User's Guide

EDFA TDE Personality for HP 71450B/1B/2B

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1400 Fountaingrove Parkway,
Santa Rosa, CA
95403-1799, USA

Regulatory Information. The specifications and characteristics chapter of the *HP 71450B/1B/2B Optical Spectrum Analyzers Reference* contains regulatory information.

EDFA Analysis with the EDFA TDE Personality

The EDFA Time Domain Extinction (TDE) Personality characterizes the gain and noise figure of erbium-doped fiber amplifiers. The measurement technique used takes advantage of the fact that, immediately after turning off the input signal, an EDFA's amplified spontaneous emissions (ASE) has a slow recovery to the undriven state.

The TDE personality performs the following measurements on erbium-doped fiber amplifiers:

- Source wavelength.
- Gain versus wavelength.
- Noise figure versus wavelength.
- Input and output power versus wavelength.
- EDFA and input signal-to-noise ratios versus wavelength.
- EDFA noise versus wavelength.
- Integrated amplified spontaneous emission (ASE) over wavelength.

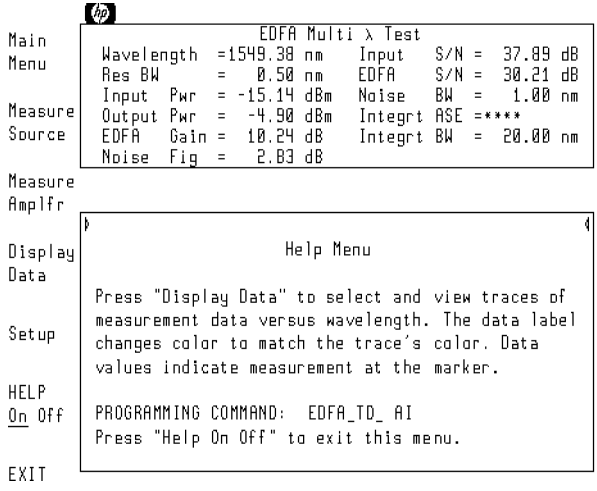
The personality is included with the HP 71452B and is available for HP 71450B/1B Option 052 optical spectrum analyzers. It can also be used on HP 71450A/1A optical spectrum analyzers that have had the HP 70953A upgrade kit installed.

The TDE personality is intended to be used with HP 8168A/B/C Tunable Lasers (Option 003 recommended). The tunable laser's modulation output triggers measurements on the optical spectrum analyzer.

If not already installed, install the program as described in Chapter 1. Once installed, you can start the program by pressing (USER) and then the `EDFA_TD` softkey.

On-line help is available

A help menu is always available by pressing the `HELP On Off` softkey. Once this menu is displayed, pressing any other softkey displays information about that softkey. The information includes an equivalent programming command if available. To remove the help menu, simply press `HELP On Off` so that `Off` is underlined.



Help menu.

Ensuring the greatest accuracy

To ensure the greatest possible accuracy, observe the following:

- Maintain a resolution bandwidth $\geq$ 0.5 nm for best amplitude accuracy.
- Perform a user calibration of the optical spectrum analyzer as described in Chapter 2.
- Optical isolator reduces reflections.

  Inserting isolators at the input and output of the erbium-doped fiber amplifier reduces the effect of external reflections on amplifier performance.
- Clean connections are required for best accuracy. When connecting fiber-optic cables, do the following steps:

  1. Clean the connectors as described in Chapter 1 of the *HP 71450B/1B/2B Optical Spectrum Analyzers User's Guide*. Dry connections are recommended.
  2. Align connectors so that the fiber end does not touch the outside of the mating connector. Do not rub the fiber end against any other surfaces.
  3. After the ferrule is properly seated inside the connector, use one hand to keep it straight and finger-tighten it with the other hand. Refer to the manufacturer's data sheet for torque recommendations. Overtightening or undertightening connectors can result in misalignment and nonrepeatable connections.
- Fusion splices reduce measurement uncertainty.

  The largest source of measurement uncertainty in EDFA measurements is repeatability of fiber-optic connections. Fusion splices reduce typical connector uncertainties of $\pm$0.25 dB to a $\pm$0.05 dB splice uncertainty.

Control program using softkeys or programming commands

The EDFA TDE personality can be controlled either via softkey menus or remote programming commands. Softkeys are the seven buttons located on each side of the screen. The functions of softkeys change according to the menus displayed on the screen. Generally, left-side softkeys access major menus. Refer to Chapter 3 for a definition of the programming commands.

Use the following three front-panel keys on the HP 70004A display to select the available softkey menus:

- Press (USER) to view EDFA TDE personality menus. The personality must first be installed as described in Chapter 1.
- Press (MENU) to view optical spectrum analyzer menus.
- Press (DISPLAY) to view HP 70004A display menus.

Key Conventions

The following key conventions are used in this guide:

(Front-panel key)	Text shown like this represents a key physically located on the spectrum analyzer.
`Softkey`	Text shown like this represents a softkey. (The softkeys are located next to the softkey labels, and the softkey labels are the annotation on the right or left side of the spectrum analyzer display.)
`Screen Text`	Text printed in this typeface indicates text displayed on the instrument's screen.

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Warranty Service

Warranty service may be obtained from the nearest Hewlett-Packard sales office or other location indicated in the owner's manual or service booklet.

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1

Installing the Personality

Installing the Personality

If you have an HP 71452B optical spectrum analyzer, the EDFA TDE personality has already been installed at the factory. Use the procedures in this chapter to install the personality into HP 71450A/0B/1A/1B instruments and to reinstall the program if it is erased from memory. Copies of the program are included in the following forms:

- Memory card.
- 3.5-inch diskette. *(HP-LIF format)*

Do you have an HP 70004A display?

YES Install the personality from the memory card. Refer to "To install from the memory card" in this chapter.

NO Install the personality directly from the an external HP-IB disk drive. Refer to "To install from a 3.5-inch dikette drive" in this chapter.

Battery Power

Once installed, the program is stored in battery-powered memory. If the internal battery loses power, the program is erased from memory. With normal use, the internal battery lasts for several years. To replace the internal battery, return the optical spectrum analyzer to a Hewlett Packard service center.

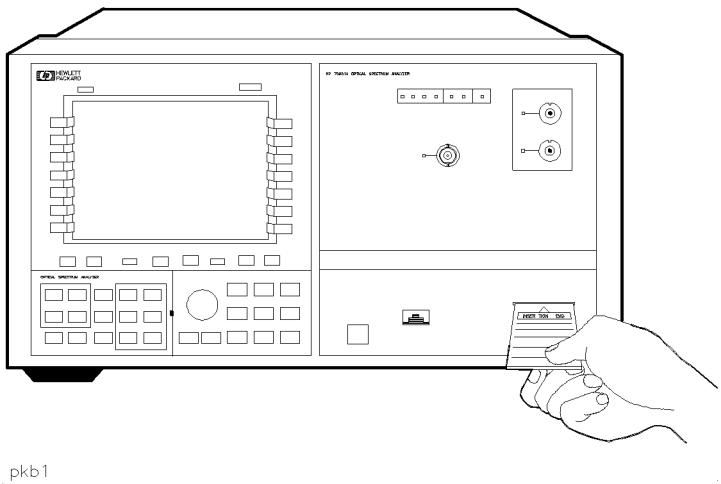
Installing on HP 71450A/1A optical spectrum analyzers

The EDFA TDE Personality can be installed in HP 71450A/1A optical spectrum analyzers if the HP 70953A upgrade kit is installed.

Chapter Contents

To Install From the Memory Card

1. Press (USER). If the softkey `EDFA_TD` appears, the personality is already installed. Continue with Chapter 2 to learn how to perform measurements.
2. Locate the memory card containing the program.
3. Locate the arrow printed on one end of the card.
4. Insert the card into the HP 70004A display's front-panel card slot. Match the card's arrow with the arrow printed above the card slot.



pkb1

5. Press (DISPLAY) and then the left-side `Mass Storage` softkey.
6. Press `msi` and then `MEMORY CARD`.
7. Press (MENU) and then the left-side `Misc` softkey.
8. Press `MORE 1 of 3` and then `catalog & MSI`.

9. Press `HP-MSIB CARD` to display all files contained on the memory card.

   If `2053 Storage device error` is displayed, either the card is missing or the card's HP-MSIB address is listed incorrectly. The HP-MSIB address for the card is the same address as the display's HP-IB address and is normally set to 4. If the address is not correct, enter the correct address using the numeric keypad.

10. Press the `LOAD FILE` softkey.

11. Use the numeric keypad to enter the `EDFA_TD` file number. (Normally, this means pressing (1) and then `ENTER`.)

    The front-panel LED next to the card slot lights indicating that the file is being copied into the (USER) menu.

12. If the error message `2011 Memory overflow` is displayed, there is not enough free memory in the optical spectrum analyzer to load the program. Refer to "If a memory error is displayed" in this chapter.

To Install From a 3.5-inch Diskette Drive

When copying programs directly from an external diskette drive, the drive must be a 3.5 inch, CS80-compatible drive, such as an HP 9122. The diskette containing the EDFA_TD advanced-measurement program uses the LIF format.

1. Press (USER). If the softkey `EDFA_TD` appears, the EDFA TDE personality is already installed. Continue with Chapter 2 to learn how to perform measurements.
2. Connect a 3.5-inch diskette drive to the MMS mainframe that contains the optical spectrum analyzer module. Use an HP-IB cable.
3. Insert the diskette containing the program into the diskette drive.
4. Press (DISPLAY) and then the left-side `Mass Storage` softkey.
5. Press `msi` and then `HPIB DISK`. Ignore any message such as `Unable to read device.`
6. Press (MENU) and then the left-side `Misc` softkey.
7. Press `MORE 1 of 3` and then `catalog & MSI`.
8. Press `HPIB DISK`, and use the numeric keypad to enter the diskette drive's address.

   New addresses are entered in the following form: *A.UV*

   where:

   A is a digit from 0 to 7, representing the drive's HP-IB address.

   U is a digit from 0 to 9, representing the unit number. The unit number is typically 0 or 1 and refers to an individual disk drive slot. The default value is 0.

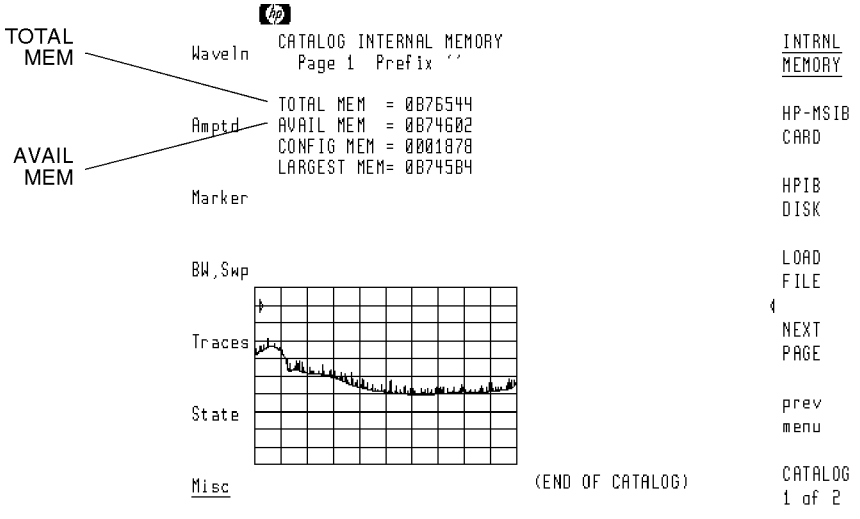
   V is a digit from 0 to 9, representing the volume number. Volume numbers are used for hard disk drives. So, for reading diskettes, the volume number should be 0. The default value is 0.

For example, entering *3.00* indicates an address of 3, a unit number of 0 and a volume number of 0. This accesses a diskette in the left drive of an external diskette drive at HP-IB address 3.

9. Press the `ENTER` softkey.
10. Press the `LOAD FILE` softkey.
11. Use the numeric keypad to enter the `EDFA_TD` file number. (Normally, this means pressing 1 and then `ENTER` .)
12. If the error message `2011 Memory overflow` is displayed, there is not enough free memory in the optical spectrum analyzer to load the program. Refer to "If a memory error is displayed" in this chapter.

If a Memory Error is Displayed

1. Press (MENU) and then the left-side `Misc` softkey.
2. Press `MORE 1 of 3` and then `catalog & MSI`.
3. Press `INTRNL MEMORY`. The following figure shows a typical display. Notice the **TOTAL MEM** and **AVAIL MEM** listings. You must increase **AVAIL MEM** (available memory) by deleting existing files to free additional memory. Or, if you have an HP 71450A/1A optical spectrum analyer, you may need to install additional memory; if **TOTAL MEM** is approximately 131000 bytes of memory, a 1 MB memory assembly can be installed by qualified service personnel. Order the HP 70953A upgrade kit.



smallmem

Optical spectrum analyzer memory configuration.

