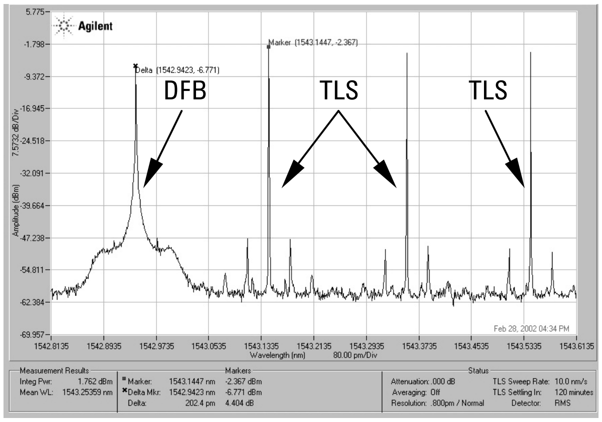


Figure 3. The spectrum of a DFB laser and three tunable lasers measured on HRS.

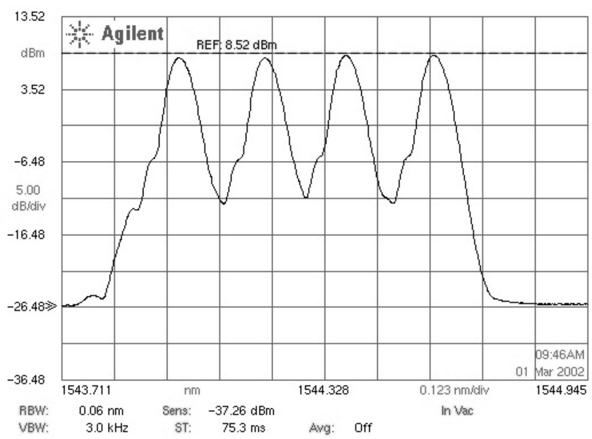


Figure 4. The same signal measured on an OSA.

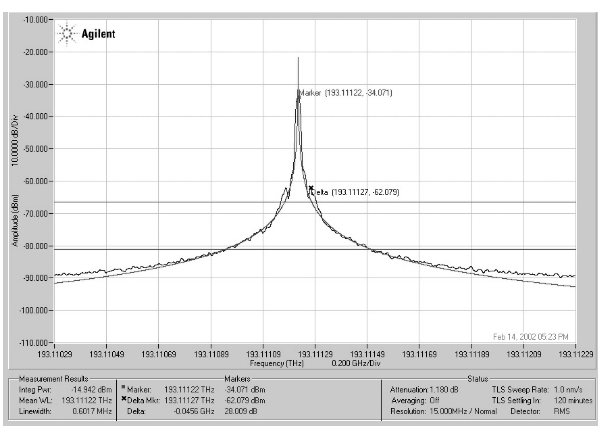


Figure 5. The HRS system provides a built-in linewidth measurement function that measures the laser's linewidth.

DWDM signal measurements

With the 83453B in the wide resolution setting, you can view signals with spans from 1 to 50 nm. Once you have located the signals of interest, there are a number of ways to zoom in. The 83453B allows you to set the displayed wavelength range using either start and stop wavelength, or span and center wavelength function keys. Or use the zoom functions on the touch screen, or with the mouse, to hone in to the desired part of the signal. You can then utilize the normal and high-resolution modes to resolve the fine details of your signal. Investigate and characterize channel cross talk, channel, and other DWDM measurements by using the 83453B built-in zoom and delta marker features. Turn on the built-in ITU grid markers to observe DWDM positions, and TLS tuning accuracy.

Unmodulated signal measurements

The high resolution of the 84543B makes it suitable for characterizing unmodulated DFB and tunable lasers. Find resonance peaks and the spontaneous emission envelope of DFB lasers, or locate the side modes of a TLS as shown on Figures 3 and 6. Note the fine structure and the side modes of the TLS that cannot be seen with grating-based OSAs (Figure 4). Unlike the HRS, the OSA can not distinguish between a DFB and TLS.

Linewidth and spectral widths

The measure of phase noise of the laser's output is called linewidth. The HRS system provides a built-in linewidth measurement function that automatically measures the laser linewidth, as shown in Figure 5. The 83453B also includes bandwidth markers that allow you to measure the –3, –10, –20 dB or any user-defined bandwidth (Figure 9). The system also provides integrated power levels over the span range. The 83453B instrument control, bandwidth markers, measurements, and the capability to export data and graphics, provide you with a powerful tool to characterize the linewidth spectral content of your lasers and optical system.

Relaxation oscillation

The 83453B allows you to view close in features, such as the relaxation oscillation resonance of lasers. Relaxation oscillation is a resonance that causes peaking in the noise floor of lasers. The maximum direct-modulation rate of a laser is directly related to the location of this resonance. The relaxation oscillation resonance can also cause harmonic distortions to occur on analog or other signals that are in this region. This relaxation oscillation moves up in frequency and broadens as more bias current is applied to the laser.

