

Errata

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OPERATING AND PROGRAMMING MANUAL

HP 8157A OPTICAL ATTENUATOR

SERIAL NUMBERS

This manual applies directly to instruments with serial number 2720600101 and higher. Any change made in instruments having serial numbers higher than the above number will be found in a "Manual Changes" supplement supplied with this manual. Be sure to examine the supplement for changes which apply to your instrument and record these changes in the manual.

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First Edition

October 1987

Effective Pages

Date

ALL

October 1987

PRINTING HISTORY

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The date on the title page and back cover of the manual only changes when a new edition is published. When an edition is reprinted, all the prior updates to the edition are incorporated. No information is incorporated into a new edition unless it appears in a prior update.

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SECTION I

GENERAL INFORMATION

1.1 INTRODUCTION

This manual contains the information required to install, test, and operate the Hewlett-Packard Model HP 8157A Optical Attenuator.

1.2 SPECIFICATIONS

Specifications of the Model HP 8157A are given in Table I-1. These specifications are the performance standards or limits against which the instrument is tested. The specifications are measured with Diamond[®] HMS-10/HP (Opt.011) connector interfaces and Diamond[®] HMS-10/HP connectors.

1.3 SAFETY CONSIDERATIONS

The Model HP 8157A is a Safety Class I instrument (instrument with an exposed metal chassis that is directly connected to earth via the power supply cable). The symbol used to indicate a protective earth terminal in the instrument is Ⓧ.

Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be followed to ensure safe operation and to maintain the instrument in a safe condition.

CAUTION

Every time that you connect a fiber to the HP 8157A, CLEAN the connectors. This is because any dirt particles on the ferrule of the HP 8157A connector will effect the return loss of the instrument and could also lead to permanent damage of the optical block.

DO NOT use index matching gel on the HP 8157A connectors, as this could damage the instrument. If you must improve connections, use only immersion oils.

Recommended Immersion Oils

R.P. Cargille Laboratories, INC
Refractive Index Liquid, use one with the refractive index of glass.

Zeiss Immersion Oil
HP Part Number 6040-0648

CAUTION

If you wish to use a DIN multimode connector on this instrument, screw the connector onto the HP 8157A's connector interface very softly, otherwise permanent damage can be caused to the ferrule of the HP 8157A.

1.4 INSTRUMENTS COVERED BY THIS MANUAL

Each Model HP 8157A has a two-part serial number. The first 4 digits and the letter comprise the serial number prefix; the last 5 digits a sequential suffix which is unique to each Model HP 8157A. The contents of this manual apply directly to optical attenuators having serial numbers above 2720G00101.

1.5 DESCRIPTION

The HP 8157A Optical Attenuator is precisely calibrated at 1300nm and 1550nm over the whole 60dB attenuation range. Because of the advanced optical system, including the lens design and coating, the attenuation can be easily corrected for other wavelengths in the respective ranges by simple entry of the desired wavelength into the instrument memory. This enables you to match the attenuator exactly to the center wavelength of your source, thus ensuring reliable measurement results. The following lists the features of the HP 8157A Optical Attenuator:

- designed for single-mode fibers
- full HP-IB programmability
- 60dB attenuation range, 0.01dB resolution and 0.04dB repeatability
- correction of attenuation between 1200nm and 1650nm

1.6 ACCESSORIES SUPPLIED

The Model HP 8157A is supplied complete with the following accessories:

Item	HP Part No.
T 800mA, 250Vac Fuse (100/120V)*	2110-0020
T 400mA, 250Vac Fuse (220/240V)*	2110-0340
Power Cord	see Figure 2-2

* one fitted and one supplied

1.7 ACCESSORIES AVAILABLE

A number of interface cables are available for simplifying connection of the Model HP 8157A to various optical signal sources and receivers. For a list of these adapter cables and connectors, see the latest Ordering Guide. The following lists the company options available for the HP 8157A:

Option 907	Front Handle Kit
Option 908	Rack Flange Kit
Option 916	Additional Operating and Programming Manual
P/N 5061-9071	Bail Handle Kit

An additional accessory for the Model HP 8157A is the HP 15475A Cleaning Kit. This kit includes cleaning material (brush, tissue, tape, etc.) to clean optical surfaces such as connectors and is supplied in a plastic carrying case.

Table 1-1: Specifications

Specifications describe the instrument's warranted performance. They are measured with Diamond® HMS-10/HP connector interfaces (Opt.011) and Diamond® HMS-10/HP connectors, if not otherwise specified. The connectors must have Manufacturing Date Code 31-87, or higher to achieve the warranted return loss values.

Optical Characteristics

Specifications are measured at 1300nm and 1550nm using a CW laser diode source with constant output power and single-mode fibers with 9/125 μm (NA=0.1).

Wavelength Range:
1200nm to 1650nm

Attenuation Range (excl. insertion loss): 60.00dB

Insertion Loss (incl. both connectors)

	HMS-10/HP Opt.011	FC/PC, DIN, ST Opt.012,013,014
worst case	< 4.0dB	< 6.0dB
typical	2.0dB	2.0dB

Linearity: ±0.20dB, typically 0.05dB

Return Loss (incl. two Diamond® HMS-10/HP connector interfaces and a terminated fiber end*): >33dB

Typical Return Loss (incl. two connector interfaces and a terminated fiber end*):

HMS-10/HP	PC	ST	DIN 47256	FC**
> 30dB	> 30dB	> 20dB	> 33dB	< 14dB

* Far end of fiber connected to the output port is terminated reflection-free.

** Note: FC is not a physical contact connector, therefore return loss is < 14dB.

Repeatability (of attenuation after any parameter has been changed and reset): < ±0.04dB

Display

Display Range: 0.00 to 64.00dB

Display Resolution: 0.01dB (min. step size)

Supplementary Performance Characteristics

(Description of non-warranted typical performance parameters)

Repeatability (of attenuation after a max. of 6 matings of same connector pair): <0.2dB

Operating Modes

Output disable: Optical signal path interrupted.

λ : Entry of wavelength for automatic correction of attenuation using typical correction values

Att: Attenuation is displayed and can be varied

Cal: Entry of calibration factor to adjust display so that displayed value indicates actual power level at output connector of attenuator. Range: ± 99.99 dB

General

Recalibration period: 1 year

No warm-up time required if previously stored within operating temperature range.

HP-IB Capability

All modes and parameters can be programmed.

Listen (time for HP 8157A to receive, verify and execute a message).

Output disable/enable, attenuation, λ : < 20 to 550ms (depending on actual setting/programmed parameter)

Cal: < 5ms

Talk (time for HP 8157A to transmit a message).

Query commands: < 1ms/character

HP-IB Interface Function Code: SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0

Environmental

Storage temperature: -40°C to +75°C

Operating temperature: 0°C to +55°C

Humidity: <95% R.H. from 0°C to 40°C

Power: 100/120/220/240Vrms, +5%, -10%, 90VA max., 48-400Hz

Battery back-up (for non-volatile memory): with instrument switched off all current modes and data will be maintained for at least 10 years after instrument delivery

Dimensions: 89mm H, 212.3mm W, 345mm D (3.5"x8.36"x13.6")

Weight: net 6.3 kg (13.9 lbs), shipping 10.6 kg (23.4 lbs)

For adapter cables and other accessories see latest Ordering Guide.

Data subject to change.

SECTION II

INSTALLATION

2.1 INTRODUCTION

This section provides installation instructions for the Model HP 8157A and its accessories. It also includes information about initial inspection and damage claims, preparation for use, packaging, storage and shipment.

2.2 INITIAL INSPECTION

Inspect the shipping container for damage. If the container or cushioning is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been verified both mechanically and electrically.

