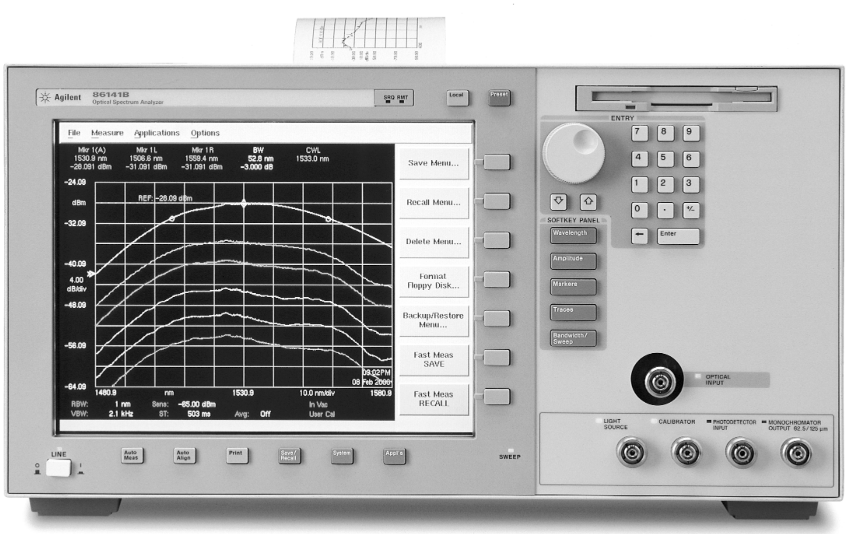
Agilent Optical Spectrum Analyzer WDM Test Application

Product Note 86140-4



Automated WDM System Analysis

- Fast, accurate OSNR measurement
- Channel wavelengths accurate to 10 pm
- Flexible and easy to configure
- Filter mode adds channel drop capability

Agilent Technologies

Today and into the future, wavelength division multiplexing (WDM) will provide the means by which massive amounts of data and voice information are transferred from one location to another. WDM, in concert with advances in time division multiplexing (TDM), are enabling exponential increases in bandwidth using existing fiber networks. The ever-increasing demand for bandwidth has caused an explosion in the fiber optic market. Because of this explosion, network equipment manufacturers must be able to characterize WDM systems in a fast, accurate and efficient manner.

The parameters required to characterize the performance of WDM systems are channel count, signal wavelength, signal power, optical signal to noise ratio (OSNR), and spectral flatness. Accurate OSNR measurements are key for assessing the performance of a WDM system. The WDM application on the 8614xB optical spectrum analyzer (OSA) allows manufacturers and designers of WDM systems to quickly characterize their systems with accuracy and confidence.

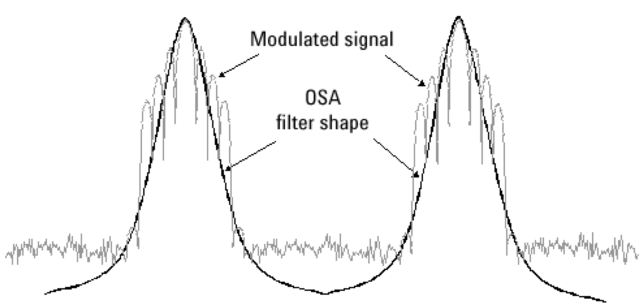


Figure 1. When measuring signal power, a filter that is too narrow will introduce an error.

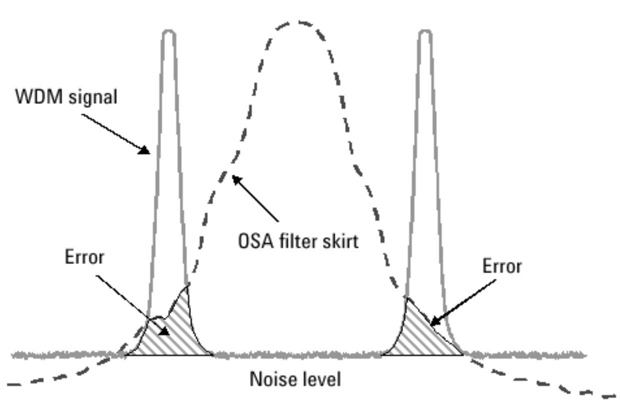


Figure 2. When measuring the noise power spectral density between channels, a filter that is too broad will introduce an error.

