Agilent 83400-Series Lightwave Source and Receiver Modules User's Guide

Agilent Technologies

Agilent Part No. 5962-5933
Printed in USA
February 2000

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CAUTION

The *caution* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

WARNING

The *warning* sign denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

⚠ The instruction manual symbol. The product is marked with this warning symbol when it is necessary for the user to refer to the instructions in the manual.

The laser radiation symbol. This warning symbol is marked on products which have a laser output.

∿ The AC symbol is used to indicate the required nature of the line module input power.

| The ON symbols are used to mark the positions of the instrument power line switch.

❍ The OFF symbols are used to mark the positions of the instrument power line switch.

The CE mark is a registered trademark of the European Community.

The CSA mark is a registered trademark of the Canadian Standards Association.

The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.

ISM1-A This text denotes the instrument is an Industrial Scientific and Medical Group 1 Class A product.

Typographical Conventions.
The following conventions are used in this book:

Key type for keys or text located on the keyboard or instrument.

Softkey type for key names that are displayed on the instrument's screen.

`Display type` for words or characters displayed on the computer's screen or instrument's display.

User type for words or characters that you type or enter.

Emphasis type for words or characters that emphasize some point or that are used as place holders for text that you type.

The Agilent 83400-Series—At a Glance

Agilent 83400-series sources

The Agilent 83400-series sources can be amplitude modulated by an external RF source. They can be modulated with up to +14 dBm (about 25 mW) of RF power.

Source	Wavelength	Unmodulated Output Power	Modulation Range	Optical Fiber	Laser Type
83402C	1300 nm	< 3.0 mW	300 kHz to 6 GHz	9/125 µm	DFB
83403C	1550 nm	< 3.0 mW	300 kHz to 6 GHz	9/125 µm	DFB

WARNING **Use of controls or adjustments or performance of procedures other than those specified herein can result in hazardous radiation exposure.**

WARNING **Do not enable the laser when no fiber or equivalent device is attached to the** OPTICAL OUTPUT **connector.**

Agilent 83400-series receivers

The receivers are used to demodulate lightwave signals. With no modulation signal, lightwave receivers produce no electrical output. If the optical power exceeds 3 mW, the front-panel OVER ILLUMINATION indicator lights. Power must be decreased below 2.5 mW for the indicator to turn off.

Receiver	Wavelength	Demodulation Range (sine wave)	Optical Fiber
83410C	1300/1550 nm	300 kHz to 3 GHz	62.5/125 µm
83411C/D	1300/1550 nm	300 kHz to 6 GHz	9/125 µm
83412B	850 nm	300 kHz to 3 GHz	62.5/125 µm

Laser Classification

The Agilent 83402C is classified as an FDA Laser Class IIIb (IEC Laser Class 3B). The total power of light energy radiated out of the OPTICAL OUTPUT connector is no greater than 5 mW at a wavelength of 1300 nm. The following figure shows the IEC and FDA labels (and their placement) on the Agilent 83402C.

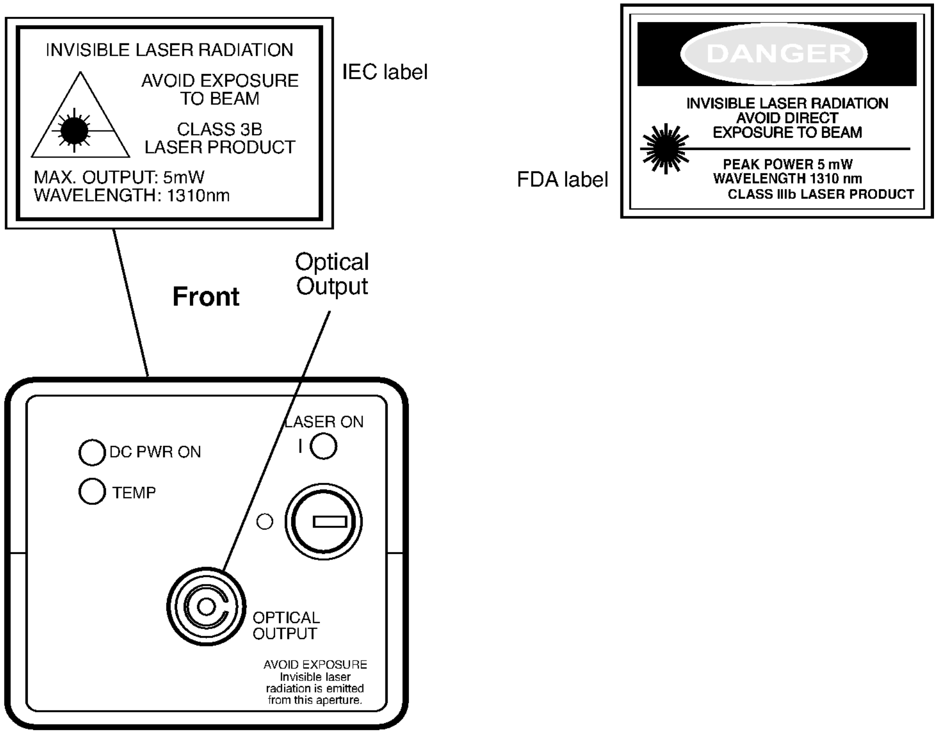
The Agilent 83403C is classified as an FDA LASER Class I (IEC LASER Class 1). The total power of light energy radiated out of the OPTICAL OUTPUT connector is no greater than 5 mW at a wavelength of 1550 nm.

No adjustments or maintenance are required to keep these products compliant with their classification. The IEC labels shown in the figure could not be affixed at the factory. Instructions on page 1-5 explain how they are to be attached.

WARNING **Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

WARNING **Do not enable the laser when no fiber or equivalent device is attached to the OPTICAL OUTPUT connector.**

These products *cannot* be serviced. If service is required, return the instrument to Agilent Technologies.



lightout2

IEC and FDA labels (and their placement) on an Agilent 83402C

General Safety Considerations

This product has been designed and tested in accordance with IEC Publication 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, and has been supplied in a safe condition. The instruction documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

WARNING **If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in a normal condition (in which all means for protection are intact) only.**

WARNING **To prevent electrical shock, disconnect the Agilent 83400-Series from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **This is a Safety Class 1 product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

WARNING **For continued protection against fire hazard, replace line fuse only with same type and ratings, (type T 0.315A/250V for 100/120V operation and 0.16A/250V for 220/240V operation). The use of other fuses or materials is prohibited. Verify that the value of the line-voltage fuse is correct.**

- For 100/120V operation, use an IEC 127 5×20 mm, 0.315 A, 250 V, Agilent part number 2110-0449.
- For 220/240V operation, use an IEC 127 5×20 mm, 0.16 A, 250 V, Agilent Technologies part number 2110-0448.

CAUTION Before switching on this instrument, make sure that the line voltage selector switch is set to the line voltage of the power supply and the correct fuse is installed. Assure the supply voltage is in the specified range.

CAUTION This product is designed for use in Installation Category II and Pollution Degree 2 per IEC 1010 and 664 respectively.

CAUTION VENTILATION REQUIREMENTS: When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4°C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

CAUTION Always use the three-prong ac power cord supplied with this instrument. Failure to ensure adequate earth grounding by not using this cord may cause instrument damage.

CAUTION *Do not* connect ac power until you have verified the line voltage is correct. Damage to the equipment could result.

CAUTION This instrument has autoranging line voltage input. Be sure the supply voltage is within the specified range.

Contents

1

Getting Started

Getting Started

The instructions in this chapter show you how to install your Agilent 83400-series source or receiver module. Because these products are key accessories for the Agilent 8702-series lightwave component analyzers, this book emphasizes installation into the Agilent 8702D.

Calibration data describes each device

Four procedures are provided in this chapter for loading source or receiver calibration data into an Agilent 8702-series lightwave component analyzer. Select the appropriate procedure depending upon your situation.

Each source and receiver module comes with its own calibration data that describes its magnitude and phase modulation response. Because no two sources or receivers are exactly alike, the calibration data should not be used with any other source or receiver. The calibration data is provided in three forms:

- Coefficients printed on a label.
- Data on a DOS-formatted disk.
- Data on a LIF-formatted disk.

For more information about the calibration data, refer to "Calibration Data Information" on page 2-7.

Some notes on safety and care

Be sure to read the safety and introductory material in the front of this book before operating your Agilent 83400-series source or receiver module. Refer to Chapter 3, "Specifications and Regulatory Information" for information on operating conditions, such as temperature.

If you should ever need to clean the cabinet, use a damp cloth only.

CAUTION Exposing the Agilent 83400-series source or receiver module to temperatures above 55°C may cause the optical fiber in the front-panel connector to shrink and retract.

CAUTION This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 601010 and 60664 respectively.

Measurement accuracy—it's up to you!

Fiber-optic connectors are easily damaged when connected to dirty or damaged cables and accessories. The Agilent 83400-series' front-panel optical connector is no exception. When you use improper cleaning and handling techniques, you risk expensive instrument repairs, damaged cables, and compromised measurements.

Before you connect any fiber-optic cable to the Agilent 83400-series source or receiver module, refer to "Cleaning Connections for Accurate Measurements" on page 2-11.

Inspecting the Shipment

1 Verify that all components ordered have arrived by comparing the shipping forms to the original purchase order. Inspect all shipping containers.

If your shipment is damaged or incomplete, save the packing materials and notify both the shipping carrier and the nearest Agilent Technologies sales and service office. Agilent Technologies will arrange for repair or replacement of damaged or incomplete shipments without waiting for a settlement from the transportation company. Notify the Agilent Technologies customer engineer of any problems.

2 Make sure that the serial number and options listed on the instrument's rear-panel label match the serial number and options listed on the shipping document. The following figure is an example of the rear-panel serial number label.

Figure 1-1. Serial number label

Connecting a Source

1 For Agilent 83402C products, perform the following two steps:

a If you are located outside of the United States or Canada, locate the yellow sheet of IEC laser classification and laser safety labels supplied with the source. Labels are provided for most major languages.

b Select the two labels in the desired language, and place them on the source at the two positions shown in Figure 1-2 on page 1-6. FDA labels should already be located at these positions.

WARNING **Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

2 Connect a terminated fiber-optic cable or device to the source's OPTICAL OUTPUT connector. This protects the user from exposure to laser radiation. See Figure 1-3 on page 1-7.

3 Connect the DC cable, supplied with the source, between the source's rear-panel DC IN connector and a PROBE POWER jack.

You'll find PROBE POWER jacks on the following products:

- Agilent 8702A/B/D lightwave component analyzer
- Agilent 11899A probe power supply

4 Make sure that the BNC short is connect to the rear-panel REMOTE SHUTDOWN connector.

The source will *not* operate without the BNC short connected.

5 Insert the key into the source's front panel.

6 Turn the key to turn the source on.

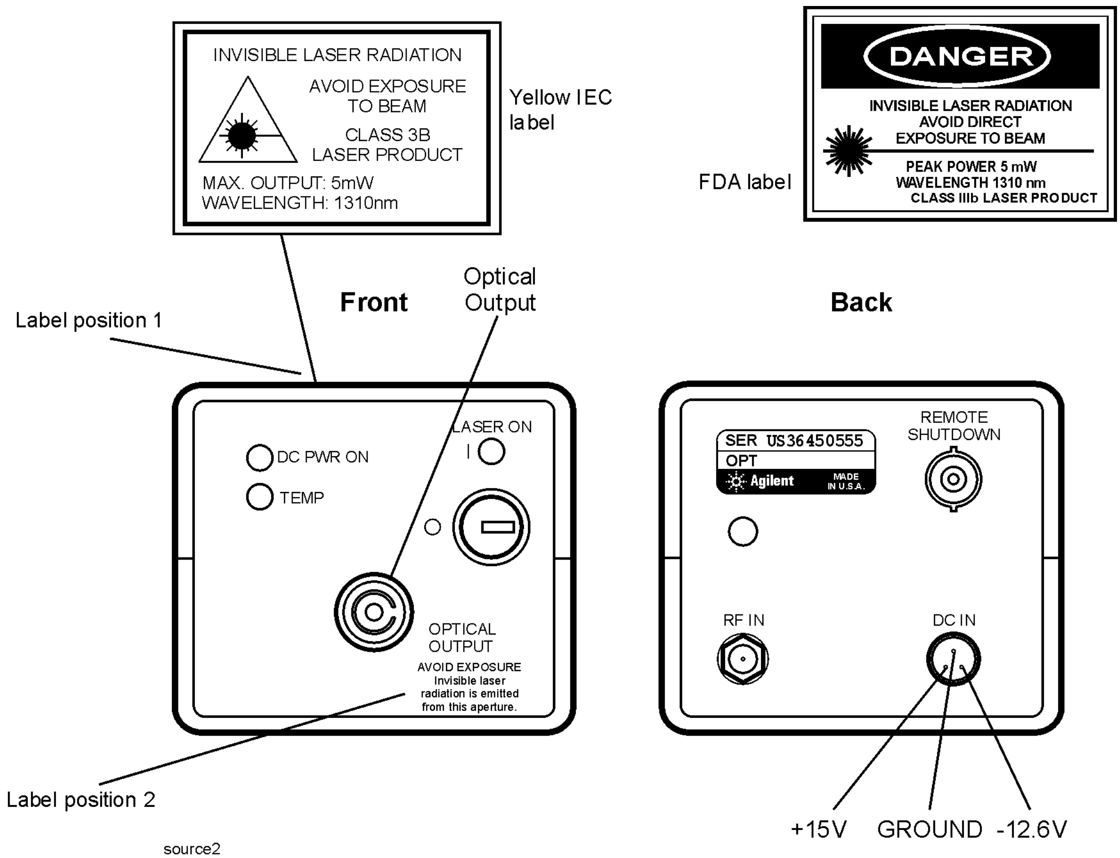


Figure 1-2. Location of laser safety labels

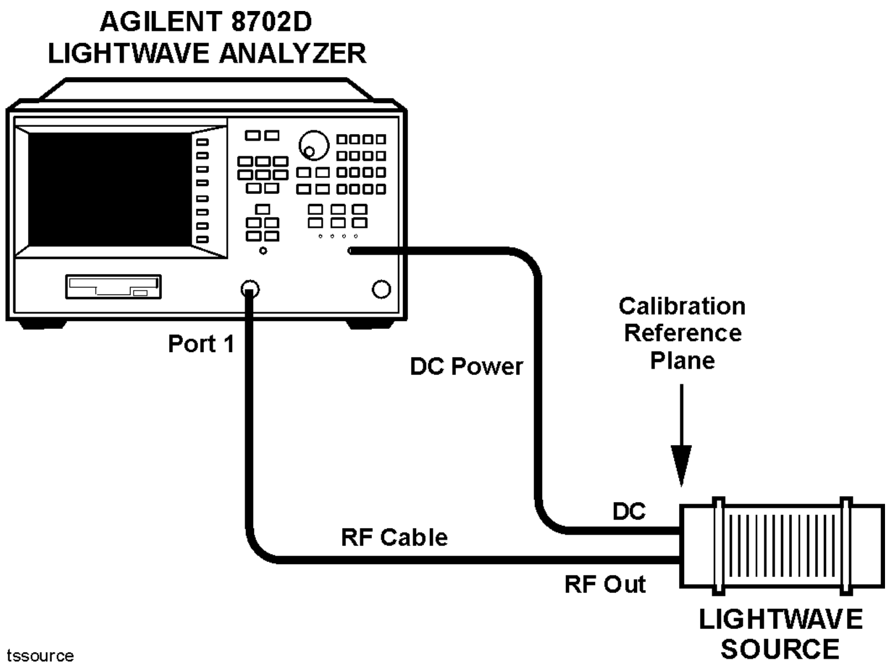


Figure 1-3. Source connections

If you encounter a problem

If the TEMP LED comes on, or the LASER ON LED goes off, one or more of the following conditions may have occurred:

