

Agilent 8163A/4A/6A Lightwave Series Mainframes

# Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Power Sensor Module User's Guide



Agilent Technologies  
Innovating the HP Way

Second Edition

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The Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System.

## Line Power Requirements

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.).

The Performance Tests give procedures for checking the operation of the instrument. 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 Agilent Technologies Sales/Service Office.

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically.

### Initial Inspection

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.



### Safety Symbols

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.

**WARNING**

Before operation, review the instrument and manual, including the red safety page, for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

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. Agilent Technologies Company assumes no liability for the customer's failure to comply with these requirements.

## Safety Considerations

condensation within it.

This module can be stored or shipped at temperatures between  $-40^{\circ}\text{C}$  and  $+70^{\circ}\text{C}$ . Protect the module from temperature extremes that may cause

## Storage and Shipment

The safety information in the Agilent 8163A Lightwave Multimeter, Agilent 8166A Lightwave Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System User's Guide summarizes the operating ranges for the Agilent 81632A/3A/4A Power Sensor Module and Agilent 81635A Dual Power Sensor Module. In order for these modules to meet specifications, the operating environment must be within the limits specified for the Agilent 8163A Lightwave Multimeter, Agilent 8164A Lightwave Measurement System, and Agilent 8166A Lightwave Multichannel System.

## Operating Environment

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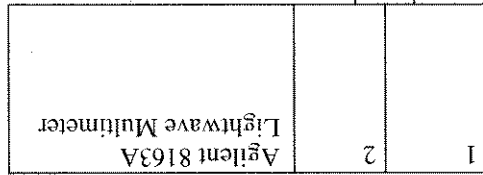


# Accessories

The Agilent 81632A/3A/4A Power Sensor Module and the Agilent 81635A Dual Power Sensor Module are available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

# Modules and Options



**Power Sensors**  
 81632A 10 dBm to -90 dBm  
 81635A 10 dBm to -110 dBm

**Connector Interfaces**  
 81000AI Diamond HMS-10  
 81000FI FC/PC/SPC  
 81000GI D4  
 81000JI SMA  
 81000KI SC/APC  
 81000NI FC/APC  
 81000PI E-2000  
 81000SI DIN 47526  
 81000VI ST  
 81000WI Biconic

**Connector Interfaces**  
 81000FI FC/PC/SPC  
 81000FB Bare Fiber Adapter  
 81000KI SC/APC  
 81000KB Bare Fiber Adapter

**Bare Fiber Adapters**  
 81000SI DIN 47526  
 81000SB Bare Fiber Adapter  
 81000VI ST

**Connector Interfaces and Bare Fiber Adapters**  
 81000FI FC/PC/SPC  
 81000FB Bare Fiber Adapter  
 81000KI SC/APC  
 81000KB Bare Fiber Adapter  
 81000SI DIN 47526  
 81000SB Bare Fiber Adapter  
 81000VI ST

**Figure 1** Recommended Connector Interfaces and Bare Fiber Adapters

**Table 1** Connector Interfaces

Product Number	Connector Interface Type
81000AI	Diamond HMS-10
81000FI	FC/PC/SPC
81000GI	D4
81000JI	SMA
81000KI	SC/APC

Product Number	Bare Fiber Adapter	Product Number	Connector Interface
81000FB	Bare Fiber Adapter	81000FI	FC/PC/SPC
81000KB	Bare Fiber Adapter	81000KI	SC/APC
81000SB	Bare Fiber Adapter	81000SI	DIN 47526
81000SB	Bare Fiber Adapter	81000VI	ST

Table 2 Connector Interface and Bare Fiber Adapter Combinations

Product Number	Connector Interface Type
81000NI	FC/APC
81000PI	E-2000
81000SI	DIN 47526
81000VI	ST
81000WI	Biconic

Table 1 Connector Interfaces

# Specifications

Agilent 81632A/3A/4A Power Sensor Modules and the Agilent 81635A Dual Power Sensor Module are produced to the ISO 9001 international quality system standard as part of Agilent's commitment to continually increasing customer satisfaction through improved quality control.

Specifications describe the modules' warranted performance. Supplementary performance characteristics describe the modules' and heads' non-warranted typical performance.

Because of the modular nature of the instrument, these performance specifications apply to these modules and heads rather than the mainframe unit.

# Definition of Terms

This section defines terms that are used both in this chapter and "Performance Tests" on page 21.

Generally, all specifications apply for the given environmental conditions and after warmup time.

Measurement principles are indicated. Alternative measurement principles of equal value are also acceptable.

## Averaging Time

Time defining the period during which the power meter takes readings for averaging. At the end of the averaging time the average of the readings is available (display- or memory-update). Symbol  $T_{avg}$ .