2

Performing Measurements

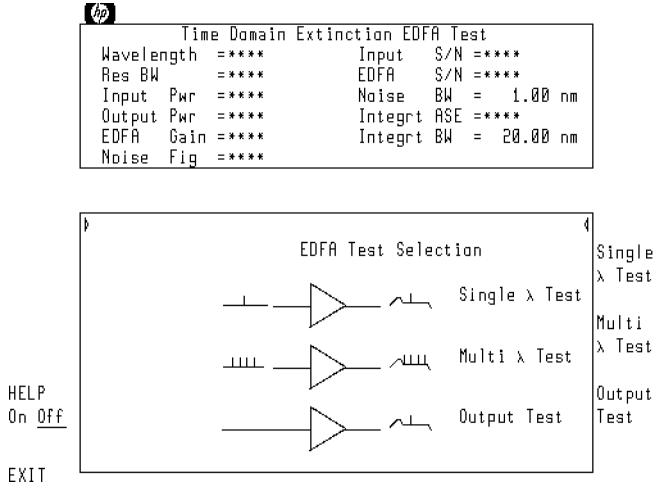
Performing Measurements

In this chapter, you'll learn how to characterize erbium-doped fiber amplifiers. The EDFA TDE personality provides three separate testing modes:

Single λ Test — measures EDFA noise figure and gain at a single wavelength.

Multi λ Test — measures EDFA noise figure and gain over a wavelength range using a tunable laser source.

Output Test — measures output signal, output noise, and output signal-to-noise ratio at the output of an EDFA or in a system. Use Output Test in situations when total system performance is required.



Select the tests from the Main menu.

To get the most from your measurements, be sure to read "Configuring the Program" in this chapter; it describes customizing the measurements via the Setup menu.

To ensure accurate measurements . . .

During calibrations and measurements, lightwave instrumentation and test setups are sensitive to vibration and movement. To ensure accurate measurements avoid bumping, moving, or otherwise jarring the instrument, test equipment, and supporting structure.

Chapter Contents

Calibrating the Optical Spectrum Analyzer

Performing a user calibration on the optical spectrum analyzer ensures maximum wavelength and amplitude accuracy for your EDFA measurements. User calibrations require a stable (amplitude and wavelength) single-frequency laser within the 600 to 1700 nm range. You can access the Calibration menu from the optical spectrum analyzer's `Amptd` menu. (Press (MENU) and then `Amptd`.)

The optical spectrum analyzer's maximum calibration adjustment is about 2 nm in wavelength. If a larger adjustment is attempted, error 2023, `Illegal Cal signal` is displayed.

Guard against changes due to polarization

Because the optical spectrum analyzer is slightly polarization sensitive, this calibration should be performed by persons knowledgeable on the effects of polarization on optical power measurements. During the calibration, the light source's output power is first measured with a power meter. Then, the fiber-optic cable is disconnected from the power meter and connected to the optical spectrum analyzer. Because moving fiber-optic cables changes polarization, the measured value of the output power may vary.

Use a wavelength within the amplifier's range

For optimum results, perform the calibration at a wavelength that is within the range of the amplifier you are testing.

During a calibration, the optical spectrum analyzer defaults expect a signal within the following limits:

Power	−5 dBm ±5 dB
Wavelength	1300 ±2 nm

You must enter the wavelength and amplitude of your calibration source if it is different from these values.

To calibrate the optical spectrum analyzer

Ensuring amplitude accuracy

During this procedure, avoid moving the fiber-optic cables whenever possible. Moving fiber-optic cables changes the polarization of the light which affects power measurements.

The following procedure requires a power meter and a polarization controller. The HP 11896A is the suggested polarization controller. For HP 71450A/1A optical spectrum analyzers perform the steps listed in "To calibrate an HP 71450A/1A" in this chapter.

Measure the source wavelength

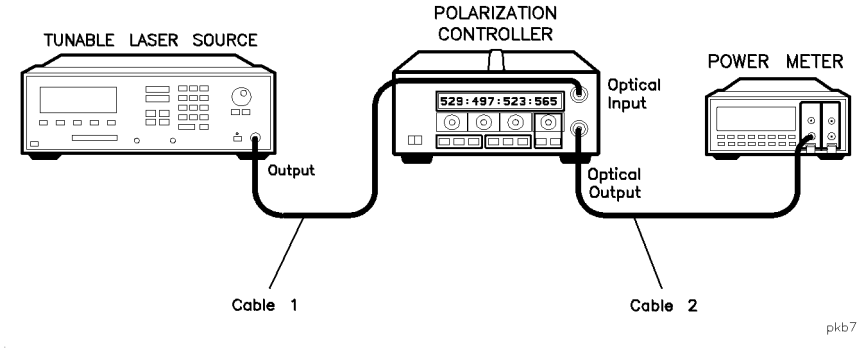
1. Measure the wavelength of a precision single-mode laser using a wavelength meter. Enter the wavelength in the space provided below.

   The laser must have a wavelength between 600 to 1700 nm. Because the optical spectrum analyzer's monochromator is air filled, measure the wavelength as in air.

   wavelength:_____nm

Measure the average power

2. Connect the laser, polarization controller, and power meter as shown in the following figure.



For accurate measurements

Do not disconnect cable 1 or cable 2 from the laser or polarization controller during the calibration procedure. Maintaining this connection ensures the greatest measurement accuracy.

3. Adjust the polarization controller to achieve the maximum power reading on the power meter. Record the power level on the following line:

   maximum power:_____dBm

4. Adjust the polarization controller to achieve a minimum power reading on the power meter. Record the power level on the following line:

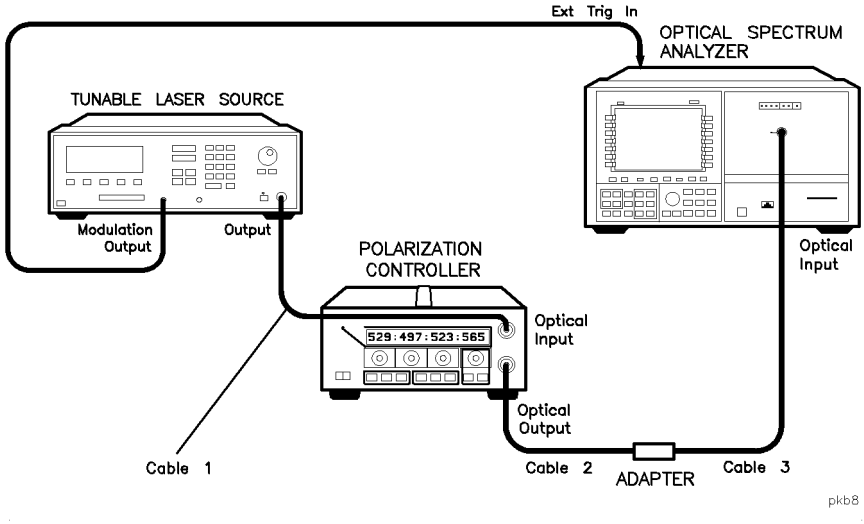
   minimum power:_____dBm

5. Calculate the average of the two power readings recorded in steps 3 and 4 using the following equation. Record the result below:

$$average\ power = \frac{minimum\ power + maximum\ power}{2}$$

   average power:_____dBm

6. In the test setup, replace the power meter with the optical spectrum analyzer as shown in the following figure. Be sure to use two cables and an adapter to connect the optical spectrum analyzer to the polarization controller.
7. Turn the laser on.



For accurate measurements

Do not disconnect cable 3 from the optical spectrum analyzer during or after the calibration procedure. Maintaining this connection ensures the greatest measurement accuracy, since your optical spectrum analyzer will be calibrated at the free end of cable 3. For fusion splice measurements, the adapter is replaced with a fiber splice.

Determine correction factor for source spontaneous emission

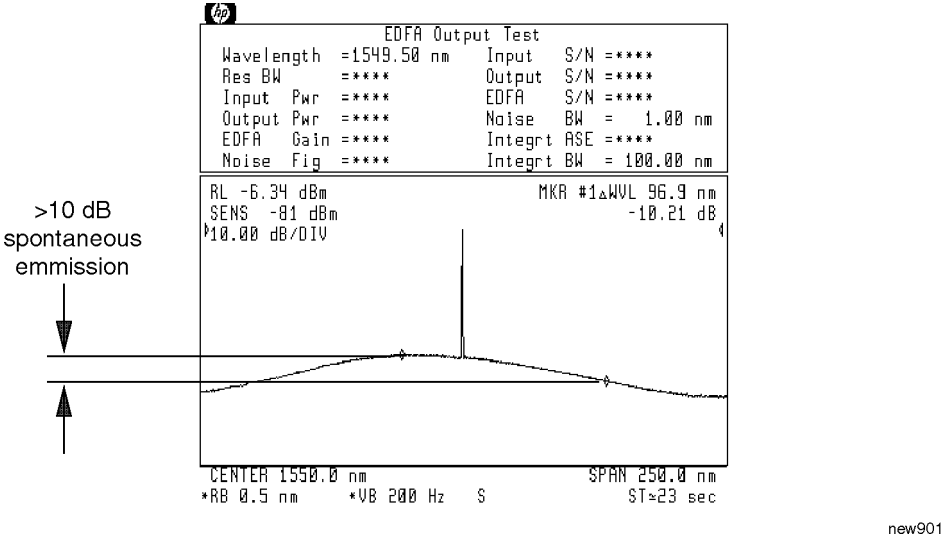
8. Press (INSTR PRESET).
9. Press (AUTO MEAS) to display the laser's response.
10. Press (AUTO ALIGN) to align the optical spectrum analyzer.
11. If the instrument you are calibrating has the Option 051 personality, perform the following steps:

    a. Press (USER) and then `EDFA` to start the EDFA test personality.

    b. Press `Output Test`.

    c. Locate the peak of the spontaneous emission. Adjust the wavelength span so that, on either side of this peak, 10 dB of spontaneous emmision is visible.

       Use the (SPAN) key along with the front-panel knob to change the span.



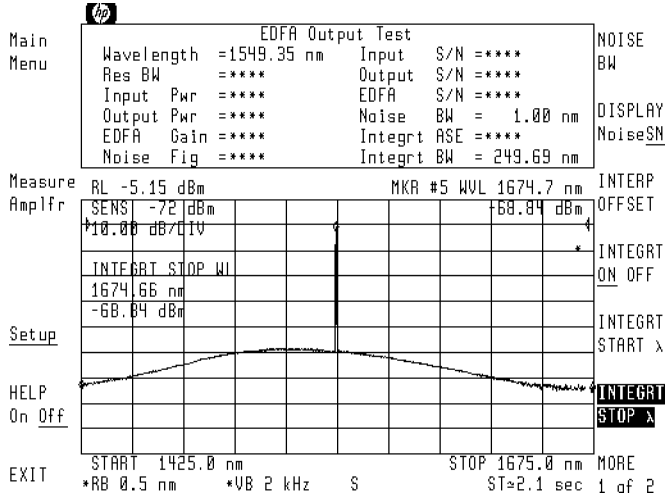
new901

Span adjusted for proper spontaneous emmission levels.

    d. Press `Setup` and then `INTEGRT START λ`.

e. Use the front-panel knob to move the left-integration marker to the left edge of the display.

f. Press `INTEGRT STOP λ`, and use the front-panel knob to move the right-integration marker to the right edge of the display.



g. Press the left-side `Measure Amplr` softkey.

h. When the measurement is complete, record the displayed `Output Pwr` and `Integrt ASE` measurements on the following lines:

`Output Pwr`:_____dBm
`Integrt ASE`:_____dBm

i. Subtract the `Integrt ASE` from the `Output Pwr` to determine the ratio of the two power levels. Record the result on the following line:

$$\Delta\ power\ (dB) = Output\ Pwr\ (dBm) - Integrt\ ASE\ (dBm)$$

Δ power:_____dB

12. If the instrument you are calibrating does not contain the Option 051 personality, perform the following steps:

a. Record the value of the signal peak on the following line:

`Output Pwr`:_____dBm

b. Press (NORMAL On/Off), and use the front-panel knob to place the marker on the maximum level of the spontaneous emission spectrum.

c. Press `Marker`, `MORE 1 of 4`, and then `MKNOISE On Off` so that `On` is underlined.

d. Record the marker value on the following line:

MKR_{noise}:_____dBm/nm

e. Press `MKNOISE On Off` so that `Off` is underlined.

f. Press `MORE 2 of 4`, `mkr bw/ zoom bw`, and then `MKR BW On Off` so that `On` is underlined. Make sure that the marker bandwidth is set to −3 dB.

g. Record the displayed `Marker Bandwidth` value:

MKR_{BW}:_____nm

h. Calculate the ASE using the values recorded above, and record the ASE on the line below:

$$ASE\ (dBm) = MKR_{noise} + 10\ log(MKR_{BW})$$

`Integrt ASE`:_____dBm

i. Subtract the `Integrt ASE` *(step 12h)* from the `Output Pwr` *(step 12a)* to determine the ratio of the two power levels. Record the result on the following line:

$$\Delta\ power\ (dB) = Output\ Pwr\ (dBm) - Integrt\ ASE\ (dBm)$$

Δ power:_____dB

j. Press `MKR BW On Off` so that `Off` is underlined.