- The key switch is in the OFF position (O).
- The ambient temperature is out of the specified range (25°C ±5°C).
- The remote shutdown is open.
- The power supply voltage(s) are out of spec (–12.6 V ±5% and +15 V ±5%).
- There is an internal malfunction of the unit; contact Agilent Technologies for assistance.

These products *cannot* be serviced. If service is required, return the instrument to Agilent Technologies.

Connecting a Receiver

1 Connect the DC cable, supplied with the receiver, between the receiver's rear-panel DC IN connector and a PROBE POWER jack.

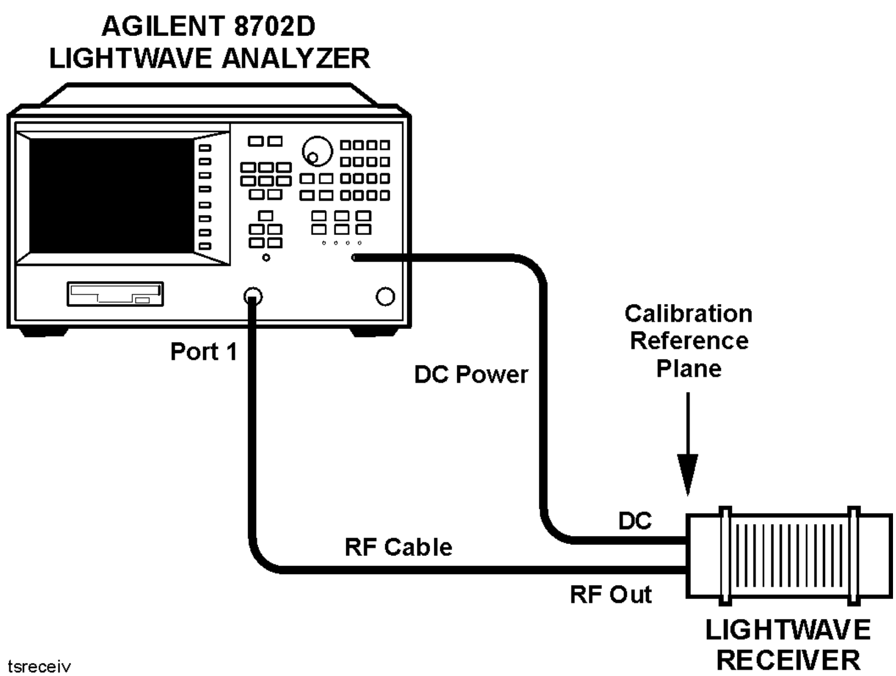
You'll find PROBE POWER jacks on the following products:

- Agilent 8702A/B/D lightwave component analyzer
- Agilent 11899A probe power supply

2 Locate the SMA RF cable supplied with the receiver.

3 Use adapters to connect the SMA RF cable between the Agilent 8702's RF port and the receiver's rear-panel RF OUT connector.

4 Connect a fiber-optic cable or device to the receiver's OPTICAL INPUT connector.



Entering Calibration Data into an Agilent 8702D

Agilent 83400-series lightwave sources and receivers have calibration data which must be entered into the Agilent 8702. The data is supplied on a disk and printed on a label. The most accurate data is contained on the disk. The calibration data for newer lightwave sources and receivers is supplied on a DOS formatted disk which can be read using the front-panel disk drive. On older sources and receivers, the disk uses the LIF format.

Calibration standards come in the following forms:

- Already loaded in the Agilent 8702's memory.

  For optical transmission measurements, a thru connection (short length of fiber-optic cable) is used. For reflection measurements, a Fresnel reflection (3.5% reflected power) is used. This is a clean connector on the output of a lightwave coupler. For electrical measurements, standard devices include short circuit, open circuit, termination (for example, 50Ω load), and thru connection. Electrical standards are packaged together as calibration kits.

- Provided with the device and must be loaded into the Agilent 8702's memory.

  For example, the Agilent 83400-series lightwave sources and receivers are shipped with calibration data stored on a disk. This disk must be placed into the instrument's front-panel disk drive so that the data can be loaded into memory.

- Calibration standards that you create for your own devices.

Loading calibration data into an Agilent 8702D

Before using your source or receiver with an Agilent 8702D lightwave component analyzer, you must load the calibration data as described in this section. Two simple procedures are provided in this section. Although both are easy to perform, copying from a disk is slightly faster. The data on the disk provides the most accurate model of the frequency response of the calibration standard. As an alternative, entering the coefficients that are printed on the label (located on the source or receiver) provides lower accuracy.

For steps on entering calibration data into an Agilent 8702A/B, refer to "Entering Calibration Data into an Agilent 8702A/B" on page 1-11.

To copy the data from the disk

The following procedure is written specifically for entering source data. If you are entering data for a receiver, simply substitute the word *RECEIVER* for *SOURCE* and the word *RCVR* for *SRC*.

1 Locate the DOS-formatted calibration disk provided with the source.

2 Place the disk in the Agilent 8702D's front-panel disk drive.

3 Press CAL, *CAL KITS & STDS*, *SOURCE STANDARDS*, *LOAD SRC DISK MENU*. This will display the disk directory screen.

4 Use the arrow keys or front panel knob to select a cal data file.

5 Load the cal data file into either of two internal registers by pressing the corresponding *LOAD* softkey.

To manually enter data from the label

The following procedure is written specifically for entering source data. If you are entering data for a receiver, simply substitute the word *RECEIVER* for *SOURCE* and the word *RCVR* for *SRC*.

1 Press CAL, *CAL KITS & STDS*, *SOURCE*, *CAL STD:SRC COEFF* and then *ENTER SRC COEFF*.

2 Press each softkey corresponding to the nine coefficients (A through I), using the *MORE* softkey, and enter the coefficients. The coefficients are listed on a label that is on the source. After all of the coefficients are entered, press *RETURN*.

3 Press *LABEL STD*.

4 Use the front-panel knob and the *SELECT LETTER* softkey to write a title for the calibration data.

5 Press *STD DONE (DEFINED)* and then *SAVE SRC COEFF*.

6 Press CAL, *CALIBRATE MENU*, *RESPONSE*, and then *SOURCE*.

7 When the *SOURCE* softkey is underlined, press *DONE: RESPONSE*.

Entering Calibration Data into an Agilent 8702A/B

Before using your source or receiver with an Agilent 8702A/B lightwave component analyzer, you must load the calibration data as described in this section. Two procedures are provided in this section. The first procedure is the standard method. You will most likely use it. However, if you have an GPIB external disk drive, you can use the second procedure. For more information on calibration data, refer to "Entering Calibration Data into an Agilent 8702D" on page 1-9.

To install from the front panel

The following procedure is written specifically for entering source data. If you are entering data for a receiver, simply substitute the word *RECEIVER* for *SOURCE* and the word *RCVR* for *SRC*.

1 On the Agilent 8702A/B, press:

PRESET
CAL, *CAL KITS & STDS*, *SOURCE [COEFF]*, *SRC COEFF*, *ENTER SRC COEFF*

2 Use the available softkeys to enter the coefficients that are listed on the label that is attached to the source.

3 Press LABEL STD, and enter a label for the calibration data.

4 Press STD DONE and then SAVE SRC COEFF.

To install from an external disk drive

If you have an HP 9122-series dual-sided disk drive connected to your Agilent 8702A/B, use this procedure to enter the source or receiver's calibration data.

The following procedure is written specifically for entering source data. If you are entering data for a receiver, simply substitute the word *RECEIVER* for *SOURCE* and the word *RCVR* for *SRC*.

1 Locate the LIF-formatted calibration disk provided with the source.

2 Place the disk in the disk drive.

3 On the Agilent 8702A/B, press:

PRESET
LOCAL, *SYSTEM CONTROLLER*
CAL, *CAL KITS & STDS*, *SOURCE [COEFF]*, *CAL STD: SRC DISK*
LOAD SRC DISK, *READ FILE TITLES*, *LOAD* <*filename*>.

2

General Information

Operating

Laser sources

Front and rear panel features

The DC POWER ON light turns on whenever DC power is supplied.

The front-panel OPTICAL OUTPUT connector has a special adapter which allows you to easily change the front-panel connector to one of many standard interfaces. Refer to “Replaceable Parts” on page 2-5 for a figure which shows each available connector.

The front-panel RF IN connector is an SMA threaded female connector for input of the modulation signal. The source can be modulated with a signal which is DC offset, providing this offset does not exceed 20 volts DC.

If the environmental temperature rises above the safe operating range, the laser source turns off, and the front-panel TEMP light turns on. Refer to “Operating Specifications for Sources and Receivers” on page 3-13 for safe operating temperatures.

WARNING **Use of controls or adjustments or performance of procedures other than those specified herein can result in hazardous radiation exposure.**

WARNING **Do not enable the laser when no fiber or equivalent device is attached to the OPTICAL OUTPUT connector.**

Three safety mechanisms are provided

The Agilent 83400-series sources have three safety mechanisms:

- A laser safety cap
- A key switch
- A rear-panel REMOTE SHUTDOWN BNC connector

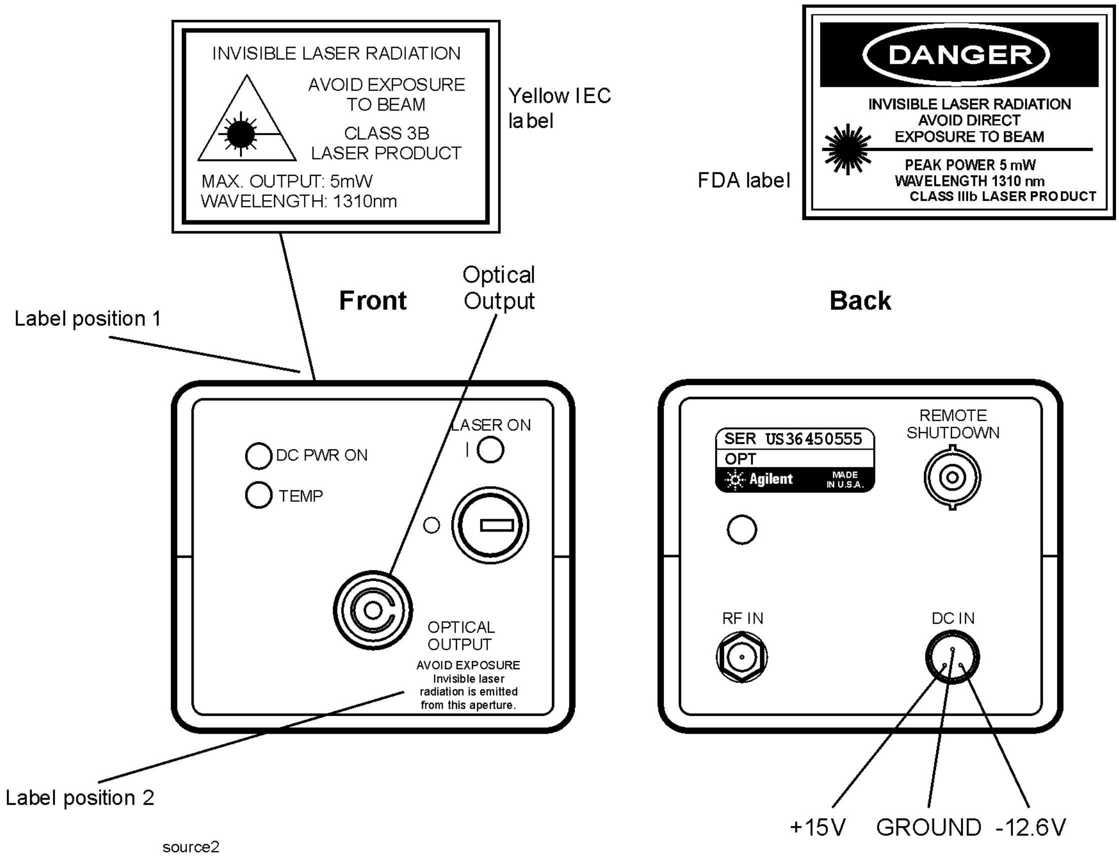


Figure 2-1. Front and rear panels on a source

When the key is turned on, the laser is turned on and the front-panel LASER ON light turns on. However, the rear-panel REMOTE SHUTDOWN BNC connector *must* be shorted for the laser to operate. When the BNC short is *removed* from the connector, the accessible radiation does not exceed the AEL for FDA LASER Class IIIb (IEC LASER Class 3B) for the Agilent 83402C and FDA LASER Class I (IEC LASER Class 1) for the Agilent 83403C according to IEC Publication CE/IEC 821-1: 1993. Use your own short, switch, or other circuitry to control the remote shutdown.