Procedures for checking the optical operation are given in Section 4. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Hewlett-Packard office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting settlement.

2.3 PREPARATION FOR USE

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

When operating the HP 8157A in the vertical position i.e. standing on the rear panel feet, care should be taken to ensure the instrument does not fall over and cause operator injury.

2.4 Power Requirements

The instrument requires a power source of 100/120/220/240 Vrms (+10%, -5%) at a frequency of 48-400 Hz single phase. The maximum power consumption is 90 VA.

2.5 Line Voltage Selection

CAUTION

BEFORE SWITCHING ON THE INSTRUMENT, make sure that the instrument is set to the local line voltage.

The switch is combined with the power line voltage receptacle on the rear panel. If it is necessary to change the setting, **THE POWER CORD MUST FIRST BE DISCONNECTED.** Then insert a screwdriver into the recess at the left-hand side of the assembly and prise open the cover. Figure 2-1 shows the main details of the assembly. To change the voltage setting, the selector must be removed and then replaced with the new setting value displayed. If necessary, change the fuse in accordance with the new voltage setting.

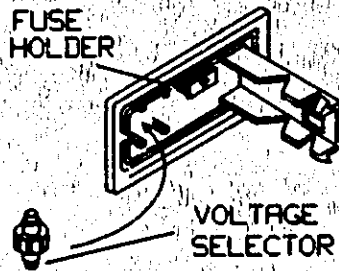


Figure 2-1. Line Voltage Switch Assembly.

VOLTAGE

100/120V

220/240V

FUSE

T 800mA, 250Vac

T 400mA, 250Vac

2.6 Power Cable

In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part numbers of the power cables available.

WARNING

To avoid the possibility of injury or death, the following precautions must be followed before the instrument is switched on.

- If this instrument is to be energized via an autotransformer for voltage reduction, ensure that the Common terminal is connected to the grounded pole of the power source.
- The power cable plug shall only be inserted into a socket outlet provided with a protective ground contact. The protective action must not be negated by the use of an extension cord without a protective conductor.
- Before switching on the instrument, the protective ground terminal of the instrument must be connected to a protective conductor. This is verified by using the power cord which is supplied with the instrument.

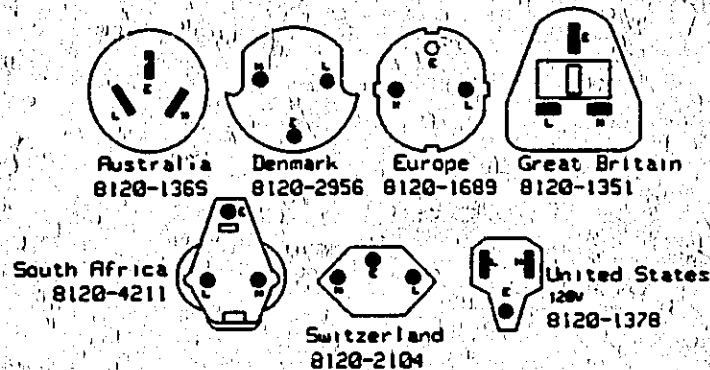


Figure 2-2: Power Cables - Plug Identification

The following work should be carried out by a qualified electrician - all local electrical codes being strictly observed. If the plug on the cable does not fit the power outlet, or the cable is to be attached to a terminal block, cut the cable at the plug end and re-wire it.

The color coding used in the cable will depend on the cable supplied (see Figure 2-2). If a new plug is to be connected, it should meet local safety requirements and include the following features:

- Adequate load-carrying capacity (see table of specifications in Section 1).
- Ground connection.
- Cable clamp.

2.7 HP-IB Connector

The rear panel HP-IB connector (Fig 2-3), is compatible with the connector on Cable Assemblies 10833A, B, C and D. If a cable is to be locally manufactured, use connector male, HP part number 1251-0293.

2.8 HP-IB Logic Levels

The HP 8157A HP-IB lines use standard TTL logic, the levels being as follows:

True = Low = digital ground or 0V dc to 0.4V dc.

False = High = open or 2.5V dc to 5V dc.

All HP-IB lines have LOW assertion states. High states are held at 3.0V dc by pull-ups within the instrument. When a line functions as an input, approximately 3.2mA of current is required to pull it low through a closure to digital ground. When a line functions as an output, it will sink up to 48mA in the low state and approximately 0.6mA in the high state.

NOTE: Isolation, the HP-IB line screens are not isolated from ground.

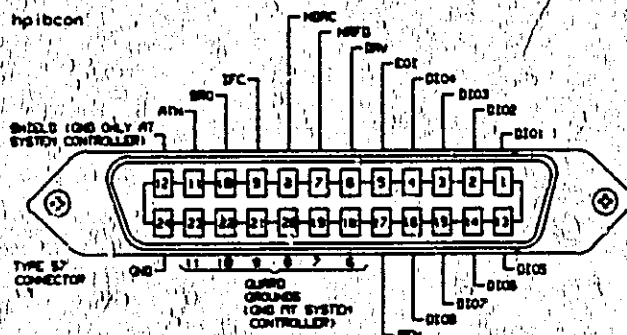


Figure 2-3. HB-IB Connector

2.9 OPERATING ENVIRONMENT

The operating temperature limits are 0°C to 55°C. The specifications also apply over this range.

2.10 CLAIMS AND REPACKAGING

If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Hewlett-Packard Service Office. The Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

2.11 STORAGE AND SHIPMENT

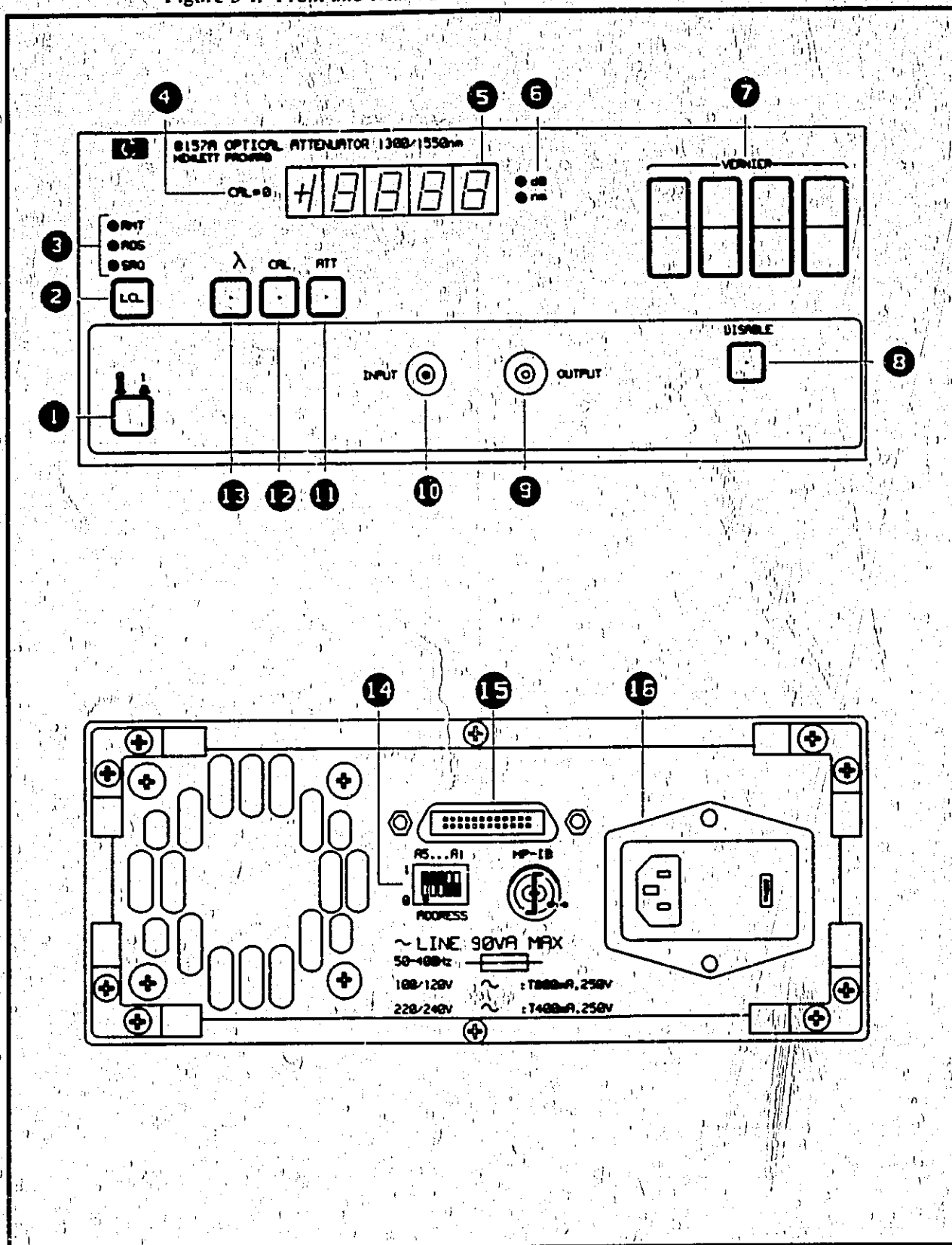
The instrument can be stored or shipped at temperatures between minus 40 deg C and plus 75 deg C. The instrument should be protected from temperature extremes which may cause condensation within it.

