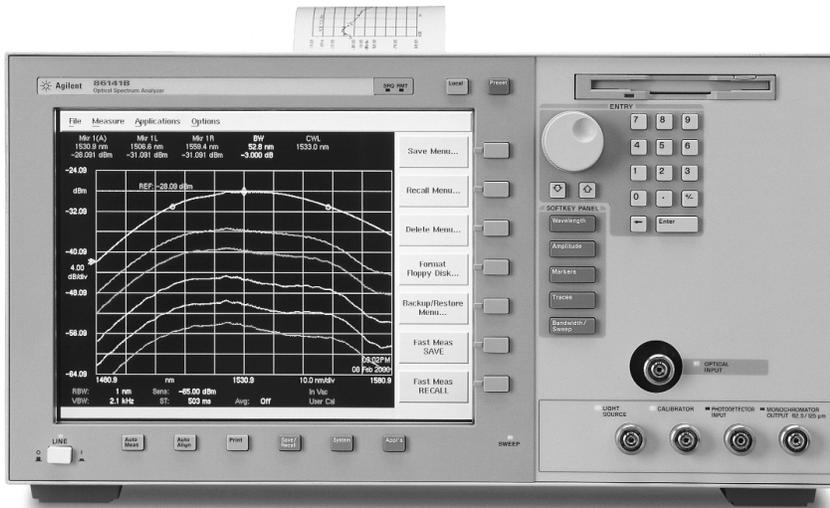


# Agilent Optical Spectrum Analyzer Amplifier Test Application

Product Note 86140-5



## Flexible—low cost, optical amplifier characterization

- Time Domain Extinction (TDE) test method—Now available
- Integration Source Subtraction (ISS) test method
- Characterization of various types of optical amplifiers
- Single or multichannel source stimulus measurements



Agilent Technologies

**Optical amplifiers spanning the C-Band (1530–1565 nm), L-Band (1565–1625 nm) and S-Band (1460–1530 nm) are the enabling technology for long-haul optical transmission with expansion capability.** With the rapid deployment of DWDM systems, the demand for optical amplifiers continues to drive the need for high-volume manufacturing of these key components. Optical amplifier manufacturers and DWDM system designers need testing solutions to increase throughput without degrading the measurement accuracy.

The Agilent Optical Spectrum Analyzer (8614xB OSA) amplifier test application provides a cost-effective solution for reducing test time. The functionality is provided by a standard on-board application. This application offers fast and easy measurement of gain and noise figure for optical amplifiers. Characterization of multiple types of amplifiers including EDFAs, EDWAs, Raman and Semiconductor Optical Amplifiers (SOAs) is fast, easy and accurate.

## Test Methods

The amplifier test application on the OSA uses the Interpolated Source Subtraction (ISS) method and for the 86146B offers the Time Domain Extinction (TDE) technique. With these techniques, an optical amplifier can be characterized using either a single stable source or several multiplexed stable sources. When using multiple stable sources, the amplifier can be characterized in a more realistic saturation condition, yielding more accurate results than when using a single source. Distributed feed-back lasers (DFB) or tunable laser sources work well as the stimulus for amplifier test. Spectral measurements of the laser source(s) alone and the amplified sources are required to determine the noise figure and gain of the amplifier.

The purpose of an optical amplifier is to provide gain, which is defined as the ratio of the output signal power to the input signal power. When these power levels are measured for each signal channel on a log scale, with units of dBm, the gain is calculated as the difference between the two signals (Figure 1).

The amplifier noise figure quantifies the signal-to-noise ratio degradation after a signal passes through the amplifier. Large noise figures are detrimental to system

performance. The noise figure of an optical amplifier is calculated from the measurements of signal and amplified spontaneous emission (ASE) levels (Figure 2).

Both the ISS and TDE methods measure gain in a similar manner. The difference between the techniques is how the ASE levels are characterized for an accurate calculation of noise figure.

