Errata

Title & Document Type: 83402A Lightwave Source Operating and Service Manual

Manual Part Number: 83402-90001

Revision Date: 1988-11-01

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

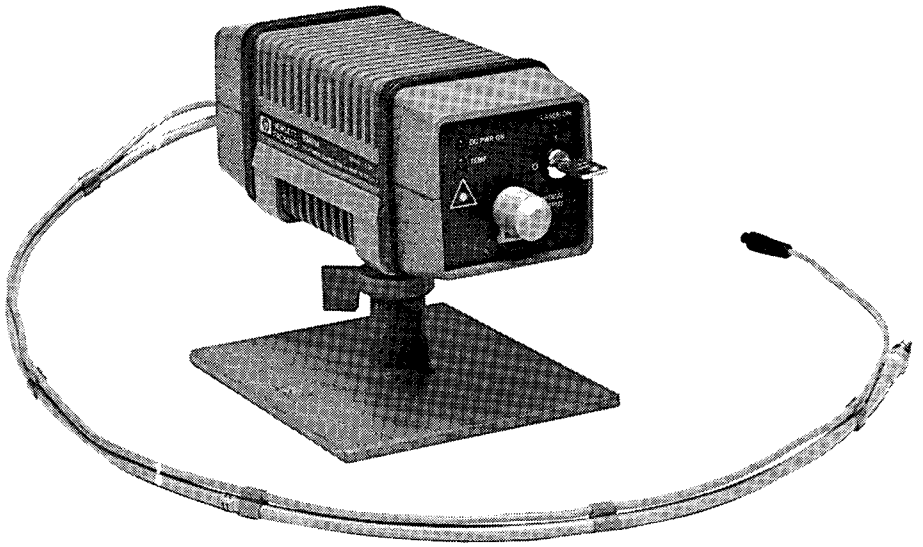
www.tm.agilent.com

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

OPERATING AND SERVICE MANUAL

HP 83402A LIGHTWAVE SOURCE



HP Part Number 83402-90001
Printed November 1988
Edition 2

HEWLETT PACKARD

HP 83402A
LIGHTWAVE SOURCE
(SMF – 1300 nm – 6 GHz BW)

SERIAL NUMBERS

This manual applies directly to instruments beginning with serial number 2826A00101.

If applicable, a Manual Changes Supplement will be supplied or made available through the nearest HP office to document any changes to this manual or any instruments not covered by this manual.

MANUAL PART NO. 83402-90001

Printed: SEPTEMBER 1991

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (NIST, formerly NBS), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of delivery. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

BP21.2

TABLE OF CONTENTS
HP 83402A
Lightwave Source

General Information

INTRODUCTION

The HP 83402A Lightwave Source is a general purpose stable laser source.

It is a DC powered laser that emits a 1300 nm beam from a single mode fiber output (9 um core / 125 um cladding). It is designed to be intensity modulated up to 6 GHz (sinewave). Although it is designed for use with the HP Lightwave Component Analyzers, it can be used for any appropriate application if properly DC powered and if its maximum ratings are not exceeded (see SPECIFICATIONS). Specifically, it is intended as analog source for making frequency domain measurements of the modulation characteristics of lightwave components (fiber optic systems).

Although the HP 83402A can be used as a lightwave source with other equipment, this manual concentrates on its use with the HP 8702A (Option 006) Lightwave Component Analyzer using an HP 85047A Test Set. For other applications information, contact a Hewlett Packard Systems Engineer and request assistance.

CALIBRATION DATA

This lightwave source has accompanying calibration data (3.5 inch disc and label) that describes its modulation response characteristics. The purpose of this data is to allow you to measure your own E/O device on the HP Lightwave Component Analyzer. By entering this characterization data into the analyzer and performing the calibration measurement, the analyzer can mathematically calculate the effects of the modulation characteristics of the HP source to correct subsequent E/O device measurements. Thus, you can insert your E/O device knowing that a measurement reference plane has been established, based upon the known characteristics of the HP source. In this manner, you can make accuracy enhanced (calibrated) measurements of the modulation characteristics of your DUT (device under test). Also, you can return your source to the factory at yearly intervals for recharacterization (new cal data).

CONNECTOR ADAPTER OPTIONS

This source must be ordered with one or more of the following connector adapter types:

Option 011 (HP 81000AI) —HMS-10/HP (Diamond)
Option 012 (HP 81000FI) —FC/PC
Option 013 (HP 81000SI) —DIN 47256
Option 014 (HP 81000VI) —ST

These options are mechanical connector adapters which are attached to the source's optical output (fiber end). The optical output (fiber end) of the laser source has an HMS-10/HP flange mount that receives the HMS-10/HP end of the connector adapter. The other end of the connector adapter is the specific connector type: PC, FC, ST, HMS/10-HP, or DIN. For example, Option 012 allows you to connect either an FC or a PC connector the to source's laser output; in the case of a PC connector, the HMS-10/HP fiber end of the source will make contact with the PC fiber end of the cable or device you attach.

In addition, many other connectors can be used with the appropriate patch cords (cables).

ABOUT THIS MANUAL

Read this manual to familiarize yourself with the HP 83402A Lightwave Source before using it. If you are using an HP 8702A Lightwave Component Analyzer, you can consider this source manual a supplemental reference because most typical applications are covered in the HP 8702A manual.

Should any changes occur to this manual, a manual changes supplement (change sheet) will be provided or made available through any Hewlett-Packard office. This supplement may contain information that adapts this manual to your instrument or changes this manual, depending upon your instrument's serial number or serial number prefix (first four numbers).

RECEIVING AND INSPECTION

Before unpacking, compare the shipping documents to your original order. Inspect all shipping containers. Carefully unpack the shipment and save all shipping materials and documents. Check the instrument serial numbers on the documents to be sure they are the same as those on the instrument. Inspect the instrument for damage. If your shipment is damaged or incomplete, notify both the shipping carrier and the nearest Hewlett-Packard Sales and Service Office. HP will arrange for repair or replacement of damaged or incomplete shipments without waiting for a settlement from the carrier. In all cases, notify your HP Field Engineer or Customer Engineer of any problems.

NOTE: Be sure to save all packing material because your source can be returned to the factory for subsequent recharacterization of its calibration data.

GENERAL SAFETY AND SERVICE CONSIDERATIONS

Because there is no AC line voltage attached to the HP source, high-voltage safety precautions are not necessary. However, the DC connectors, the SMA electrical connectors, and the optical port should always be kept clean (inspect regularly) and any protective caps should be kept on these ports when not in use.

Avoid static discharge. To ensure safety and to protect the instrument, be sure to ground yourself before touching any of the connectors.

Do NOT open the instrument cover. HP will void the warranty of any source that has been opened. There are no replaceable parts or adjustments for this instrument. Do not attempt to repair or replace any connectors on the source. Only the connector adapter (ordered by option number) that attaches to the mounting flange (HMS-10/HP interface) can be changed.

Refer all servicing to HP. This instrument is covered by the standard one year return-to-HP warranty. In the event of failure or malfunctioning contact your nearest HP office giving model number and name. In addition, Option W30 can be ordered to provide two additional years (year 2 and 3) of *warranted repair*. Contact your nearest HP office for information.

LASER SAFETY, CLASSIFICATIONS AND LABELS

Laser Safety

Before operation, the instrument and manual should be reviewed for safety markings and instructions. Follow these instructions and warnings to ensure safe operation and to maintain the instrument in a safe condition.

The HP 83402A uses a laser diode that operates in the infrared *A* spectrum (780-1400 nm), where the greatest danger from exposure is: 1) to the eyes where cataract formation and/or retinal burn is possible, and 2) to the skin where burning is possible.

CAUTION

This instrument should only be serviced by authorized personnel!

Do not enable the laser when no fiber or equivalent device is attached to the optical output connector.

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

Classifications

United States —FDA Class 1. The HP 83402A is rated USFDA (United States Food and Drug Administration) Safety Class 1 according to Part 1040, Performance Standards for Light Emitting Products, from the Center for Devices and Radiological Health.