If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office, attach a tag showing owner, return address, model number and full serial number and the type of service required.

The original shipping carton and packing material may be reusable, but the Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packing is no longer available or reusable. General instructions for repacking are as follows:

1. Wrap instrument in heavy paper or plastic.
2. Use strong shipping container. A double wall carton made of 350-pound test material is adequate.
3. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of the instrument to provide a firm cushion and prevent movement inside container. Protect control panel with cardboard.
4. Seal shipping container securely.
5. Mark shipping container **FRAGILE** to encourage careful handling.
6. In any correspondence, refer to instrument by model number and serial number.

Figure 3-1. Front and Rear Panel Controls, Indicators and Connectors



SECTION III

OPERATING AND PROGRAMMING

3.1 INTRODUCTION

This section explains the functions of controls, indicators and connectors, as well as providing operating and programming information. Figure 3-1 provides a numbered illustration of the front and rear panel controls, and should be folded out when reading the description "Getting to Know Your Instrument" on the following pages. This description should be read before continuing with the more detailed operating information. Programming information is located at the end of this section.

3.2 SPECIAL OPERATING CONSIDERATIONS

The following points should be noted before applying power to the instrument:

- ☐ Read the safety summary at the beginning of this manual.
- ☐ Ensure that the VOLTAGE SELECTOR switch on the rear panel is set for operation at the local line voltage.

If any change is made to the setting of the VOLTAGE SELECTOR switch, the fuse must also be changed. Before making either of these changes, switch the instrument off and disconnect the power cord.

WARNING

How to Avoid Potential Exposure to Radiation

When connecting the Model HP 8157A into the optical path between an optical source and optical receiver, complete the connection between the Model HP 8157A and receiver first. Then regarding the connection between Model HP 8157A and source, make the Model HP 8157A connection before the source connection. This avoids any potential exposure to radiation.

3.3 OPERATORS CHECKS

The HP 8157A performs a self-test routine at power switch-on. At the start of this routine, all front panel LEDs should be momentarily lit. In the event of a fault being detected, an error code will be presented in the digital display. The error codes and required action are listed as follows:

- ☐ Keyboard test failed. Check that no key is stuck in pressed position.

Exxx where xxx is a 3-digit number. Indicates a serious fault and instrument should be returned to the nearest Hewlett-Packard Service Office.

3.4 GETTING TO KNOW YOUR INSTRUMENT

The following should be read in conjunction with Figure 3-1 which can be folded out to aid understanding.

Frontpanel

1. LINE switch. Power on/off switch.
2. LCL key. This key returns the HP 8157A to local manual operation when the instrument is under program control. Note that this key is disabled when the LOCAL LOCKOUT command has been sent by the system controller to the instrument.
3. Program status LEDs. When illuminated, the following is indicated.
 - RMT: Indicates remote control. All front panel pushbuttons (except the LCL pushbutton) are disabled.
 - ADS: Indicates that the instrument is being addressed under program control, although the front panel pushbuttons may still be enabled depending on the status of the RMT LED.
 - SRQ: Indicates that a Service Request has been sent by the instrument to the controller.
4. CAL \neq 0 LED. Indicates that a non-zero value is currently selected for the CAL factor (see description for CAL key 13). The difference between the displayed attenuation and actual attenuation = the CAL factor.
5. Digital display. Displays numerical value of currently selected parameter (wavelength, CAL-factor or attenuation).
6. Unit LEDs. Operate in conjunction with the digital display (6) to indicate the base units of the currently selected parameter.
7. VERNIER rocker keys. Used to vary parameter values.
8. DISABLE key. Used to enable/disable the optical output (10). When the key LED is illuminated, the optical output is disabled.
9. Connector for optical output.
10. Connector for optical input.
11. ATT key. Used to set the attenuation. When pressed, current attenuation is displayed and can be changed via VERNIER keys (8).
12. CAL key. Used to offset the displayed attenuation value (as set via key (12)). When pressed, current offset (CAL factor) is displayed and can be changed via VERNIER keys (8). NOTE: When CAL key is already active, i.e. key LED illuminated, holding the key down will display the insertion loss for the selected fiber mode.
13. λ key. Used for setting the wavelength. When pressed, the current wavelength is displayed and can be changed via VERNIER keys (8).

Rearpanel

14. HP-IB address switch.
15. HP-IB connector.
16. LINE connector assembly (including VOLTAGE SELECTOR switch). A three-pronged receptacle to provide chassis ground through the power cable for operator protection.

3.5 SETTING THE ATTENUATION

3.6 Basic Considerations

When you press the ATTenuation key on the HP 8157A front panel, the displayed setting automatically takes into consideration:

- The operating wavelength of the optical input. (Selected by λ key 13).

Due to the fact that attenuation is dependent on wavelength, you must first set the HP 8157A to the operating wavelength of the optical input to ensure attenuation accuracy. To make sure that you obtain the optimum performance from your optical system, use the center wavelength of your source. This can be found, for example, on the heatsink at the rear of the HP8154B. To set the wavelength, press λ key (13) and the current setting will be displayed. You can then change this setting via VERNIER keys (7), and the HP 8157A adjusts the attenuating filters automatically.

NOTE

Although instrument operation is specified for wavelengths 1300nm and 1550nm the setting range is 1200nm to 1650nm. For any setting other than that specified, the attenuation is based on a wavelength correction factor which is typically interpolated from the specified values.

With wavelength selected, the HP 8157A now performs automatic correction for any attenuation settings you make via the ATT key (11).

3.7 Optimize The Display With The CAL Key

The CAL key can be used to change the displayed attenuation setting without a corresponding change in actual attenuation at the output. Two examples of how this would be useful are as follows:

1. Making relative settings. If you want the displayed attenuation to be referenced to 20 dB, then entering -20 dB via the CAL key will set 20 dB actual attenuation to be the 0 dB displayed setting.
2. Adjusting the displayed attenuation to take known external losses into account. Consider the typical setup shown in the following figure 3-2.