### ISS Test Method for Measuring ASE—Agilent 8614xB Family

In order to correctly determine the noise figure, the ASE level must be measured at each signal wavelength. However, this cannot be measured directly because the signals mask the ASE level at the peak wavelength. Thus, the noise figure measurement made by the application is based on interpolation, either linear or quadratic. The ASE of the amplifier at each signal wavelength is determined by measuring the total spontaneous emissions (SE) at a wavelength just above and just below each signal, and then interpolating to determine the level at each signal wavelength (Figure 3).

The accuracy of the ISS measurement is dependent not only upon the performance of the OSA, but on the specifications of the other components in the system. Please contact your Agilent representative for further information regarding uncertainty calculations.

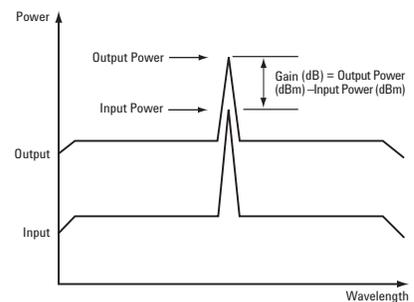


Figure 1. Spectral measurements used to determine amplifier gain

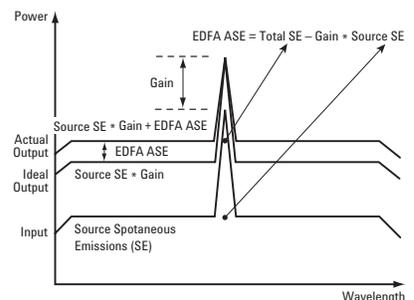


Figure 2. Spectral information required for determination of amplifier noise figure

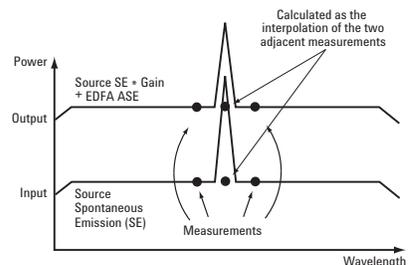


Figure 3. Use of linear or quadratic fit interpolation to determine the spontaneous emission levels

**ISS Setup**

Characterization of optical amplifiers using the ISS test method is easy to setup and implement. The setup does not require additional modulators or complex measurement timing circuitry. The configuration for measuring the laser spectrum is shown in Figure 4.

The output spectrum of the amplifier, stimulated by a single or multiple sources, is measured by connecting the source output to the input of the amplifier and the amplifier’s output to the OSA as shown in Figure 5.

All the measurements are configured from an intuitive setup menu, which guides the user through the setup.

**TDE Test Method for Measuring ASE—Agilent 86146B**

Because the Erbium has a relatively long relaxation constant (~1 ms), the ASE power level of EDFAs does not change immediately when the input signal is turned off. The TDE technique uses this characteristic to measure the ASE at any wavelength, including that of the signal. During TDE measurements, the input signal is directly modulated at a frequency of 25 kHz or higher using the TLS or DFB modular sources within the 816xB Lightwave Measurement System (LMS). Figure 6 illustrates how the ASE change during modulation is then kept small, compared to the change of ASE power when the input signal is turned off for a period greater than the full relaxation time of the erbium (Figure 7).