International —IEC Class 3B. The HP 83402A is rated IEC (International Electrotechnical Commission) Safety Class 3B laser products according to Publication 825.

The REMOTE SHUTDOWN and the KEY SWITCH on the HP Lightwave Source (laser) help satisfy the international (IEC 825) safety requirements.

NOTE: Instruments with malfunctioning lasers MUST be returned to the factory for repair as explained under the heading titled SERVICE.

Labels

Attach the laser safety label next to the laser aperture below and to the right. These labels are supplied in several languages and shipped with your instrument.

Installation and Connections

General Description

Installation of the source is simplified because there are only four possible connecting interfaces and because the source is designed to be used on a table or bench, with or without the accompanying stand.

Because the HP 83402A is most often used with the HP 8702A Lightwave Component Analyzer (Option 006), its installation in that system is described in the HP 8702A User's Guide where it is shown with the RF input signal coming from the HP 85047A Test Set. In addition, it is also shown used with the HP 83411A Lightwave Receiver capable of 6 GHz demodulation or detection.

To help you connect the source in any system, three items are included below: 1) a picture of the source with its connections and indicators, 2) a list of the connections and switches that are used when installing the source, and 3) a typical test setup drawing. Also, note that several plastic cable clips are included. Use these clips to keep the RF and DC cables attached together if desired.

NOTE: When connecting the source to the HP 8702A, do NOT touch the center pin of the HP 85047A Test Set port 1 or the RF OUT connector on the analyzer (or any cable connected to it) —a static charge could cause damage to the internal RF source.

CAUTION

Exposure to temperatures above 55 degrees C may cause the front panel fiber to retract, in which case a matching compound may be required for low reflection measurements and for the instrument to meet specifications.

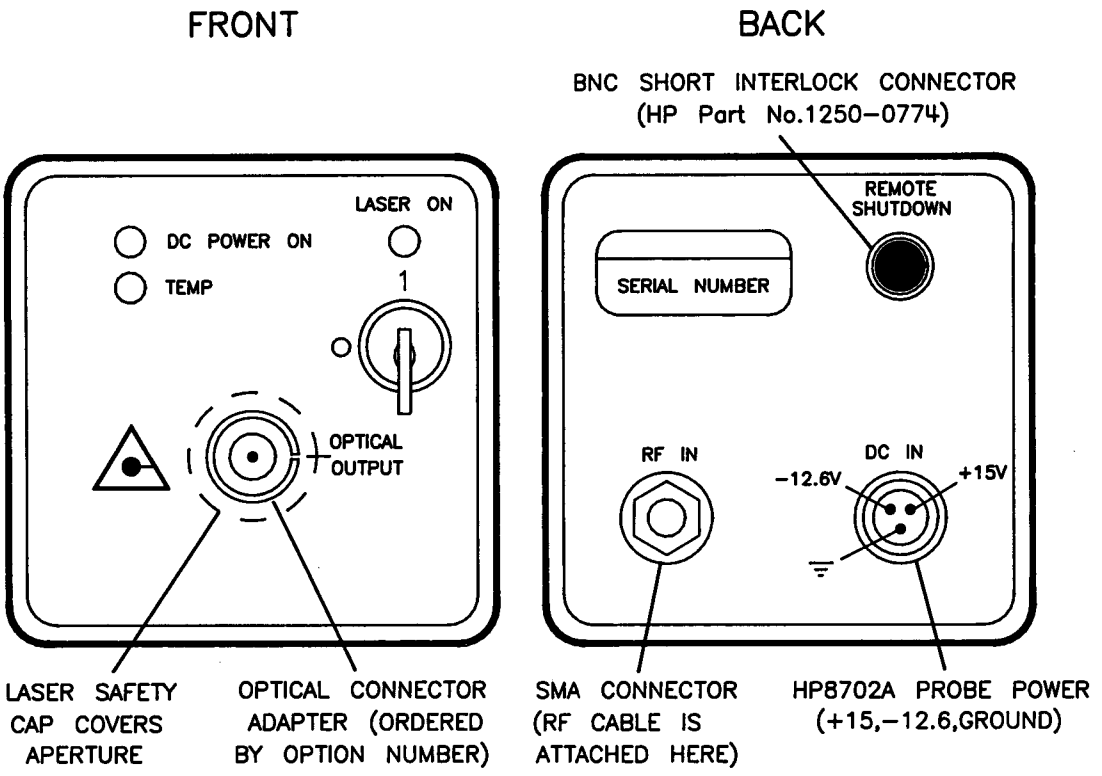


Figure 1. Lightwave Source Connectors and Indicators

LIST OF CONNECTIONS AND SWITCHES

Front Panel Connectors

- **OPTICAL OUTPUT**: This connector type depends upon the option (connector adapter) ordered with the source. Connect your fiber to this input. The plastic safety cap is spring loaded and remains closed when no fiber is connected.
- **KEY SWITCH:** Two keys are supplied with each source to control the ON/OFF function of the laser. Because of the dangers involved with laser radiation, the keys provide safety by preventing use of the laser by unauthorized personnel. When the key is turned on, the LASER ON led will light.

Back Panel Connectors

- **DC IN**: This 3 prong male input is connected to the output of the HP 8702A front panel connector marked PROBE POWER fused. Make this connection using the keyed cable supplied with the source. Refer to the drawing for pin voltages.
- **RF IN**: This SMA threaded female connector is used to receive the modulation signal. Use the flexible RF cable supplied with the source to connect this input to the RF modulation signal. Recommended torque is 5 in/lbs for this SMA connector. For connection to an HP 8702A, refer to the User's Guide or make the connection (using the cable) between the HP 85047A Test Set and this RF IN connector: you will need to make the connection from port 1 of the HP test set (7mm) to this connector (3.5mm) using an adapter like the HP 1250-1746 (3.5 mm male to 7 mm).

- **REMOTE SHUTDOWN:** This is a safety feature. The BNC connector on the rear panel must be shorted for the laser to operate. When the terminals of the connector are open-circuited (BNC short removed), the accessible radiation does not exceed the AEL for Class 1 and Class 2 according to IEC Publication 825 (1984). Use your own short, switch, or other circuitry with a BNC cable to operate (open or short) the remote shutdown as desired. HP does not supply any other accessories with this connector/feature.

Accessories

- **STANDS:** Use the stand, supplied with the source, to keep it elevated if desired. The stand is not required for proper operation.
- **CABLES:** Each lightwave source comes with one *DC IN to Probe Power* cable and one *Flexible RF cable* that connects from the RF modulation signal to the RF IN (SMA) on the lightwave source.

NOTE: Refer to the REPLACEABLE PARTS list, in this manual, for part numbers.

CONNECTOR CARE

Always keep the connectors clean and free from contamination. Metal connectors and fiber ends can be cleaned with non-corrosive alcohol or a liquid Freon product (TF). Use a clean lint-free swab or cloth to clean the connector, and allow it to dry —use clean compressed air, if desired. If you use an index matching compound on the fiber end, be sure to remove it completely (using the proper solvent). Keep the protective cover on the connector when not in use. Refer to the HP Connector Care manual for part numbers of lint-free swabs, Freon, and compressed air.

TYPICAL SYSTEM CONNECTION

The drawing below shows the HP lightwave source in a typical measurement application.