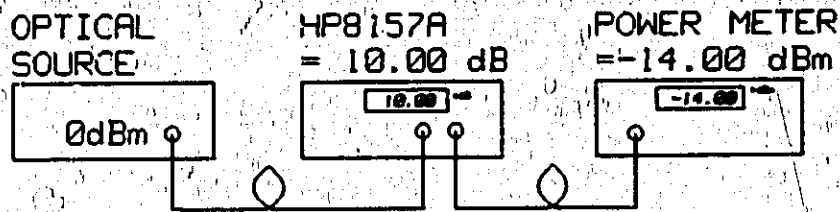


Figure 3-2.

Total attenuation from source to power meter is 14 dB, although the HP 8157A's displayed attenuation setting is 10 dB. There are therefore 4 dB external losses. By entering 4 dB via the CAL key, the displayed attenuation setting will change to 14 dB to include the 4 dB external losses, thus corresponding to power meter reading. Note that the CAL \neq 0 LED is now illuminated. This informs you that the displayed attenuation has been corrected via the following formula to include the CAL factor:

$$\text{Actual attenuation} + \text{CAL factor} = \text{Displayed attenuation}$$

Substituting the values in the example gives the following:

$$10\text{dB} + 4\text{dB} = 14\text{dB}$$

3.8 PROGRAMMING

3.9 WHAT YOU NEED TO KNOW

Programming information in this section is restricted to HP 8157A specifics, and assumes that you have a working knowledge of HP-IB intrinsics. If you are not familiar with HP-IB, then refer to the following publications:

- HP Publication 5952-0156, "Tutorial Description of HP-IB"
- ANSI/IEEE-488-1978, "Digital Interface for Programmable Instrumentation" published by the Institute of Electrical and Electronic Engineers

For a complete list of the HP 8157A programming commands, refer to the pages at the end of this section.

3.10 . . . About The HP 8157A's HP-IB Capabilities

The HP 8157A interfaces to the HP-IB as defined by the IEEE Standard 488-1978. The interface functional subset which the HP 8157A implements is specified in Table 3-1.

Table 3-1. HP-IB Capabilities

MNEMONIC	INTERFACE FUNCTION NAME
SH1 AH1 T6	SOURCE HANDSHAKE CAPABILITY ACCEPTOR HANDSHAKE CAPABILITY BASIC TALKER, SERIAL POLL, UNADDRESSED IF MY LISTEN ADDRESS
L4	BASIC LISTENER, UNADDRESSED IF MY TALK ADDRESS
SR1 RL1 PPO DC1 DTO CO	SERVICE REQUEST CAPABILITY REMOTE/LOCAL CAPABILITY NO PARALLEL POLL CAPABILITY DEVICE CLEAR CAPABILITY NO DEVICE TRIGGER CAPABILITY NO CONTROLLER CAPABILITY

3.11 . . . About Programming Examples in This Section

Programming examples are given in this section to aid explanation. These examples assume the following:

- an HP9000, Series 200 or 300 Computer, is controller
- that BASIC is the programming language
- the HP 8157A is set to HP-IB address 28 (factory setting)

3.12 GETTING STARTED

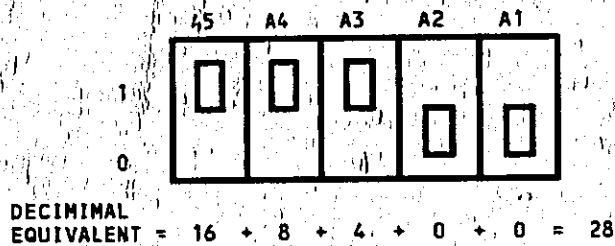
If this is the first time you are programming the HP 8157A, the following gives you a few simple tasks to carry out prior to detailed program development. The benefits are twofold in that it gets you started on programming the HP 8157A, at the same time checking remote operation of your instrument.

3.13 Setting the Address

Each instrument that you connect to the interface bus has a unique "address", and the HP 8157A is no different. The address used in a typical BASIC statement takes the form "7xx" where:

- 7 = the interface select code
- xx = the instrument address, which can be any integer from 00 to 30 (21 is usually reserved for the controller)

The HP 8157A is preset at the factory to address 28 as shown in the following illustration of the address switch (you can check this by pressing the front panel LCL key to display the address).



If you are satisfied with this address, then continue with the next task "Checking Remote Operation" (Note that all examples in this section assume the address is set to 28).

If you want to change the address, first ensure that the HP 8157A is in local mode and not addressed (i.e. the ADS and RMT LEDs (3) are not illuminated), then change the bit settings on rear panel address switch (16). Now press the front panel LCL key, and the new address will be activated and displayed.

3.14 Checking Remote Operation

You can now check remote operation using a few simple commands as follows:

10 DIM AS[7]	
20 CLEAR 728	-clears HP 8157A's input/output buffers
30 OUTPUT 728: "ATT 5.00 dB"	-sets attenuation to 5.00 dB
40 OUTPUT 728: "ATT?"	-interrogates attenuation setting
50 ENTER 728:AS	-transfers setting data to controller
60 PRINT AS	
70 END	

The controller output should read " 5.00" which indicates that both the Listener and Talker functions of the HP 8157A are operating correctly.

3.15 SENDING DATA TO THE HP 8157A (LISTENER FUNCTION)

All the settings you can make via front panel switches can also be programmed via HP-IB. To aid explanation, consider the following programming example:

```
10 OUTPUT 728:"WVL 1300 NM:Cal 0dB:D0:Att 3.2dB"  
20 END
```

This sets the HP 8157A to a wavelength of 1300nm, attenuation 3.2dB, CAL factor 0.0dB and output ON. The points to note on the setting "string" are as follows:

- Each setting in the string must be terminated by a ":"
- Either upper or lower case may be selected (d0 is the same as D0)
- Any of 3 different data formats may be used. The following settings are equivalent and will be interpreted correctly:
wvl 1300 nm WVL 1.3 um WVL 1300 e-09 m WVL 1.3E-06
- If no unit is specified, then the default unit will be assumed. The default unit is dB for attenuation and CAL factor, and meter for wavelength

(A complete list of the setting commands is given at the end of this section).

3.16 RECEIVING DATA FROM THE HP 8157A (TALKER FUNCTION)

Just as you can program all HP 8157A settings via HP-IB, you can also interrogate all settings - either individually or as a complete set (learn string). The HP 8157A can also send data regarding installed firmware, error and status reports. (A complete list of the interrogating commands is given on the blue pages at the end of this section).

From the programming example given in the previous sub-section, the wavelength was set to 1300nm. If you now want to interrogate this setting, you could use the following simple program:

```
10 DIM AS[11]                -dimensions string AS for 11 characters
20 OUTPUT 728;"WVL?"        -interrogates the wavelength setting
30 ENTER 728;AS             -transfer setting data to controller
40 DISP AS                  -displays the setting data. ( 0.1300E-05)
50 END
```

Depending on which setting is being interrogated, the length of the character string returned to the controller is 1 to 11 characters long. You can also interrogate the complete settings using a single command. The following provides an example:

```
10 DIM AS[56]
20 OUTPUT 728;"LRN?"
30 ENTER 728;AS
40 PRINT AS
50 END
```

The Model HP 8157A then returns its settings as a 56-character string to the controller. The setting sequence is always the same and listed as follows:

Fiber setting	4 characters
Output state	4 characters
SRQ mask	8 characters
CAL factor	12 characters
Attenuation	12 characters
Wavelength	16 characters