Receivers

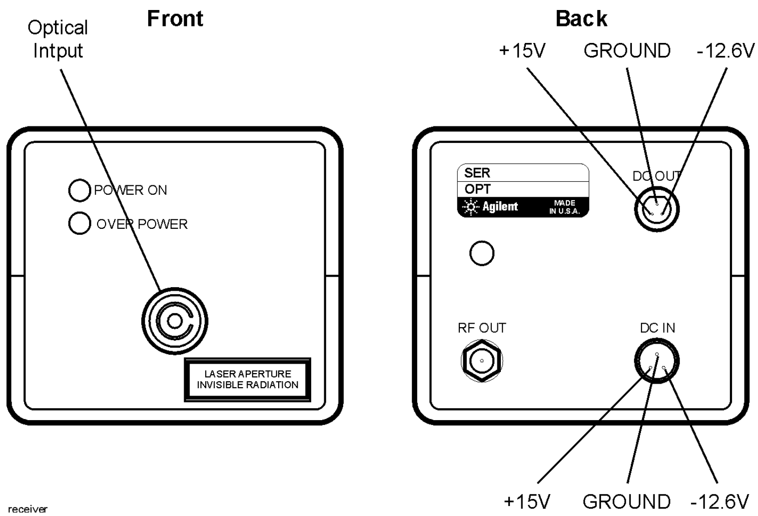


Figure 2-2. Front and rear panels on a receiver

Front and rear panel features

While the DC IN connector provides a connection to power the receiver, the DC OUT connector can be used to power to another source or receiver.

The front-panel OPTICAL INPUT connector has a special adapter which allows you to easily change the front-panel connector to one of many standard interfaces. Refer to “Replaceable Parts” on page 2-5 for a figure which shows each available connector. For Agilent 83411C/D receivers, use a single-mode 9 µm optical fiber. For Agilent 83410C and Agilent 83412B receivers, use an 62.5 µm multimode optical fiber.

The AVG POWER connector provides an output voltage that is proportional to the average optical power into the receiver.

The OVER ILLUMINATION light turns on whenever RF input power is too high. The POWER ON light turns on when DC power is supplied.

The RF OUT connector provides the output for the demodulation (electrical) signal. It is an SMA threaded female connector.

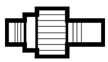
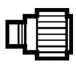
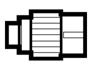
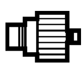
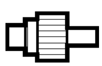
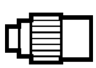
Replaceable Parts

Table 2-1. Replaceable Parts for Sources and Receivers

Description	Agilent Part Number
RF cable (SMA)	8120-5157
DC cable (probe power)	83400-60005
Cable clips	83400-20008
Laser shutter cover *(sources)*	08145-64521
Safety key *(sources)*	3100-1984
BNC short (m) for rear-panel REMOTE SHUTDOWN connector *(sources)*	1250-0774

One OPTICAL OUTPUT adapter must be ordered with the instrument. These adapters are ordered as Option 011, 012, 013, 014, 015, or 017. These adapters with their Agilent Technologies model numbers are shown in the following figure.

Front-Panel Optical Adapters

Front Panel Fiber-Optic Adapter	Description	Agilent Part Number
	Diamond HMS-10	81000AI
	FC/PC[a]	81000FI
	D4	81000GI
	SC	81000KI
	DIN	81000SI
	ST	81000VI
	Biconic	81000WI

Dust Covers	
FC connector	1005-0594
Diamond HMS-10 connector	1005-0593
DIN connector	1005-0595
ST connector	1005-0596
SC connector	1005-0597

a. The FC/PC adapter is the standard adapter supplied with the instrument.

Calibration Data Information

The Agilent 8702-series lightwave component analyzers use the Agilent 83400-series calibration data to mathematically remove contributing errors from a measurement. Subsequent E/O and O/E device measurements provide accurate measurements of your devices.

Recalibration is recommended every year

Although the Agilent 83400-series source and receiver modules are designed to be stable, they can be returned to the factory for recharacterization (calibration) at a desired time for a reasonable fee. Agilent Technologies recommends that recharacterization be done at approximately one year intervals. When returning the source or receiver modules for recharacterization, you *must* return the original data disk. The disk and the instrument have the same CAL DATA number. Contact an Agilent Technologies office for assistance.

Calibration data comes in two forms

Two types of calibration data are supplied with sources and receivers:

- Data points supplied on a 3.5 inch disk. For Agilent 8702A/B instruments, a LIF-formatted disk is provided. It contains data for 101 points. For Agilent 8702D instruments, a DOS-formatted disk is provided. This disk contains data for 202 data points.
- 9 coefficients supplied on the source or receiver itself.

Both of these items represent the modulation transfer characteristics of your particular source or receiver. Because no two sources or receivers are alike, the calibration data should not be used with any other source or receiver.

The calibration data is loaded into the Agilent 8702's memory as a calibration kit. Your source or receiver was measured at the factory under optimal conditions and the calibration data is a model of its response under those conditions. In this manner, your source or receiver is a standard because its response has already been characterized (modeled) and is now used to calibrate the system. Therefore, when you measure any other E/O or O/E device, the modeled Agilent response is removed from the system, along with the response of the optical/electrical cables and the lightwave source or receiver.

Making a backup disk

Hewlett-Packard[1] recommends that you make a backup or extra copy of the disk data, label it properly, and make sure it is only used with the source or receiver that its data describes.

If you need to make a backup copy of a LIF-formatted disk, you must have an HP controller (computer). This includes all 200 and 300-series HP 9000 controllers such as, HP 9836, 9826, 310, 320, etc. In addition, the disk drive must be an HP CS80 disk drive, such as an HP 9122C/D dual-sided model.

Refer to the computer's User's Guide for instructions on how to make back-up copies or copy files.

How labeled coefficients are used

The labeled coefficient data consists of nine coefficients that are used in a polynomial curve to describe the magnitude and phase modulation response of the source or receiver. The curve terms (A through I) are derived from the same data points that are on the disk.

A typical label, as shown in Figure 2-3 on page 2-9, has a CAL DATA # which describes the data.

1. Hewlett-Packard and HP are registered trademarks of Hewlett-Packard Company.

Interpreting filenames

Each digit in a filename has a specific meaning. For example, consider the number S2300045. The digits, from left to right, have the following definitions:

Digit	Description
1st	S indicates single-mode fiber. M indicates multimode fiber. D indicates diode only.
2nd	Indicates the modulation frequency range. 1 means up to 3 GHz. 2 means up to 6 GHz.
3rd	Indicates the wavelength. 3 means 1300 nm. 5 means 1550 nm. 8 means 850 nm.
4th thru 8th	These remaining 5 digits are the specific calibration data number for your source or receiver. This number is not the same as the instrument's serial number.
9th thru 10th	CR indicates a receiver. CS indicates a source. For DOS formatted files, these digits form the filename extension.

```
        CAL DATA # S2355555
              83402C
A= -.0097856 (Responsivity) F= 6.7218E-5
B= 10.323 (Delay)           G= -.0023049
C= .024162                  H= .86953
D= 1.6015                   I= 48.52
E= -61.393                  1325.9 nm
```

Figure 2-3. Calibration data label

In the Agilent 8702D, these coefficients are applied to the following equation:

$$responsivity\ (\omega) = \frac{(Ae^{-j\omega B})(C(j\omega)^3 + D(j\omega)^2 E(j\omega) + 1)}{F(j\omega)^4 + G(j\omega)^3 + H(j\omega)^2 + I(j\omega) + 1}$$

where, $\omega = 2\pi(frequency)$, $j = \sqrt{-1}$, and e represents the base of the natural log.

In the equation, the coefficients are scaled as shown in the following table. Although the coefficients are scaled as shown in the table, enter them exactly as listed on the label.

Table 2-2. Coefficient Scaling in Equation

Coefficient	Scale Factor	Coefficient	Scale Factor
B	-10^{-9}	F	10^{-39}
C	10^{-30}	G	-10^{-30}
D	10^{-21}	H	-10^{-21}
E	10^{-12}	I	10^{-12}

Cleaning Connections for Accurate Measurements

Today, advances in measurement capabilities make connectors and connection techniques more important than ever. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices can degrade measurement accuracy and damage instruments. Replacing a damaged connector can cost thousands of dollars, not to mention lost time! This expense can be avoided by observing the simple precautions presented in this book. This book also contains a brief list of tips for caring for electrical connectors.

Choosing the Right Connector

A critical but often overlooked factor in making a good lightwave measurement is the selection of the fiber-optic connector. The differences in connector types are mainly in the mechanical assembly that holds the ferrule in position against another identical ferrule. Connectors also vary in the polish, curve, and concentricity of the core within the cladding. Mating one style of cable to another requires an adapter. Agilent Technologies offers adapters for most instruments to allow testing with many different cables. Figure 2-4 on page 2-12 shows the basic components of a typical connectors.

The system tolerance for reflection and insertion loss must be known when selecting a connector from the wide variety of currently available connectors. Some items to consider when selecting a connector are:

- How much insertion loss can be allowed?
- Will the connector need to make multiple connections? Some connectors are better than others, and some are very poor for making repeated connections.
- What is the reflection tolerance? Can the system take reflection degradation?
- Is an instrument-grade connector with a precision core alignment required?
- Is repeatability tolerance for reflection and loss important? Do your specifica-

tions take repeatability uncertainty into account?

- Will a connector degrade the return loss too much, or will a fusion splice be required? For example, many DFB lasers cannot operate with reflections from connectors. Often as much as 90 dB isolation is needed.

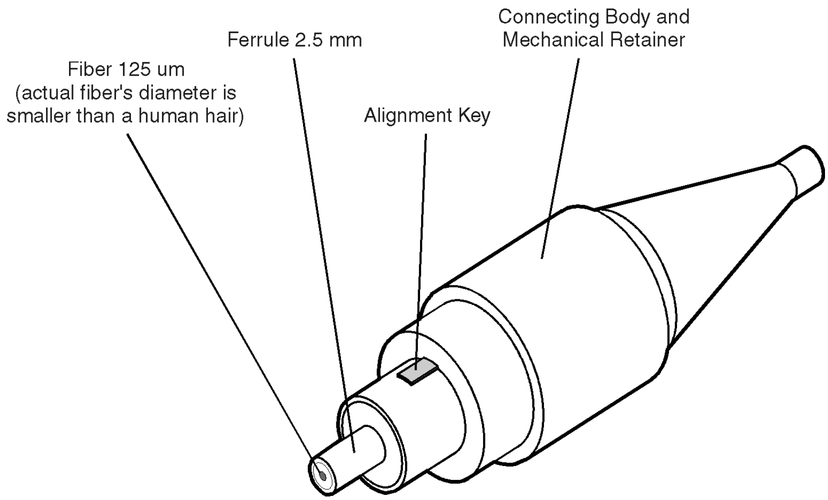


Figure 2-4. Basic components of a connector.

Over the last few years, the FC/PC style connector has emerged as the most popular connector for fiber-optic applications. While not the highest performing connector, it represents a good compromise between performance, reliability, and cost. If properly maintained and cleaned, this connector can withstand many repeated connections.

However, many instrument specifications require tighter tolerances than most connectors, including the FC/PC style, can deliver. These instruments cannot tolerate connectors with the large non-concentricities of the fiber common with ceramic style ferrules. When tighter alignment is required, Agilent Technologies instruments typically use a connector such as the Diamond HMS-10, which has concentric tolerances within a few tenths of a micron. Agilent Technologies then uses a special universal adapter, which allows other cable types to mate with this precision connector. See Figure 2-5.

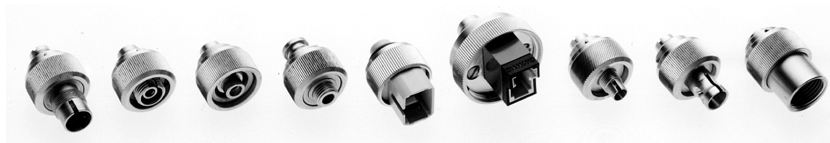


Figure 2-5. Universal adapters to Diamond HMS-10.

The HMS-10 encases the fiber within a soft nickel silver (Cu/Ni/Zn) center which is surrounded by a tough tungsten carbide casing, as shown in Figure 2-6.

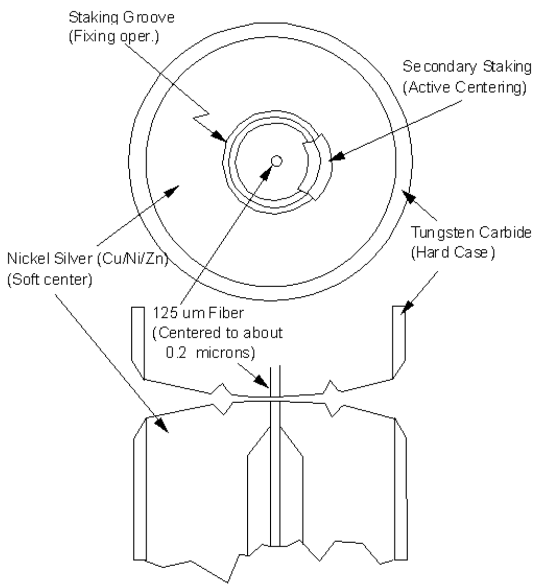


Figure 2-6. Cross-section of the Diamond HMS-10 connector.

The nickel silver allows an active centering process that permits the glass fiber to be moved to the desired position. This process first stakes the soft nickel silver to fix the fiber in a near-center location, then uses a post-active staking to shift the fiber into the desired position within 0.2 µm. This process, plus the keyed axis, allows very precise core-to-core alignments. This connector is found on most Agilent Technologies lightwave instruments.