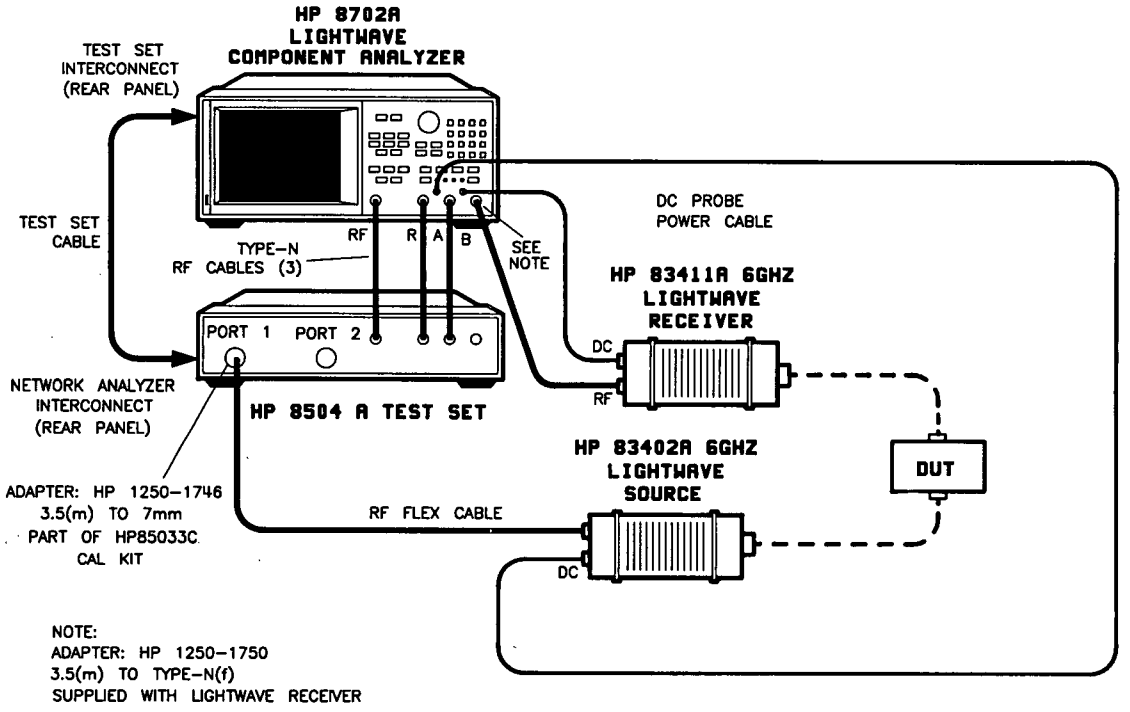


Figure 2. Typical System Connection (Optical Transmission Measurement)

Operation

OVERVIEW

The HP 83402A provides a 1300 nm diverging light beam that can be modulated by an external signal up to 6 GHz. Without modulation, light coming out of the source is less than 2.8 milliwatts (about +3 dBm) of power out. However, it can be modulated with up to +14 dBm (about 25 mW) of RF power. The only requirement for actual electrical operation is that DC power (−12.6V, +15V, and ground) be supplied to the DC IN connector of the source. After that, whenever the laser key switch is turned on (position 1), the laser is activated and the LED goes on (LASER ON). If a modulation signal is applied to the source's RF IN connection, the result is a modulated light beam that is launched into the fiber connector at the source's output.

In addition to the keyed laser switch, there are two other safety features. One is the thermal control circuitry. If the temperature of the source exceeds its presset value, it will automatically shut down.

The other is the BNC connector that is on the rear panel that must be shorted for the laser to operate.

During normal operation with the HP 8702A, the source is often connected *in* and *out* of the transmission path for different applications. However, if you are making repeated measurements, you can turn off the laser while the DC IN bias and any RF signal remain connected and turned on.

The source can be modulated with a signal that is DC offset, providing this offset does not exceed 20 volts DC.

The HP 8702A Operating and Programming manual contains measurement examples and describes how to use the HP 83402A in conjunction with the HP 8702A. Although it may refer to the HP 83400A or 83401A Lightwave Source, the HP 83402A is used in the same way, except the HP 85047A Test Set is used to double (x2) the RF signal from the HP 8702A. Refer to the Getting Started section containing the User's Guide.

NOTE: When this source is used with the 6 GHz HP 8702A (Option 006), measurements made below 3 MHz (300 kHz to 3 MHz) must be done without activating the 6 GHz frequency range.

WARNING

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

THEORY OF OPERATION

In order to understand more about the lightwave source, refer to the figure below.

The lightwave source consists of a laser diode, bias circuitry, and control circuitry. The attenuator and impedance matching network blocks the DC component from the RF input that modulates the laser light.

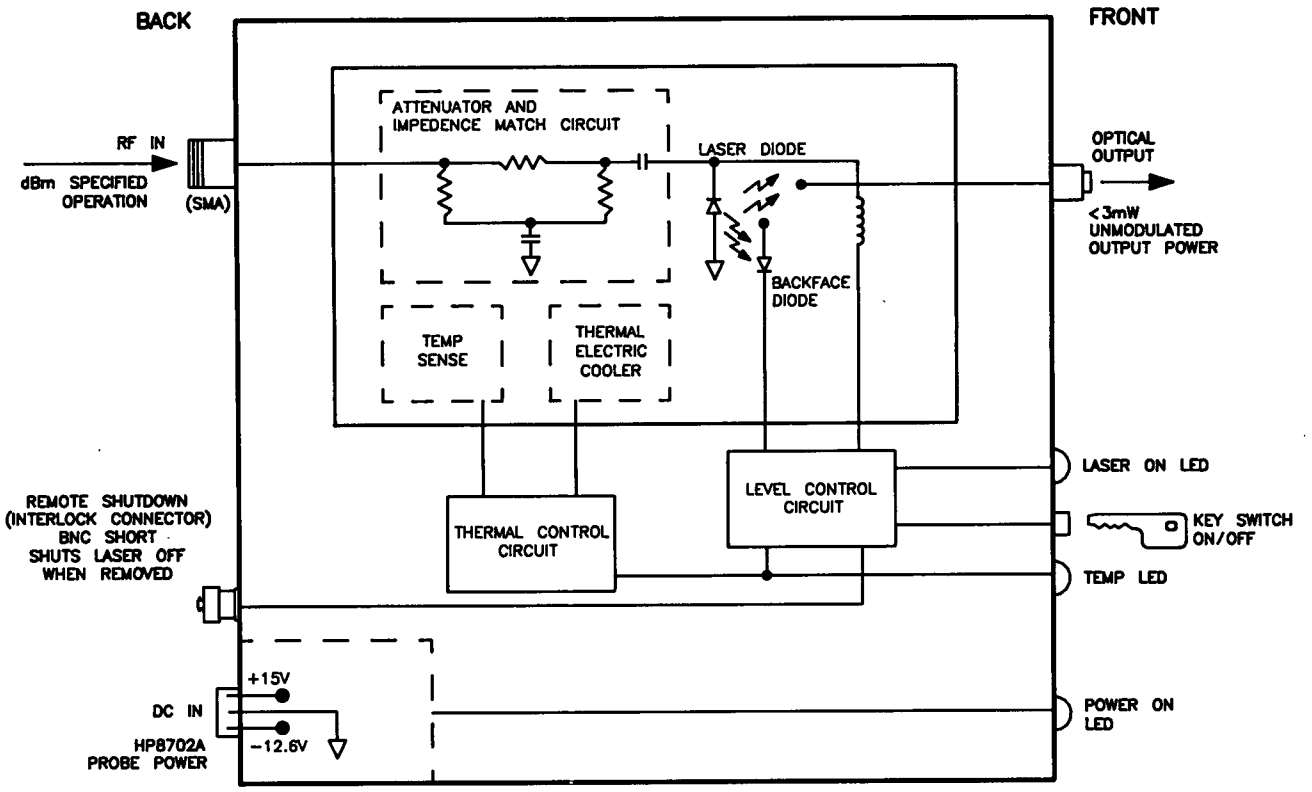


Figure 3. Lightwave Source Block Diagram

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 radiates light in both directions. The backface 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 is in error of the preset 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.

Conforming to the IEC (Publication 825, 1984, Section Two —Manufacturing Requirements, 4.4), 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: the laser is setup in a room where you do not want anyone entering while the laser is on; the remote interlock connector (BNC) is connected by circuitry or cabling to the door; when the door is opened, the remote interlock is *opened* and the laser is shut down.