## Linearity

The linearity error is defined as the relative difference between the displayed power ratio,  $D^x/D_0$ , and the actual (true) power ratio  $P^x/P_0$  caused by changing the displayed power level from the reference level,  $D_0$ , to an arbitrary displayed level,  $D^x$ . Symbol  $N$ .

if expressed in %

$$N = \left( \frac{D^x/D_0}{P^x/P_0} - 1 \right) 100$$

if expressed in dB

$$N_{dB} = 10 \log \left( \frac{D^x/D_0}{P^x/P_0} \right)$$

Conditions: reference level 10  $\mu$ W, displayed power levels within the specified range, zero less than specified time prior to measurement.

Note 1: ideally  $E = 0$  %, respectively 0 dB.

Note 2: the power-dependent nonlinearity,  $N(P^x)$ , can alternatively be expressed

by the following formula:

$$N(P^x) = \frac{r(P_0)}{r(P^x) - r(P_0)}$$

where  $r(P)$  is the power-dependent responsivity (for a power meter, the responsivity is defined as the ratio of displayed power to actual input power).

Uncertainty of power reading when using a coherent source, due to a periodic change of the power meter's responsivity caused by optical interference between reflective interfaces within the power meter's optical assembly.

Conditions: constant wavelength, constant power level, angled connector as specified, linewidth of source < 100 MHz, temperature as specified.

## Relative uncertainty (spectral ripple) due to interference

The specified conditions during the spectral responsivity calibration, or conditions which are extrapolated from the conditions during calibration, *Conditions*: power level, beam diameter or fiber type, numerical aperture, wavelength, spectral width, ambient temperature as specified, at the day of calibration. → Noise and drift observed over a specified observation time, with a temperature change of not more than  $\pm\Delta T$ .

## Reference conditions

The power range is defined from the highest specified input power level to the smallest input power level that causes a noticeable change of displayed power level.

*Conditions*: wavelength, averaging time as specified.

## Power range

The peak-to-peak change of displayed power level with zero input power level (dark).

Conditions: Zero prior to measurement, averaging time and observation time as specified, lowest power range selected and wavelength range as specified.

*Measurement*: the measurement result is obtained by:

$$Noise = P_{max} - P_{min}$$

expressed as peak-to-peak within the given time span. Any offset is automatically excluded this way.

## Noise

FWHM spectral bandwidth. The 3 dB width of the optical spectrum, expressed in Hertz. Symbol:  $\Delta f$ .

## Linewidth



The range of wavelengths for which the power meter is calibrated.

## Wavelength Range

meter.

The uncertainty for the specified set of reference conditions, including all uncertainties in the calibration chain from the national laboratory to the test

## Uncertainty at reference conditions

temperature change of not more than  $\pm\Delta T$ .

*Conditions:* power level, beam diameter or fiber type, numerical aperture, wavelength, spectral width, ambient temperature, re-calibration period as specified.  $\rightarrow$ Noise and drift observed over a specified observation time, with a

drift.

The uncertainty for a specified set of operating conditions, including noise and

## Total uncertainty

in nm. Symbol: *FWHM*.

Full width at half maximum. The 3 dB width of the optical spectrum, expressed

## Spectral width of optical source

radiation source.

*Conditions:* the return loss excludes any reflections from the fiber end used as

$$RL = 10 \log \left( \frac{P_{in}}{P_{back}} \right)$$

Symbol: *RL*.

The ratio of the incident power to the reflected power expressed in dB.

## Return loss:

*Conditions:* laser source with variable polarization state, generation of all possible polarization states (covering the entire Poincaré sphere), constant wavelength, constant power level, angled connector as specified, temperature as specified.

Also termed polarization-dependent responsivity (PDR), the relative uncertainty due to polarization is the uncertainty of the displayed power level on the input polarization state, expressed as the difference between the highest and the lowest displayed power. Uncertainty figures are based upon a 95% confidence level.

## Relative uncertainty due to polarization

Note: Selectable wavelength setting of the power meter for useful power  
measurements (operating wavelength range).

Literature

[1] *Fiber optic test and measurement*, Hewlett Packard Professional Books,  
edited by Prentice Hall, ISBN 0-13-534330-5

# Power Sensor Specifications (Aurange Mode)

Table 3 Power Sensor Specifications

Agilent 81632A	Agilent 81635A	Agilent 81633A	Agilent 81634A
Sensor Element		InGaAs	InGaAs (dual)
Wavelength Range		800 - 1700 nm	
Power Range		+10 to -80 dBm	+10 to -90 dBm
Display Resolution		0.0001 dB/dBm, 0.01 pW to 10 pW (depending on power range)	
Applicable Fiber Type		Standard SM and MM up to 62.5 μm core size, NA ≤ 0.24	
Uncertainty (accuracy) at Reference Conditions <sup>1</sup>		< ±3% (1200 nm to 1630 nm)	
Total Uncertainty <sup>2</sup>		< ±4.5% (1000 nm to 1650 nm)	
Relative Uncertainty		±0.015 dB typical	
Due to Polarization <sup>3</sup>		±0.005 dB	
Spectral Ripple (due to interference) <sup>4</sup>		±0.005 dB	
Linearity (power) <sup>5</sup>		CW +10 to -60 dBm (1200 to 1630 nm) < ±0.02 dB ± 20 pW <sup>9</sup> < ±0.06 dB ± 20 pW <sup>9</sup>	
Return Loss <sup>7</sup>		> 40 dB	
Noise (peak to peak) <sup>5, 6</sup>		> 20 pW	
Averaging Time (minimal)		100 μs	
Dimensions (H x W x D)		75 mm x 32 mm x 335 mm (2.8" x 1.3" x 13.2")	
Weight		0.5 kg	
Recalibration Period		2 years	
Operating Temperature		+10°C to +40°C	
Humidity		Non-condensing	
Warm-up time		20 minutes	