The advantage of the dual sweep technique

Measuring OSNR of a WDM signal requires an accurate measurement of both the signal power and the noise power spectral density. This is becoming more and more difficult due to decreasing channel spacing and increasing modulation rates. To accurately measure modulated signal power, a "broad" filter should be used so that all the power of a signal including the modulation sidebands is captured. See Figure 1.

In contrast, to measure noise power spectral density between channels, a "narrow" filter should be used so that the true signal noise floor can be measured. If a "broad" filter is used, then the filter skirts may overlap, especially with closely spaced WDM signals, thereby masking the true noise floor, as shown in Figure 2.

To ensure the most accurate OSNR measurements, Agilent uses a patented "dual sweep"

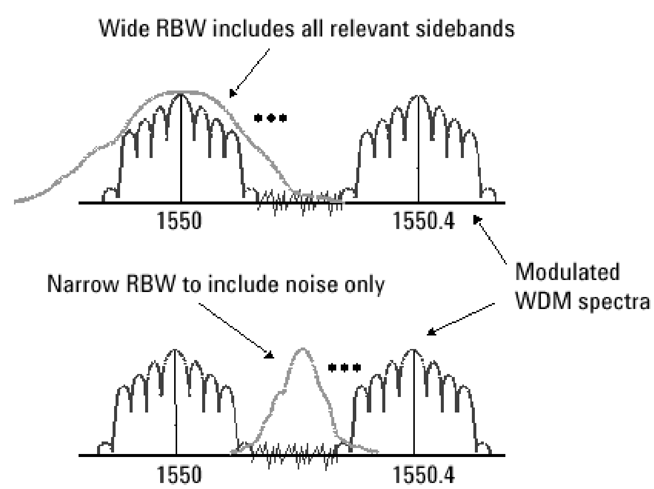
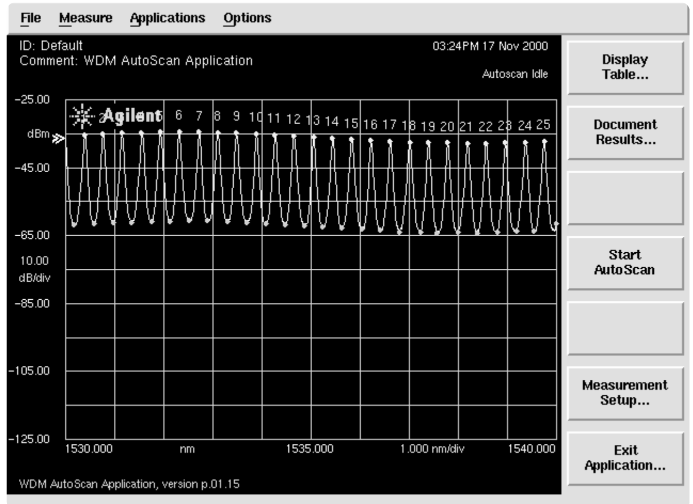
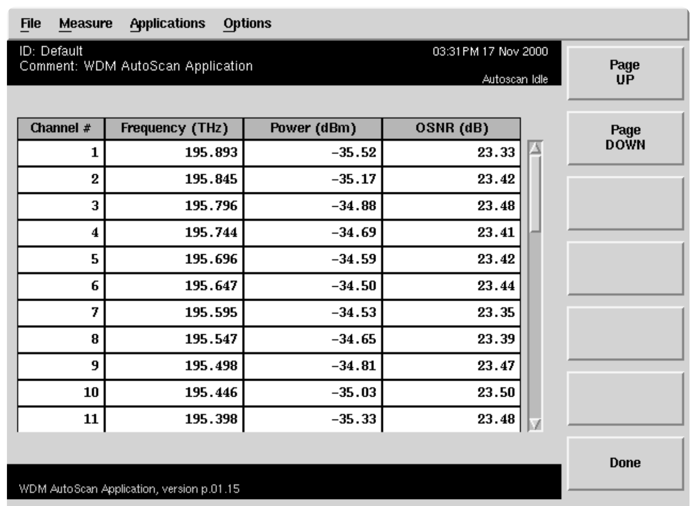