3.17 STATUS/ERROR REPORTING (TALKER FUNCTION)

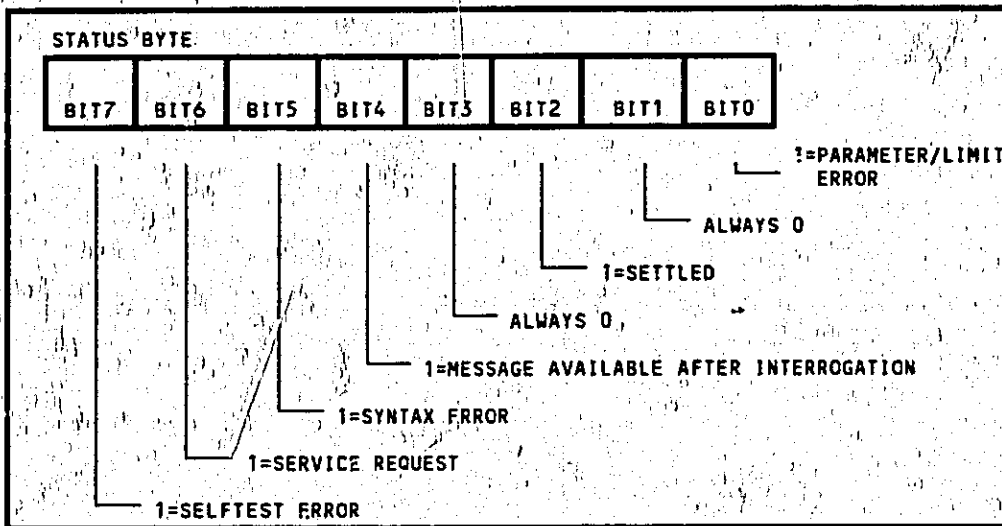
Another important feature of the HP 8157A is that you can program it to interrupt the controller when certain status/error conditions are met. The Require Service (SRQ) message is used to implement this feature and is independent of all other HP-IB activity. However, the HP 8157A must be programmed for the interrupt, via the SRQ mask, before the interrupt will take place. The possible interrupt conditions that can be programmed via the SRQ mask are listed as follows:

- Self-Test Error** If an error is detected by the self-test at power-on, or via the "TST?" command (e.g. OUTPUT 728;"TST?").
- Settled** When the HP 8157A's hardware has settled to the new setting values (Hardware Ready).
- Parameter Error** A wrong value has been set for a parameter.
- Message Available** When the HP 8157A is ready to respond to an interrogation command.
- Syntax Error** An invalid instruction has been sent.

These 6 interrupt conditions are monitored by an 8-bit Status Register, the content of this register being referred to as the Status Byte.

3.18 Status Register and Status Byte

The following shows which bit in the Status Register is allocated to which interrupt condition:



When an interrupt condition is true, the corresponding bit in the status Register is set to 1 - independent of the SRQ mask setting. However, an interrupt (SRQ) will only occur when the SRQ mask has been set for that condition. It is therefore possible for one or more bits of the Status Register to be true without the HP 8157A causing an interrupt - because the SRQ mask has not been set for these bits.

This is typically the case at power-on or after "Device Clear" - as the SRQ mask is then set to decimal 000 and all interrupts are disabled. If the HP 8157A is now serial polled or receives the "STB?" command, the decimal equivalent of the Status Byte is returned to the controller - but the Status Byte remains unchanged. To clear the Status Byte, the "CSB" (Clear Status Byte) command must be used. For example:

10	DIM AS[7]	-	Dimension of A-string
20	CLEAR 728	-	Clears HP 8157A's I/O buffers, SRQ mask = 000
30	OUTPUT 728:"CSB"	-	Clear Status Byte
40	OUTPUT 728:"wvl?"	-	Interrogate wavelength setting
50	S=SPOLL(728)	-	Serial poll of HP 8157A
60	IF BIT(S,4) = 0 THEN GOTO 50	-	Check Status Byte; if Bit 4=0, repeat Serial poll; if Bit 4=1, message available
70	ENTER 728:AS	-	Transfer wavelength setting to controller
80	PRINT AS	-	Print result
90	OUTPUT 728:"CSB"	-	Clear Status Byte
100	END		

If the SRQ mask is set for certain conditions, and one of these conditions occur, bit 6 of the Status Register will go true ("1" state), the SRQ LED on the front panel will illuminate, and the HP-IB SRQ message will be sent. At this point, it will be necessary to address the HP 8157A as talker by using the Serial Poll command or "STB?" command:

10	A=SPOLL(728)	-	Transfers Status Byte to variable "A"
20	PRINT A		
30	END		
	or		
10	OUTPUT 728:"STB?"	-	Interrogates the Status Byte
20	ENTER 728:A	-	Transfers the Status Byte to variable "A"
30	PRINT A		
40	END		

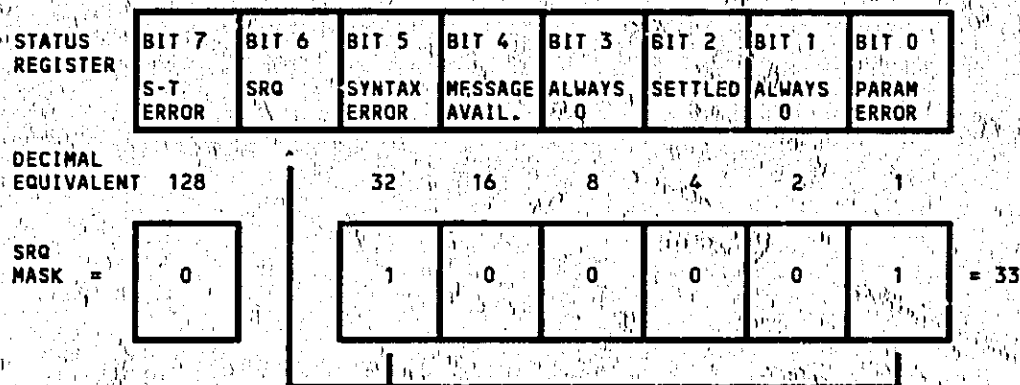
The Status Byte is returned to the controller as a decimal number which can be broken down into its 8 binary components to determine which bit has gone true. At the same time, the Status Register is cleared and SRQ set false.

NOTES

- Once SRQ is set true, the Status Byte remains unchanged until serial polled or interrogated via the "STB?" command. For any interrupt condition going true during this period, the corresponding bit in the Status Register will not be set. Instead, the "1" state will be held in HP 8157A memory and loaded into the Status Register after it is cleared e.g. by serial poll.
- For this reason, if several conditions are enabled by the SRQ mask and they all go true, only the condition that occurred first will have its bit set in the Status Register. The bit settings for the other conditions will be held in HP 8157A memory, and loaded simultaneously into the Status Register after it is cleared. If you have set more than one condition by the SRQ mask, therefore, your program should serial poll the HP 8157A twice to ensure that the Status Register is cleared and SRQ set false.