The soft core, while allowing precise centering, is also the chief liability of the connector. The soft material is easily damaged. Care must be taken to minimize excessive scratching and wear. While minor wear is not a problem if the glass face is not affected, scratches or grit can cause the glass fiber to move out of alignment. Also, if unkeyed connectors are used, the nickel silver can be pushed onto the glass surface. Scratches, fiber movement, or glass contamination will cause loss of signal and increased reflections, resulting in poor return loss.

Inspecting Connectors

Because fiber-optic connectors are susceptible to damage that is not immediately obvious to the naked eye, poor measurements result without the user being aware. Microscopic examination and return loss measurements are the best way to ensure good measurements. Good cleaning practices can help ensure that optimum connector performance is maintained. With glass-to-glass interfaces, any degradation of a ferrule or the end of the fiber, any stray particles, or finger oil can have a significant effect on connector performance. Where many repeat connections are required, use of a connector saver or patch cable is recommended.

Figure 2-7 shows the end of a clean fiber-optic cable. The dark circle in the center of the micrograph is the fiber's 125 μm core and cladding which carries the light. The surrounding area is the soft nickel-silver ferrule. Figure 2-8 shows a dirty fiber end from neglect or perhaps improper cleaning. Material is smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can grind off the glass face and destroy the connector.

Figure 2-9 shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles or using improper cleaning tools. When severe, the damage of one connector end can be transferred to another good connector endface that comes in contact with the damaged one. Periodic checks of fiber ends, and replacing connecting cables after many connections is a wise practice.

The cure for these problems is disciplined connector care as described in the following list and in "Cleaning Connectors" on page 2-18.

Use the following guidelines to achieve the best possible performance when making measurements on a fiber-optic system:

- Never use metal or sharp objects to clean a connector and never scrape the connector.
- Avoid matching gel and oils.

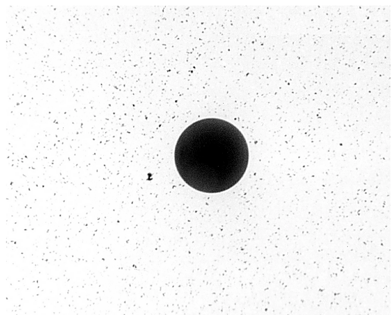


Figure 2-7. Clean, problem-free fiber end and ferrule.

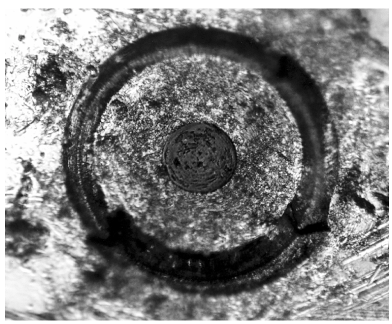


Figure 2-8. Dirty fiber end and ferrule from poor cleaning.

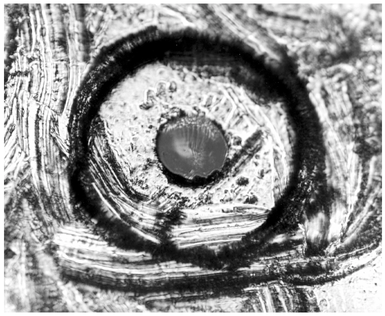


Figure 2-9. Damage from improper cleaning.

While these often work well on first insertion, they are great dirt magnets. The oil or gel grabs and holds grit that is then ground into the end of the fiber. Also, some early gels were designed for use with the FC, non-contacting connectors, using small glass spheres. When used with contacting connectors, these glass balls can scratch and pit the fiber. If an index matching gel or oil must be used, apply it to a freshly cleaned connector, make the measurement, and then immediately clean it off. Never use a gel for longer-term connections and never use it to improve a damaged connector. The gel can mask the extent of damage and continued use of a damaged fiber can transfer damage to the instrument.

- When inserting a fiber-optic cable into a connector, gently insert it in as straight a line as possible. Tipping and inserting at an angle can scrape material off the inside of the connector or even break the inside sleeve of connectors made with ceramic material.
- When inserting a fiber-optic connector into a connector, make sure that the fiber end does not touch the outside of the mating connector or adapter.
- Avoid over tightening connections.

Unlike common electrical connections, tighter is *not* better. The purpose of the connector is to bring two fiber ends together. Once they touch, tightening only causes a greater force to be applied to the delicate fibers. With connectors that have a convex fiber end, the end can be pushed off-axis resulting in misalignment and excessive return loss. Many measurements are actually improved by backing off the connector pressure. Also, if a piece of grit does happen to get by the cleaning procedure, the tighter connection is more likely to damage the glass. Tighten the connectors just until the two fibers touch.

- Keep connectors covered when not in use.
- Use fusion splices on the more permanent critical nodes. Choose the best connector possible. Replace connecting cables regularly. Frequently measure the return loss of the connector to check for degradation, and clean every connector, every time.

All connectors should be treated like the high-quality lens of a good camera. The weak link in instrument and system reliability is often the inappropriate use and care of the connector. Because current connectors are so easy to use, there tends to be reduced vigilance in connector care and cleaning. It takes only one missed cleaning for a piece of grit to permanently damage the glass and ruin the connector.

Measuring insertion loss and return loss

Consistent measurements with your lightwave equipment are a good indication that you have good connections. Since return loss and insertion loss are key factors in determining optical connector performance they can be used to determine connector degradation. A smooth, polished fiber end should produce a good return-loss measurement. The quality of the polish establishes the difference between the “PC” (physical contact) and the “Super PC” connectors. Most connectors today are physical contact which make glass-to-glass connections, therefore it is critical that the area around the glass core be clean and free of scratches. Although the major area of a connector, excluding the glass, may show scratches and wear, if the glass has maintained its polished smoothness, the connector can still provide a good low level return loss connection.

If you test your cables and accessories for insertion loss and return loss upon receipt, and retain the measured data for comparison, you will be able to tell in the future if any degradation has occurred. Typical values are less than 0.5 dB of loss, and sometimes as little as 0.1 dB of loss with high performance connectors. Return loss is a measure of reflection: the less reflection the better (the larger the return loss, the smaller the reflection). The best physically contacting connectors have return losses better than 50 dB, although 30 to 40 dB is more common.

Visual inspection of fiber ends

Visual inspection of fiber ends can be helpful. Contamination or imperfections on the cable end face can be detected as well as cracks or chips in the fiber itself. Use a microscope (100X to 200X magnification) to inspect the entire end face for contamination, raised metal, or dents in the metal as well as any other imperfections. Inspect the fiber for cracks and chips. Visible imperfections not touching the fiber core may not affect performance (unless the imperfections keep the fibers from contacting).

WARNING **Always remove both ends of fiber-optic cables from any instrument, system, or device before visually inspecting the fiber ends. Disable all optical sources before disconnecting fiber-optic cables. Failure to do so may result in permanent injury to your eyes.**

Cleaning Connectors

The procedures in this section provide the proper steps for cleaning fiber-optic cables and Agilent Technologies universal adapters. The initial cleaning, using the alcohol as a solvent, gently removes any grit and oil. If a caked-on layer of material is still present, (this can happen if the beryllium-copper sides of the ferrule retainer get scraped and deposited on the end of the fiber during insertion of the cable), a second cleaning should be performed. It is not uncommon for a cable or connector to require more than one cleaning.

CAUTION Agilent Technologies strongly recommends that index matching compounds *not* be applied to their instruments and accessories. Some compounds, such as gels, may be difficult to remove and can contain damaging particulates. If you think the use of such compounds is necessary, refer to the compound manufacturer for information on application and cleaning procedures.

Table 2-3. Cleaning Accessories

Item	Agilent Part Number
Pure isopropyl alcohol	—
Cotton swabs	8520-0023
Small foam swabs	9300-1223
Compressed dust remover (non-residue)	8500-5262

Table 2-4. Dust Caps Provided with Lightwave Instruments

Item	Agilent Part Number
Laser shutter cap	08145-64521
FC/PC dust cap	08154-44102
Biconic dust cap	08154-44105
DIN dust cap	5040-9364
HMS10/dust cap	5040-9361
ST dust cap	5040-9366

To clean a non-lensed connector

CAUTION Do not use any type of foam swab to clean optical fiber ends. Foam swabs can leave filmy deposits on fiber ends that can degrade performance.

1. Apply pure isopropyl alcohol to a clean lint-free cotton swab or lens paper.

   Cotton swabs can be used as long as no cotton fibers remain on the fiber end after cleaning.

2. Clean the ferrules and other parts of the connector while avoiding the end of the fiber.
3. Apply isopropyl alcohol to a new clean lint-free cotton swab or lens paper.
4. Clean the fiber end with the swab or lens paper.

   Do *not* scrub during this initial cleaning because grit can be caught in the swab and become a gouging element.

5. Immediately dry the fiber end with a clean, dry, lint-free cotton swab or lens paper.
6. Blow across the connector end face from a distance of 6 to 8 inches using filtered, dry, compressed air. Aim the compressed air at a shallow angle to the fiber end face.

   Nitrogen gas or compressed dust remover can also be used.

CAUTION

Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

7 As soon as the connector is dry, connect or cover it for later use.

If the performance, after the initial cleaning, seems poor try cleaning the connector again. Often a second cleaning will restore proper performance. The second cleaning should be more arduous with a scrubbing action.

To clean an adapter

The fiber-optic input and output connectors on many Agilent Technologies instruments employ a universal adapter such as those shown in the following picture. These adapters allow you to connect the instrument to different types of fiber-optic cables.

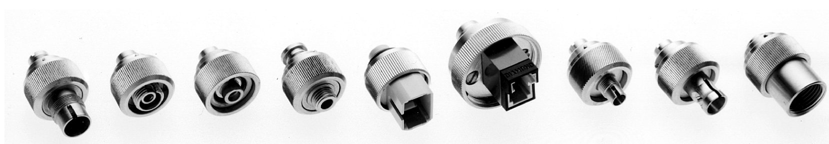


Figure 2-10. Universal adapters.

1 Apply isopropyl alcohol to a clean foam swab.

Cotton swabs can be used as long as no cotton fibers remain after cleaning. The foam swabs listed in this section's introduction are small enough to fit into adapters.

Although foam swabs can leave filmy deposits, these deposits are very thin, and the risk of other contamination buildup on the inside of adapters greatly outweighs the risk of contamination by foam swabs.

2 Clean the adapter with the foam swab.

3 Dry the inside of the adapter with a clean, dry, foam swab.

4 Blow through the adapter using filtered, dry, compressed air.

Nitrogen gas or compressed dust remover can also be used. Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

Theory of Operation

Agilent 83402C and Agilent 83403C sources

The lightwave sources consist of a laser diode, bias circuitry, and control circuitry. An attenuator and impedance matching network blocks the DC component from the RF input that modulates the laser light. The laser diode is made from InGaAsP (Indium Gallium Arsenide Phosphide) and has a corresponding back-face diode that is used to control or stabilize the lightwave output. Notice that the laser creates light in both directions. The back-face diode senses the laser output and sends a proportional current into the level control circuit. This level control circuit sends more or less current through the coil to adjust the bias current that controls the laser output.

The thermal control circuit uses a temperature sensor and a thermal electric cooler to keep the laser at a steady ambient temperature. If the temperature of the laser deviates from the present temperature by more than 5 degrees, the thermal control circuit sends a signal to the level control circuit, which then shuts down the laser. When this happens, the TEMP LED on the front panel goes on.

The source also has a remote shut-down connector (BNC short) that, when removed, turns off the laser. If properly used, this feature allows you to turn the laser off from a distance. You will have to provide your own coaxial cable with BNC connectors and, if desired, an appropriate switch or circuit. A typical example would be a laser setup in a room where you do not want anyone entering while the laser is on. You could control the laser so that when the door is opened, the remote shut-down connector is opened, and the laser automatically turns off.

The DC IN connector provides power to the instrument from the Agilent 8702A/B/D front-panel PROBE POWER connector or by a separate compatible power supply.

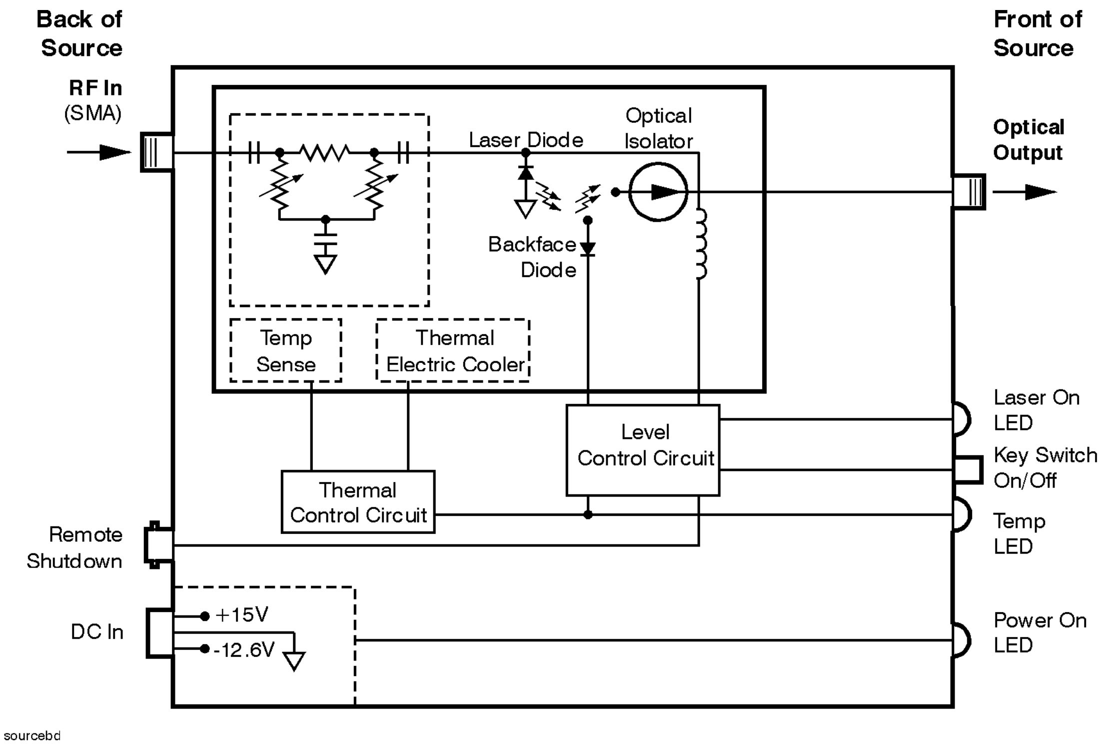


Figure 2-11. Source block diagram

Agilent 83410C, 83411C/D, and 83412B receivers

The lightwave receivers consist of an optical input connector and fiber, launch objects, a PIN diode detector, a thin-film hybrid amplifier, and one DC circuit board. The receiver's input is a keyed HMS 10 connector with a graded index fiber (9 µm for the Agilent 83411C/D receivers, 62.5 µm for the Agilent 83410C and 83412B receivers) that is terminated into a graded index lens. The design provides good environmental sealing and allows a low loss and low reflection signal coupling to the diode.