With the resolution and span control of the HRS, you can measure a DFB laser's line width, spectral modes, relaxation oscillation resonance and relative positions at the same time.

Modulation, distortion, and chirp measurements

The high dynamic range and variable span capability makes the HRS ideal for viewing and characterizing modulation side modes and spectral spreading. Incidental frequency modulation (chirp) may occur when DFB lasers or electro-absorption modulated lasers (EML) are intensity modulated.

Figure 7 shows the classic sin(x)/x shape of a non-chirped external modulated TLS, while Figure 8 shows the chirp resulting from the direct modulation of a laser with a 2.4 Gb/s signal. The unwanted chirp causes spectral spreading and signal distortion after transmission over dispersive fiber. It also can lead to channel cross-talk in a densely packed DWDM system.

The 83453B is ideal for investigating this spectrum spreading due to modulation. The 83453B is well suited to detect these effects and can display them in either frequency or wavelength units.

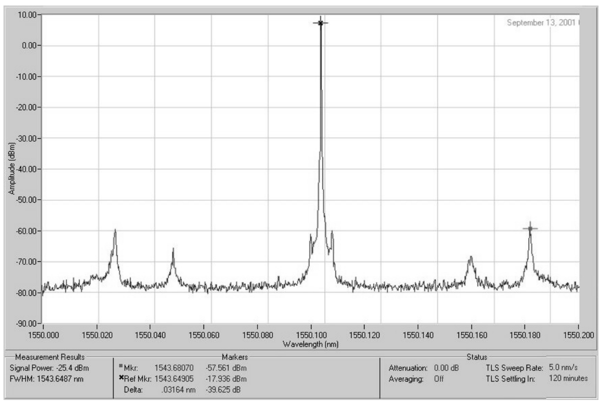


Figure 6. Unmodulated TLS and its sidemodes.

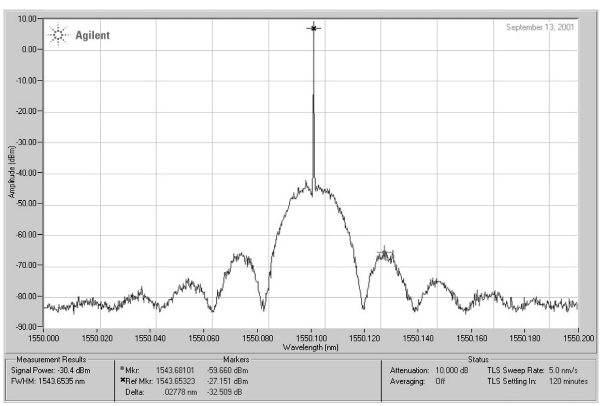


Figure 7. Same TLS with external 2.48 Gb/s modulation.

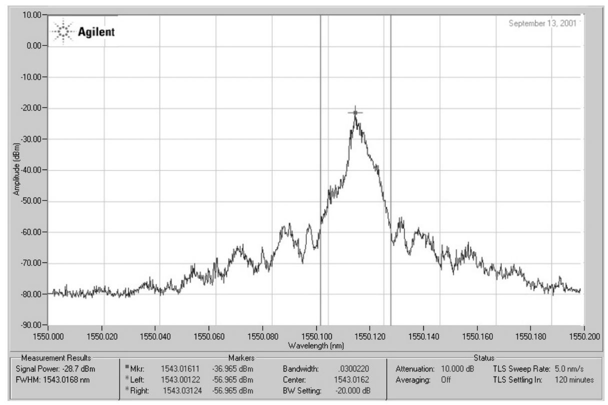


Figure 8. Direct modulated laser showing chirp at 2.4 Gb/s.

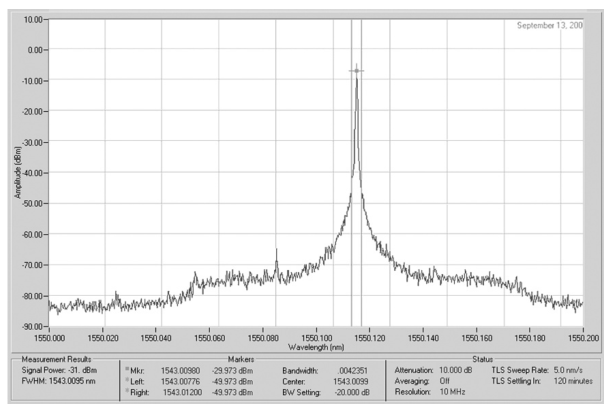


Figure 9. Unmodulated DFB, its spectral shape and relaxation resonance can be seen.

Specifications

Wavelength and amplitude accuracy specifications require an angled connector from the source output to the receiver input ports. Wavelength specifications are defined with frequency terms. For convenience, the frequency delta ranges are provided with wavelength units (in parentheses) assuming a center wavelength of 1550 nm. Unless otherwise specified, amplitude specifications apply in peak detection mode, with unmodulated linewidths < 2 MHz.