3.19 Setting the SRQ Mask

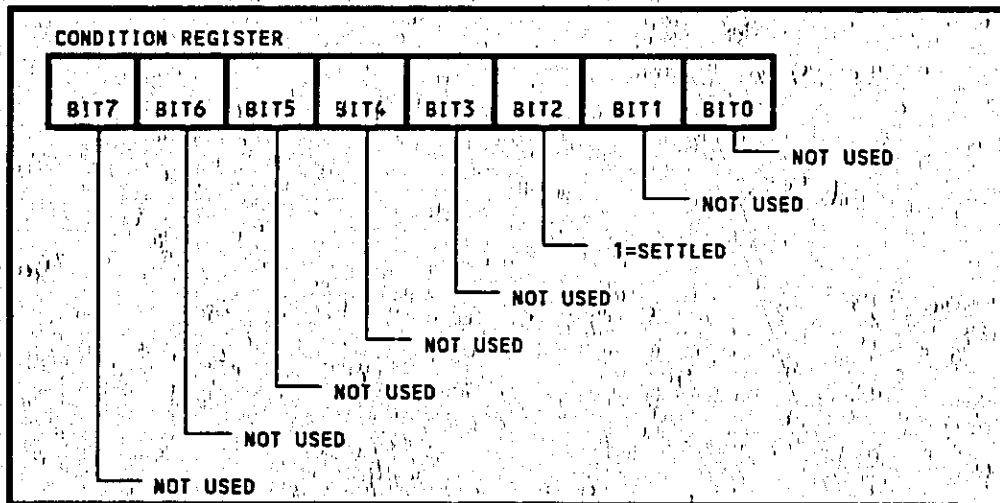
The SRQ mask can be set to mask bits 0-5 and bit 7 on the Status Register. Default mask value is 0 i.e. all interrupt conditions are disabled and no SRQ can be generated. To set the mask first determine which conditions you want to interrupt the controller, e.g. parameter error, syntax error, etc. Determine the decimal number (1-191) corresponding to those conditions. A "1" in the mask byte enables the corresponding interrupt condition. Then output the "SRE" instruction mnemonic followed by the decimal number. The following shows the Status Register and the SRQ mask set for bit 1 and bit 5, syntax error and parameter error. (OUTPUT 728:"SRE33").



3.20 Condition Register

Whereas the Status Register monitors events, i.e. when an interrupt condition occurs, a bit is set and remains set until the register is cleared, the condition register monitors the current status regarding "settled" and "attenuation > display".

The bit allocation in the condition register is as follows:



When the condition register is interrogated via the "CNB?" command, the contents are returned to the controller as a decimal number. This number can then be broken down into its binary components to determine which bit has been set to "1".

HP 8157A COMMAND SUMMARY

SETTINGS (LISTENER FUNCTION)

Parameter/Operation	Mnemonics	Data	Unit	Comment
Select Single-Mode	F	1		These commands will be ignored, as always single-mode i.e. 1. Here due to compatibility to HP 8158B.
Select Multimode	F	2		
Enable Output	D	0		
Disable Output	D	1		
Set Wavelength	WVL	value	M MM UM NM	meter. Default if no unit defined millimeter micrometer nanometer
Set Attenuation	ATT	value	DB	Default is dB if no unit defined
Set CAL Factor	CAL	value	DB	Default is dB if no unit defined
Set SRQ Mask	SRE	value		value = decimal number (0-191). A "1" in the binary equivalent sets SRQ on this condition.
Clear Status Byte	CSB			Always clears Status Byte independent of SRQ state.
Clear Device	CLR			Clears all I/O buffers. Same as Universal Device Clear Command.

INTERROGATING SETTINGS (TALKER FUNCTION)

Parameter/Operation	Mnemonics	Comment
Learn Mode	LRN?	Returns 56-character string detailing all settings.
Interrogate setting	F?	Always returns 1, i.e. single-mode.
	WVL?	Returns 11-character string for λ setting. Always in meters.
	CAL?	Returns 7-character string for CAL factor. Always in dB.
	ATT?	Returns 7-character string for attenuation setting. Always in dB.
	D?	Returns integer (0 or 1) for output off/on.

STATUS/ERROR REPORTING (TALKER FUNCTION)

Interrogation	Mnemonics	Comment
Status Byte	STB?	Returns 3-digit integer (000-191). With SRQ false, does not clear Status Byte.
Status Byte Mask	SRE?	Returns 3-digit integer (000-191)
Condition Byte	CNB?	Returns 2-digit integer (00-06)
Self-test	TST?	Executes self-test and returns 0 or 1 to indicate passed or failed
Error Number	ERR?	Returns 3-digit integer representing HP 8157A error code (details given in Service info). 000 means no error. An error code is only available if bit 7 (self-test) in the Status Byte has been set. Other error conditions in the Status Byte will not cause an error code. On readout, the error code is transferred to the 'Last Error Number' register.
Last Error Number	LERR?	Returns 3-digit integer for last active error. This is a destructive readout.
Operation Complete	OPC?	1 if no further command to interpret and execute in the input buffer. 0 if further commands in the input buffer.
Identifier	IDN?	Returns 40-character string identifying currently installed firmware and manufacturer model no.

UNIVERSAL COMMANDS

Command	ASCII Character	Equivalent Forms		
		Binary	Octal	Decimal
Device Clear	DC ₄	00010100	024	20
Selected Device Clear	EOT	00000100	004	4

Both "CLEAR" commands clear all input/output buffers, reset SRQ mask to all disabled and SRQ to false, but have no effect on HP 8157A mode/parameter settings.

SECTION IV

PERFORMANCE TESTS

4.1 INTRODUCTION

The procedures in this section test the optical performance of the instrument. The complete specifications to which the HP 8157A is tested are given in Table 1-1. All tests can be performed without access to the interior of the instrument.

4.2 EQUIPMENT REQUIRED

Equipment required for the performance test is listed in Table 4-1. Recommended Test Equipment. Any equipment which satisfies the critical specifications given in the table may be substituted for recommended models.

Table 4-1. Recommended Test Equipment

Instrument/Accessory	Rec. Model	Critical Specification
Power Meter Standard	HP8152A HP81521B	Accuracy: < 2%, Dynamic Range >60dB, Accuracy (rel) <0.15dB
Lens Adapter	HP81010BL	
Connector Adapter	HP81000AA	
Single-Mode Fibers	HP81101AC 2 off	Date code 31-87 and higher.
Laser Source	HP8155A Opt.002/011	1300nm -3dBm into single-mode fiber
CW Laser Source	HP8155A Opt.003/011	1550nm -3dBm into single-mode fiber
OTDR	HP8115A Opt.002/011 or Opt.003/011	
Optical Attenuator	HP8158B Opt.002/011 or HP8157A Opt.011	
Single-Mode Fiber	>0.5Km length with 2 Diamond HMS-10/HP connectors	
Connector Adapters	P/N 08154-61701 (Opt 011), if required	
Cleaning Kit	HP15475A	

4.3 TEST RECORD

Results of the performance test may be tabulated on the Test Record provided at the end of the test procedures. It is recommended that you fill out the Test Record and refer to it while doing the test. Since the test limits and setup information are printed on the Test Record for easy reference, the record can also be used as an abbreviated test procedure (if you are familiar with test procedures). The Test Record can also be used as a permanent record and may be reproduced without written permission from Hewlett-Packard.

4.4 TEST FAILURE

If the HP 8157A fails any performance test, return the instrument to the nearest Hewlett-Packard Sales/Service Office for repair.

4.5 INSTRUMENTS SPECIFICATION

Specifications are the performance characteristics of the instrument which are certified. These specifications, listed in Table 1-1, are the performance standards or limits against which the HP 8157A can be tested. Table 1-1 also lists some supplementary characteristics of the HP 8157A and should be considered as additional information.

Any changes in the specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement or revised manual. The specifications listed here supercede any previously published.

4.6 PERFORMANCE TEST

The performance tests given in this section are separated into Total Insertion Loss Test, Attenuation Accuracy Test, Attenuation Repeatability Test and Return Loss Test. Perform each step in the tests in the order they are given using the corresponding test equipment.

NOTE

Make sure that all optical connections of the test setups given in the procedure are dry and clean. For cleaning use accessory kit Model HP15475A. **DO NOT USE INDEX MATCHING GEL.**

The Optical Cables from the Laser Source to the HP 8157A and from the Attenuator to the Power Meter must be fixed on the table to ensure minimum cable movement during the tests.

All tests and equipment mentioned in the Performance Test section refer to tests carried out with the Diamond® HMS-10/HP connectors with date codes 31-87 and higher.

4.7 TOTAL INSERTION LOSS TEST

Specification:

Insertion loss (including both connectors) < 4.0 dB with single-mode fiber 9 μm .