13. Use the following equation to calculate the correction factor for the broadband power meter to the narrow band optical spectrum analyzer measurement:

$$factor = 10\ log\left(1 - \frac{1}{10^{\frac{x}{10}} + 1}\right)$$

where **x** is the Δ power recorded in step 11i or 12i.

source spontaneous emission correction factor:_____dB

Total the correction factors

14. Power meters generally are calibrated with an open beam of light. By simply using a fiber adapter, they will measure the optical power in the beam emerging from the fiber end. This is lower than the power in the fiber by 3.6%. If you wish to have power measurements relative to open-beam power emerging from the fiber, enter a correction factor of +0.16 dB. If you wish to have power measurements relative to power in the fiber, enter 0 dB.

    correction factor:_____dB

15. Add the values from steps 13 and 14. Be sure to keep track of the sign of each number.

    total correction factor:_____dB

Calculate corrected power level

16. Add the value recorded in step 15 to the average power recorded in step 5. Record the result on the following line.

    corrected power level:_____dBm

Measure the average power on OSA

17. Press (PEAK SEARCH) and then (TO CENTER).
18. Press (SPAN), and enter a wavelength span of 1 nm.
19. Press (PEAK SEARCH) and then (TO CENTER).
20. Press (SPAN), and enter a wavelength span of 0 nm.
21. Press (MENU).
22. Press the left-side `Amptd` softkey.
23. Press `LOG dB/DIV`, (1), and `dB` to select a 1 dB logarithmic amplitude scale.
24. Press the left-side `BW,Swp` softkey.
25. Press `SWPTIME AutoMan`, (1), (0), and then `s`.
26. Adjust the polarization controller to "peak" the trace displayed on the optical spectrum analyzer.

    This sets the polarization for a maximum power reading.

27. Press (PEAK SEARCH), and record the power level indicated by the marker:

    maximum power:_____dBm

28. Press (Δ).

29. Adjust the polarization controller to "dip" the trace displayed on the optical spectrum analyzer to a minimum power value.

30. Record the absolute value of the Δ marker's power ratio on the following line:

    Δ power: _____ dBm

31. Use the values recorded in steps 27 and 30 to calculate the average displayed power as shown in the following equation. Record the result below:

$$average\ power = maximum\ power - \frac{\Delta\ power}{2}$$

    average power: _____

32. Press the left-side `Amptd` softkey.

33. Press `MORE 1 of 4`, `MORE 2 of 4`, and then `A METER On Off` so that `On` is underlined.

34. Adjust the polarization controller to achieve a displayed Amplitude Meter power level equal to the power level recorded in step 31.

Ensuring amplitude accuracy

It is very important not to move the fiber-optic cables during the remaining steps of this procedure.

Enter the calibration power and wavelength

35. Press the left-side `Waveln` softkey. Then, press `MORE 1 of 2`, `cal menu`, `cal setup`, and then `POWER FOR CAL`.
36. Use the numeric keypad to enter the corrected power level calculated in step 16.
37. Press `WAVELEN FOR CAL`. Enter the wavelength recorded in step 1. Then, press `prev menu` and then `CAL ALL`.

To calibrate an HP 71450A/1A

Ensuring amplitude accuracy

During this procedure, avoid moving the fiber-optic cables whenever possible. Moving fiber-optic cables changes the polarization of the light which affects power measurements.

The following procedure requires a power meter and a polarization controller. The HP 11896A is the suggested polarization controller.

The optical spectrum analyzer's ROM version is used to select which calibration procedure should be performed on the instrument.

Determine the ROM version

1. Press the left-side `Misc` softkey to enter the Miscellaneous menu.
2. Press the `MORE 1 of 3` and then `service` softkeys.
3. Press the `ROM VERSION` softkey. The version of the ROM is displayed in the upper right corner of the display.
   - If the ROM version is `B.05.00` or above, do not perform this procedure. Instead, perform the steps in "To calibrate the optical spectrum analyzer" in this chapter.
   - If the ROM version is `B.04.04` or below, continue with this procedure.

Measure the source wavelength

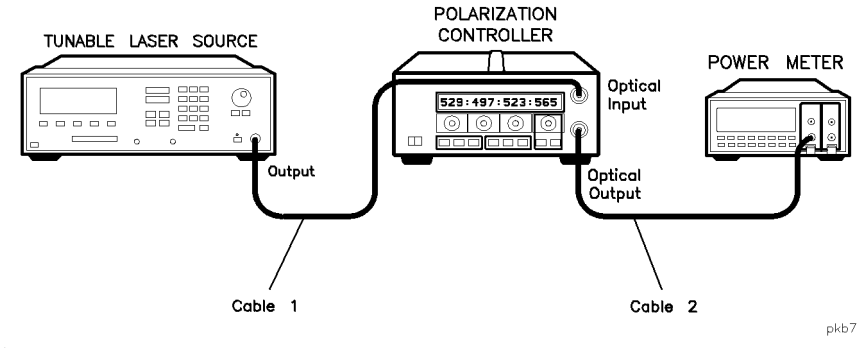
4. Measure the wavelength of a precision single-mode laser using a wavelength meter. Enter the wavelength in the space provided below.

   The laser must have a wavelength between 600 to 1700 nm. Because the optical spectrum analyzer's monochromator is air filled, measure the wavelength as in air.

   wavelength:_____nm

Measure the average power

5. Connect the laser, polarization controller, and power meter as shown in the following figure.



For accurate measurements

Do not disconnect cable 1 or cable 2 from the laser or polarization controller during the calibration procedure. Maintaining this connection ensures the greatest measurement accuracy.

6. Adjust the polarization controller to achieve the maximum power reading on the power meter. Record the power level on the following line:

maximum power:_____dBm

7. Adjust the polarization controller to achieve a minimum power reading on the power meter. Record the power level on the following line:

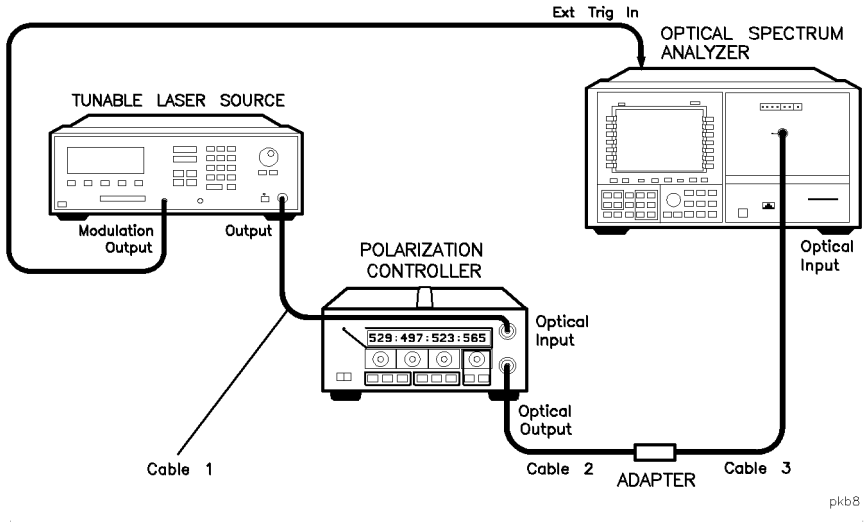
minimum power:_____dBm

8. Calculate the average of the two power readings recorded in steps 6 and 7 using the following equation. Record the result below:

$$average\ power = \frac{minimum\ power + maximum\ power}{2}$$

average power:_____dBm

9. In the test setup, replace the power meter with the optical spectrum analyzer as shown in the following figure. Be sure to use two cables and an adapter to connect the optical spectrum analyzer to the polarization controller.
10. Turn the laser on.



For accurate measurements

Do not disconnect cable 3 from the optical spectrum analyzer during or after the calibration procedure. Maintaining this connection ensures the greatest measurement accuracy, since your optical spectrum analyzer will be calibrated at the free end of cable 3. For fusion splice measurements, the adapter is replaced with a fiber splice.

Determine correction factor for 0.2 nm RBW

11. Press (AUTO MEAS) to display the laser's response.
12. Press (AUTO ALIGN) to align the optical spectrum analyzer.
13. Press (RES BW), and enter a 0.2 nm bandwidth.
14. Record the source amplitude on the following line:

    power (0.2 nm RBW):_____dBm
15. Press (RES BW), and enter a 0.5 nm bandwidth.
16. Record the source amplitude on the following line:

    power (0.5 nm RBW):_____dBm
17. Subtract the reading in step 16 from the reading in step 14 and record the result on the following line:

$$correction\ factor = POWER_{step\ 14} - POWER_{step\ 16}$$

0.2 nm RBW correction factor:_____dB

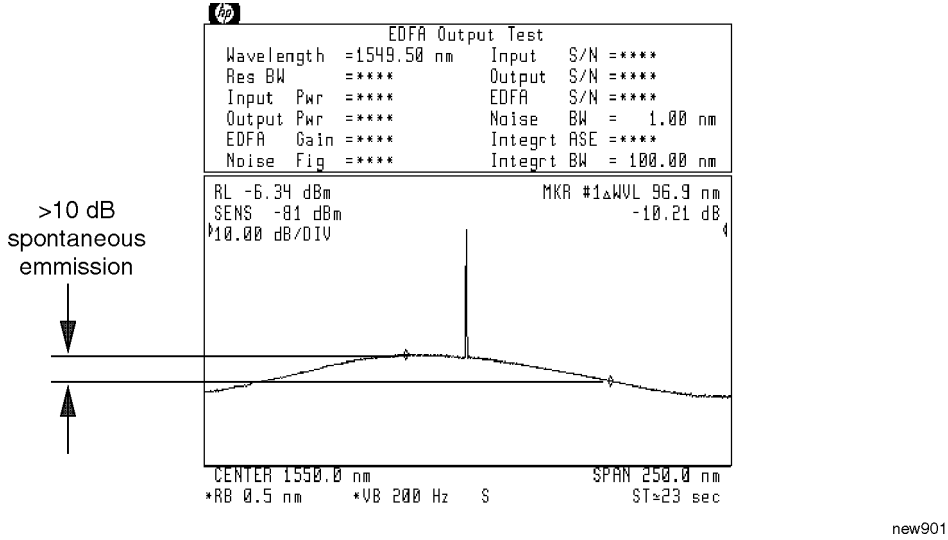
NOTE

This number should be between 0 dB and —0.2 dB.

Determine correction factor for source spontaneous emission

18. Press (INSTR PRESET).
19. If the instrument you are calibrating has the Option 051 personality, perform the following steps:
    a. Press (USER) and then `EDFA` to start the EDFA test personality.
    b. Press `Output Test`.
    c. Locate the peak of the spontaneous emission. Adjust the wavelength span so that, on either side of this peak, 10 dB of spontaneous emmision is visible.

Use the SPAN key along with the front-panel knob to change the span.

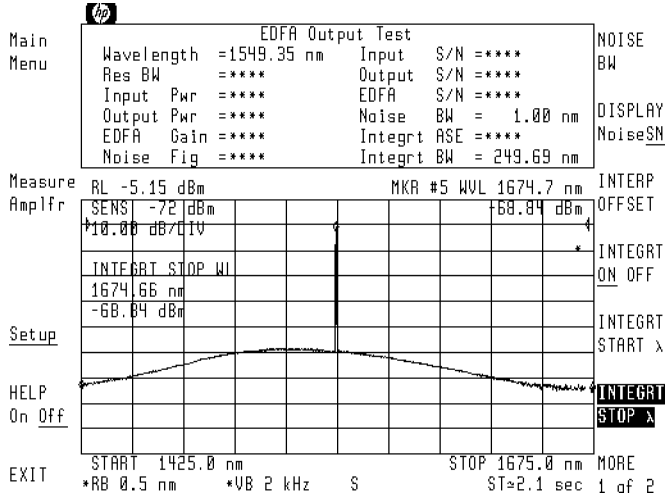


Span adjusted for proper spontaneous emmission levels.

d. Press `Setup`, and then `INTEGRT START λ`.

e. Use the front-panel knob to move the left-integration marker to the left edge of the display.

f. Press `INTEGRT STOP λ`, and use the front-panel knob to move the right-integration marker to the right edge of the display.



g. Press **Measure Amplr**.

h. When the measurement is completed, record the displayed **Output Pwr** and **Integrt ASE** measurements on the following lines:

Output Pwr:_____dBm
Integrt ASE:_____dBm

i. Subtract the **Integrt ASE** from the **Output Pwr** to determine the ratio of the two power levels. Record the result on the following line:

$$\Delta\ power\ (dB) = Output\ Pwr\ (dBm) - Integrt\ ASE\ (dBm)$$

Δ power:_____dB

20. If the instrument you are calibrating does not contain the Option 051 personality, perform the following steps:

a. Record the value of the signal peak on the following line:

Output Pwr:_____dBm

b. Press (NORMAL On/Off), and use the front-panel knob to place the marker on the maximum level of the spontaneous emission spectrum.

c. Press `Marker`, `MORE 1 of 4`, and then `MKNOISE On Off` so that `On` is underlined.

d. Record the marker value on the following line:

MKR_{noise}:_____dBm/nm

e. Press `MKNOISE On Off` so that `Off` is underlined.

f. Press `MORE 2 of 4`, `mkr bw/ zoom bw`, and then `MKR BW On Off` so that `On` is underlined. Make sure that the marker bandwidth is set to −3 dB.

g. Record the displayed `Marker Bandwidth` value:

MKR_{BW}:_____nm

h. Calculate the ASE using the values recorded above, and record the ASE on the line below:

$$ASE\ (dBm) = MKR_{noise} + 10\ log(MKR_{BW})$$

`Integrt ASE`:_____dBm

i. Subtract the `Integrt ASE` *(step 12i)* from the `Output Pwr` *(step 12a)* to determine the ratio of the two power levels. Record the result on the following line:

$$\Delta\ power\ (dB) = Output\ Pwr\ (dBm) - Integrt\ ASE\ (dBm)$$

Δ power:_____dB

j. Press `MKR BW On Off` so that `Off` is underlined.