The DC IN connector is a three pin plug that is designed for use with the HP 8702A front panel PROBE POWER (fused) connector or by a separate compatible power supply. Notice that the center pin is ground and the two other pins have a potential difference of −12.6 volts (left) and +15 volts (right). When DC power is supplied to the source, the LED (labeled: POWER ON) is lit on the front panel but the laser light is not turned on by it.

The two keys are supplied with each source to prevent anyone from turning on the laser without a key. This key switch is the ON and OFF switch for the laser. When the key switch is turned on, the level control circuit turns on both the laser and the LED (labeled: LASER ON) on the front panel.

In summary, general operation of the lightwave source is simple, consisting mostly of making connections and following safety precautions. Because the source does not have any adjusting controls and because it requires connection to other instruments, it is often considered an accessory. For this reason, its operation with the HP 8702A Lightwave Component Analyzer is also described in the HP 8702A Operating and Programming manual. However, read the CALIBRATION DATA section below for an explanation of how to use the accompanying Calibration Data.

Calibration Data

(used with the HP Lightwave Component Analyzer)

GENERAL DESCRIPTION

The following paragraphs contain information about the use of the calibration data. If you are using an HP 8702A, you can use this information or the information in the User's Guide of the HP 8702A OPERATING and PROGRAMMING manual.

Two types of calibration data are supplied with the lightwave source:

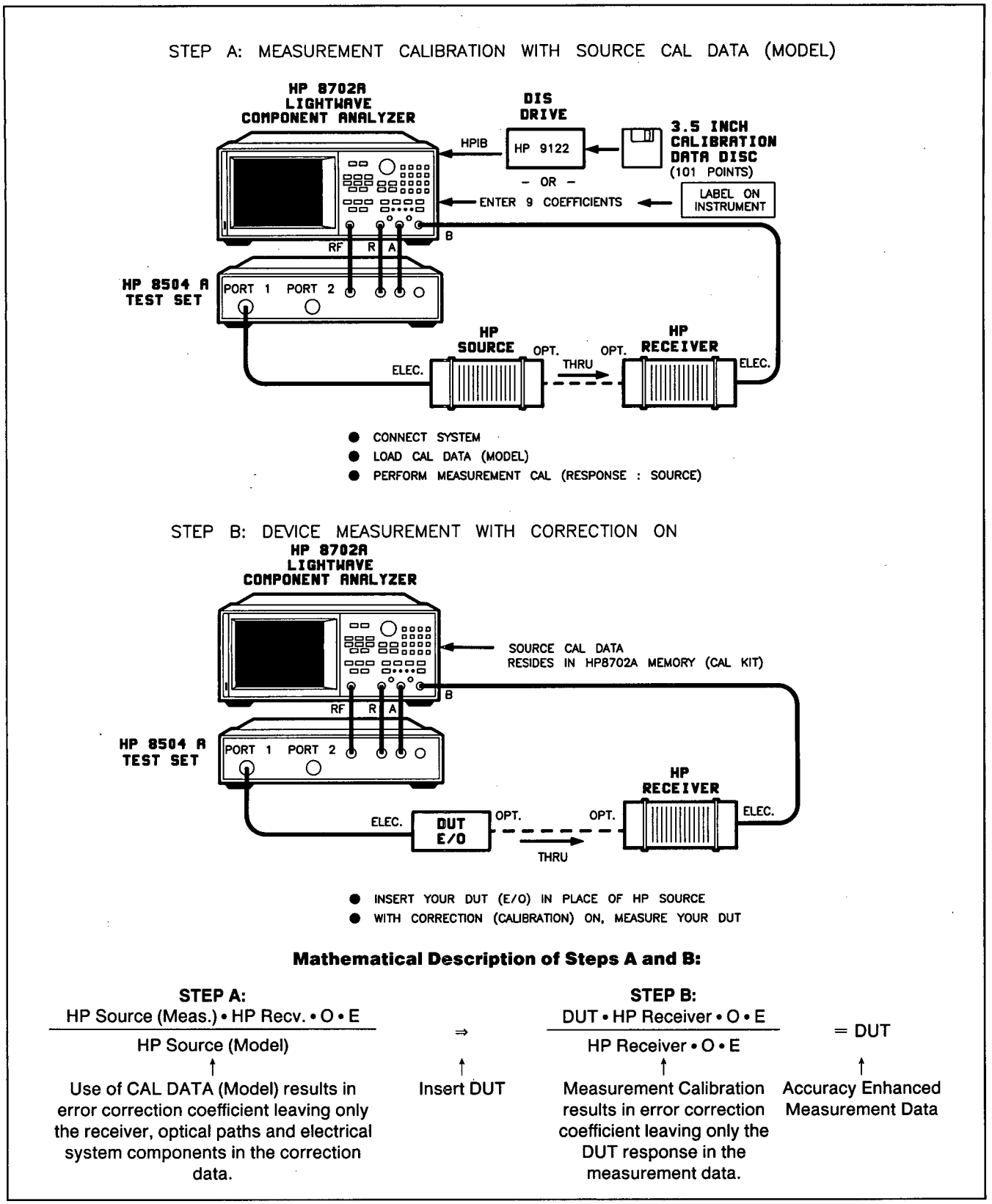
1. 3.5 inch double sided disc —contains 101 data points and can be loaded into the HP lightwave component analyzer without a computer. Only a dual-sided disc drive (HP 9122-series) and an HP-IB cable are required.

2. Labeled coefficients —each source is labeled with a cal data number that contains nine coefficients that can be manually loaded into the HP lightwave component analyzer using the front panel keys.

Both of these items represent the modulation transfer characteristics of your particular lightwave source. Because no two sources are exactly alike, the cal data disc and the labeled coefficients should not be used with any other source.

Each source is measured from 3 MHz to 6 GHz at 1300 nm on the factory test system. The measured data (101 data points) is then digitized and transferred to the disc. The coefficients on the label are derived from the measured data. Both CAL data (disc data and the coefficients) are mathematical models (error correction coefficient) that describe the source's modulation transfer characteristics under optimal conditions.

By using the CAL DATA and the HP lightwave component analyzer's ability to mathematically remove contributing errors from a measurement, subsequent E/O device measurements provide accurate DUT measurement data. The drawings and explanations below describe, in simple block terms, how this is accomplished.



Mathematical Description of Steps A and B:

$$\frac{\text{STEP A: HP Source (Meas.)} \bullet \text{HP Recv.} \bullet O \bullet E}{\text{HP Source (Model)}} \Rightarrow \frac{\text{STEP B: DUT} \bullet \text{HP Receiver} \bullet O \bullet E}{\text{HP Receiver} \bullet O \bullet E} = \text{DUT}$$

↑ Use of CAL DATA (Model) results in error correction coefficient leaving only the receiver, optical paths and electrical system components in the correction data.

⇒ ↑ Insert DUT

↑ Measurement Calibration results in error correction coefficient leaving only the DUT response in the measurement data.

= DUT ↑ Accuracy Enhanced Measurement Data

Figure 4. Using Calibration Data to Enhance the Accuracy of E/O DUT Measurements.

DISK (3.5 in) CALIBRATION DATA

Each disk contains 101 complex data points, based upon factory measurement, that describe the magnitude and phase modulation response of your particular source. This cal data disk can be inserted into an active dual-sided disk drive (HP 9122-series) that is connected via HP-IB to the HP lightwave component analyzer and properly addressed. Then, using the HP lightwave component analyzer's *Guided Setup* or its CAL menu selection, the digitized disk data is loaded into the analyzer's Cal Kit memory array. This data will remain in the analyzer's non-volatile memory as a Cal Kit. Therefore, you should only have to enter it once for your particular source, unless the instrument remains turned off for several days.

Whenever you enter the calibration data and perform a measurement calibration, your source's factory modeled modulation characteristics are used to mathematically correct subsequent DUT measurements. This is possible because your source 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 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 device (source), the modeled HP source response is removed from the system along with the response of the optical/electrical cables and the lightwave receiver. The *CORRECTION ON* (measurement calibration) feature of the HP 8702A accomplishes this task —your data is corrected with reference to the measurement calibration you made using the HP source and its calibration data.