Equipment required:

1300nm single-mode tests

HP8155A Opt.002/011 Laser Source with constant output power 1300nm wavelength.

Power Meter Standard with Optical Head, connector adapter and lens adapter for single-mode fiber. (8152A; 81521B; 81010BL; 81000AA)

Optical Cable (9 μm) HP81101AC

Optical Cable (9 μm) HP81101AC

1550nm single-mode tests

HP8155A Opt.003/011 Laser Source with constant output power 1550nm wavelength.

Power Meter Standard with Optical Head, connector adapter and lens adapter for single-mode fiber. (8152A; 81521B; 81010BL; 81000AA)

Optical Cable (9 μm) HP81101AC

Optical Cable (9 μm) HP81101AC

Carry out the following **TOTAL INSERTION LOSS** test for 1300nm or 1550nm single-mode, using the equipment listed above.

1. Using the VERNIER rocker keys set the HP 8157A attenuation to 0000 dB.
2. Connect the equipment as shown in Figure 4-1

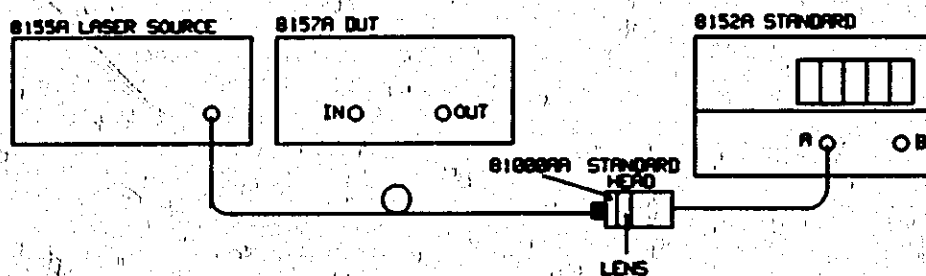


Figure 4-1. Reference Measurement Set-up

3. Set the Average Power Meter to Autorange. Display [dB].
4. Set DISPlay to REference on the power meter 8152A.

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

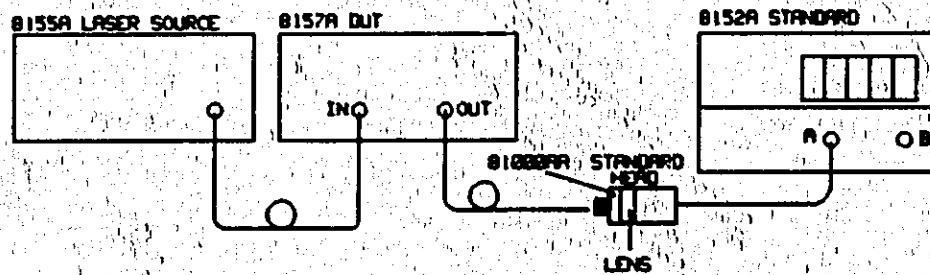


Figure 4-2. Total Insertion Loss Test Set-up

6. Enable the HP 8157A attenuator output and record the power meter reading (in dB) on the Test Record and check that it is within specifications.

4.8 ATTENUATION ACCURACY

Specifications:

Linearity for single-mode, ± 0.2 dB

Equipment required:

1300nm single-mode tests

HP8155A Opt.002/011 Laser Source with constant output power 1300nm wavelength.

Power Meter Standard with Optical Head, connector adapter and lens adapter for single-mode fiber. (8152A; 81521B; 81010BL; 81000AA)

Optical Cable (9 μ m) HP81101AC

Optical Cable (9 μ m) HP81101AC

1550nm single-mode tests

HP8155A Opt.003/011 Laser Source with constant output power 1550nm wavelength.

Power Meter Standard with Optical Head, connector adapter and lens adapter for single-mode fiber. (8152A; 81521B; 81010BL; 81000AA)

Optical Cable (9 μ m) HP81101AC

Optical Cable (9 μ m) HP81101AC

Carry out the following ATTENUATION ACCURACY tests for 1300nm single-mode and 1550nm single-mode using the equipment listed above.

1. Set HP 8157A as follows:

λ as required

CAL to 0.00 dB

ATT to 0.00 dB

2. Connect equipment as shown in Figure 4-3.

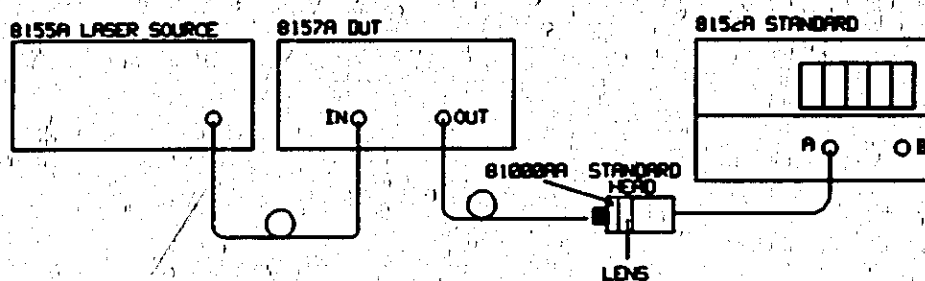


Figure 4-3. Attenuation Accuracy Test Set-up

3. Set HP 8157A output power level as 0.00 dB reference level on the Average Power Meter and check the following attenuation settings for ± 0.2 dB accuracy.

0.00 dB = Reference

1 dB	11 dB
2 dB	12 dB
3 dB	13 dB
4 dB	14 dB
5 dB	24 dB
6 dB	34 dB
7 dB	44 dB
8 dB	54 dB
9 dB	
10 dB	

4.9 ATTENUATOR REPEATABILITY

Specifications:

Repeatability after any parameter has been changed and reset $< \pm 0.04$ dB.

Equipment required:

Use the same equipment, test set-up and HP 8157A settings as used for the ATTENUATION ACCURACY test (either for 1300nm or 1550nm wavelength).

1. Set the HP8157A attenuation to the values shown in step 3 and note the AVG Power Meter reading in the Test Record.
2. Set the HP8157A attenuation to any other value (eg.0.00dB) and then back to the previous value. Note the AVG Power Meter reading in the Test Record and check that the second reading is within ± 0.04 dB of the first reading.
3. Repeat steps 1 and 2 for following attenuation settings:

5dB
12dB
24dB
36dB
48dB
50dB
53dB

4.10 ATTENUATOR RETURN LOSS

Specifications:

Return Loss > 33 dB

Equipment required:

Return Loss Test

HP8145A Optical Time Domain Reflectometer Opt.002/011 or Opt.003/011.

Single-Mode Fiber with 2 HMS10/HP Connectors (>0.5km)

HP8157A or HP8158B Opt.002/011 Attenuator

2 off HP81101AC Single-Mode Fibers

15475-68701 Adhesive Tape Kit (Part of HP15475A Cleaning Kit) to terminate the HP8157A output.

1. Make sure that all optical connectors are cleaned carefully.
2. Connect equipment as shown in Figure 4-4

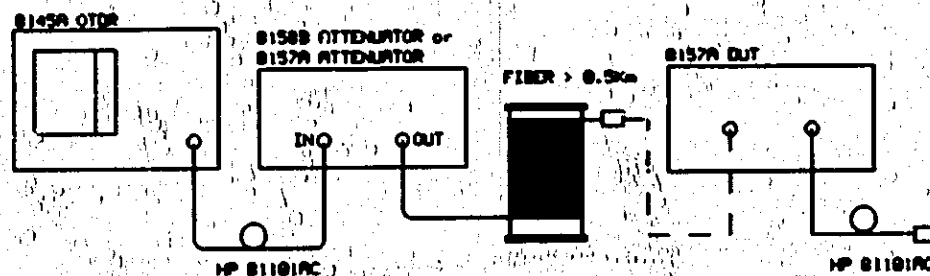


Figure 4-4. Return Loss Set-up

3. Set the 8158B (or HP 8157A) to min. attenuation and enable the output.
4. Set the HP8145A as follows:

Press RCL 0 ENTER and then START.