The PIN diode has high linearity, wide bandwidth, and low dark current. Notice that it is directly coupled into the first amplifier stage. This physically small low impedance connection limits the effect of standing waves and diode capacitance on the frequency response of the receiver. Three AC (capacitor) coupled 50 ohm amplifiers follow the first amplifier stage.

Active bias circuitry is used in the first amplifier stage to hold its DC bias fixed, while the DC photocurrent from the PIN diode varies. A combination threshold/hysteresis function on the DC board monitors the output of the active bias current and uses the signal to light the OVER ILLUMINATION LED if the average optical input power exceeds 3.5 mW. If the input power continues to increase, the receiver goes into an unspecified state and measurement data will be invalid. If average power exceeds 5 mW, permanent damage could result.

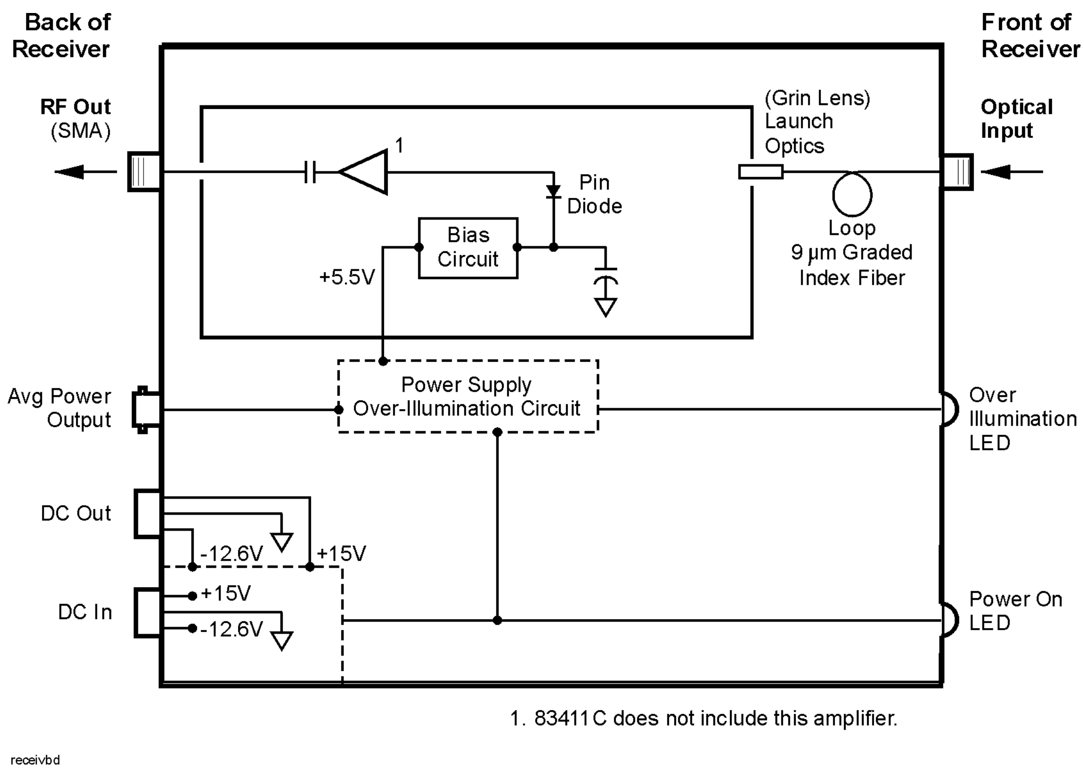


Figure 2-12. Agilent 83411C/D block diagram

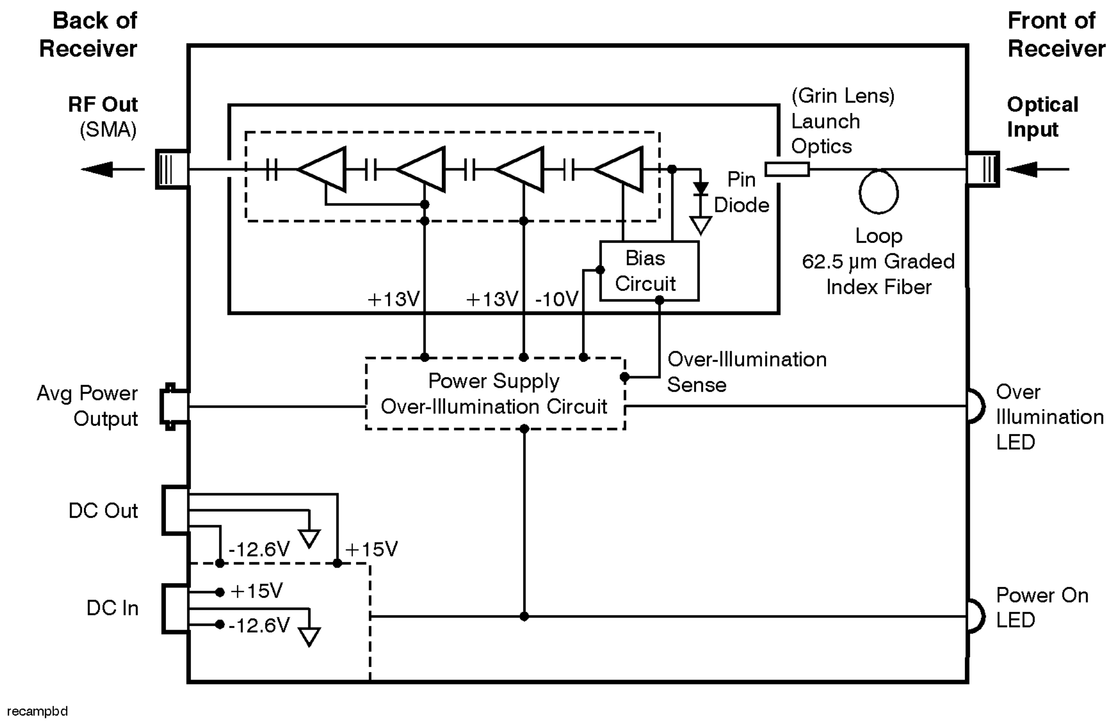


Figure 2-13. Agilent 83410C and 83412B block diagram

Returning the Instrument for Service

The instructions in this section show you how to properly return the instrument for repair or calibration. Always call the Agilent Technologies Instrument Support Center first to initiate service *before* returning your instrument to a service office. This ensures that the repair (or calibration) can be properly tracked and that your instrument will be returned to you as quickly as possible. Call this number regardless of where you are located. Refer to "Agilent Technologies Service Offices" on page 2-28 for a list of service offices.

Agilent Technologies Instrument Support Center. . . . . (800) 403-0801

If the instrument is still under warranty or is covered by an Agilent Technologies maintenance contract, it will be repaired under the terms of the warranty or contract (the warranty is at the front of this manual). If the instrument is no longer under warranty or is not covered by an Agilent Technologies maintenance plan, Agilent Technologies will notify you of the cost of the repair after examining the unit.

When an instrument is returned to a Agilent Technologies service office for servicing, it must be adequately packaged and have a complete description of the failure symptoms attached. When describing the failure, please be as specific as possible about the nature of the problem. Include copies of additional failure information (such as the instrument failure settings, data related to instrument failure, and error messages) along with the instrument being returned.

Preparing the instrument for shipping

1 Write a complete description of the failure and attach it to the instrument. Include any specific performance details related to the problem. The following

information should be returned with the instrument.

- Type of service required.
- Date instrument was returned for repair.
- Description of the problem:
  - Whether problem is constant or intermittent.
  - Whether instrument is temperature-sensitive.
  - Whether instrument is vibration-sensitive.
  - Instrument settings required to reproduce the problem.
  - Performance data.
- Company name and return address.
- Name and phone number of technical contact person.
- Model number of returned instrument.
- Full serial number of returned instrument.
- List of any accessories returned with instrument.

2 Cover all front or rear-panel connectors that were originally covered when you first received the instrument.

CAUTION Cover electrical connectors to protect sensitive components from electrostatic damage. Cover optical connectors to protect them from damage due to physical contact or dust.

CAUTION Instrument damage can result from using packaging materials other than the original materials. Never use styrene pellets as packaging material. They do not adequately cushion the instrument or prevent it from shifting in the carton. They may also cause instrument damage by generating static electricity.

3 Pack the instrument in the original shipping containers. Original materials are available through any Agilent Technologies office. Or, use the following guidelines:

- Wrap the instrument in antistatic plastic to reduce the possibility of damage caused by electrostatic discharge.
- For instruments weighing less than 54 kg (120 lb), use a double-walled, corrugated cardboard carton of 159 kg (350 lb) test strength.
- The carton must be large enough to allow approximately 7 cm (3 inches) on all sides of the instrument for packing material, and strong enough to accommodate the weight of the instrument.
- Surround the equipment with approximately 7 cm (3 inches) of packing material, to protect the instrument and prevent it from moving in the carton. If packing foam is not available, the best alternative is S.D-240 Air Cap™ from

Sealed Air Corporation (Commerce, California 90001). Air Cap looks like a plastic sheet filled with air bubbles. Use the pink (antistatic) Air Cap™ to reduce static electricity. Wrapping the instrument several times in this material will protect the instrument and prevent it from moving in the carton.

4 Seal the carton with strong nylon adhesive tape.

5 Mark the carton "FRAGILE, HANDLE WITH CARE".

6 Retain copies of all shipping papers.

Agilent Technologies Service Offices

Before returning an instrument for service, call the Agilent Technologies Instrument Support Center at (800) 403-0801, visit the Test and Measurement Web Sites by Country page at http://www.tm.agilent.com/tmo/country/English/index.html, or call one of the numbers listed below.

Agilent Technologies Service Numbers

Austria	01/25125-7171
Belgium	32-2-778.37.71
Brazil	(11) 7297-8600
China	86 10 6261 3819
Denmark	45 99 12 88
Finland	358-10-855-2360
France	01.69.82.66.66
Germany	0180/524-6330
India	080-34 35788
Italy	+39 02 9212 2701
Ireland	01 615 8222
Japan	(81)-426-56-7832
Korea	82/2-3770-0419
Mexico	(5) 258-4826
Netherlands	020-547 6463
Norway	22 73 57 59
Russia	+7-095-797-3930
Spain	(34/91) 631 1213
Sweden	08-5064 8700
Switzerland	(01) 735 7200
United Kingdom	01 344 366666
United States and Canada	(800) 403-0801

3

Specifications and Regulatory Information

Specifications and Regulatory Information

This chapter lists specifications and characteristics of the instruments and also includes regulatory information pertaining to the instruments. Specifications describe warranted performance over the temperature range 25°C ±5°C and relative humidity <95% (unless otherwise noted). All specifications apply after the instrument's temperature has been stabilized after 1 hour of continuous operation, and that the optical connector adapter used is an HMS 10 Diamond.

Specifications

Specifications describe warranted performance.

Characteristics

Characteristics provide useful, but nonwarranted, information about the functions and performance of the instrument. *Characteristics are printed in italics.*

Calibration cycle

Agilent Technologies warrants instrument specifications over the recommended calibration interval. To maintain specifications, periodic recalibrations are necessary. We recommend that Agilent 83411C/D receivers be calibrated at an Agilent Technologies service facility every 24 months. We recommend that all other sources and receivers be calibrated every 12 months.

Specifications for Sources

The following section includes specifications and characteristics of the Agilent 83400-series sources.