Below is a typical key press sequence for loading the calibration data, beginning with the HP 8702A *Guided Setup*. However, you could press the front panel [CAL] key to access CAL KITS & STDS menu and load the data from there:

HP 8702A Loading Procedure

Press the following keys in this order:

1. **[Guided Setup]**
2. Select the type of measurement (for example, BANDWIDTH)
3. **[continue]**
4. Select the type of DUT **[E/O]**
5. **[continue]**
6. Configure or connect the equipment as shown on CRT
7. **[continue]**
8. Set the START/STOP modulation frequencies and **[continue]**.
9. Set Sweep Time, Source Power, Sweep Type
10. **[continue]**
11. Select Cal Type **[RESPONSE]**
12 Select **[CAL STD]** and **[SRC DISC]**
13. With the disk in the drive, select **[LOAD SRC DISC]** and **[SYSTEM CONTROLLER]** to allow the HP 8702A to control the disk drive.
14. Select **[READ FILE TITLES]** and the filenames will appear.
15. Select **[LOAD** filename**]** —the cal data is loaded from the disk.

After loading the disk data, it will remain in memory. Press the **[PRIOR MENU]** keys to return to the calibration menu.

16. Press **[RESPONSE]** and **[continue]** and **[SOURCE]**. At this point the analyzer will make the calibration measurement and the calibration will automatically be turned on after you press **[DONE]**. Notice the left side of the CRT where the abbreviation for correction (calibration) is: *Cor*.

17. You are now ready to insert your E/O device in place of the HP Lightwave Source and make accuracy enhanced (calibrated) measurements.

Refer to the analyzer's Operating and Programming manual for information on making measurements.

How to Interpret Filenames

Disc data file names will be displayed as a CAL STD name. For example, consider the number *S2300045.* The *S* means SMF (single mode fiber), the following *2* means that the frequency range is up to 6 GHz, and the *3* means that the wavelength is 1300 nm. The remaining 5 digits are the specific calibration data number of your source (not the same as the instrument serial number).

Making a Backup Disc

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

You must have an HP controller (computer) to copy the files. This includes all 200 and 300 series HP 9000 controllers such as: 9836, 9826, 310, 320, etc. In addition, the disc drive must be an HP CS80 disc drive, such as an HP 9122C or D dual sided model.

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

LABELED CAL DATA (COEFFICIENTS)

The labeled data on the source is comprised of nine coefficients that are used in a polynomial curve to describe the magnitude and phase modulation response of the particular source. The curve fit terms (A through I) are derived from the same data (101 points) that is on the disc.

A typical cal data label has the information shown below. For example, consider the number *S2300045.* The *S* means SMF (single mode fiber), the following *2* means that the frequency range is up to 6 GHz, and the *3* means that the wavelength is 1300 nm. The remaining 5 digits are the specific calibration data number of your source (not the same as the instrument serial number).

A typical label looks like this:

CAL DATA #S23XXXXX
83402A

A=xxxxx	(Responsivity)	F=xxxxx
B=xxxxx	(Delay)	G=xxxxx
C=xxxxx		H=xxxxx
D=xxxxx		I=xxxxx
E=xxxxx		xxxx.x nm

The equation used by the HP 8702 is as follows:

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

where $\omega = 2\pi$ (Frequency) and $j = \sqrt{-1}$

NOTE: The upper-case Greek E represents the natural log (ln).

In the HP 8702 coefficients are scaled as follows:
B • (10^{-9}), C • (10^{-30}), D • (10^{-21}), E • (10^{-12}), F • (10^{-39}), G • (10^{-30}), H • (10^{-21}), I • (10^{-12}).

Although the coefficients are scaled as follows, enter them exactly as listed on the label:

Typically, you enter these values in the HP 8702A Cal Kit that is accessed by pressing the keys shown in the following procedure.

HP 8702A Loading Procedure

Press the following keys in this order:

1. **[Guided Setup]**
2. Select the type of measurement (for example, BANDWIDTH)
3. **[continue]**
4. Select the type of DUT **[E/O]**
5. **[continue]**
6. Configure or connect the source as shown on CRT
7. **[continue]**
8. Set the START/STOP modulation frequencies and **[continue]**.
9. Set Sweep Time, Source Power, Sweep Type
10. **[continue]**
11. Select Cal Type **[RESPONSE]**
12 Select **[CAL STD −COEFF]** and **[ENTER SRC COEFF]**
13. Enter the Coefficients from the label. You must enter all of the coefficients (A through I).
14. Select **[PRIOR MENU]** and **[SAVE SRC COEFF]**

After loading the data, it will remain in memory. Press the **[PRIOR MENU]** keys to return to the calibration menu. Then press **[continue]**.

15. Select **[SOURCE]**. At this point the HP lightwave component analyzer will make the calibration measurement and the calibration will automatically be turned on after you press **[DONE]**. Notice the left side of the CRT where the abbreviation for correction (calibration) is: *Cor*.

16. You are now ready to insert your E/O device in place of the HP Lightwave Source and make accuracy enhanced (calibrated) measurements.

    Refer to the HP lightwave component analyzer's Operating and Programming manual for information about making measurements.

RECHARACTERIZING YOUR SOURCE

Although the HP 83402A is designed to be stable (refer to the Table of Specifications), it can be returned to the factory for recharacterization (calibration) at any desired time for a reasonable fee. HP recommends that recharacterization be done at approximately one year intervals.

When returning the source for recharacterization, you must return the original data disc with the instrument: the disc and the instrument have the same CAL DATA number. Contact the nearest HP Office for assistance.

Specifications

The information below describes the specifications of the HP 83402A. The values were determined at the factory and are based upon measurements using a calibrated HP 8702A system, optical power meter, and optical spectrum analyzer.

The following section, under the heading PERFORMANCE TESTS, contains procedures to test and verify the values listed in the Table of Specifications below.

Weight and Dimensions

Net Weight: 1.5 kilograms
Width: 8.5 cm
Height: 8.5 cm
Length: 23 cm

Temperature Limits

Non-Operating: −40 to 55°C
Operating: 0 to 55°C

Absolute Maximum Ratings (do not exceed)

- RF input power: 20 dBm
- DC power input: −12.6 to −15 volts and +15 to +17 volts
- DC into RF port: 20 volts

Assumptions or Conditions

(where applicable, listed by number in the Table of Specifications)

1. Applies at 25 ±5 degrees Celsius.
2. Optical connector: HMS 10/HP Diamond. (The use of an index matching oil may be required to meet specifications.)*
3. Instrument must be warmed-up for one-half hour.
4. Factory test system.
5. Receiver: HP 83411A with disc calibration data.
6. HP 85047A Electrical Test Set.
7. No intensity modulation applied.

* The index matching oil currently recommended is available as HP part number 6040-0648.

TABLE OF SPECIFICATIONS

- CENTER WAVELENGTH, conditions: 1 – 4, 7.
  minimum: 1288 nanometers
  typical: 1308 nanometers
  maximum: 1328 nanometers
- TYPICAL CENTER WAVELENGTH STABILITY, assumptions: 1 and 7.
  0.3% per year
- SPECTRAL WIDTH, assumptions: 1 – 4, 7.
  maximum: 3.0 nanometers
- AVERAGE POWER OUT, assumptions 1 – 4, 7.
  minimum: 600 microwatts
  typical: 1700 microwatts
  maximum: 2800 microwatts
- TYPICAL POWER STABILITY: 1 and 7.
  0.6% per 1000 hours
- MODULATION FREQUENCY RESPONSE, conditions: 1 – 5.
  +/–5.0 dB (Watts/ampere)
  at 0 dBm RF input 300 kHz to 6 GHz.