Figure 3. Dual sweep technique ensures accurate OSNR measurements.

technique in the OSA's WDM application. This technique, as shown in Figure 3, takes two sweeps and determines the OSNR from the composite results. The first sweep is taken at a user-specified wide resolution bandwidth filter (e.g. 0.2 nm) to ensure accurate signal amplitude measurements. The second sweep is taken at a user-specified narrow resolution bandwidth filter (e.g. 0.06 nm) to ensure accurate noise power spectral density measurements. With the fast sweep speed of the Agilent OSA, the result is a quick and accurate OSNR measurement.





Channel #	Frequency (THz)	Power (dBm)	OSNR (dB)
1	195.893	–35.52	23.33
2	195.845	–35.17	23.42
3	195.796	–34.88	23.48
4	195.744	–34.69	23.41
5	195.696	–34.59	23.42
6	195.647	–34.50	23.44
7	195.595	–34.53	23.35
8	195.547	–34.65	23.39
9	195.498	–34.81	23.47
10	195.446	–35.03	23.50
11	195.398	–35.33	23.48

Figures 4 and 5. Graphical and tabular results.

Automated analysis of WDM spectra

Using the WDM application's AUTOSCAN feature, the OSA implements the dual sweep method to measure channel wavelength, signal amplitude and OSNR. Each channel is individually marked and numbered for a quick verification of channel count. The center wavelength is reported with industry leading wavelength accuracy throughout C-Band and L-Band. Additionally, the application automatically analyzes the results and reports:

- span tilt* in dB/nm and normalized to dB
- peak-to-peak deviation
- minimum and maximum channel power
- minimum and maximum OSNR

Easy access to results

The results are available in either a graphical or tabular display. The table can be configured to display the results in either units of frequency (THz) or wavelength (nm).

The graph and table can be printed to either the internal OSA printer or an external printer. The table can be saved to a floppy in .CSV format. The WDM application is fully GPIB-controllable, making it the perfect solution for fast-paced manufacturing environments.

* Span tilt is defined as the slope of the line that is the best fit to the channel powers in dB/nm.

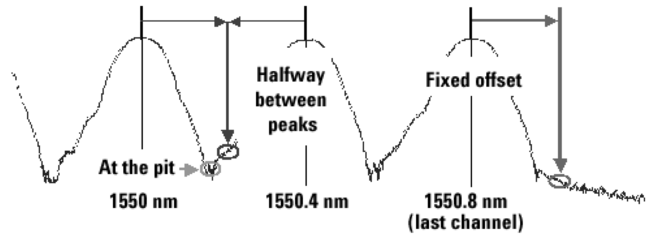


Figure 6. Flexibility in choosing location of noise measurement.

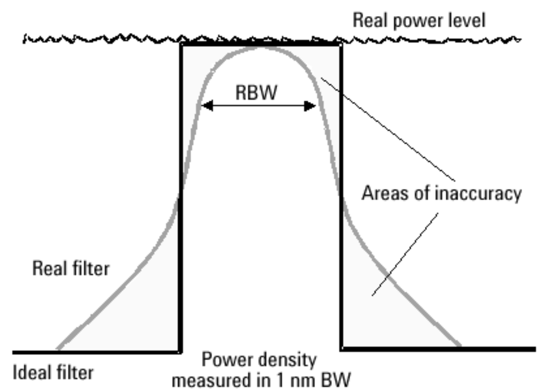


Figure 7. The OSA's noise markers ensure accuracy when measuring noise.