Specifications and *Characteristics* for Sources (1 of 2)

Specification/*Characteristic*	**83402C**	**83403C**
WAVELENGTH		
Center Wavelength [a,b]	1310 ±30 nm	1550 ±30 nm
Center Wavelength Stability [b]	*0.3% per year*	*0.3% per year*
Spectral Width (maximum) [a,b]	*< 50 MHz*	*< 50 MHz*
POWER		
Average Power Out [a,b]	2000 µW – 3000 µW	2000 µW – 3000 µW
Optical Port Match (return loss) [c] *(characteristics)*	*≥ 35.0 dBo*	*≥ 35.0 dBo*
MODULATION		
RF Input Power (maximum) (characteristics)	*+11 dBm*	*+11 dBm*
DC into RF Port (maximum)	20 V	20 V
Electrical Input Port Match (return loss) [d]	≥ 11 dB	≥ 11 dB
Modulation Frequency Response [a] 300 kHz to 6 GHz Corrected (disk) *Corrected (polynomial) (characteristic)* *Uncorrected (characteristic)*	 ±0.5 dBe *±1.5 dBe* *+0.2/–4.8 dBe*	 ±0.5 dBe *±1.5 dBe* *+0.2/–4.8 dBe*
Responsivity at 140 MHz Modulation Frequency (characteristics)	*0.038 W/A* *(–28 dBe)*	*0.038 W/A* *(–28 dBe)*
Modulation (harmonic) Distortion [e] *(characteristics)* *RF power +10 dBm* *300 kHz to 1 GHz* *1 GHz to 3 GHz* *3 GHz to 6 GHz*	 *25.0 dBc* [f] *8.0 dBc*	 *25.0 dBc* [f] *8.0 dBc*
Third Order Intercept (minimum) [e] (characteristics)	*23 dBm*	23 dBm

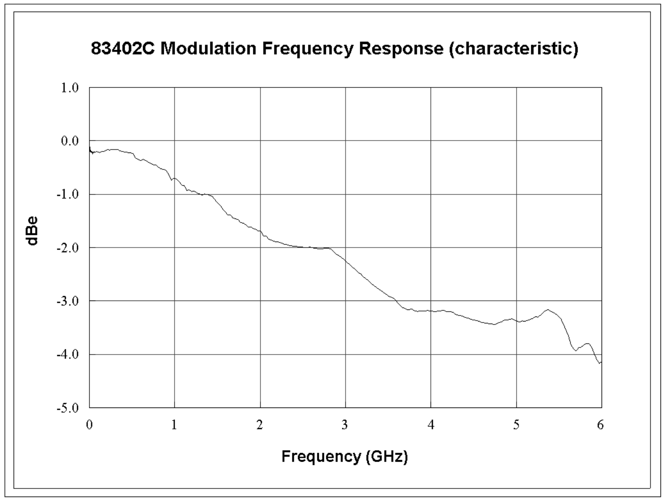
Specifications and *Characteristics* for Sources (2 of 2)

Specification/*Characteristic*	**83402C**	**83403C**
Equivalent Input Noise (characteristics)		
0.01 to 5 GHz	–124 dBm/Hz	–124 dBm/Hz
5 to 6 GHz	–119 dBm/Hz	–119 dBm/Hz
Reflection Sensitivity [g] (characteristics)		
300 kHz to 6 GHz	*±0.04 dBe*	*±0.04 dBe*
LASER CLASSIFICATION	FDA Laser Class III according to 21 CFR 1040.10. IEC Laser Class 3B according to IEC 60825.	FDA Laser Class I according to 21 CFR 1040.10. IEC Laser Class 1 according to IEC 60825.

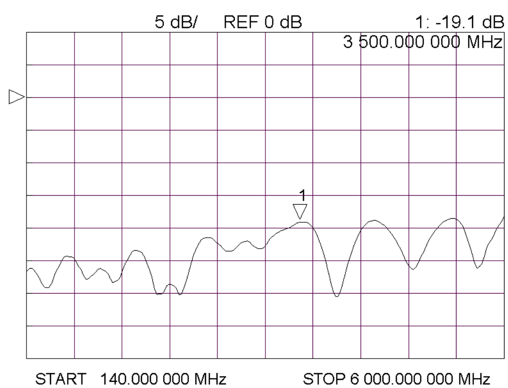
a. Factory test system.
b. No intensity modulation applied.
c. Measured with Agilent 8153A and Agilent 81534A return loss module.
d. Measured on Agilent 8703 from 130 MHz to 6 GHz.
e. Measured with +10 dBm RF input power, 0.01 to 6 GHz.
f. Changes linearly from 25 dBc at 1 GHz to 8 dBc at 3 GHz.
g. To a Fresnel reflection using a 9:1 optical coupler, averaging factor = 16.

Note

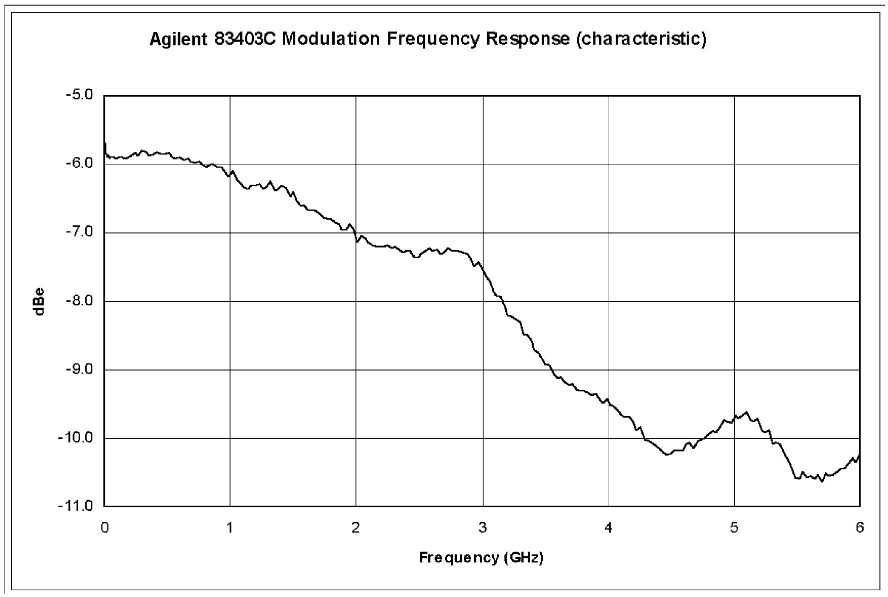
For the following graphs, all X-axis data begins at 0.0003 GHz.



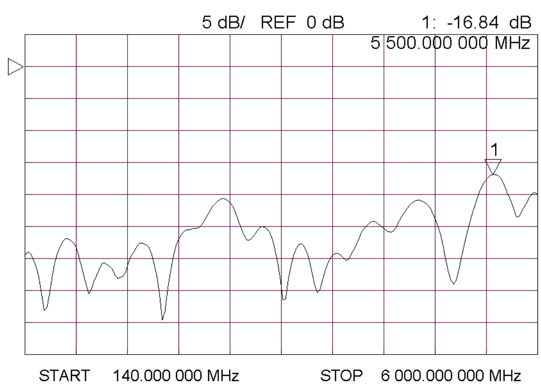
Agilent 83402C: Modulation frequency response *(characteristic)*



Agilent 83402C: Electrical input port return loss *(characteristic)*



Agilent 83403C: Modulation frequency response *(characteristic)*



Agilent 83403C: Electrical input port return loss *(characteristic)*

Specifications for Receivers

In the following table, demodulation frequency response values are determined as defined by the following equation:

$$1\ dB\ (A/W) = 20\log\frac{linear\ responsivity}{1\ (A/W)}$$

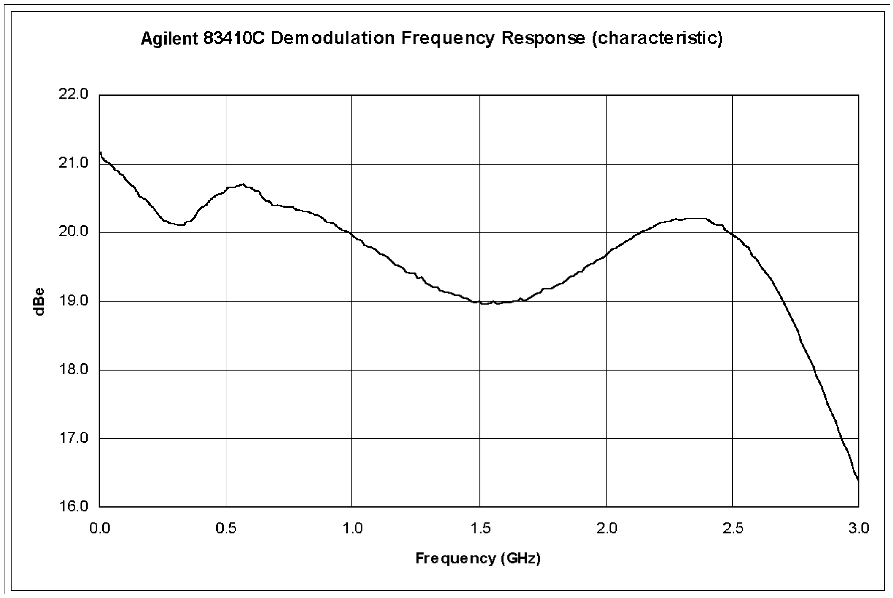
Specifications and *Characteristics* for Receivers (1 of 2)

Specification/*Characteristic*	**83410C**	**83411C**	**83411D**	**83412B**
OPTICAL PORT				
Optical Port Match (return loss)[a] *(characteristic)*	*≥ 30 dB*	*≥ 30 dB*	*≥ 30 dB*	*≥ 30 dB*
Maximum Average Optical Input Power	5 mW	5 mW	5 mW	5 mW
Responsivity (characteristic)				
850 nm	–	–	–	*16.5 dB, 6.5 A/W*
1300 nm and 1550 nm	*20 dB, 10 A/W*	–	–	–
1300 nm	–	*–7 dB, 0.45 A/W*	*17.0 dB, 7.0 A/W*	–
1550 nm	–	*–8 dB, 0.40 A/W*	*16.0 dB, 6.3 A/W*	–
ELECTRICAL PORT				
Electrical Input Port Match (return loss)				
300 kHz to 3 GHz	≥ 13 dB	–	–	≥ 13 dB
300 kHz to 6 GHz	–	≥ 13 dB	≥ 9.0 dB	–
DC into RF Port (maximum)	20 V	20 V	20 V	20 V
Reverse RF Power Into RF OUT	20 dBm	20 dBm	20 dBm	20 dBm
DEMODULATION				
Dynamic Accuracy (characteristics)				
300 kHz to 2 GHz				
0 to 30 dB Optical Attenuation	*±1.5 dB*[b]	–	–	–
0 to 40 dB Optical Attenuation	*±1.5 dB*[c]	–	–	*± 1.5 dB*

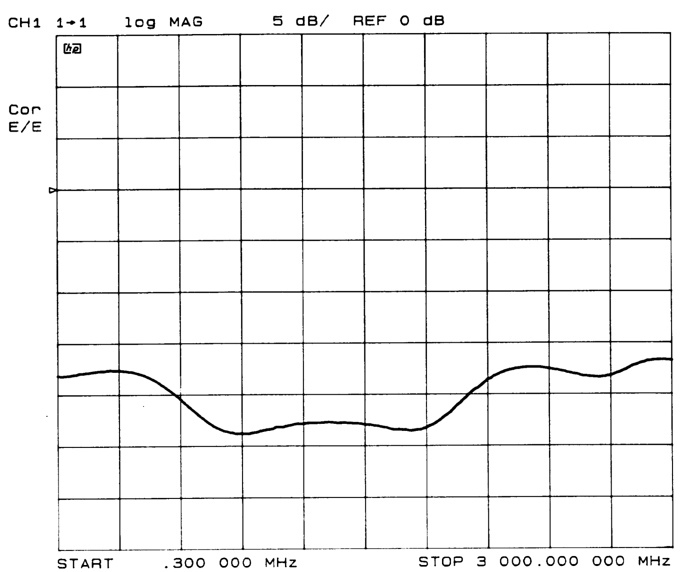
Specifications and *Characteristics* for Receivers (2 of 2)

Specification/*Characteristic*	**83410C**	**83411C**	**83411D**	**83412B**
300 kHz to 3 GHz				
0 to 20 dB Optical Attenuation	–	*± 1.5 dB* [b]	–	–
0 to 25 dB Optical Attenuation	–	*± 1.5 dB* [c]	–	–
0 to 30 dB Optical Attenuation	–	–	*± 1.5 dB*	–
2 GHz to 3 GHz				
0 to 40 dB Optical Attenuation	*± 2.0 dB* [c]	*± 2.0 dB* [c]	–	*± 2.0 dB*
3 GHz to 6 GHz				
0 to 20 dB Optical Attenuation	–	*± 1.5 dB* [c]	–	–
0 to 25 dB Optical Attenuation	–	–	*± 2.0 dB* [c]	–
Demodulation Frequency Response				
Corrected (disk)				
300 kHz to 2.5 GHz	±0.5 dBe [c]	–	–	–
2.5 GHz to 3 GHz	±0.6 dBe [c]	–	–	–
300 kHz to 3 GHz (characteristic)	–	–	–	*±0.5 dBe (Char.)*
300 kHz to 6 GHz	–	±0.5 dBe [c]	±0.5 dBe [c]	–
Corrected (polynomial) (characteristic)				
300 kHz to 2 GHz	*±1.5 dBe* [c]	–	–	*±2.5 dBe*
2 GHz to 3 GHz	*±1.5 dBe* [c]	–	–	*±1.5 dBe*
300 kHz to 6 GHz	–	*±1.5 dBe* [c]	*±1.5 dBe* [c]	–
Uncorrected (characteristic)				
300 kHz to 2 GHz	*±3.0 dBe* [c]	–	–	*±3.0 dBe*
2 GHz to 3 GHz	*+3.0/–12.0 dBe* [c]	–	–	*+3.0/–13.0 dBe*
300 kHz to 6 GHz	–	*+2.0/–3.0 dBe* [c]	*±3.0 dBe* [c]	–
Harmonic Distortion (with –5 dBm output power) (characteristic)				
300 kHz to 3 GHz	*25 dBc*	–	–	*25 dBc*
300 kHz to 6 GHz	–	*25 dBc*	*25 dBc*	–
Compression Level (characteristic) (1 dB) (electrical output power)				
300 kHz to 2 GHz	*> 1 mW*	–	*> 5 mW*	*> 1 mW*
Average Power Out (characteristic)				
Scale	*2 V/mW*	*2 V/mW*	*2 V/mW*	*2 V/mW*
Offset	*50 mV*	*1 mV*	*1 mV*	*50 mV*
Average Output Noise (characteristic)	*– 135 dBm/Hz*	*–135 dBm/Hz*	*–85 dBm/Hz*	*– 135 dBm/Hz*