21. Use the following equation to calculate the correction factor for the broadband power meter to the narrow band optical spectrum analyzer measurement:

$$factor = 10\ log\left(1 - \frac{1}{10^{\frac{x}{10}} + 1}\right)$$

where `x` is the Δ power recorded in step 19i or 20i.

source spontaneous emission correction factor:_____dB

Total the correction factors

22. Power meters generally are calibrated with an open beam of light. By simply using a fiber adapter, they will measure the optical power in the beam emerging from the fiber end. This is lower than the power in the fiber by 3.6%. If you wish to have power measurements relative to open-beam power emerging from the fiber, enter a correction factor of +0.16 dB. If you wish to have power measurements relative to power in the fiber, enter 0 dB.

    correction factor:_____dB

23. Add the values from steps 17, 21, and 22. Be sure to keep track of the sign of each number.

    total correction factor:_____dB

Calculate corrected power level

24. Add the value recorded in step 23 to the average power recorded in step 8. Record the result on the following line.

    corrected power level:_____dBm

Measure the average power on OSA

25. Press (PEAK SEARCH) and then (TO CENTER).
26. Press (SPAN), and enter a wavelength span of 1 nm.
27. Press (PEAK SEARCH) and then (TO CENTER).
28. Press (SPAN), and enter a wavelength span of 0 nm.
29. Press (MENU).
30. Press the left-side `Amptd` softkey.
31. Press `LOG dB/DIV`, (1), and `dB` to select a 1 dB logarithmic amplitude scale.
32. Press the left-side `BW,Swp` softkey.
33. Press `SWPTIME AutoMan`, (1), (0), and then `s`.
34. Adjust the polarization controller to "peak" the trace displayed on the optical spectrum analyzer.

    This sets the polarization for a maximum power reading.

35. Press (PEAK SEARCH), and record the power level indicated by the marker:

maximum power:_____dBm

36. Press (Δ).
37. Adjust the polarization controller to "dip" the trace displayed on the optical spectrum analyzer to a minimum power value.
38. Record the absolute value of the Δ marker's power ratio on the following line:

    Δ power: _____ dBm

39. Use the values recorded in steps 35 and 38 to calculate the average displayed power as shown in the following equation. Record the result below:

$$average\ power = maximum\ power - \frac{\Delta\ power}{2}$$

    average power: _____

40. Press the left-side `Amptd` softkey.
41. Press `MORE 1 of 4`, `MORE 2 of 4`, and then `A METER On Off` so that `On` is underlined.
42. Adjust the polarization controller to achieve a displayed Amplitude Meter power level equal to the power level recorded in step 39.

Ensuring amplitude accuracy

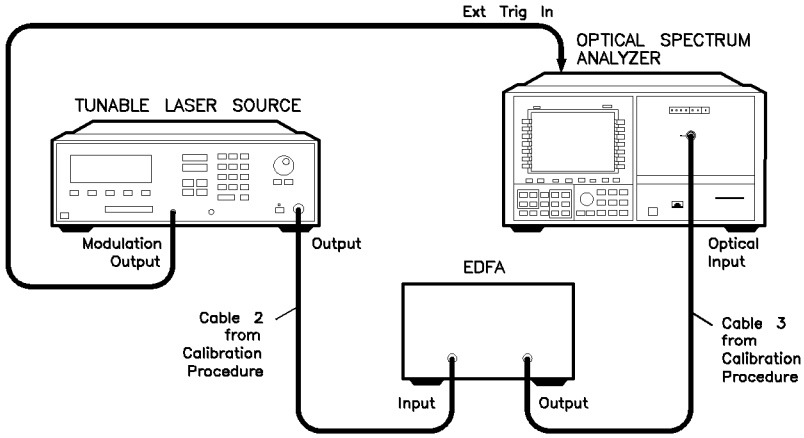
It is very important not to move the fiber-optic cables during the remaining steps of this procedure.

Enter the calibration power and wavelength

43. Press the left-side `Waveln` softkey. Then, press `MORE 1 of 2`, `cal menu`, `cal setup`, and then `POWER FOR CAL`.
44. Use the numeric keypad to enter the corrected power level calculated in step 24.
45. Press `WAVELEN FOR CAL`. Enter the wavelength recorded in step 4. Then, press `prev menu` and then `CAL ALL`.

Each testing mode displays messages that guide you through the correct measurement sequence. Generally, the source's output is measured, and then the amplifier's output is measured. (The exception is the Output Test which does not measure the source.) You can disable these prompts at any time by pressing `PROMPT On Off` so that `Off` is underlined. If a prompt message obscures the view of the trace, remove the prompt by pressing (HOLD).

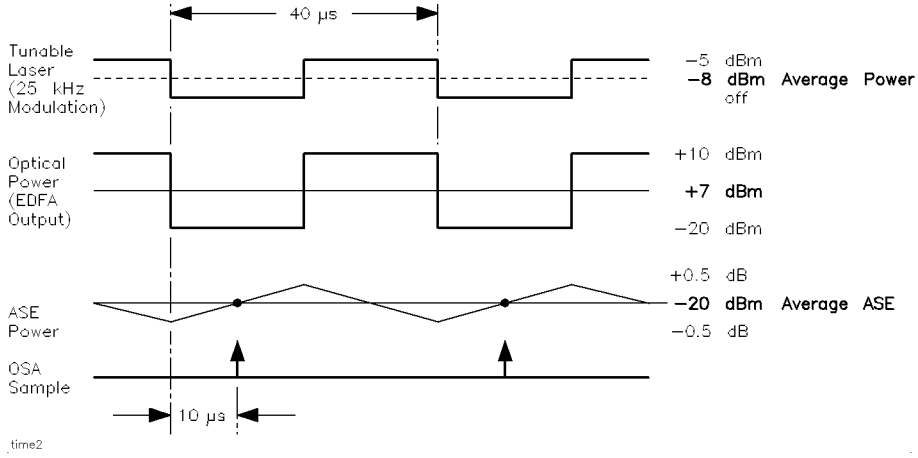
Using the EDFA TDE personality requires the following test setup.



Set the laser for the desired average power level

The EDFA TDE personality measures the average ASE power level resulting from a modulated laser's average power. Before you begin testing an EDFA, determine the average power level of the laser input desired for your application. Next, set the test laser's unmodulated power level 3 dB higher than this level. For example, if the modulated laser's power into the amplifier is −10 dBm, set your test laser's output power to −7 dBm. When modulated at the 50% duty cycle, the test laser's power will be equal to the level used in your application.

The following figure shows the timing required to measure the average ASE value from an input laser saturating the EDFA. The laser is modulated at a 25 kHz rate and 50% duty cycle. In this example, the laser's average power is −8 dBm (−8 dBm = −5 dBm −3 dB). The optical spectrum analyzer samples the data 10 μs after the laser is turned off. This point is half way through the laser's off cycle and in the region where the ASE varies linearly. As you can see in the figure, the ASE power level increases when the laser is turned off and decreases when the laser turns on. Measuring the ASE at 10 μs provides the average ASE level for the given average input power of the modulated laser.



Measurement timing diagram.

To perform a single wavelength test

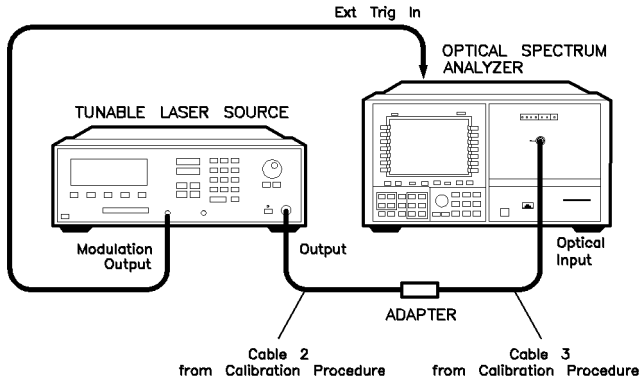
The following measurements are made in this test:

- Wavelength
- EDFA gain
- Noise figure
- Input power
- Output power
- Input S/N
- EDFA S/N
- Integrated ASE

Procedure

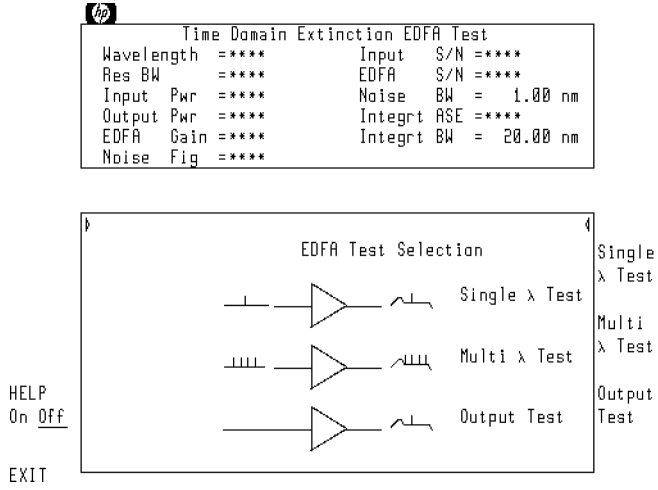
1. Connect the output of the laser to the optical spectrum analyzer as shown in the following figure. The adapter allows you to use the same cables that were used in the calibration procedure. These same cables will be used when the EDFA is inserted. Do not disconnect these cables from the laser or optical spectrum analyzer during the test.

   On HP 71450B/2B optical spectrum analyzers, the input connector is labeled `OPTICAL INPUT`. On HP 71451B optical spectrum analyzers, the input connector is labeled `MONOCHROMATOR INPUT`. External triggering requires a TTL-compatible signal with a minimum of 0V and a maximum of +5V. For more information on triggering the HP 70950B/1B/2B modules, refer to "Triggering Sweeps" in Chapter 2 of the *HP 71450B/1B/2B Optical Spectrum Analyzers User's Guide*.



2. Turn on the laser.
3. Do the following steps to configure the HP 8168A/B/C laser:
   a. Press the front-panel (WAVELENGTH) key, and enter the desired wavelength.
   b. Press the (OUTPUT POWER) key, and enter the source power.
   c. Press `Mod/CW` to turn the modulation on.
   d. Toggle the `Freq/Power` softkey so that the softkey label reads `Power` (frequency is selected).
   e. Enter a modulation value of 25 kHz.
4. On the optical spectrum analyzer, press (AUTO MEAS).
5. Press (USER) and then `EDFA_TD` to start the EDFA TDE personality.

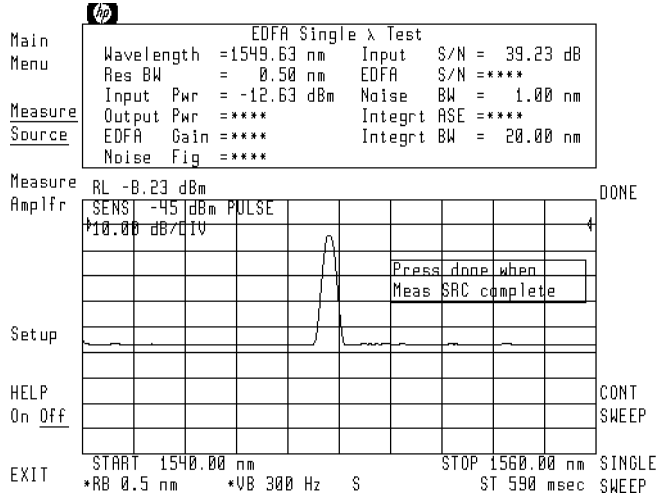
6. Press `Single λ Test`.



7. Perform the following steps if you need to change the tuning range of the optical spectrum analyzer:
   a. Enter the (START) wavelength.
   b. Enter the (STOP) wavelength.
   c. Press (HOLD).
8. Press `Measure Source`.

   The EDFA TDE personality measures the signal and noise levels at the end of the sweep.

9. Allow at least one complete measurement cycle. Then, press DONE.



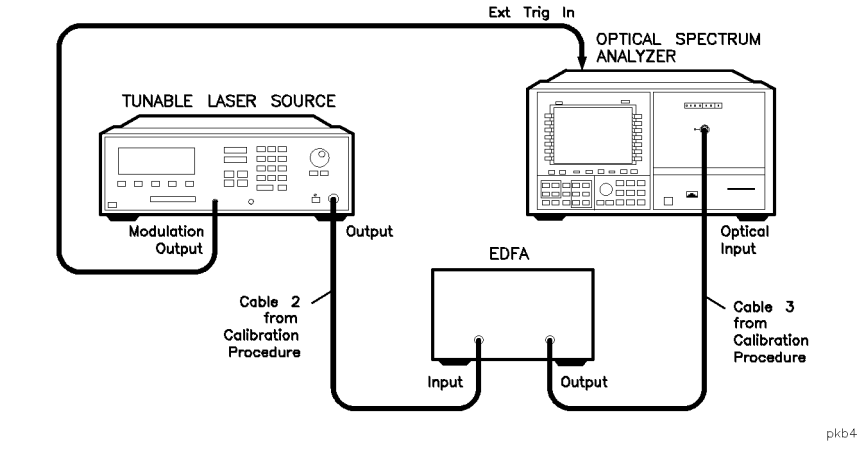
Measurement of the laser source.