Calculating OSNR

Ideally, OSNR is determined by calculating the ratio of the signal amplitude to the noise power at that signal wavelength. Unfortunately, the noise at the signal wavelength cannot be measured directly because the signal itself obscures the measurement. In order to calculate noise power, the WDM application measures the noise on both sides of each channel and interpolates to determine the noise value at the signal wavelength. Additionally, the user may specify where the noise is measured with respect to each channel. The WDM application offers the choice of halfway between channels, at the pit or lowest point between channels, or at a user-specified offset. The Telecommunications Industry Association in TIA/EIA-526-19 defines OSNR using the noise power at halfway between channels.[1]

Noise markers ensure accuracy

To ensure the most accurate noise power density measurement, the WDM application uses the 8614xB noise markers. A noise marker reports the value of the noise power spectral density normalized over either a 0.1 nm or 1 nm window. When measuring noise, the shape of the OSA's filter cannot be ignored because the power measurement depends on this shape. Noise markers correct for the difference between the shape of the OSA filter compared to an "ideal" filter shape. The noise equivalent bandwidth of the OSA filter is used instead of the half-power bandwidth. The noise equivalent bandwidth of a filter is such that it would pass the same total noise power as a rectangular passband that has the same area as the actual filter. The height of the equivalent rectangular passband is the same as the height of the actual filter at its center wavelength, as indicated in Figure 7. In addition, the noise marker includes wavelength-dependent calibration data to correct for each Agilent OSA's filter shape, rather than assuming an average correction factor that applies to every OSA.

Configure with ease

All setup parameters relevant to WDM analysis are easily accessible from one simple measurement setup menu. Set these parameters once, and analyze any WDM spectrum with one button press. (Figure 8)

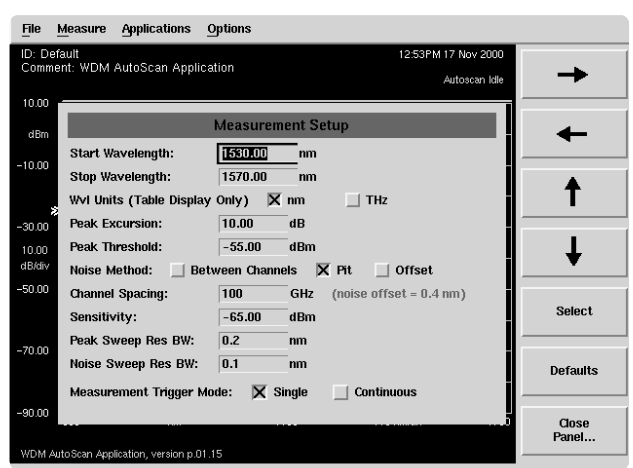


Figure 8. WDM application setup menu.

[1] OFSTP-19-Optical Signal-to-Noise Ratio Measurement Procedures for Dense Wavelength Division Multiplexed Systems (ANSI/TIA/EIA-526-19-2000)

The measurement range can be specified up to 75 nm anywhere from 600 to 1700 nm. To insure that noise peaks are not confused with true signals, the application provides for the definition of signal peaks with “peak excursion” and “peak threshold” parameters.

The user selects the resolution bandwidth for each of the two sweeps. The first sweep measures the signal amplitude and requires a wide resolution bandwidth. The second sweep measures the noise and requires a narrow resolution. The resolution bandwidth settings will depend on how tightly spaced the channels are and the modulation rate. The 8614xB is optimized for 50 GHz channel spacing.

The sensitivity is user-specified to ensure that the true noise floor is being measured while optimizing the sweep time. Additionally, the WDM application can be set to run either a single measurement or continually sweep to observe how the signal parameters are changing in time.

Filter Mode

The heart of Agilent’s grating based optical spectrum analyzer is the monochromator. The monochromator spreads the input light spectrum so that a selected band of the spectrum can be analyzed. The time it takes to analyze the entire spectrum is referred to as the sweep time. When in filter mode, the monochromator stops sweeping and analyzes only one selected portion of the input spectrum. The signal is then diverted by an internal flexure from a 50 µm multi-mode internal fiber into a 9 µm single-mode internal fiber that leads to the front panel. At the front panel the user has the option of routing the light back into the OSA via a front panel jumper, or to couple the output to another instrument for further testing. This filter mode feature is only available on the Agilent 86144B and 86146B models.