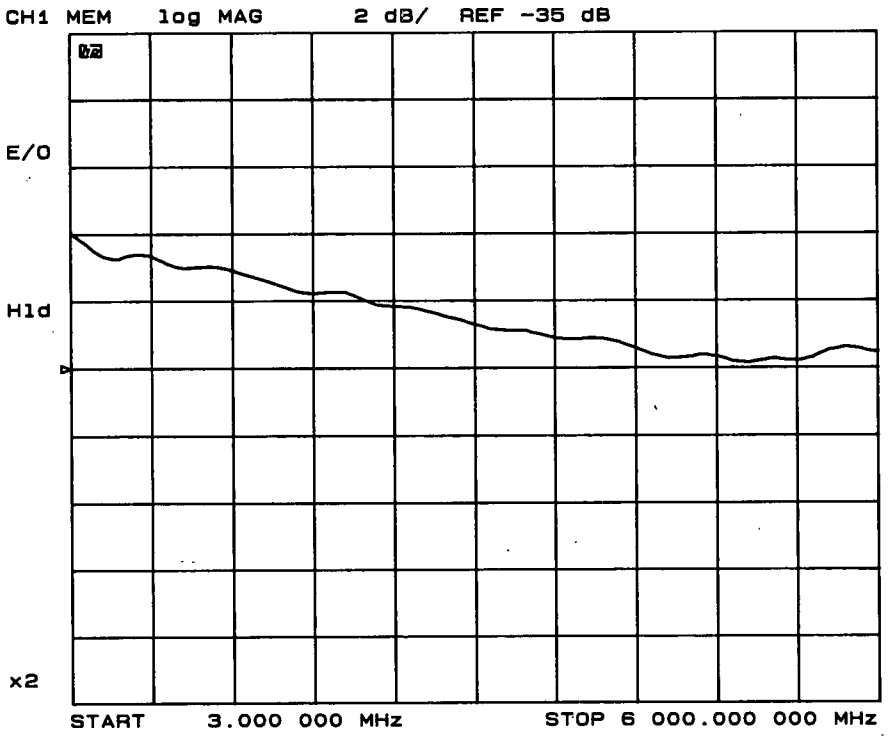


Figure 5. Typical MOD FREQ RESP PLOT

- ELECTRICAL INPUT MATCH, assumptions: 1 − 6.

  minimum: 13 dB using an HP 85047A Test Set, 3 MHz to 6 GHz.

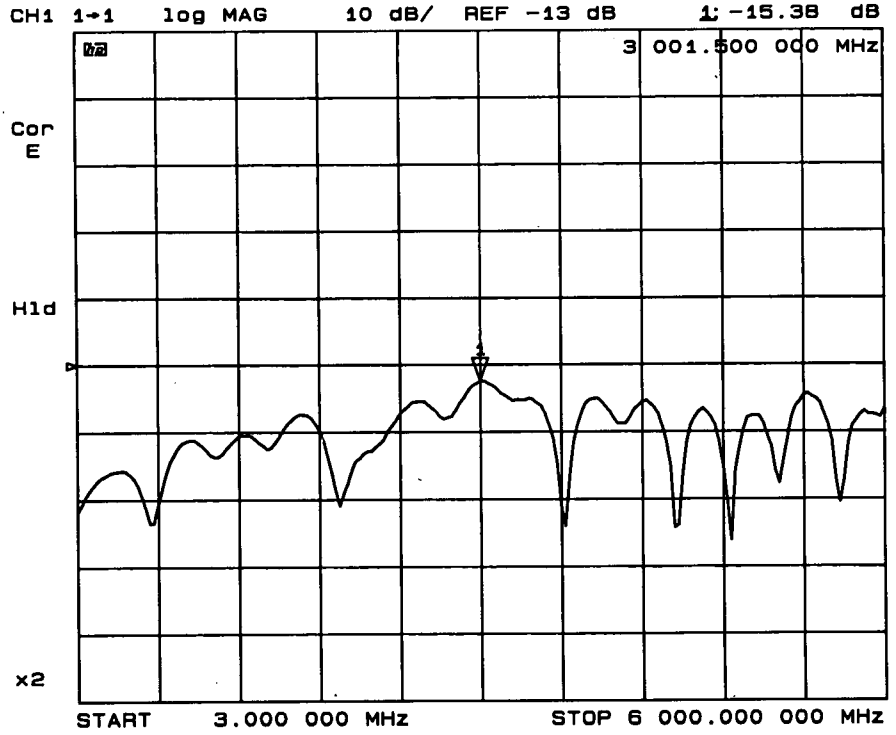


Figure 6. Typical Electrical Input Port Return Loss

OTHER TYPICAL SPECIFICATIONS

- RESPONSIVITY, at 50 MHz modulation frequency:

  0.022 Watts/Amp or −34 dB

- DYNAMIC ACCURACY

  300 kHz to 3 GHz, RF power −26 to +14 dBm, referenced to −6 dBm: +/−1 dB (Watts/Ampere)

  3 GHz to 6 GHz, RF power −46 to −6 dBm, referenced to −26 dBm: +/−1 dB (Watts/Ampere)

- MODULATION (harmonic) DISTORTION, RF power +14 dBm:

  300 kHz −1 GHz: −20 dBc
  1 GHz −6 GHz: −7 dBc

- 1 dB MODULATION COMPRESSION LEVEL, modulated at 50 MHz:

  +17 dBm RF power

Performance Tests

The procedures in this section test the performance of the instrument for those specifications listed with each of the following tests. All tests can be performed without access to the interior of the instrument.

REQUIRED EQUIPMENT

Any equipment which satisfies the critical specifications listed in the table may be substituted for recommended models.

- Optical Spectrum Analyzer
- Optical Power Meter (Model Number HP 8152A —head 81521B)
- Optical Cable (HP 11896A Interconnect Cable Kit)
- HP Lightwave Component Analyzer
- HP 83411A Lightwave Receiver (with disc cal data)
- HP 85047A Electrical Test Set
- HP 9122-series (dual-sided) disc drive
- HP 3.5 mm Calibration Devices, currently:

  Open —HP Part Number 1250-1767
  Short —HP Part Number 1250-1769
  Load —HP Model Number 909D Option 011 or 040

CENTER WAVELENGTH AND SPECTRAL WIDTH

Spectral Width: Max 3.0 nm
Center Wavelength: 1308 nm +/-20 nm

Procedure

1. Connect the test system as shown below.

   NOTE: The *absolute level* is not critical. Also, do not use *RF modulation* when testing.

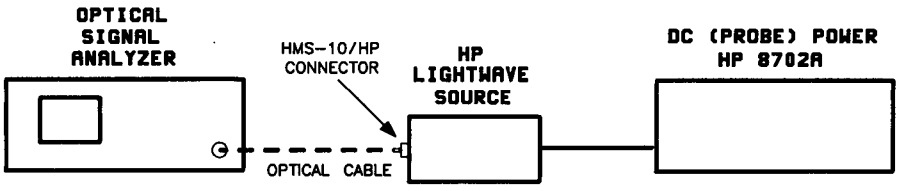


Figure 7. Test Setup

2. Make the following optical signal analyzer adjustments:

   a. Center wavelength: 1308 nm.
   b. Sweep width: 5 nm/division
   c. Reference level: −10 dBm
   d. Y −Scale Log
   e. Resolution: 0.1 nm
   f. Average Time: 1

3. Measure the lightwave source's mode pattern.

4. Adjust the analyzer's REF level and Center Wavelength so that the maximum peak is in the top graticule division and the pattern is centered on the CRT so that the first peak is almost equal to the last peak in amplitude.

5. Make another measurement of the Source's mode pattern. A pattern similar to the figure below should result. Measure the frequency and amplitude of each peak greater than −35 dBc (35 dB below the maximum peak) and record the value in Table 1.