Using the "SINGLE SWEEP" and "CONT SWEEP" softkeys

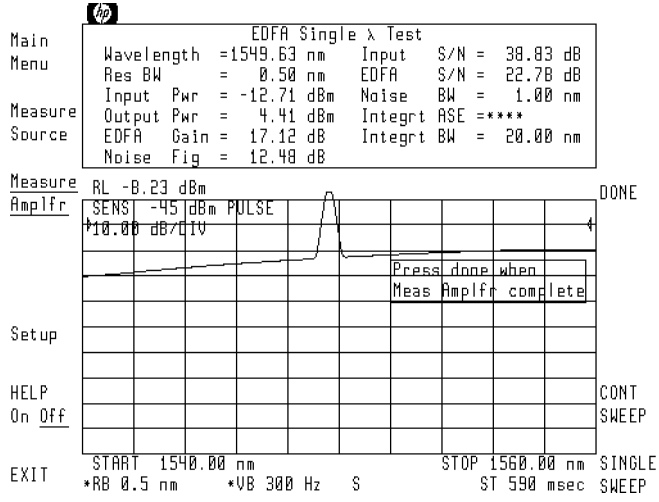
Until you press the DONE softkey, the test continuously measures the input signal. The SINGLE SWEEP and CONT SWEEP softkeys allow you to manually step through a measurement. For each measurement, SINGLE SWEEP must be pressed three times. The first press measures the wavelength using a smoothed peak in a wide wavelength span (indicated by a blue line). The second press measures the amplitude of the smoothed peak in a narrow wavelength span. The third press measures the noise at wavelength of the signal in a wide wavelength span (indicated by a red line).

The CONT SWEEP softkey gives you the ability to return to automated testing.

10. Remove the adapter, and connect the EDFA as shown in the following figure.



11. Press `Measure Amplfr`. After the first complete sweep occurs, the display lists all the measurement results at the top of the screen.



12. When you are finished with measuring the amplifier, press **DONE**.

To perform a multi wavelength test

The following procedure is meant to be used with an HP 8168A/B/C tunable laser source. Other sources can be used as explained in the procedure. In this example, the following settings are used:

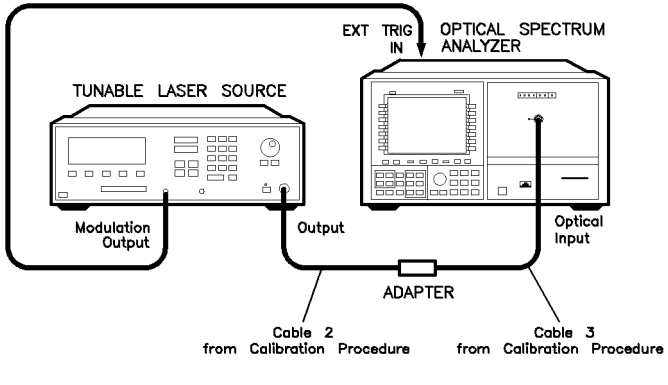
Start wavelength ..... 1540 nm
Stop wavelength ..... 1560 nm
Step size ..... 2 nm

These settings are for example only. You can use any valid range.

Procedure

1. Connect the output of the HP 8168A/B/C tunable laser source to the optical spectrum analyzer's input as shown in the following figure. The adapter allows you to use the same cables that were used in the calibration procedure. These same cables will be used when the EDFA is inserted. Do not disconnect these cables from the laser or optical spectrum analyzer.

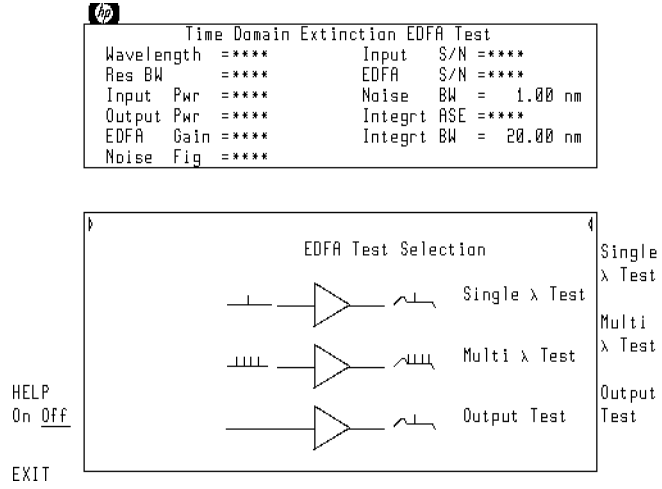
   On HP 71450B/2B optical spectrum analyzers, the input connector is labeled `OPTICAL INPUT`. On HP 71451B optical spectrum analyzers, the input connector is labeled `MONOCHROMATOR INPUT`.



2. Press (USER) and then `EDFA_TD` to start the EDFA TDE personality.

Select the test

3. Press `Multi λ Test`.



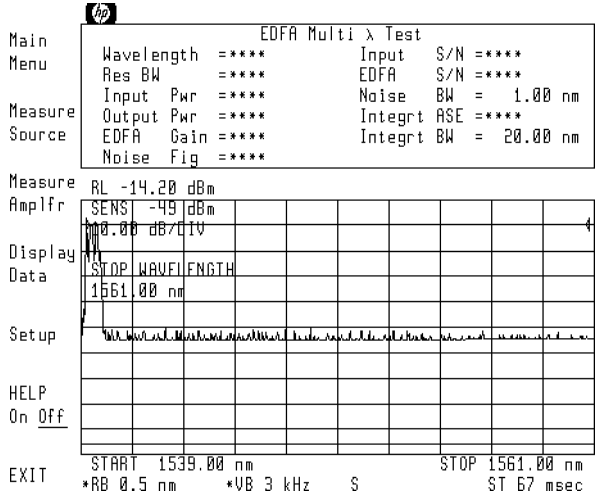
4. Do the following steps to modulate the HP 8168A/B/C laser at a 25 kHz rate:
   a. Press the (OUTPUT POWER) key.
   b. Press `Mod/CW` to turn the modulation on (`POWER` and `FREQ` are displayed).
   c. Toggle the `Freq`/`Power` softkey so that the softkey label reads `Power`.
   d. Enter a modulation value of 25 kHz.
5. On the HP 8168A/B/C, press `λ-Sweep`, and enter the start, stop, and step wavelength settings. In this case 1540 nm, 1560 nm, and 2 nm respectively.
6. Turn the laser on.
7. On the HP 8168A/B/C, press `Manual`.

8. On the optical spectrum analyzer, enter the start and stop wavelength settings:

   START ..... 1539 nm
   STOP ..... 1561 nm

NOTE

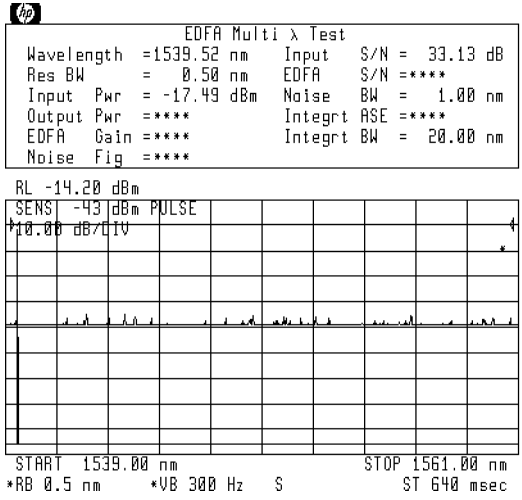
The start wavelength should be visible on the optical spectrum anayzer's display. In relatively narrow spans, as in this example, set the span slightly wider than the laser's tuning range. This ensures that the start and stop wavelengths can be identified during testing.



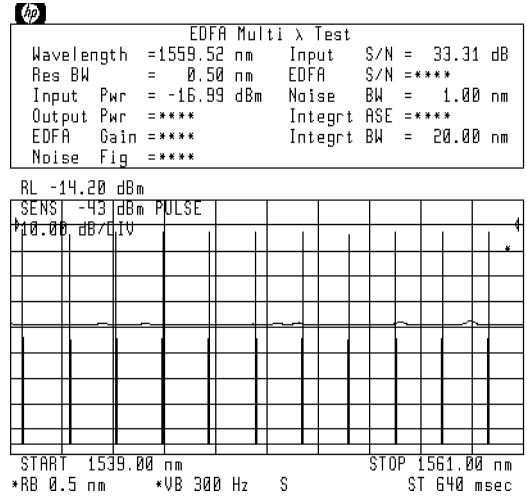
9. On the optical spectrum analyzer, press HOLD.

Measure the source

10. Press the left-side `Measure Source` softkey.
11. Repeat the following steps for each wavelength to be measured:
    a. Press `TAKE SWEEP` on the optical spectrum analyzer.
    b. Wait until the `TAKE SWEEP` softkey is no longer highlighted.
    c. Press `Next` on the HP 8168A/B/C to tune the laser to the next wavelength.



`TAKE SWEEP` **pressed. First wavelength measured.**



All wavelengths measured.

Restarting the test

You can restart testing at any time by resetting the laser and pressing `Measure Source`. This clears any previously measured data points.

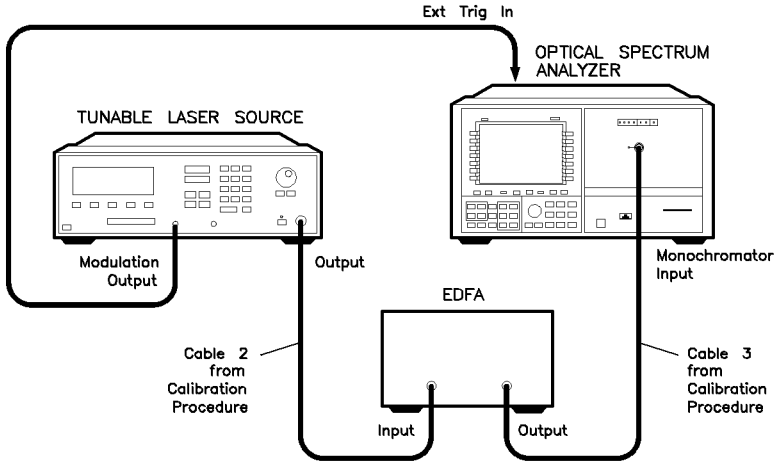
12. Press DONE after all the wavelengths are captured.

Using the "SINGLE SWEEP" and "CONT SWEEP" softkeys

When you press TAKE SWEEP, a measurement routine takes three sweeps to characterize the signal. The SINGLE SWEEP softkey allows you to manually step through each of these sweeps. To characterize a wavelength manually, SINGLE SWEEP must be pressed three times. The first press measures the wavelength using a smoothed peak in a wide wavelength span (indicated by a blue line). The second press measures the amplitude of the smoothed peak in a narrow wavelength span. The third press measures the noise at wavelength of the signal in a wide wavelength span (indicated by a red line). To return to automated testing, press TAKE SWEEP.

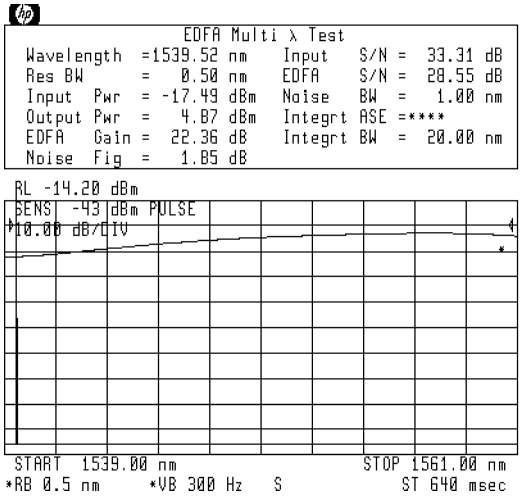
When the CONT SWEEP softkey is pressed, the three-sweep measurement routine repeats continuously until SINGLE SWEEP is pressed. To return to automated testing, press TAKE SWEEP.

13. On the HP 8168A/B/C, press Stop and then Manual.
14. Remove the adapter, and connect the EDFA as shown in the following figure.

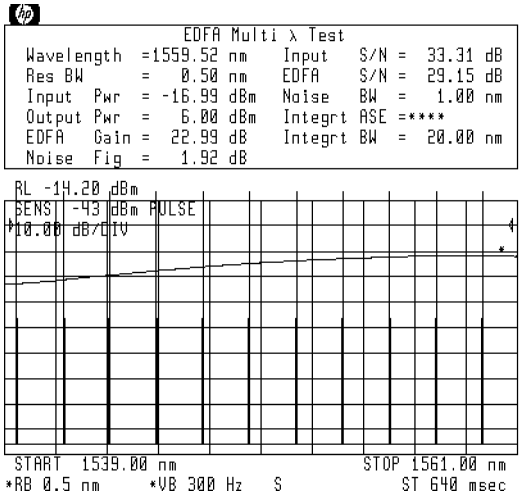


Measure the amplifier

15. Press `Measure Amplfr`.
16. Repeat the following steps for each wavelength to be measured:
    a. Press `TAKE SWEEP` on the optical spectrum analyzer.
    b. Wait until the `TAKE SWEEP` softkey is no longer highlighted.
    c. Press `Next` on the HP 8168A/B/C to tune the laser to the next wavelength.



`TAKE SWEEP` **pressed. First wavelength measured.**



All wavelengths measured.