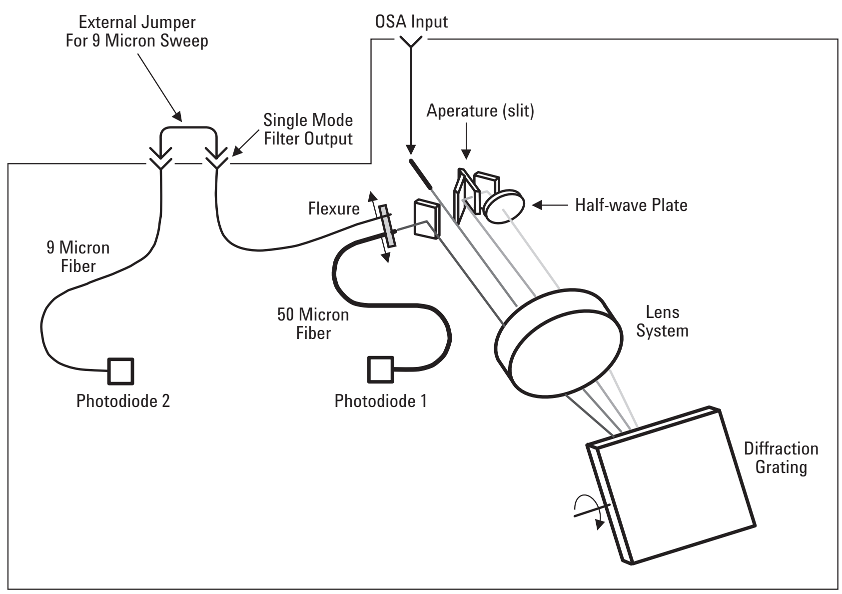


Figure 9. OSA monochromator simplified block diagram

The OSA’s filter mode allows a single tightly spaced DWDM signal to be isolated. The WDM firmware application can sequentially or selectively drop WDM channels that require additional analysis. It is possible to select a specific wavelength or channel number to be dropped out. It can then be quantitatively analyzed in the time domain.

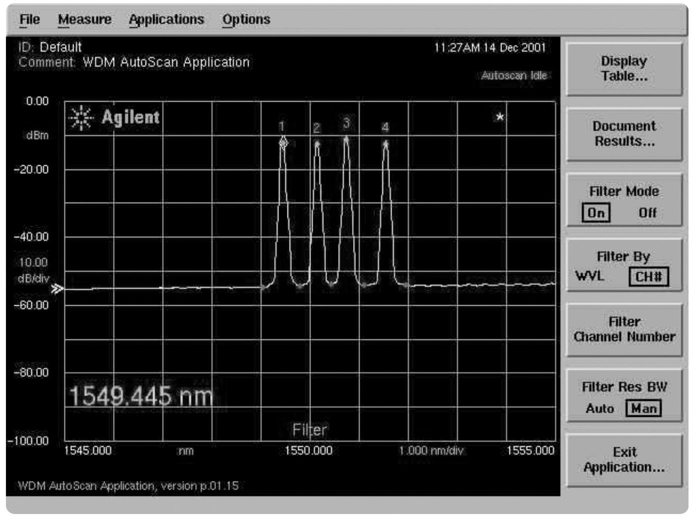


Figure 10. OSA’s filter mode

The WDM application is a standard feature on all 8614xB OSAs. A firmware upgrade via the internet adds the WDM application to existing 8614x OSAs, at no additional cost. Please refer to the following website for firmware upgrades, www.agilent.com/comms/osaupgrade.

Specifications

Optical Signal-to-Noise Ratio[1]

	Standard		High-Performance		Flexible	
	86140B Benchtop	86143B/86144B Portable	86142B/86146B Benchtop	86145B Portable	86141B Benchtop	86140B, Option 025 Benchtop
Maximum measurable OSNR[2,3,4,5]						
50 GHz channel spacing	28 dB				28 dB	
100 GHz channel spacing	43 dB				40 dB	
200+ GHz channel spacing	58 dB				58 dB	
Measurement Uncertainty						
OSNR <30 dB: Peak sweep RBW 0.2 nm, Noise sweep RBW 0.06 nm	—		0.7 dB		—	
OSNR <20 dB: Peak sweep RBW 0.2 nm, Noise sweep RBW 0.1 nm	—		0.4 dB		—	

[1] Characteristic, non-warranted information
[2] ResBW for noise measurement is 0.6 nm
[3] Noise in OSNR calculation is per 0.1 nm
[4] Signal broadening due to chirp and modulation is negligible
[5] Dynamic range exceeds measured noise by 10 dB

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