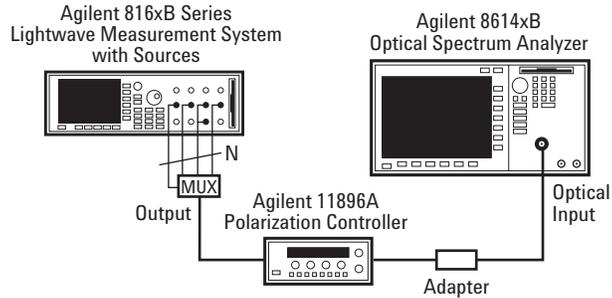


Figure 4. ISS configuration for stimulus source measurement

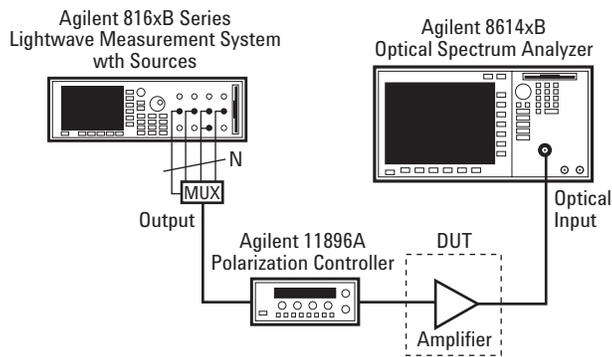


Figure 5. ISS configuration for amplifier measurement

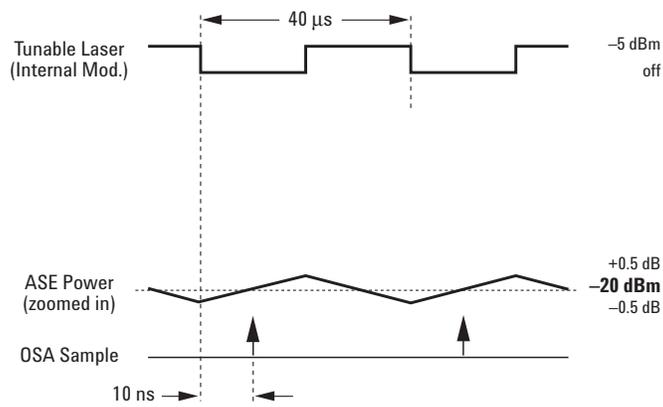


Figure 6. TDE timing diagram

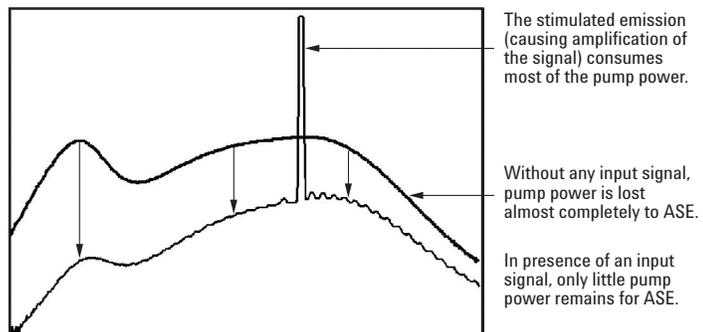


Figure 7. EDFA output spectrum with and without input signal

The 86146B is then gated externally, to produce measurements in either the on or off state. The “signal-off” spectrum allows direct determination of the ASE intensity as shown in Figure 7 lower trace, without the signal peak(s). The “signal-on” spectrum is similar to the lower trace of Figure 7.

Note that the RMS power of the modulated signal, and not the peak, is the relevant parameter for describing the operation point of the amplifier. This method is also applicable to erbium-doped waveguide amplifiers (EDWAs).

### TDE Setup

Characterization of EDFAs and EDWAs may require a more accurate approach that is available with the Time Domain Extinction setup. The ability to measure the ASE power more accurately provides an advantage of the TDE method compared to the ISS method. The configuration for measuring the laser spectrum is shown in Figure 8. This setup includes the DFB and TLS modular sources in the 816xB LMS family.

The amplifier output spectrum is measured by connecting the input of the DUT to the output of single or multiple modulated sources as shown in Figure 9. The modular sources enable modulation on the signal for the TDE measurement. A modulation trigger output from the 816xB connects to the 86146B trigger input for signal gating.

All the measurements are configured from an intuitive menu, which guides users through the setup.