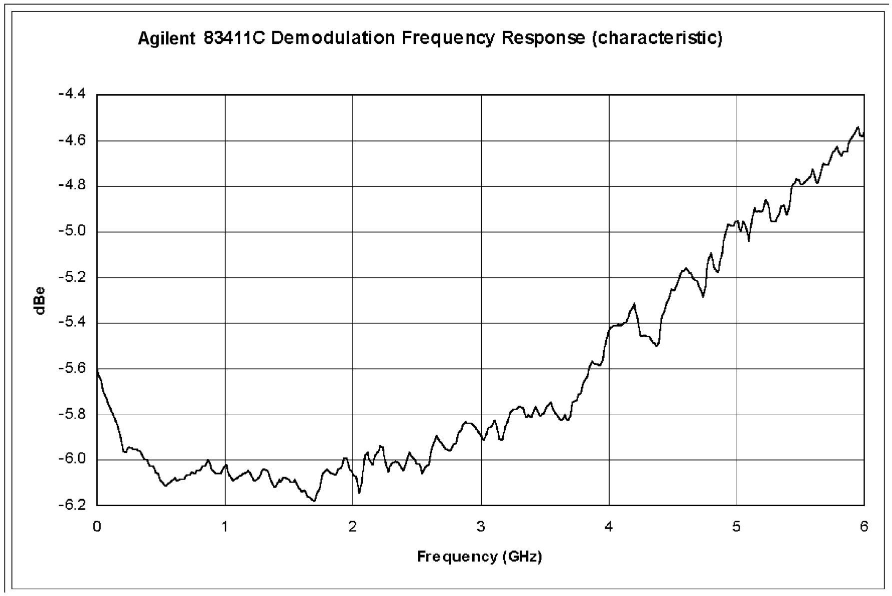
a. Measured on an Agilent 8702 system using time domain
b. 1550 nm
c. 1300 nm



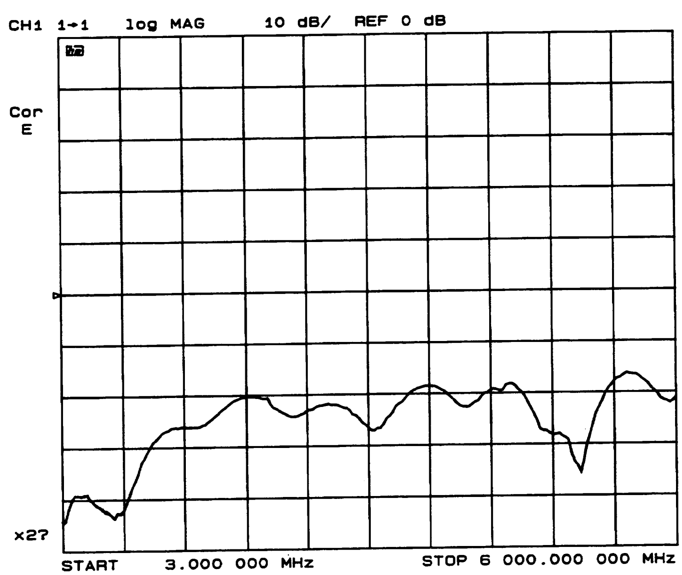
Agilent 83410C: Demodulation frequency response *(characteristic)*



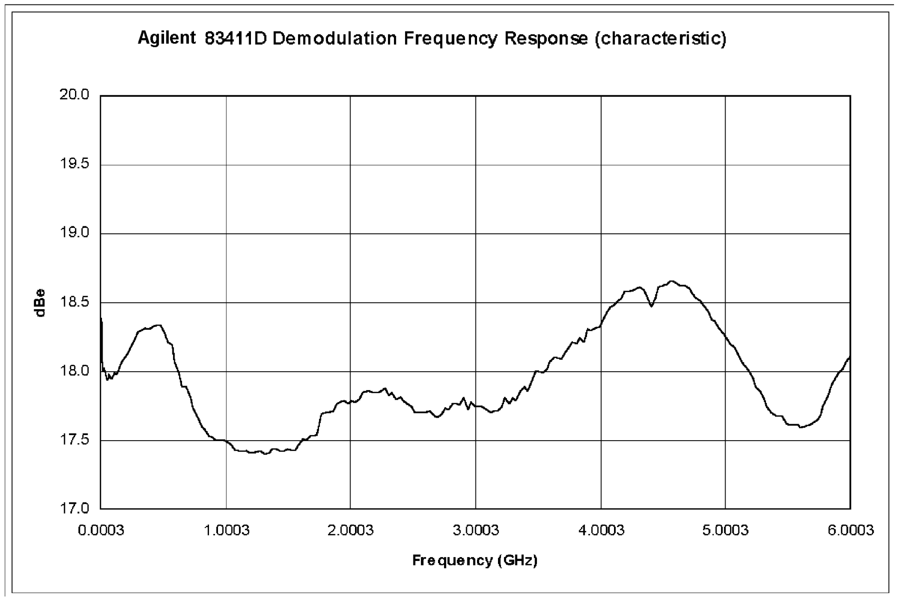
Agilent 83410C: Electrical output port return loss *(characteristic)*



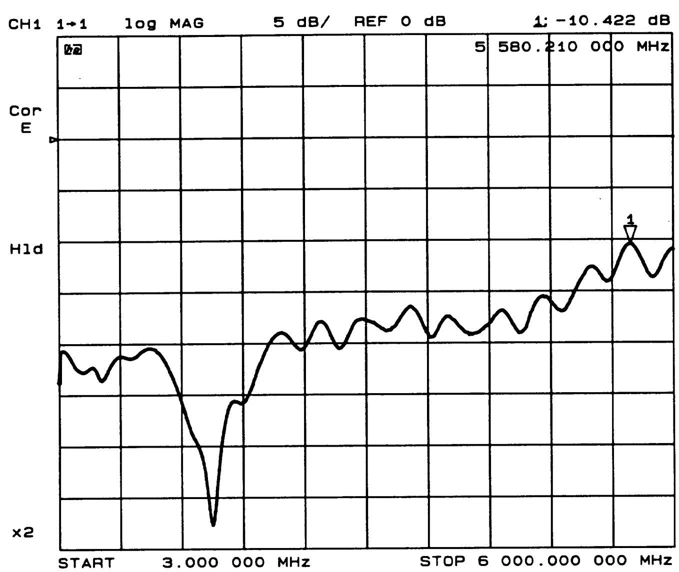
Agilent 83411C: Demodulation frequency response *(characteristic)*



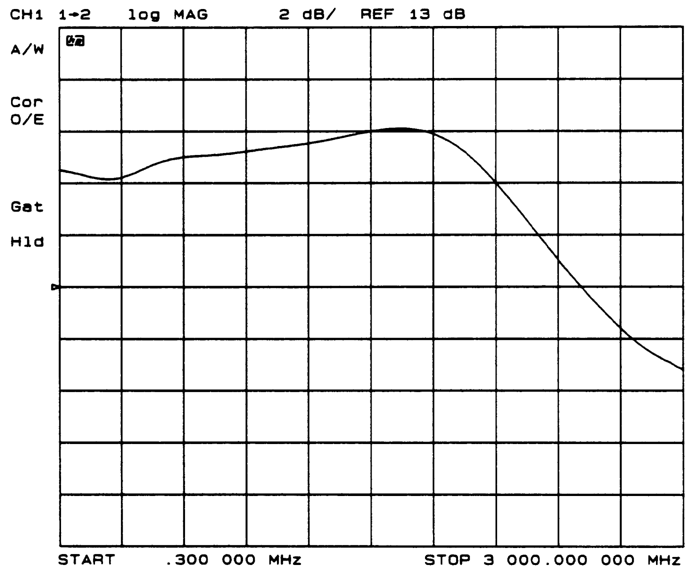
Agilent 83411C: Electrical output port return loss *(characteristic)*



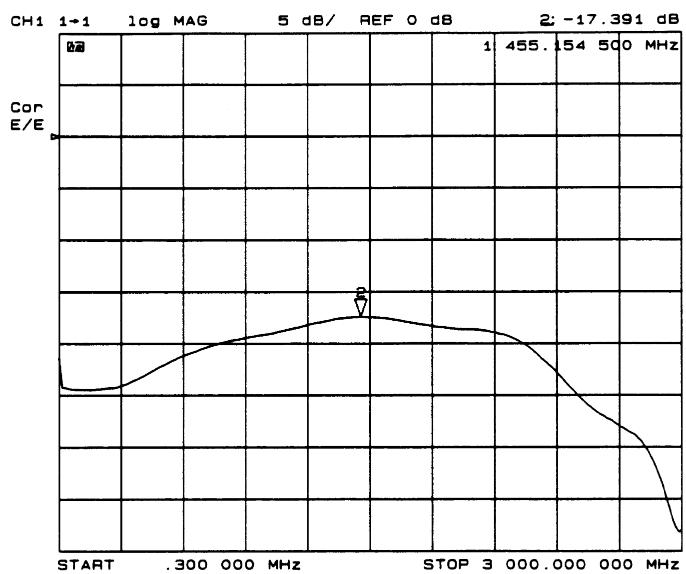
Agilent 83411D: Demodulation frequency response *(characteristic)*



Agilent 83411D: Electrical output port return loss *(characteristic)*



Agilent 83412B: Demodulation frequency response *(characteristic)*



Agilent 83412B: Electrical output port return loss *(characteristic)*

Operating Specifications for Sources and Receivers

Use	Indoor
Voltage (DC power input)	–12.6 V ±5% +15 V ±5%
Temperature Limits	
Operating [a]	0°C to +55°C
Non-operating	–40° to +55°C
Maximum relative humidity	< 95%
Weight	1.5 kg (3.3 lb)
Dimensions (H x W x D)	8.5 x 8.5 x 23 cm (3.3 x 3.3 x 9.1 in)

a. This temperature range describes the operating limits of the instrument. Specifications and characteristics apply over the reduced temperature range as described on page 3-2.

Regulatory Information

- Laser Classification:
  - The Agilent 83402C is classified as an FDA LASER Class IIIb (IEC LASER Class 3B).
  - The Agilent 83403C is classified as an FDA LASER Class I (IEC LASER Class 1).
- The lightwave sources comply with 21 CFR 1040.10 and CE/IEC 825-1: 1993.
- The products described in this manual are designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 61010 and 60664 respectively.

Notice for Germany: Noise Declaration

This is to declare that this instrument is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermverordnumg –3.GSGV Deutschland).

Acoustic Noise Emission	Geraeuschemission
LpA < 70 dB Operator position Normal position per ISO 7779	LpA < 70 dB am Arbeitsplatz normaler Betrieb nach DIN 45635 t.19

DECLARATION OF CONFORMITY

acccording to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name:	Hewlett-Packard Co.
Manufacturer's Address:	1400 Fountaingrove Parkway Santa Rosa, CA 95403-1799 USA

declares that the products:

Product Name:	Lightwave Sources
Model Number:	HP 83402C, HP 83403C
Product Options:	This declaration covers all options of the above products.

conform to the following Product specificiations:

Safety	IEC 1010-1:1990+A1 /EN 61010-1:1993 CAN/CSA-C22.2 No. 1010.1-92
EMC:	CISPR 11:1990/EN 55011:1991 Group 1, Class A IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD IEC 801-3:1984/EN 50082-1:1992 3V/m, 27-500 MHz IEC 801-4:1984/EN 50082-1:1992 0.5 kV sig. lines, 1 kV power lines IEC 1000-3-2:1995 / EN 61000-3-2:1995 IEC 1000-3-3:1994 / EN 61000-3-3:1995

Supplementary Information:
The products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carry the CE-marking accordingly.

Santa Rosa, CA, USA   23 June 1997

John Hiatt/Quality Engineering Manager

European Contact: Your local Hewlett-Pckard Sales and Service Office or Hewlett-Packard GmbH, Department HQ-TRE, Herrenberger Strasse 130, D-71034 Böblingen, Germany (Fax +49-7031-14-3143)

Declaration of conformity (sources)

DECLARATION OF CONFORMITY
according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Co.

Manufacturer's Address: 1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799
USA

declares that the product:

Product Name: Lightwave Receiver Modules

Model Number: HP 83410C, HP 83411C, HP 83411D, HP 83412B

Product Options: This declaration covers all options of the above product.

conforms to the following Product specifications:

Safety: IEC 348:1978/HD 401:1980
CAN/CSA-C22.2 No. 231 Series-M89

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 3 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV Sig. Lines, 1 kV Power Lines
IEC 1000-3-2:1995 / EN 61000-3-2:1995
IEC 1000-3-3:1994 / EN 61000-3-3:1994

Supplementary Information:

These products herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC. Safety qualification of these products was performed prior to 1 December 1993.

Santa Rosa, California, USA 2/6/96

Dixon Browder/Quality Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ/Standards Europe, Herrenberger Strasse 130, D-71034 Böblingen, Germany (FAX: +49-7031-14-3143)

Declaration of conformity (receivers)

Performance Tests

Performance Tests

The procedures in this section test the Agilent 83400-series performance using the specifications listed in Chapter 3, "Specifications and Regulatory Information" as the performance standard. None of these tests require access to the interior of the instrument. Before beginning any tests, be sure to observe the following points:

- Use an optical cable with a Diamond HMS-10 connector. Other connector types may have greater return loss or may cause reflections resulting in measurement errors.
- Be sure that all optical connections are clean. Refer to "Cleaning Connections for Accurate Measurements" on page 2-11.
- Allow the source or receiver to warm up for 1 hour before doing any of the performance tests.

WARNING **Do NOT, under any circumstances, look into the optical output or any fiber/device attached to the output while the laser is in operation.**

Calibration cycle

Agilent Technologies warrants instrument specifications over the recommended calibration interval. To maintain specifications, periodic recalibrations are necessary. We recommend that Agilent 83411C/D receivers be calibrated at an Agilent Technologies service facility every 24 months. We recommend that all other sources and receivers be calibrated every 12 months.

Table 4-1. Required Equipment for Performance Tests

Instrument	Recommended Agilent Technologies Model	83402C 83403C	83410C	83411C/D	83412B
Optical Spectrum Analyzer	71450 series	•			
Polarization Controller	11896A			•	
Lightwave Component Analyzer	8702 8702 Option 006	 •	• 	 •	•
APC 7 mm to 3.5 mm Adapter		•	•	•	•
Lightwave Power Meter	8153A	•			
Optical Attenuator	8156A		•	•	•
Lightwave Source 1300 nm 1550 nm 850 nm	 83400/2 83403 83404		 • • 	 • • 	 •
Reference Receiver[a]			•	•	•

a. Characterized using a dual heterodyne YAG system (available only at the factory).