Select span and move the end-reflection of the connected fiber to the center of the screen.

Next press the center position softkey.

STOP measurement.

Change the HP8145A as follows:

vertical offset	to:	7dB
vertical scale	to:	2.5dB
span	to:	1Km
measurement mode	to:	fast refresh

5. Press MEASUREMENT START. The displayed end-reflection signal shows that the receiver is in saturation. Therefore increase the attenuation of the HP8158B (HP 8157A) until the displayed end-reflection shows only one peak which should be approx. one minor division below saturation.
6. Using vertical offset move the peak (fresnel reflection of 4%) to the upper graticule line as reference (14 dB).
7. Check the dynamic range by pressing the open fiber connector slightly against a piece of adhesive tape supplied with the HP15475A Cleaning Kit. The end-reflection signal should decrease by at least 5 divisions. If the end-reflection is higher, clean the connectors again.
8. Connect the open fiber connector to the input of the HP8157A DUT, set CAL and ATT to 0.00 and enable the output.
9. Terminate the output cable of the HP8157A DUT by pressing the open connector slightly against the piece of adhesive tape and check that the end-reflection decreases below to the center horizontal graticule line. Note the reading in dB, multiply by 2 and add 14 dB. Note the result in the Performance Test Record.

NOTE: The HP8145A OTDR displays the measurement results only for one way in the fiber, therefore the displayed results must be multiplied by 2. The measurement results are referenced to 14dB fresnel reflection which must be added.

PERFORMANCE TEST RECORD FOR HP 8157A OPT.011

Hewlett-Packard Model 8157A

Test Performed By _____

Optical Attenuator

Date _____

Serial Number _____

Comments _____

TOTAL INSERTION LOSS TEST

Test Conditions; 1300nm with single-mode fibers
1550nm with single-mode fibers
with Diamond HMS-10/HP connectors

Description	Test Pass Fail
1300nm with single-mode fibers < 4.0dB	
Output via 8157A (min. ATT.)	
Total Insertion Loss = _____ dB	_____
1550nm with single-mode fibers < 4.0dB	
Output via 8157A (min. ATT.)	
Total Insertion Loss = _____ dB	_____

PERFORMANCE TEST RECORD FOR HP 8157A OPT.011

Hewlett-Packard Model 8157A

Test Performed By _____

Optical Attenuator

Date _____

Serial Number _____

Comments _____

ATTENUATION ACCURACY TEST

Test Condition: 1300nm with single-mode fibers
with Diamond HMS-10/HP connectors

Attenuation Setting	Power Meter Reading			Test Pass	Test Fail
	min.	act.	max.		
0 dB	0.00 dB Reference				
1 dB	0.8dB	_____ dB	1.2dB	_____	_____
2 dB	1.8dB	_____ dB	2.2dB	_____	_____
3 dB	2.8dB	_____ dB	3.2dB	_____	_____
4 dB	3.8dB	_____ dB	4.2dB	_____	_____
5 dB	4.8dB	_____ dB	5.2dB	_____	_____
6 dB	5.8dB	_____ dB	6.2dB	_____	_____
7 dB	6.8dB	_____ dB	7.2dB	_____	_____
8 dB	7.8dB	_____ dB	8.2dB	_____	_____
9 dB	8.8dB	_____ dB	9.2dB	_____	_____
10 dB	9.8dB	_____ dB	10.2dB	_____	_____
11 dB	10.8dB	_____ dB	11.2dB	_____	_____
12 dB	11.8dB	_____ dB	12.2dB	_____	_____
13 dB	12.8dB	_____ dB	1.2dB	_____	_____
24 dB	23.8dB	_____ dB	24.2dB	_____	_____
34 dB	33.8dB	_____ dB	34.2dB	_____	_____
44 dB	43.8dB	_____ dB	44.2dB	_____	_____
54 dB	53.8dB	_____ dB	54.2dB	_____	_____

PERFORMANCE TEST RECORD FOR HP 8157A OPT.011

Hewlett-Packard Model 8157A

Test Performed By _____

Optical Attenuator

Date _____

Serial Number _____

Comments _____

ATTENUATION ACCURACY TEST

Test Condition: 1550nm with single-mode fibers
with Diamond HMS-10/HP connectors

Attenuation Setting	Power Meter Reading			Test Pass	Test Fail
	min.	act.	max.		
0 dB	0.00 dB Reference				
1 dB	0.8dB	_____ dB	1.2dB	_____	_____
2 dB	1.8dB	_____ dB	2.2dB	_____	_____
3 dB	2.8dB	_____ dB	3.2dB	_____	_____
4 dB	3.8dB	_____ dB	4.2dB	_____	_____
5 dB	4.8dB	_____ dB	5.2dB	_____	_____
6 dB	5.8dB	_____ dB	6.2dB	_____	_____
7 dB	6.8dB	_____ dB	7.2dB	_____	_____
8 dB	7.8dB	_____ dB	8.2dB	_____	_____
9 dB	8.8dB	_____ dB	9.2dB	_____	_____
10 dB	9.8dB	_____ dB	10.2dB	_____	_____
11 dB	10.8dB	_____ dB	11.2dB	_____	_____
12 dB	11.8dB	_____ dB	12.2dB	_____	_____
13 dB	12.8dB	_____ dB	1.2dB	_____	_____
24 dB	23.8dB	_____ dB	24.2dB	_____	_____
34 dB	33.8dB	_____ dB	34.2dB	_____	_____
44 dB	43.8dB	_____ dB	44.2dB	_____	_____
54 dB	53.8dB	_____ dB	54.2dB	_____	_____

PERFORMANCE TEST RECORD FOR HP 8157A OPT.011

Hewlett-Packard Model 8157A

Test Performed By _____

Optical Attenuator

Date _____

Serial Number _____

Comments _____

ATTENUATOR REPEATABILITY TEST

Test Condition: 1300nm or 1550nm with single-mode fibers
with Diamond HMS-10/HP connectors.

Attenuation Setting	Reading 1	Power Meter Reading 2	Reading 1-2	Spec.	Test Pass	Test Fail
5 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____
12 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____
24 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____
36 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____
48 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____
53 dB	_____ dB	_____ dB	_____ dB	+/-0.04dB	_____	_____

PERFORMANCE TEST RECORD FOR HP 8157A OPT.011

Hewlett-Packard Model 8157A

Test Performed By _____

Optical Attenuator

Date _____

Serial Number _____

Comments _____

RETURN LOSS TEST

Test Condition: 1300nm or 1550nm with single-mode fibers
with Diamond HMS-10/HP connectors

Specification

>33 dB

Actual Return Loss Measured

_____ dB

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GENERAL — This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

OPERATION — BEFORE APPLYING POWER comply with the installation section. Additionally, the following shall be observed:

Do not remove instrument covers when operating.

Before the instrument is switched on, all protective earth terminals, extension cords, auto-transformers and devices connected to it should be connected to a protective earth via a ground socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in serious personal injury. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuseholders must be avoided.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present. Do not replace components with power cable connected.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

SAFETY SYMBOLS



The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.



Indicates dangerous voltages.



Earth terminal

WARNING

The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice or the like, 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.

CAUTION

The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a **CAUTION** sign until the indicated conditions are fully understood and met.

WARNING

Dangerous voltages, capable of causing serious personal injury, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