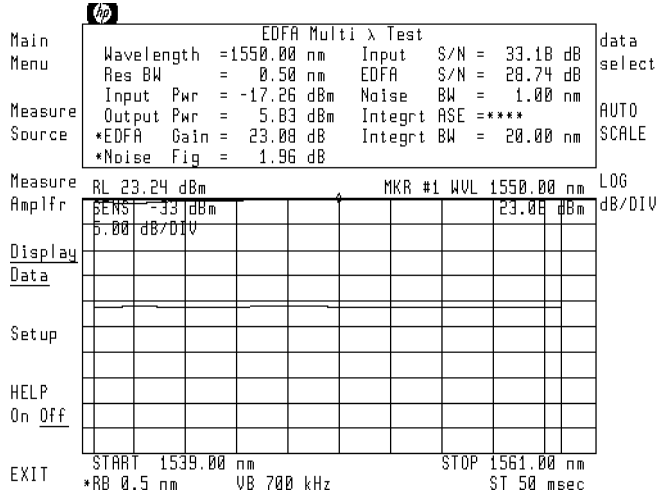
Restarting the test

You can restart testing at any time by resetting the laser and pressing `Measure Amplfr`. This clears any previously measured data points.

17. Press `DONE` after all the wavelengths are captured.

Display the measurement results

18. Press `Display Data` to view traces of measurement data.
19. Press the right-side `data select` softkey.
20. Select from one of the displayed softkeys to view a trace of measurement data versus wavelength. For this example, press `GAIN and NF`.
21. Press `AUTO SCALE` to automatically scale the traces.



Gain and noise figure versus wavelength.

Color matches trace and measurement

Notice that the measurement values change color to match the color of the displayed trace.

22. If you want to manually scale the display, use `LOG dB/DIV`. Use the front-panel knob, step keys, or numeric keypad to enter a new value.
23. Press (NORMAL ON/OFF), and turn the front-panel knob to move the marker. The display shows the data measured at the marker wavelength.

To perform an output test

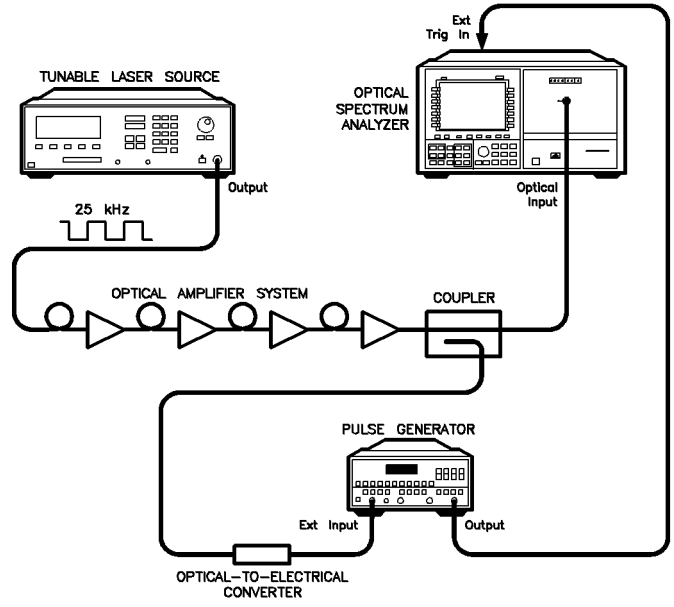
During the output test, the source is not characterized. The measurements performed include the following:

- Output wavelength and power
- Output noise
- Output signal-to-noise ratio

Procedure

1. Connect the system with the EDFA to the optical spectrum analyzer as shown in the following figure. The suggested pulse generator is an HP 8112A.

   On HP 71450B/2B optical spectrum analyzers, the input connector is labeled `OPTICAL INPUT`. On HP 71451B optical spectrum analyzers, the input connector is labeled `MONOCHROMATOR INPUT`.



2. Turn on the laser.
3. Do the following steps to configure the HP 8168A/B/C laser:
   a. Press the front-panel (WAVELENGTH) key, and enter the desired wavelength.
   b. Press the (OUTPUT POWER) key, and enter the source power.
   c. Press `Mod/CW` to turn the modulation on.
   d. Toggle the `Freq/Power` softkey so that the softkey label reads `Power` (frequency is selected).
   e. Enter a modulation value of 25 kHz.
4. Press (AUTO MEAS) on the optical spectrum analyzer.
5. Press (USER) and then `EDFA_TD` to start the EDFA TDE personality.
6. Press `Output Test`.
7. Perform the following steps if you need to change the tuning range of the optical spectrum analyzer:
   a. Enter the (START) wavelength.
   b. Enter the (STOP) wavelength.
   c. Press (HOLD).
8. Press `Measure Amplfr`. After the first complete sweep occurs, the display lists all the measurement results at the top of the screen.

Restarting the test

You can restart testing at any time by resetting the laser and pressing `Measure Source`. This clears any previously measured data points.

9. Press `DONE` after all the wavelengths are captured.

Using the "SINGLE SWEEP" and "CONT SWEEP" softkeys

Until you press the DONE softkey, the test continuously measures the input signal. The SINGLE SWEEP and CONT SWEEP softkeys allow you to manually step through a measurement. For each measurement, SINGLE SWEEP must be pressed three times. The first press measures the wavelength using a smoothed peak in a wide wavelength span (indicated by a blue line). The second press measures the amplitude of the smoothed peak in a narrow wavelength span. The third press measures the noise at wavelength of the signal in a wide wavelength span (indicated by a red line).

The CONT SWEEP softkey gives you the ability to return to automated testing.

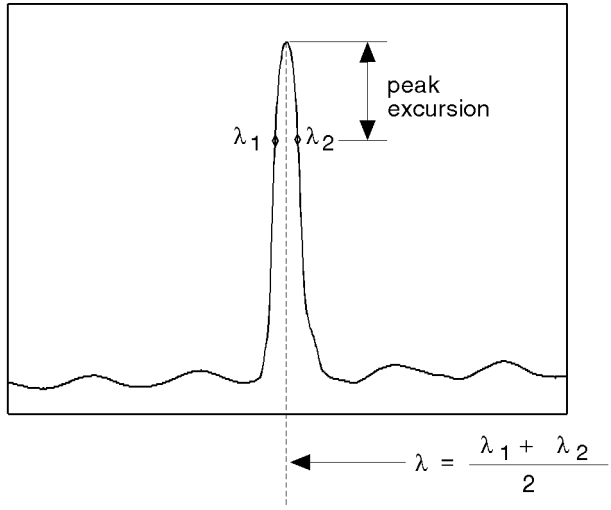
This section explains some of the features available with the Setup menu. The Setup menu allows you to configure the following parameters:

- Change the noise bandwidth.
- Display noise values instead of signal-to-noise values.
- Change vertical amplitude scale.
- Define the calculation for signal wavelength.
- Adjust the noise integration window.

Normally, the measurement results display input and EDFA signal-to-noise values. Using the Setup menu, you can change this so that noise values are displayed instead. In addition, the Setup menu allows you to change the logarithmic amplitude scale. For example, you could change the scale from 10 dB per division to 5 dB per division.

The wavelength value is calculated

The signal's wavelength value is calculated as the center of the signal. You can designate which amplitude points are included in determining the wavelength by changing the peak-excursion value. (Refer to "To change the peak excursion value" in this manual.) As shown in the following figure, signal wavelength is the average of the wavelength values at the peak excursion amplitude offset.



wavelen

where:

λ_1 is the wavelength to the left side of the signal peak that is equal in amplitude to the signal peak minus the peak excursion value.

λ_2 is the wavelength to the right side of the signal peak that is equal in amplitude to the signal peak minus the peak excursion value.

Integration range is adjustable

The `Integrt ASE` measurement is the result of integrating the noise between the start and stop integration wavelengths. These two wavelengths are identified by trace markers. The default integration points are set to the optical spectrum analyzer's start and stop sweep settings. You can change the integration window using the `INTEGRT START λ` and `INTEGRT STOP λ` softkeys.

The Setup menu's `INTEGRT On Off` softkey allows you to turn integration on or off. If integration is turned off, asterisks are displayed in place of measurement values. If integration is turned off during a Multi λ Test, the program sets the `Integrt ASE` value to −100 dBm at each wavelength. If you display the ASE trace, it will also be at −100 dBm.

You can change the noise bandwidth

The noise bandwidth (`Noise BW`) affects the `EDFA S/N` ratio measurement results. Refer to the equations in Chapter 4 to learn how the `Noise BW` value relates to each of these measurements. Use the `NOISE BW` softkey to change the normalized bandwidth value. The default value is 1 nm.

To display noise values

1. From the Main Menu, press `Output Test`, `Single λ Test`, or `Multi λ Test`.
2. Press `Setup`.
3. Press `DISPLAY NoiseSN` so that `NOISE` is underlined.

To change the amplitude scale

1. From the Main Menu, press `Output Test`, `Single λ Test`, or `Multi λ Test`.
2. Press `Setup` and then `MORE 1 of 2`.
3. Press `LOG dB/DIV`.
4. Use the knob, step keys, or numeric keypad to enter the desired amplitude scale.

To change the peak excursion value

1. From the Main Menu, press `Output Test`, `Single λ Test`, or `Multi λ Test`.
2. Press `Setup` and then `MORE 1 of 2`.
3. Press `PEAK EXCURSN`.
4. Use the knob, step keys, or numeric keypad to enter the peak excursion value that is used to calculate the signal wavelength.

To change the noise bandwidth

1. From the Main Menu, press `Output Test`, `Single λ Test`, or `Multi λ Test`.
2. Press `Setup`.
3. Press `NOISE BW`, and use the knob, step keys, or numeric keypad to enter the noise bandwidth.

   The instrument will now normalize all noise and signal-to-noise measurements to this bandwidth.

To change the ASE integration window

1. From the Main Menu, press `Output Test`, `Single λ Test`, or `Multi λ Test`.
2. Press `Setup`.
3. Press `INTEGRT START λ`, and use the knob, step keys, or numeric keypad to enter the integration's start wavelength.
4. Press `INTEGRT STOP λ`, and use the knob, step keys, or numeric keypad to enter the integration's end wavelength.
5. Press `INTEGRT On Off` so that `On` is underlined.

3

Programming

Programming

This chapter documents the programming commands for the EDFA TDE personality. EDFA TDE commands can be called from programs in the same manner as any optical spectrum analyzer command. For information on building and running programs, refer to the *HP 71450B/1B/2B Optical Spectrum Analyzers Programmer's Guide*.

Chapter Contents

Finding a command is easy

There are two ways of locating an EDFA TDE remote programming command. First, you can use the `HELP On Off` softkey to display a Help menu that lists an equivalent programming command. The second method of locating a command is to refer to the command listings in this chapter.

Some optical spectrum analyzer commands are used

The following table lists EDFA TDE functions that should be controlled using optical spectrum analyzer commands. These functions have no equivalent EDFA TDE programming command. Refer to the *HP 71450B/1B/2B Optical Spectrum Analyzers Programmer's Guide* for information on these commands.

Optical Spectrum Analyzer Commands

EDFA TDE Softkey	Definition	OSA Command
CONT SWEEP	Selects continuous sweep mode.	CONTS
SINGLE SWEEP	Selects single sweep mode.	SNGLS
LOG dB/DIV	Changes logarithmic amplitude scale.	LG
PEAK EXCURSN	Sets marker peak excursion value.	MKPX

Send commands as ASCII strings

EDFA TDE commands are sent to the optical spectrum analyzer as ASCII strings. The method used depends on the programming language and environment. Using an HP Vectra computer with the HP-IB Interface and Command Library (and programming in *C*), send a command as follows:

```
iooutputs(723L, "EDFA_TD_ AA", 11);
```

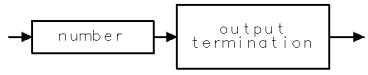
Using an HP 9000 Series 300 technical computer with the HP-BASIC language, the same command would be sent as follows:

```
OUTPUT 723;"EDFA_TD_  AA;"
```

Query responses

Some EDFA TDE commands can be issued as a query. A query causes data to be returned to the computer from the optical spectrum analyzer. The data is returned as an ASCII string. For example, the `EDFA_TD_ YA?` query

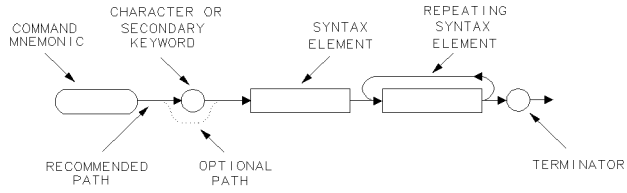
might return the string `1.550000E-006` representing 1550 nanometers. The following syntax diagram shows the form of a query response.



Querying traces in Multi λ Tests results in a string of ASCII numbers separated by commas. You must allocate enough memory to hold all the data. For the default trace length of 800 measurement points, you should allocate at least 6500 bytes.

How to read syntax diagrams

Syntax diagrams represent commands pictorially as shown in the following figure.



- Characters enclosed by an oval are commands and their arguments and must be entered *exactly as shown*.
- Characters enclosed by a circle are separators or terminators and must be entered as shown.
- Syntax-diagram elements are connected by solid and dotted lines. Any combination of elements generated by following the lines in the proper direction is correct syntactically. *Solid-line paths are recommended.*

In the syntax diagrams, numbers and units are expressed in the forms shown in the following table.