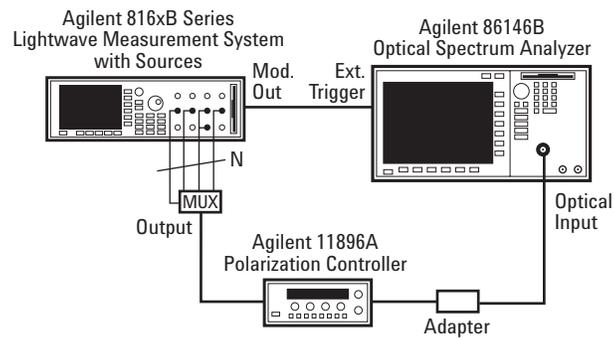


Figure 8. TDE configuration for stimulus source measurement

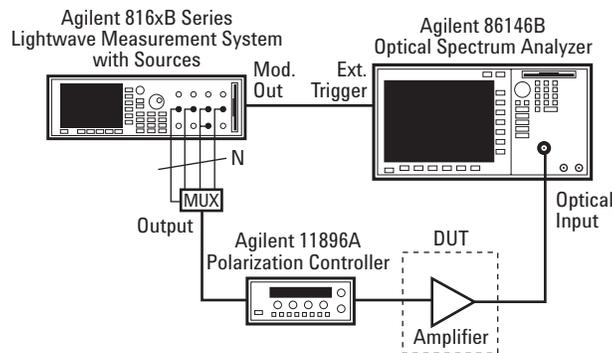


Figure 9. TDE configuration for amplifier measurement

### Measurement Flexibility

The TDE technique is used to measure amplifiers with slow relaxation states such as Erbium Doped Fiber Amplifiers (EDFAs) and Erbium Doped Waveguide Amplifiers (EDWAs).

Because the ISS technique is not reliant upon the time-dependent relaxation characteristics of Erbium Doped Fiber Amplifiers, the amplifier test application can easily characterize other types of optical amplifiers. The application automates characterization of EDFAs and EDWAs, as well as Raman amplifiers, SOAs and other rare-earth doped optical amplifiers.

Included in the application is the ability to enter a user-specified amplitude correction factor for each measurement path. This allows the user to correct for an optical attenuator or any losses in the system due to fiber optic connectors. Plus, with a correction factor specific to each path, the measurement can be further automated using fiber optic switches to switch the amplifier in and out of the measurement path.

The application can be configured to make amplifier measurements in a “continuous sweep mode” for monitoring changes in the amplifier over time. Or, configure the application in single measurement mode to provide quick verification of specified performance.

Additionally, the amplifier test application is fully controllable via GPIB, making it ideally suited for fast-paced manufacturing environments.

The Agilent OSA offers industry leading wavelength accuracy throughout C-Band and L-Band. Therefore, users can be confident of the results throughout the extended telecommunications band.

### Displaying and Documenting Results

Once the TDE or ISS application has completed the measurement, the results are easily analyzed using either the graphical display of gain and noise figure vs. wavelength or via the convenient tabular display (Figure 11).

The tabular display also provides combined power totals, facilitating easy power calibration of the system (Figure 12).

These easy-to-read results can be documented using the internal OSA printer, an external printer or by saving to a floppy disk. The amplifier test application is fully controllable via GPIB SCPI commands, results can also be downloaded to a PC for immediate analysis.