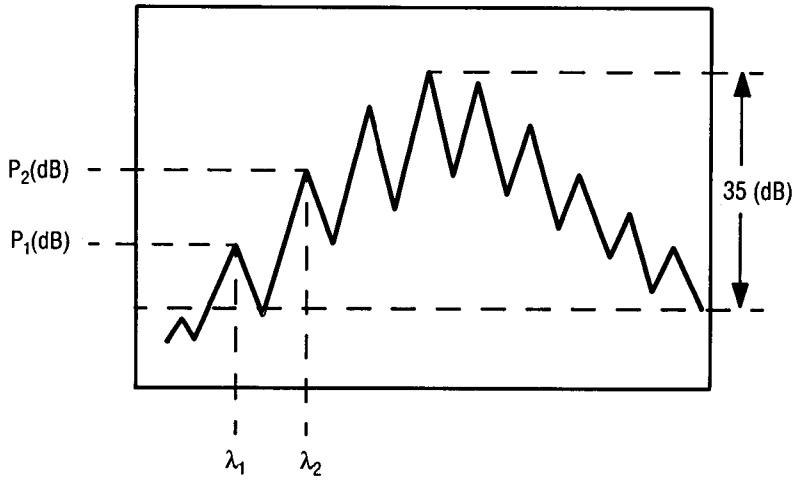


Figure 8. Typical Display of Source Mode Pattern

Table 1.

i	Pi (dB)	λi	Pi (lin)*	Pi (lin) • λi	$(\lambda i - \overline{\lambda})^2 \bullet$ Pi (lin)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
Totals					

* Pi (linear) = Pi (lin) = $10^{\left(\frac{PdB}{10}\right)}$

6. Compute the mean ($\overline{\lambda}$) and sigma (σ) as shown below, where N = the number of peaks above −35 dBc:

$$\overline{\lambda} = \frac{\sum_{i=1}^{n} \lambda i \, Pi}{\sum_{i=1}^{n} Pi}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (\lambda i - \overline{\lambda})^2 \, Pi}{\sum_{i=1}^{n} Pi}}$$

Automated BASIC Test Program (Center Wavelength and Spectral Width)

The following BASIC program will calculate the mean and sigma values for center wavelength and spectral width. It can be run on any HP-IB computer.

Program Listing –

```
10   DIM Peak_value(1:50),Correct$[5]
20   INTER Count_peaks,Y(1:50),Mean,Variance
30   OUTPUT KBD;"K"; ! CLEAR THE SCREEN
40   PRINT "Press RETURN to retain present values."
50   INPUT "Enter the START wavelength",Start_lambda,"Enter the STOP wave-
     length",Stop_lambda
60   Enter_data:!
70   PRINT "ENTER 0 WHEN DONE"
80   Count_peaks=0
90   FOR I=1 TO 1.E+6
100       PRINT "
     "
105       PRINT "
     "
107       STATUS CRT,1;Y_pos
108       CONTROL CRT,1;Y_pos-1
110       PRINT "PEAK NUMBER =";I,"The present peak value is";Peak_value(I)
120  INPUT "ENTER NEW PEAK VALUE IN dB",Peak_value(I)
130  IF Peak_value(I)=0 THEN GOTO Check
140  Wavelength=DROUND(Y(I)*(Stop_lambda-Start_lambda)/560+Start_lambda,6)
150  !
160       PRINT "PEAK NUMBER =";I,"The present wavelength is";Wavelength
170       INPUT "ENTER NEW WAVELENGTH",Wavelength
180  Y(I)=(Wavelength-Start_lambda)*560/Stop_lambda-Start_lambda)
190       STATUS CRT,1;Y_pos
191       CONTROL CRT,1;Y_pos-3
210       PRINT "PEAK NUMBER =";I,"PEAK WAVELENGTH =";Wavelength,"PEAK VALUE
          =";Peak_value(I)
220       Count_peaks=I
230  NEXT I
```

```
240 Check: !
250 PRINT
260 INPUT "IS THIS DATA CORRECT?",Correct$
270 IF UPC$(Correct$[1,1])<>"N" THEN GOTO Compute
280 GOTO Enter_data
290 Compute: !
300 PRINT "there are ";Count_peaks;" peaks"
310 Trace_max=MAX(Peak_value(*))
320 Compute_sigma(Peak_value(*),Trace_max,Count_peaks,Mean,Variance,Y(*))
330 PRINT "MEAN ";DROUND(Mean*(Stop_lambda-Start-
    _lambda)/560+Start_lambda,6),"2_SIGMA=";DROUND(2*SQR(Variance)*(Stop_lambda-
    Start_lambda)/560,3)
340 PAUSE
350 END
360 !
370 SUB Compute_sigma(Peak(*),Track_max,INTEGER Count_peaks,Mean,Variance,Y(*))
380 Compute_sigma: !(Peak(*),Trace_max, INTEGER Count_peaks,Mean,Variance,Y(*)
390       DISP "COMPUTING MEAN(CENTER) AND STANDARD DEVIATION"
400       Sigma_top=0
410       Bottom=0
420       Mean_top=0
430       FOR I=1 TO Count_peaks
440         Peak_mag=10'(Peak(I)/10)
450         Mean_top=Mean_top+Y(I)*Peak_mag
460         Bottom=Bottom+Peak_mag
470       NEXT I
480       Mean=INT(Mean_top/Bottom)
490       FOR I=1 TO Count_peaks
500         Peak_mag=10'(Peak(I)/10)
510         Sigma_top+(Y(I)-Mean)'2*Peak_mag+Sigma_top
520       NEXT I
530     Variance=INT(Sigma_top/Bottom)
540 SUBEND
550 !
```

AVERAGE OUTPUT POWER

Minimum: 600 microwatts
Typical: 1300 microwatts
Maximum: 2800 microwatts

Procedure

1. Connect the test system as shown in the figure below.

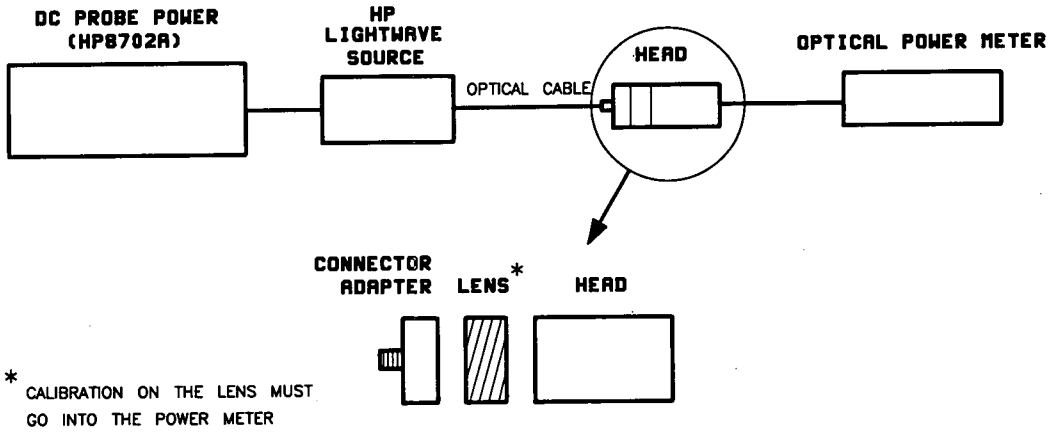


Figure 9. Test Setup

2. Power will be measured without RF modulation. Set the optical power meter frequency to 1308 nm. For example, press **[SET] [λ]**. Then use the vernier adjustment to set the wavelength to 1308 nm.
3. Adjust the optical power meter to zero, using the lens cap. Press: **[MEAS] [ZERO]**.
4. Refer to the optical power meter manual. Follow the instructions for entering the lens calibration data into the power meter.
5. Press: **[SET] [REF] [dBm]**. Use the vernier adjustment to to set the calibration.
6. Connect the optical cable to the power meter head and turn on the source.
7. Measure the power and compare the results to the specified value. Press: **[MEAS] [μW]**.

NOTES:

- Using an optical cable with a diamond HMS-10/HP connector on the source will give the most accurate results. Other connector types may have greater return loss or may cause reflections resulting in measurement errors.
- Be sure that all optical connections are clean and free from scratches, dust, dirt, etc. Use non-corrosive or non-abrasive cleaner and blow the connectors dry with clean compressed air. If necessary, use an index matching compound to reduce reflections. Be careful to properly remove the compound when finished and re-clean the connector.