Syntax Diagram Elements

Syntax Component	Definition/Range
number	Expressed as integer, decimal, or in exponential |E| form. Real Number Range: $\pm$ 1.797,693,134,862,315 $\times$ 10^{308}, including 0. Up to 15 significant figures allowed. Numbers may be as small as $\pm$ 2.225,073,858,507,202 $\times$ 10^{-308} Integer Number Range: −32,768 through +32,767
output termination	Line feed |L_F| with end-or-identify |EOI| condition. ASCII code 10 |line feed| is sent via HP-IB, with the end-or-identify control line on HP-IB set to indicate the end of the transmission.
units	Represent standard scientific units. Amplitude Units: DB, DBM, MW, NW, PW, UW, W Current Units: A, MA, UA Frequency Units: HZ, KHZ, MHZ, GHZ, KZ, MZ, GZ Time Units: S, MS, US, SC Wavelength Units: ANG, KM, NM, UM, PM

Commands by Functional Group

Softkey/Function	Programming Command	Definition
Starting the Personality		
EDFA_TD	EDFA_TD_	Starts EDFA TDE personality.
Amplitude Scale:		
AUTO SCALE	EDFA_TD_ B	Automatically scales the displayed data.
LOG dB/DIV	LG	Refer to OSA programmer's guide.
Prompt Control:		
PROMPT Off	EDFA_TD_ JB	Turns prompts off.
PROMPT On	EDFA_TD_ JA	Turns prompts on.
Measurement Parameters:		
`Integrt BW`	EDFA_TD_ YL?	Queries `Integrt BW` value.
INTEGRT On	EDFA_TD_ NA	Turns integration on.
INTEGRT Off	EDFA_TD_ NB	Turns integration off.
INTEGRT START λ	TDE_WLL	Sets and queries the left integration wavelength value.
INTEGRT STOP λ	TDE_WLR	Sets and queries the right integration wavelength value.
`Noise BW`	EDFA_TD_ YJ?	Queries `Noise BW` value.
NOISE BW	EDFA_N_BW	Enters and queries Noise bandwidth value.
PEAK EXCURSN	MKPX	Refer to OSA programmer's guide.
Menu Control:		
data select	EDFA_TD_ AJ	Displays "data select" menu.
Display Data	EDFA_TD_ AI	Displays "Display Data" menu.
DISPLAY NoiseSN	EDFA_TD_ VA	Displays "Noise" values.
DISPLAY NoiseSN	EDFA_TD_ VX	Displays "S/N" values.
DONE	EDFA_TD_ D	Stops the acquisition of measurement data.

Commands by Functional Group (continued)

Softkey/Function	Programming Command	Definition
Menu Control *continued*:		
EXIT	EDFA_TD_ Q	Quits the EDFA TDE personality.
HELP On		Turns help menu on.
HELP Off		Turns help menu off.
Main Menu	EDFA_TD_ AA	Displays the "Main" menu.
Measure Amplfr	EDFA_TD_ AF	Starts amplifier measurements.
Measure Source	EDFA_TD_ AC	Starts source measurements.
MORE 1 of 2	EDFA_TD_ F	Selects the next page of softkeys.
MORE 2 of 2	EDFA_TD_ F	Selects the next page of softkeys.
Output Test	EDFA_TD_ GA	Selects Output Test.
Setup	EDFA_TD_ AB	Displays the "Setup" menu.
Single λ Test	EDFA_TD_ GB	Selects Single λ Test.
Multi λ Test	EDFA_TD_ GC	Selects Multi λ Test.
Query Data at Marker:		
`EDFA Gain`	EDFA_TD_ YF?	Queries `EDFA Gain` value.
`EDFA S/N`	EDFA_TD_ YI?	Queries `EDFA S/N` value.
`Input Pwr`	EDFA_TD_ YC?	Queries `Input Pwr` value.
`Input S/N`	EDFA_TD_ YG?	Queries `Input S/N` value.
`Integrt ASE`	EDFA_TD_ YK?	Queries `Integrt ASE` value.
`Noise Figure`	EDFA_TD_ YE?	Queries `Noise Figure` value.
`Output Pwr`	EDFA_TD_ YD?	Queries `Output Pwr` value.
`Wavelength`	EDFA_TD_ YA?	Queries `Wavelength` value.
Query Traces (Multi λ Test):		
`EDFA Gain`	EDFA_GAIN?	Queries trace of `EDFA Gain`.
`EDFA S/N`	EDFA_SN?	Queries trace of `EDFA S/N`.
`EDFA NF`	EDFA_NF?	Queries trace of `EDFA NF`.
`Input Noise`	IN_NOISE?	Queries trace of `Input Noise`.
`Input Pwr`	IN_PWR?	Queries trace of `Input Pwr`.
`Input S/N`	IN_SN?	Queries trace of `Input S/N`.
`Integrt ASE`	INTEGRT_ASE?	Queries trace of `Integrt ASE`.

Commands by Functional Group (continued)

Softkey/Function	Programming Command	Definition
Query Traces (Multi λ Test) *continued*:		
`Output Noise`	OUT_NOISE?	Queries trace of `Output Noise`.
`Output Pwr`	OUT_PWR?	Queries trace of `Output Pwr`.
Trace Displaying (Multi λ Test):		
EDFA S/N	EDFA_TD_ CJ	Displays trace of EDFA S/N.
GAIN	EDFA_TD_ CB	Displays trace of gain.
GAIN and NF	EDFA_TD_ CA	Displays traces of gain and noise figure.
INPUT POWER	EDFA_TD_ CD	Displays trace of input power.
INTEGRT ASE[1]	EDFA_TD_ CM	Displays trace of integrated ASE.
NF	EDFA_TD_ CC	Displays trace of noise figure.
OUTPUT POWER	EDFA_TD_ CE	Displays trace of output power.
Sweep Control:		
CONT SWEEP	CONTS	Refer to OSA programmer's guide.
SINGLE SWEEP	SNGLS	Refer to OSA programmer's guide.
TAKE SWEEP	EDFA_TD_R	Refer to OSA programmer's guide.

1 If the `INTEGRT On Off` softkey is set to `Off`, all ASE measurement values are automatically set to −100 dBm.

Softkeys versus Commands

Softkey	Equivalent Programming Command	Definition
AUTO SCALE	EDFA_TD_ B	Automatically scales the displayed data.
CONT SWEEP	CONTS	Refer to OSA programmer's guide.
data select	EDFA_TD_ AJ	Displays "data select" menu.
Display Data	EDFA_TD_ AI	Displays "Display Data" menu.
DISPLAY NoiseSN	EDFA_TD_ VA, EDFA_TD_ VX	Displays noise |VA| or S/N |VX| values.
DONE	EDFA_TD_ D	Stops the acquisition of measurement data.
EDFA	EDFA_TD_	Starts EDFA TDE personality.
EDFA S/N	EDFA_TD_ CJ	Displays trace of EDFA S/N ratio in Multi λ testing.
EXIT	EDFA_TD_ Q	Quits the EDFA TDE personality.
GAIN	EDFA_TD_ CB	Displays trace of gain in Multi λ testing.
GAIN and NF	EDFA_TD_ CA	Displays traces of gain and noise figure in Multi λ testing.
HELP On Off	—	—
INPUT POWER	EDFA_TD_ CD	Displays trace of input power in Multi λ testing.
INTEGRT ASE	EDFA_TD_ CM	Displays trace of integrated ASE in Multi λ testing.
INTEGRT On Off	EDFA_TD_ NA, EDFA_TD_ NB	Turns integration on |NA| or off |NB|.
INTEGRT START λ	TDE_WLL	Sets the left integration wavelength.
INTEGRT STOP λ	TDE_WLR	Sets the right integration wavelength.

Softkeys versus Commands (continued)

Softkey	Equivalent Programming Command	Definition
LOG dB/DIV	LG	Refer to OSA programmer's guide.
Main Menu	EDFA_TD_ AA	Displays the "Main" menu.
Measure Amplfr	EDFA_TD_ AF	Starts amplifier measurements.
Measure Source	EDFA_TD_ AC	Starts source measurements.
MORE 1 of 2	EDFA_TD_ F	Selects the next page of softkeys.
MORE 2 of 2	EDFA_TD_ F	Selects the next page of softkeys.
Multi λ Test	EDFA_TD_ GC	Selects Multi λ Test.
NF	EDFA_TD_ CC	Displays trace of noise figure in Multi λ testing.
NOISE BW	EDFA_N_BW	Enters a S/N bandwidth value.
OUTPUT POWER	EDFA_TD_ CE	Displays trace of output power in Multi λ testing.
Output Test	EDFA_TD_ GA	Selects Output Test.
PEAK EXCURSN	MKPX	Refer to OSA programmer's guide.
PROMPT On Off	EDFA_TD_ JA, EDFA_TD_ JB	Turns prompts on |JA| or off |JB|.
Setup	EDFA_TD_ AB	Displays the "Setup" menu.
Single λ Test	EDFA_TD_ GB	Selects Single λ Test.
SINGLE SWEEP	SNGLS	Refer to OSA programmer's guide.

Commands in Alphabetical Order

Programming Command	Definition	Softkey
CONTS	Refer to OSA programmer's guide.	CONT SWEEP
EDFA_TD_	Starts EDFA TDE personality.	EDFA
EDFA_TD_ AA	Displays the "Main" menu.	Main Menu
EDFA_TD_ AB	Displays the "Setup" menu.	Setup
EDFA_TD_ AC	Starts source measurements.	Measure Source
EDFA_TD_ AF	Starts amplifier measurements.	Measure Amplfr
EDFA_TD_ AI	Displays "Display Data" menu.	Display Data
EDFA_TD_ AJ	Displays "data select" menu.	data select
EDFA_TD_ B	Automatically scales the displayed data.	AUTO SCALE
EDFA_TD_ CA	Displays traces of gain and noise figure in Multi λ testing.	GAIN and NF
EDFA_TD_ CB	Displays trace of gain in Multi λ testing.	GAIN
EDFA_TD_ CC	Displays trace of noise figure in Multi λ testing.	NF
EDFA_TD_ CD	Displays trace of input power in Multi λ testing.	INPUT POWER
EDFA_TD_ CE	Displays trace of output power in Multi λ testing.	OUTPUT POWER
EDFA_TD_ CJ	Displays EDFA S/N bandwidth.	EDFA S/N
EDFA_TD_ CM	Displays trace of integrated ASE in Multi λ testing.	INTEGRT ASE
EDFA_TD_ D	Stops the acquisition of measurement data.	DONE

Commands in Alphabetical Order (continued)

Programming Command	Definition	Softkey
EDFA_TD_ F	Selects the next page of softkeys.	MORE 1 of 2
EDFA_TD_ GA	Selects Output Test.	Output Test
EDFA_TD_ GB	Selects Single λ Test.	Single λ Test
EDFA_TD_ GC	Selects Multi λ Test.	Multi λ Test
EDFA_TD_ JA	Turns prompts on.	PROMPT On
EDFA_TD_ JB	Turns prompts off.	PROMPT Off
EDFA_TD_ NA	Turns integration on.	INTEGRT On Off
EDFA_TD_ NB	Turns integration off.	INTEGRT On Off
EDFA_TD_ Q	Quits the EDFA TDE personality.	EXIT
EDFA_TD_ VA	Toggles "DISPLAY NoiseSN" softkey to noise.	DISPLAY NoiseSN
EDFA_TD_ VX	Toggles "DISPLAY NoiseSN" softkey to S/N.	DISPLAY NoiseSN
EDFA_TD_ YA?	Queries **Wavelength** value at the marker.	
EDFA_TD_ YC?	Queries **Input Pwr** value at the marker.	
EDFA_TD_ YD?	Queries **Output Pwr** value at the marker.	
EDFA_TD_ YE?	Queries **Noise Figure** value at the marker.	
EDFA_TD_ YF?	Queries **EDFA Gain** value at the marker.	
EDFA_TD_ YG?	Queries **Input S/N** value at the marker.	
EDFA_TD_ YI?	Queries **EDFA S/N** value at the marker.	
EDFA_TD_ YJ?	Queries **Noise BW** value at the marker.	
EDFA_TD_ YK?	Queries **Integrt ASE** value at the marker.	
EDFA_TD_ YL?	Queries **Integrt BW** value at the marker.	
EDFA_TD_GAIN?	Queries trace of **EDFA Gain** in Multi λ Testing.	