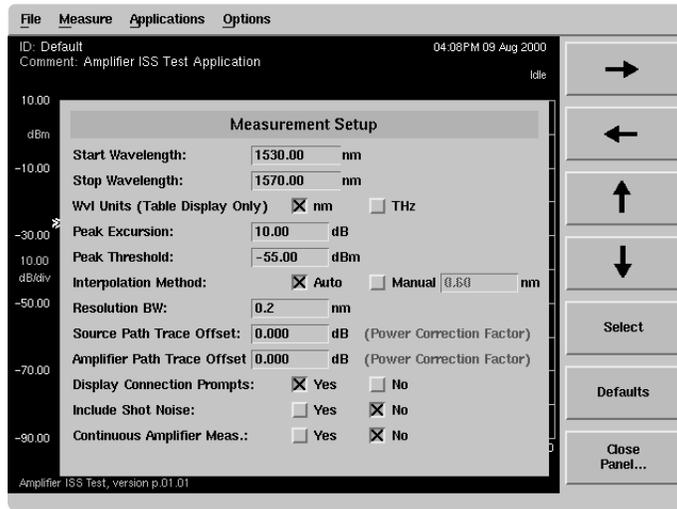


Figure 10. Amplifier test application measurement setup panel

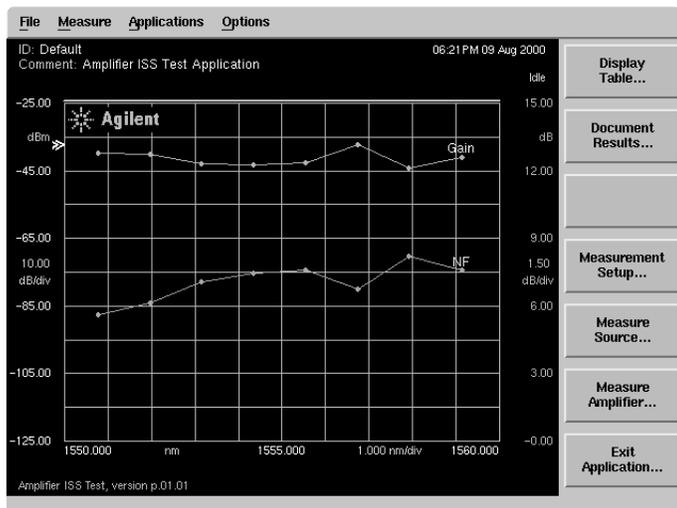


Figure 11. Graphical Display Screen Capture

Wavelength (nm)	Source Power (dBm)	Gain (dB)	Noise Figure (dB)
1554.355	-16.110	12.265	7.457
1555.551	-12.800	12.357	7.602
1556.735	-12.930	13.145	6.763
1557.925	-11.390	12.129	8.200
1559.127	-10.920	12.609	7.581
Source Mean Wvl	Sum of Src Sig Pwr		
1556.828	-5.080		
Amplifier Mean Wvl	Sum of Amp Sig Pwr		
1556.828	7.440		

Figure 12. Tabular Display Screen Capture

For performance specifications, please refer to the 8614xB Optical Spectrum Analyzer family Technical Specifications (Agilent literature # 5980-0177E).

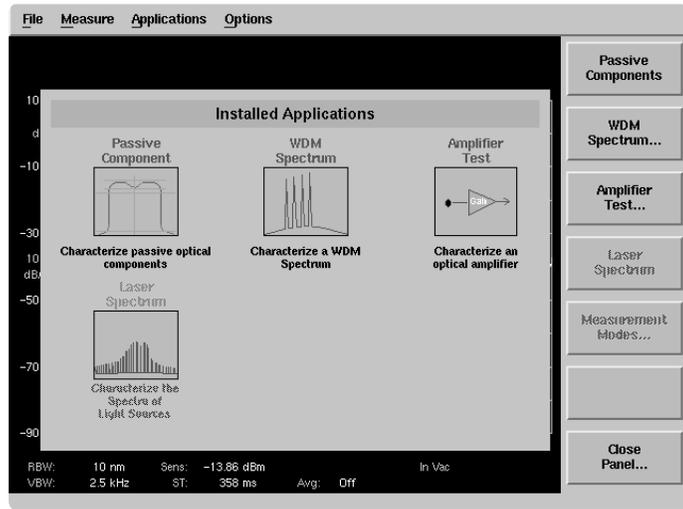


Figure 13. Application Menu Screen Capture

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Printed in USA March 15, 2002  
5988-5615EN



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