Agilent Technologies warrants that the specifications listed below will be met under the following instrument operating conditions:

- **operating temperature +20°C to +30°C**
- **wavelength within 1520 to 1620 nm.**

	High Resolution	Normal Resolution	Wide Resolution
Operating Wavelength Range with 81600B option 200 Tunable Laser	1440 to 1640 nm		
Frequency Span Range	250 MHz to 5 GHz (2 pm to 40 pm)	250 MHz 125 GHz (2 pm to 1 nm)	400 MHz to 12.5 THz (4 pm to 50 nm)
Absolute Frequency Accuracy [a b] with spans ≤ 12 GHz (100 pm)	±1.8 GHz (±15 pm)		
Relative Frequency Accuracy [c] Span ≤ 5 GHz (≤ 40 pm) Span > 5 GHz to 125 GHz (0.04 nm to 1 nm) Span 1 nm to 50 nm	 ±125 MHz (±1 pm) – – – –	 ±190 MHz (±1.5 pm) ±400 MHz (±3.2 pm) – –	 – – – – ±1.2 GHz (±10 pm) [d]
Frequency Repeatability over 5 minutes	±50 MHz (±0.4 pm)	±60 MHz (±0.5 pm)	±300 MHz (±2.4 pm)
Nominal Frequency Resolution [d]	Span / Number of Trace Points		
Minimum Frequency Resolution [d]	1 MHz	15 MHz	20 MHz
Power Accuracy [e f] over full wavelength range at –15 dBm, with spans < 12 GHz (0.1 nm)	±5 dB [g]	±2.75 dB	±6 dB [g]
Power Repeatability [h] with spans < 12 GHz (0.1 nm), over 5 minutes	±10 dB [g]	±0.75 dB	±8 dB [g]
Power Scale Fidelity with spans ≤ 100 pm (–10 dBm to –45 dBm)	±1 dB	±1 dB	– –
Polarization Dependence [g]	±1.5 dB	±1.5 dB	– –
Displayed Average Noise Level [g] RMS detection; 20 pm span; –5 dBm	– –	–65 dBm	– –
Dynamic Range [i k] at 1550 nm	– –	≥ 50 dB	– –
Spurious Free Dynamic Range [g]	≥ 40 dB	≥ 40 dB	– –
Peak Input Power before Saturation [g] with 0 dB attenuation	–5 dBm		
Maximum Safe Total Input Power	+23 dBm		
Optical Attenuation Range	0 to 20 dB in 1 dB steps		
Optical Return Loss [g]	50 dB		

a Verified at 1525 nm, 1550 nm, and 1615 nm.
b In cases where the marker resolution (which is span/(trace points –1)) exceeds a frequency/wavelength specification, the marker resolution overrides the specification.
c Assumes constant temperature over measurement interval.
d Characteristic
e Does not include PDL, scale fidelity, or repeatability.
f With unmodulated linewidths < 2 MHz.
g Characteristic
h Assumes constant temperature over measurement interval.
i With a –5 dBm level adjusted for optimum polarization.
k Applies to any fixed input power level.

General

Dimensions (without computer)
280 mm H x 325 mm W x 560 mm D

Weight
34 kg (75 lbs)

Operating Temperature Range +20°C to +30°C

Storage Temperature Range +20°C to +30°C

Humidity 15 .. 85%

Power Requirements

Voltage and Frequency
110 to 240 V AC,
50 to 60 Hz

Max. Power Consumption
400 W

Computer Interfacing

Operating System
Windows XP

Remote Control Compatibility
LAN Interface

Data Export
Spreadsheet and Word Processor Compatible (CSV)

Graphics Export
JPEG, Bitmap

Floppy Disk
3.5 inch 1.44 MB, MS-DOS

CD-ROM
40 X Maximum Speed

LAN Interface
Ethernet 10/100 Mbit/s

Graphical User Interface
TFT Monitor, XGA

Keyboard/Mouse
PS/2

Additional Interface
Data Acquisition Cards, GPIB

Ordering Information

83453B	High-Resolution Spectrometer
83453B #001	system including tunable laser 81600B option 200
83453B #002	customer furnished tunable laser

The 83453B's optical input is equipped with an angled contact interface.

Connector Interfaces (one is required)

81000NI	FC/APC (2.0 mm key width)
81000HI	E-2000 APC
81000KI	SC/APC
81000LI	LC/APC
81000MI	MU/APC
81000VI	ST/APC

Connector interfaces are user-exchangeable.

Suggested Accessories

There are applications that can utilize the Agilent 86146B OSA, with filter mode, as a preselector to the 83453B.

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Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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(fax) 1 800 829 4433

Canada:

(tel) 1 877 894 4414
(fax) 1 888 900 8921

Europe:

(tel) +31 20 547 2111
(fax) +31 20 547 2190

Japan:

(tel) 120 421 345
(fax) 120 421 678

Latin America:

(tel) +55 11 4197 3600
(fax) +55 11 4197 3800

Australia:

(tel) 1 800 629 485
(fax) 1 800 142 134

Asia Pacific:

(tel) +852 800 930 871
(fax) +852 800 908 476

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Agilent Technologies