Commands in Alphabetical Order (continued)

Programming Command	Definition	Softkey
EDFA_N_BW	Enters a noise bandwidth value.	NOISE BW
EDFA_N_BW?	Queries S/N bandwidth value.	
EDFA_NF?	Queries trace of **Noise Figure** in Multi λ Testing.	
EDFA_SN?	Queries trace of **EDFA S/N** in Multi λ Testing.	
TDE_WLL	Sets the left integration wavelength.	INTEGRT START λ
TDE_WLL?	Queries the left integration wavelength value.	
TDE_WLR	Sets the right integration wavelength.	INTEGRT STOP λ
TDE_WLR?	Queries the right integration wavelength value.	
IN_NOISE?	Queries trace of noise measured in true noise bandwidth [OSA bandwidth].	
IN_PWR?	Queries trace of **Input Pwr** in Multi λ Testing.	
IN_SN?	Queries trace of **Input S/N** in Swept λ Testing.	
INTEGRT_ASE?	Queries trace of **Integrt ASE** in Multi λ Testing.	
LG	Refer to OSA programmer's guide.	LOG dB/DIV
MKPX	Refer to OSA programmer's guide.	PEAK EXCURSN
OUT_NOISE?	Queries trace of noise measured in true noise bandwidth [OSA bandwidth].	
OUT_PWR?	Queries trace of **Output Pwr** in Multi λ Testing.	
SNGLS	Refer to OSA programmer's guide.	SINGLE SWEEP
EDFA_TD_R	Take three single sweeps. Refer to OSA programmer's guide.	TAKE SWEEP

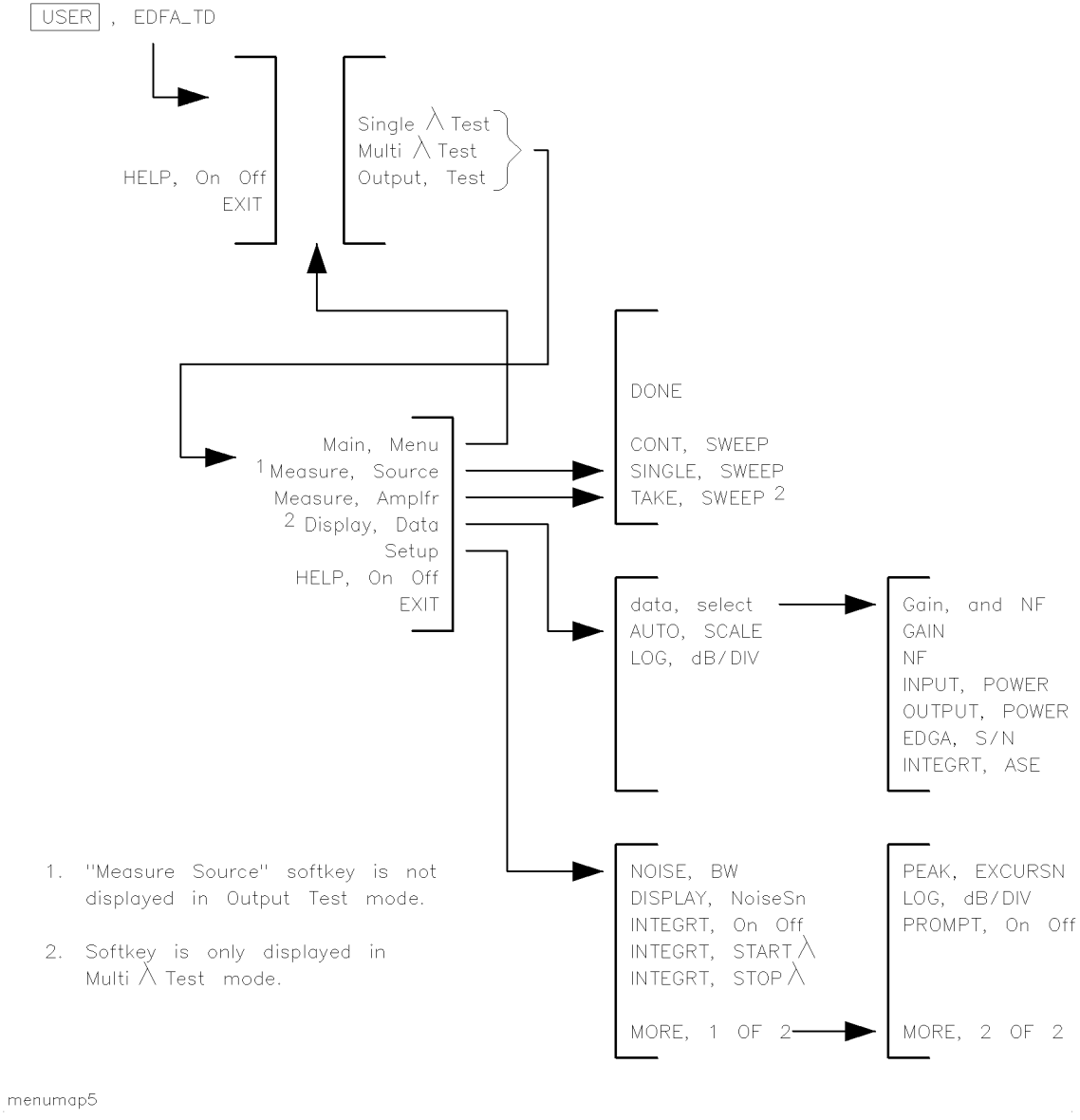
4

Reference

Reference

Chapter Contents

Menu Map


USER , EDFA_TD
HELP, On Off
EXIT
Single λ Test
Multi λ Test
Output, Test
Main, Menu
1 Measure, Source
Measure, Amplfr
2 Display, Data
Setup
HELP, On Off
EXIT
DONE
CONT, SWEEP
SINGLE, SWEEP
TAKE, SWEEP 2
data, select
AUTO, SCALE
LOG, dB/DIV
Gain, and NF
GAIN
NF
INPUT, POWER
OUTPUT, POWER
EDGA, S/N
INTEGRT, ASE
NOISE, BW
DISPLAY, NoiseSn
INTEGRT, On Off
INTEGRT, START λ
INTEGRT, STOP λ
MORE, 1 OF 2
PEAK, EXCURSN
LOG, dB/DIV
PROMPT, On Off
MORE, 2 OF 2
1. "Measure Source" softkey is not displayed in Output Test mode.
2. Softkey is only displayed in Multi λ Test mode.
menumap5

Error Messages

This section defines error messages for the EDFA test personality. Error messages not defined in this section originate with the HP 70950B/1B/2B module and are documented in the *HP 71450B/1B/2B Optical Spectrum Analyzers Reference*.

Error messages can result from incorrect operating procedures, illegal programming commands, or hardware failures. Normally, the optical spectrum analyzer removes error messages from the screen as soon as the error conditions are corrected. If you have a computer, error messages can be retrieved via HP-IB by executing the `ERR?` command. Refer to the *HP 71450B/1B/2B Optical Spectrum Analyzers Programmer's Guide* for information on the `ERR?` command.

error 111 `EDFA Memory Error:` The program has run out of free memory. To free memory, perform the following:

- Erase objects of the following types from memory: saved traces, limit lines, user menus, and downloadable programs. Refer to the chapter on managing memory in the *HP 71450B/1B/2B Optical Spectrum Analyzers User's Guide* to learn how to erase these objects.

error 112 `EDFA Noise Figure < 0 Error:` Invalid data has resulted in a noise figure calculation less than zero. Valid noise figure results are always positive values.

error 116 `EDFA Command Error:` An unrecognized argument has been used with the programming command. Refer to Chapter 3 for the correct use of the command.

Measurement Calculations

The following calculations describe each measurement result that is shown at the top of the display. A special `typeface` is used in this chapter to indicate these displayed quantities. For example, when the wavelength measurement is referenced, it is printed as `Wavelength`.

EDFA Gain

The `EDFA Gain` is defined by the following equation:

$$EDFA\ Gain = \frac{P_{out}}{P_{in}}$$

where:

P_{out} is the calculated `Output Pwr` at `Wavelength`.

P_{in} is the calculated `Input Pwr` at `Wavelength`.

`EDFA Gain` is not measured during the Output Test.

EDFA Noise

The EDFA amplifier's noise, **EDFA Noise**, is performed at **Wavelength** and is defined by the following equation:

$$EDFA\ Noise = (N_{out})\left(\frac{Noise\ BW}{Res\ BW}\right)$$

where:

N_{out} is average output noise power at **Wavelength**. However, during a Output Test if integration is turned on (see the Setup menus's `INTEGRT On Off` softkey), N_{out} is the integrated noise value.

Res BW is the optical spectrum analyer's true resolution bandwidth. It is a function of wavelength.

Noise BW is entered using the `NOISE BW` softkey. The default value is 1 nm.

EDFA S/N

The EDFA amplifier's signal-to-noise ratio, **EDFA S/N**, is performed at **Wavelength** and is defined by the following equation:

$$EDFA\ S/N = \left[\frac{P_{signal}}{N_{out}}\right]\left(\frac{Noise\ BW}{Res\ BW}\right)$$

where:

P_{signal} is the output peak power at **Wavelength**.

N_{out} is average output noise power at **Wavelength**. However, during a Output Test if integration is turned on (see the Setup menus's **INTEGRT On Off** softkey), N_{out} is the integrated noise value.

Res BW is the optical spectrum analyer's true resolution bandwidth. It is a function of wavelength.

Noise BW is entered using the **NOISE BW** softkey. The default value is 1 nm.

Input S/N

The input signal-to-noise ratio, `Input S/N`, is defined by the following equation:

$$Input\ S/N = \left(\frac{P_{signal}}{N_{in}}\right)\left(\frac{Noise\ BW}{Res\ BW}\right)$$

where:

P_{signal} is the input power at `Wavelength`.

N_{in} is the average input noise power at `Wavelength`.

`Res BW` is the optical spectrum analyer's true resolution bandwidth. It is a function of wavelength.

`Noise BW` is entered using the `NOISE BW` softkey. The default value is 1 nm. This value can be changed

`Input S/N` is not measured during the Output Test.

In the case of a tuned laser source as the input source, this parameter does not measure the input signal-to-noise ratio. It does characterize the input signal-to-noise ratio for applications where a booster amplifier is used for higher saturation power.

Input Pwr

The `Input Pwr` is defined by the following equation:

$$Input\ Pwr = P_{signal} - N_{in}$$

where:

P_{signal} is the measured input power at `Wavelength`.

`Input Pwr` is not measured during the Output Test.

Integrt ASE

The integrated amplified spontaneous emission, `Integrt ASE`, is defined by the following equation:

$$Integrt\ ASE = \sum_{\lambda=\lambda_1}^{\lambda=\lambda_2} N_\lambda$$

where:

λ_1 is the left-integration start wavelength set by the `INTEGRT START λ` softkey.

λ_2 is the right-integration stop wavelength set by the `INTEGRT STOP λ` softkey.

N_λ is the EDFA noise at the wavelength.

$$N_\lambda = (N_{out})\left(\frac{Noise\ BW}{Res\ BW}\right)$$

where:

N_{out} is average output noise power at `Wavelength`. However, during an Output Test if integration is turned on (see the Setup menus's `INTEGRT On Off` softkey), N_{out} is the integrated noise value.

`Res BW` is the optical spectrum analyer's true resolution bandwidth. It is a function of wavelength.

`Noise BW` is entered using the `NOISE BW` softkey. The default value is 1 nm.

If integration is turned off during Multi λ Tests (see the Setup menus's `INTEGRT On Off` softkey), the program sets the `Integrt ASE` value to −100 dBm at each wavelength. This means that the displayed trace will also be at −100 dBm.

Integrt BW

`Integrt BW` is not a measurement. This value is the integration bandwidth used to measure `Integrt ASE`. The default value is the current wavelength span of the optical spectrum analyzer.

Noise BW

`Noise BW` is not a measurement. This value is the noise bandwidth value that is used in the calculations. The default value is 1 nm. This value can be changed using the `Noise BW` softkey.

Noise Fig

The **Noise Fig**ure at **Wavelength** is defined by the following equation:

$$Noise\ Fig = \frac{N_{out} - N_{in}G}{h\nu GB} + \frac{1}{G}$$

where:

N_{out} is average output noise power at **Wavelength**.

N_{in} is average input noise power at **Wavelength**.

G is the **EDFA Gain** as defined in this chapter.

B is the optical spectrum analyer's true resolution bandwidth in hertz.

h is 6.626 X 10^{-34}.

ν is $\frac{c}{\lambda}$.

c is 2.99711 X 10^{8}.

Noise Figure is not measured during the Output Test.

Output Pwr

The **Output Pwr** is defined by the following equation:

$$Output\ Pwr = P_{signal} - N_{out}$$

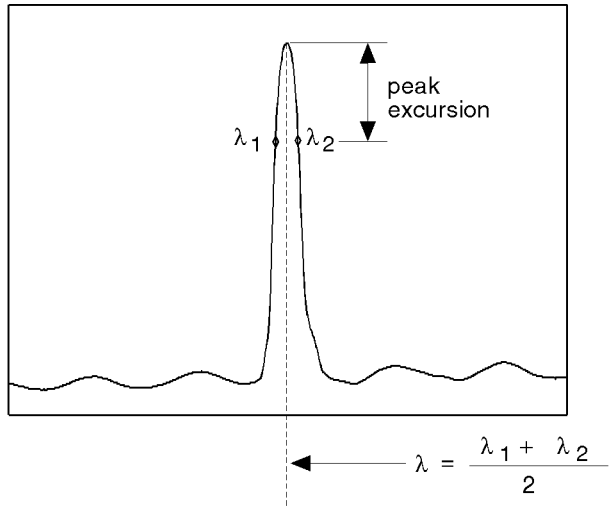
where:

P_{signal} is the measured output power at **Wavelength**.

N_{out} is the average output noise power at **Wavelength**.

Wavelength

The source `Wavelength` is defined in the following figure and equation:



wavelen

where:

λ_1 is the wavelength to the left side of the signal peak that is equal in amplitude to the signal peak minus the peak excursion value.

λ_2 is the wavelength to the right side of the signal peak that is equal in amplitude to the signal peak minus the peak excursion value.

Peak excursion values can be entered using the `PEAK EXCURSN` softkey. The default value is 3 dB.

The following table summarizes the error terms and shows the typical total measurement uncertainties. The total uncertainties are calculated as shown in the following equation:

$$uncertainty = 2\sqrt{\sum \frac{U^2}{3}}$$

where "U" is the uncertainty of each individual term.

These uncertainty calculations are based on the use of linear interpolation measurements, with an HP 71452B Optical Spectrum Analyzer. For more information, refer to application note HP 71452-2.

Uncertainties

	With Splices[1]	With Connectors[2]
Gain Uncertainty	0.22 dB	0.54 dB
Noise Figure Uncertainty	0.35 dB	0.55 dB

1 Assumes 0.05 dB uncertainty for each splice.

2 Assumes 0.25 dB uncertainty for each connector.

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