ELECTRICAL INPUT PORT MATCH

Specified value: 13 dB

Procedure

1. Connect the test system as shown in the figure below.

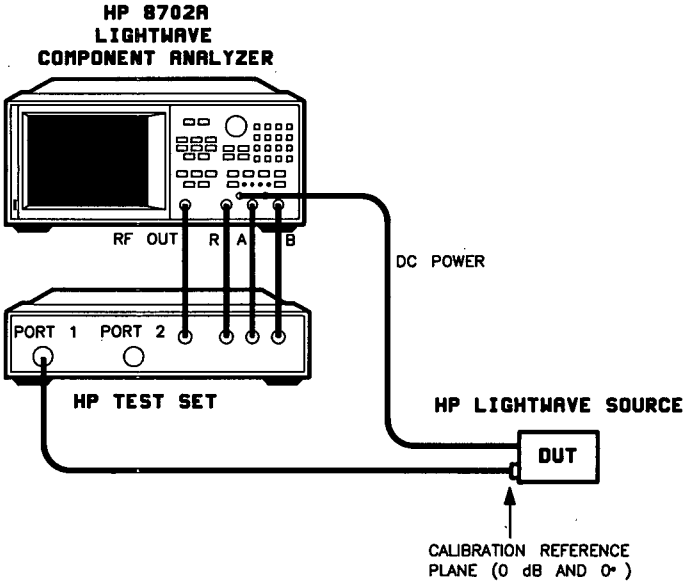


Figure 10. Test Setup

2. Set the HP 8702A parameters, press:

   [CAL] [DEVICE TYPE] [ELECTRICAL]
   STIMULUS **[MENU] [POWER] [10] [x1]**
   [AVG] [IF BW] [100] [x1].

3. Perform an S_{11} 1-Port Electrical calibration (at the calibration reference plane) using the SHORT, OPEN, and LOAD from the 3.5 mm Calibration Kit. Be sure the CAL KIT selection is set to 3.5 mm and press:

   [CAL] [CALIBRATE MENU] [S11 1-PORT].

   Connect each device, in turn, and press the appropriate softkey to measure the device. When finished, press the DONE softkey.

4. Connect the analyzer's RF cable to the lightwave source RF input and measure the S_{11} reflection to determine the match with correction on. Press: **[MENU] [TRIGGER MENU] [SINGLE]** to generate a single sweep.

   Then press: **[MKR FCTN] [MKR SEARCH] [MAX]** and the marker will locate the peak value.

5. Compare the results to the plot shown in the *Table of Specifications*.

MAINTENANCE

The source has no adjustments or maintenance except for the care of the external connectors. Keep all connectors clean and dry. Keep protective caps on the connectors when not in use. You can use non-corrosive alcohol or liquid Freon to clean the connectors with lint-free swabs. Use clean compressed air to blow them dry. If any connector becomes loose or damaged, contact HP.

REPAIR

The instrument must be returned to HP for repair. Do not void the warranty: Do not remove the instrument cover or attempt to repair the instrument yourself. If your source fails to operate properly, contact the nearest HP Sales and Service office and request the assistance of an HP Customer Engineer. If necessary, a replacement (exchange assembly) is available at a reasonable cost.

TEMP LED AND POWER SUPPLY VOLTAGES

If this LED goes on, the laser will shut off. If this happens, move the laser to a different ambient temperature: hotter or colder, depending upon the temperature conditions that may have caused the LED to light. If this does not correct the problem, check the power supply voltages (+15, −12.6 and ground). If these voltages are incorrect by 5%, the LED may go on. Be sure to verify these volatges. If the voltages are correct and the LED remains on, contact HP for assistance.

REPLACEABLE PARTS

Description	HP Part Number	CD	Qty Supplied
RF Cable (SMA)	8120-5157	2	1
DC Cable (probe power)	83400-60005	5	1
Cable Clips	83400-20008	4	5
Laser Shutter Cover	08145-64501	1	6
Key	3100-1984	8	2
HMS-10/HP Connector Adapter	08154-61701	3	—
FC/PC Connector Adapter	08154-61702	4	—
DIN Connector Adapter	08154-61703	5	—
ST Connector Adapter	08154-61704	6	—

REGIONAL SALES AND SUPPORT OFFICES

For information relating to Sales or Support of Hewlett-Packard products first contact your local Hewlett-Packard office listed in the white pages of your telephone directory. If none is listed locally, contact one of the addresses listed below to obtain the address or phone number of the Hewlett-Packard Sales or Support office nearest you.

ASIA

Hewlett-Packard Asia Ltd.
47/F, 26 Harbour Road,
Wanchai, **HONG KONG**
G.P.O. Box 863, Hong Kong
Tel: (852) 5-8330833
Telex: 76793 HPA HX
Cable: HPASIAL TD

AUSTRALASIA

Hewlett-Packard Australia Ltd.
31-41 Joseph Street
BLACKBURN, Victoria 3130
Australia
Tel: (61) 895-2895
Telex: 31-024
Cable: HEWPARD Melbourne

CANADA

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
MISSISSAUGA, Ontario L4V 1M8
Tel: (416) 678-9430
Telex: 069-8644

JAPAN

Yokogawa-Hewlett-Packard Ltd.
29-21 Takaido-Higashi, 3 Chome
Suginami-ku **TOKYO** 168
Tel: 03 (331) 6111
Telex: 232-2024 YHPTOK

MEDITERRANEAN AND MIDDLE EAST

Hewlett-Packard S.A.
Mediterranean and Middle East
Operations
Atrina Centre
32 Kifissias Avenue
Paradissos-Amarousion, **ATHENS**
Greece
Tel: (30) 682 88 11
Telex: 21-6588 HPAT GR
Cable: HEWPACKSA Athens

BENELUX & SCANDINAVIA

Hewlett-Packard S.A.
Uilenstede 475
P.O. Box 999
NL-1183 AG **AMSTELVEEN**
The Netherlands
Tel: (31) 20/43 77 71
Telex: 18 919 hpner nl

SOUTH & EAST EUROPE, AFRICA

Hewlett-Packard S.A.
7, rue du Bois-du-Lan
CH-1217 **MEYRIN** 2, Geneva
Switzerland
Tel: (41) 22/83 12 12
Telex: 27835 hmea
Cable: HEWPACKSA Geneve

FRANCE

Hewlett-Packard France
Parc d'activités du Bois Briard
2, avenue du Lac
91040 **EVRY** Cedex
Tel: 1 6/077 83 83
Telex: 6923 15F

GERMAN FEDERAL REPUBLIC

Hewlett-Packard GmbH
Hewlett-Packard-Strasse
Postfach 1641
D-6380 **BAD HOMBURG**
West Germany
Tel: 06172/400-0
Telex: 410 844 hpbhg

ITALY

Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio 9
1-20063 **CERNUSCO SUL NAVIGLIO**
(Milano)
Tel: 02/92 36 91
Telex: 334632

UNITED KINGDOM

Hewlett-Packard Ltd.
King Street Lane
Winnersh, **WOKINGHAM**
Berkshire RG11 5AR
Tel: 734/78 47 74
Telex: 847178

EASTERN USA

Hewlett-Packard Co.
4 Choke Cherry Road
ROCKVILLE, MD 20850
Tel: (301) 670-4300

MIDWESTERN USA

Hewlett-Packard Co.
5201 Tollview Drive
ROLLING MEADOWS, IL 60008
Tel: (312) 255-9800

SOUTHERN USA

Hewlett-Packard Co.
2000 South Park Place
P.O. Box 105005
ATLANTA, GA 30348
Tel: (404) 955-1500

WESTERN USA

Hewlett-Packard Co.
5161 Lankershim Blvd.
P.O. Box 3919
NO. HOLLYWOOD, CA 91609
Tel: (818) 506-3700

OTHER INTERNATIONAL AREAS

Hewlett-Packard Co.
Intercontinental Headquarters
3495 Deer Creek Road
PALO ALTO, CA 94304
Tel: (415) 857-1501
Telex: 034-8300
Cable: HEWPACK

February, 1986