Tests for Sources

1. Center Wavelength and Spectral Width

To perform this test, you need an Agilent 71450A/B-series optical spectrum analyzer. These optical spectrum analyzers come with an advanced measurement program which automatically characterizes DFB lasers. Do *not* modulate the source during this procedure.

1 Connect the equipment as shown in Figure 4-1.

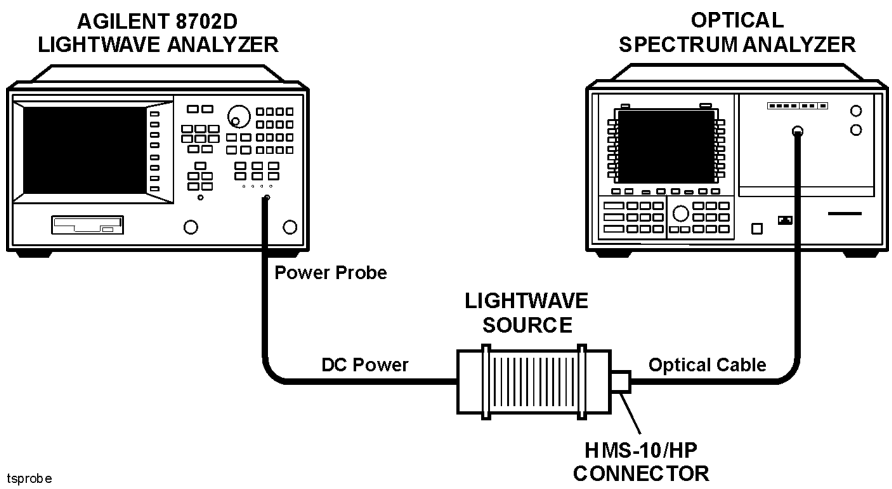


Figure 4-1. Center wavelength and spectral width test setup

2 Turn on the Agilent 83400-series source and the optical spectrum analyzer, and allow them to warm up for 1 hour.

3 Connect the output of the source to the optical spectrum analyzer's input using a 9 µm fiber-optic cable.

4 On the optical spectrum analyzer, press the AUTO MEAS key.

5 Compare the measured values to the specified values listed in Chapter 3, "Specifications and Regulatory Information".

2. Average Output Power

Do *not* modulate the source during this procedure.

1 Connect the equipment as shown in Figure 4-2.

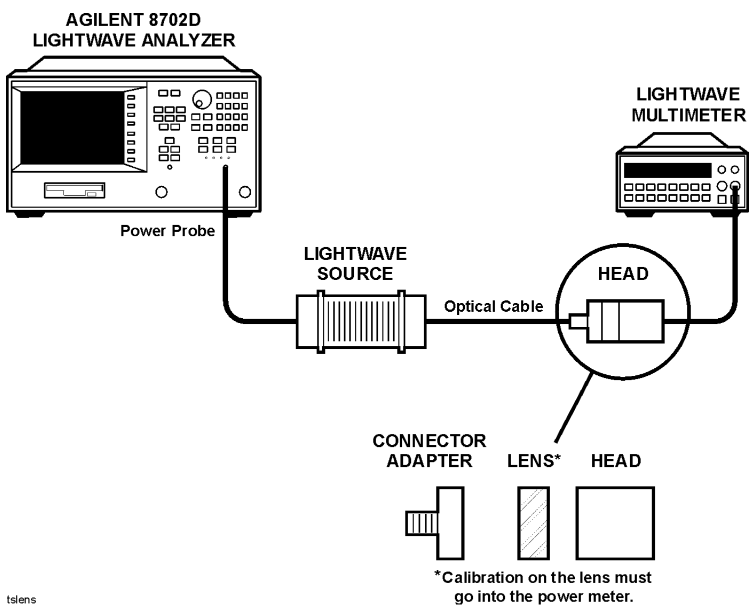


Figure 4-2. Average output power test setup

2 Turn on the Agilent 83400-series source and an optical power meter, and allow them to warm up for 1 hour.

3 Calibrate the optical power meter, and then measure the output power of the source. Compare the measured value to the specified power level listed in Chapter 3, "Specifications and Regulatory Information".

3. Electrical Input Port Match

1 Connect the equipment as shown in Figure 4-3.

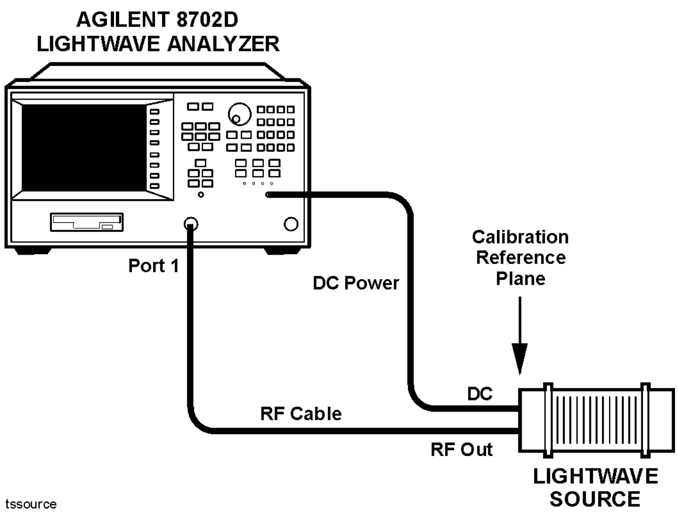


Figure 4-3. Electrical input port match test setup

2 Turn on the equipment, and allow them to warm up for 1 hour.

3 Use the Agilent 8702D's "Guided Setup" feature to perform an electrical-to-electrical response test. Use the following settings:

Start frequency: . . . . 300 kHz
Stop frequency (Agilent 83403C): . . . . 3 GHz
Stop frequency (Agilent 83402C): . . . . 6 GHz
Stimulus power: . . . . 10 dBm
IF bandwidth: . . . . 100 Hz

4 The guided setup routine will step you through an S11, 1-port, electrical calibration.

5 Place the Agilent 8702D in single-sweep mode, and use the marker functions to locate the peak of the response.

6 Compare the measurement with the specification listed in Chapter 3, "Specifications and Regulatory Information".

Tests for Receivers

1. Demodulation Frequency Response

This performance test requires the use of a special lightwave reference receiver that is calibrated using a dual-hetrodyne YAG system. Since these reference receivers are not commercially available, your instrument must be returned to the factory to verify this specification.

2. RF Port Match

1 Connect the equipment as shown in Figure 4-4.

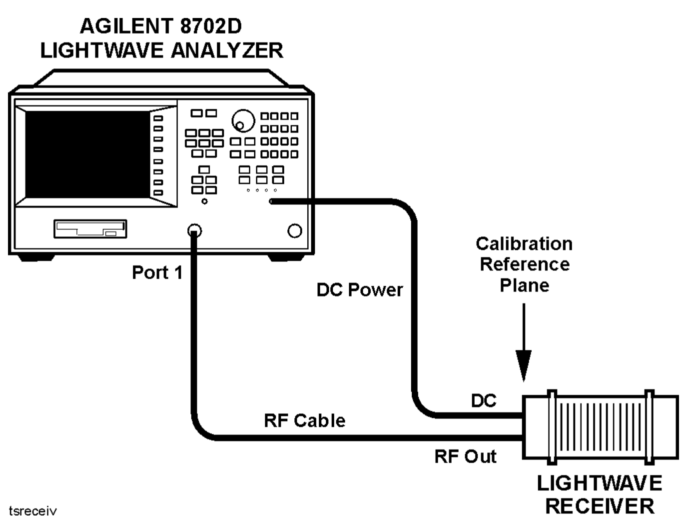


Figure 4-4. RF port match test setup

2 Turn on the equipment, and allow them to warm up for 1 hour.

3 Use the Agilent 8702D's "Guided Setup" feature to perform an electrical-to-electrical response test. Use the following settings:

Start frequency: . . . . .300 kHz
Stop frequency (Agilent 83410C/2B): . . . . .3 GHz
Stop frequency (Agilent 83411C/D): . . . . .6 GHz
Stimulus power: . . . . 10 dBm
IF bandwidth: . . . . 100 Hz

4 The guided setup routine will step you through an S11, 1-port, electrical calibration.

5 Place the Agilent 8702D in single-sweep mode, and use the marker functions to locate the peak of the response.

6 Compare the measurement with the specification listed in Chapter 3, "Specifications and Regulatory Information".

3. Dynamic Accuracy

Dynamic accuracy is not a specified performance parameter. However, this procedure is provided for comparison with the characteristic value.

1 Connect the system as shown in Figure 4-5.

2 Turn on the equipment, and allow them to warm up for 1 hour.

3 Set the Agilent 8702D to the following settings:

Start frequency: . . . . .300 kHz
Stop frequency:. . . . . .3 GHz
Stimulus power: . . . . 0 dBm
IF bandwidth: . . . . 10 Hz

4 When adjusting the power level in the previous step, set the optical attenuator so that the maximum E/E trace shown on the Agilent 8702D is –5 dBm (±0.2 dBm). This is the 0 dBm optical attenuation level.

5 Set the optical attenuator to –10 dB (optical) below the 0 dB level. On the Agilent 8702D, read the E/E trace as 20 dB below the trace level set in the previous step.

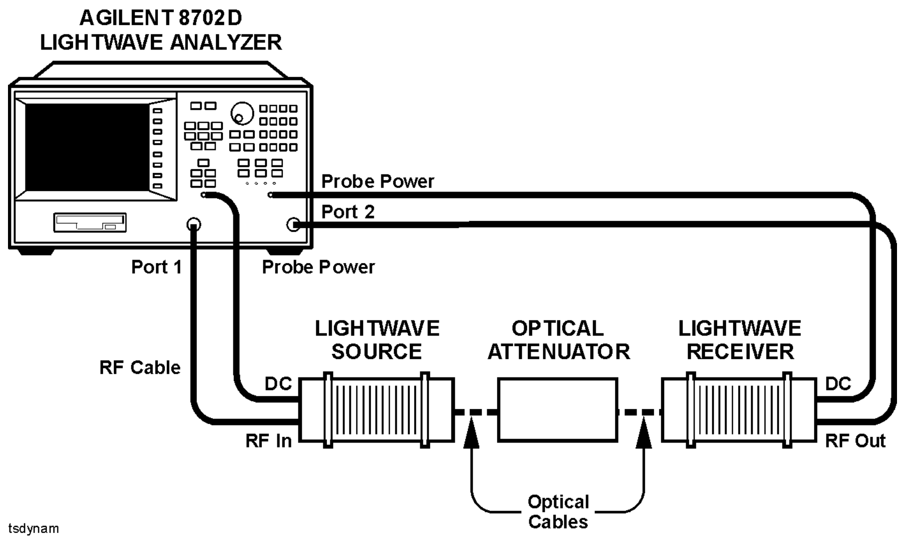


Figure 4-5. Dynamic accuracy test setup

6 Use the Agilent 8702D's "Guided Setup" feature to begin an optical bandwidth (transmission) test.

During the isolation calibration portion of the guided setup routine, temporarily set the attenuator to 0 dB attenuation. Also, turn on averaging, and set its value to 10 averages. After calibration, turn averaging off.

7 After completing the guided setup procedure, step the optical attenuator in 10 dB increments starting at 0 dB. At each step, adjust the Agilent 8702D's reference level as shown in the following list:

0 dB level: ref level = +20 dB
10 dB optical attenuation: ref level = 0 dB
20 dB optical attenuation: ref level = –20 dB
30 dB optical attenuation: ref level = –40 dB
40 dB optical attenuation: ref level = –60 dB
(1300 nm wavelength only)

Determine the maximum difference between the trace and the reference line at each 10 dB increment. Compare the measured value with the specification listed in Chapter 3, "Specifications and Regulatory Information". On the –40 dB step, add 1% smoothing. Use up to 20 averages, if necessary.

Additional Steps for 83411C/D

Repeat the procedure using a start frequency of 3 GHz and a stop frequency of 6 GHz. Insert a polarization controller between the lightwave source and the optical attenuator as shown in Figure 4-6.

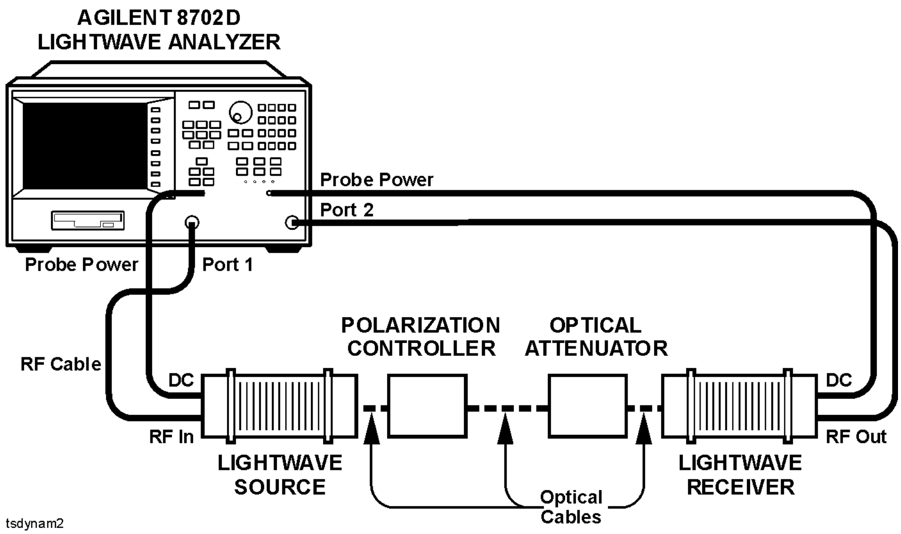


Figure 4-6. Dynamic accuracy test setup for 6 GHz modulation frequency range

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