Agilent 81632A	Agilent 81633A	Agilent 81635A	Agilent 81634A
<p><b>1 Reference Conditions</b></p> <ul style="list-style-type: none"> <li>• Power level 10 <math>\mu</math>W (-20 dBm), continuous wave (CW)</li> <li>• Fiber 50 <math>\mu</math>m graded-index, NA=0.2</li> <li>• Ambient temperature 23°C <math>\pm</math> 5°C</li> <li>• On day of calibration (add <math>\pm</math> 0.3% for ageing over one year; add <math>\pm</math> 0.6% over two years)</li> <li>• Spectral width of source &lt; 10 nm (FWHM)</li> <li>• Wavelength setting at Power Meter must correspond to source wavelength <math>\pm</math> 0.4 nm</li> </ul>			
<p><b>2 Total uncertainty includes polarization, interference, linearity conditions:</b></p> <ul style="list-style-type: none"> <li>• Fiber <math>\leq</math> 50 <math>\mu</math>m, NA <math>\leq</math> 0.2</li> <li>• Only Agilent 81632A and Agilent 81635A: For fiber 62.5 <math>\mu</math>m graded-index (NA=0.24): add <math>\pm</math> 2 %</li> <li>• Within one year of calibration, add 0.3% for second year</li> <li>• Add <math>\pm</math> 1% for Biconic connector</li> </ul>			
<p><b>3 All states of polarization at constant wavelength (1550 nm <math>\pm</math> 30 nm) and constant power, straight connector, T=23°C<math>\pm</math>5 °C</b></p> <p>For angled connector (8°C) add 0.01 dB typ.</p>			
<p><b>4 Conditions:</b></p> <p>Wavelength 1550 nm <math>\pm</math> 30 nm, fixed state of polarization, constant power, Temperature 23°C <math>\pm</math> 5°C</p> <p>Line width of source <math>\geq</math> 100 MHz, angled connector 8°.</p>			
<p><b>5 At constant temperature <math>\Delta</math>T = <math>\pm</math> 1°C</b></p>			
<p><b>6 Averaging time 1 s, T = 23°C <math>\pm</math> 5°C, observation time 300 s. Wavelength range 1200 - 1630 nm.</b></p>			
<p><b>7 Conditions</b></p> <ul style="list-style-type: none"> <li>• Wavelengths 1310 nm <math>\pm</math> 30 nm and 1550 nm <math>\pm</math> 30 nm</li> <li>• Standard single-mode fiber, angled connector min 8°</li> <li>• T = 23°C <math>\pm</math> 5°C</li> </ul>			
<p><b>8 For wavelengths &gt; 1600 nm add <math>\pm</math> 0.06 %/nm</b></p>			
<p><b>9 For input power &gt; 2 mW add <math>\pm</math> 0.02 dB</b></p>			

Table 3 Power Sensor Specifications

# Performance Tests

The procedures in this section test the performance of the instrument. The complete specifications to which the Agilent 81632A/3A/4A Power Sensor Modules and the Agilent 81635A Dual Power Sensor Module are tested are given in "Specifications" on page 13. All tests can be performed without access to the interior of the instrument. The performance tests refer specifically to tests using the Diamond HMS-10/Agilent connector.

## Equipment Required

Equipment required for the performance test is listed in the table below. Any equipment that satisfies the critical specifications of the equipment given in the table may be substituted for the recommended models.

**Table 4 Required Equipment**

Instrument/Accessory	Recommended Model	8163xA				Required	Alternative Models
		2A	3A	3A	4A		
Multimeter Mainframe	Agilent 8163A (2 each)	x	x	x	x		Agilent 8164A
CW Laser Module	Agilent 81656A	x	x	x	x		Agilent 81657A
CW Laser Module	HP 81554SM	x	x	x	x		Agilent 81657A
Power Meter Standard	HP 81533B Optical Head Interface Module with HP 81521B #C01 Working Standard Optical Head	x	x	x	x		Agilent 81657A
Power Sensor Module	HP 81532A	x	x	x	x		Agilent 81634A
Optical Attenuator	Agilent 8156A #221	x	x	x	x		Agilent 81634A
Optical Attenuator	Agilent 8156A #101	x	x	x	x		HP 8157A or HP 8158B #002
Backreflector Kit	Agilent 8156A #203	x	x	x	x		HP 8158B #002
Return Loss Module	HP 81534A	x	x	x	x		HP 8168E/F #022
Tunable Laser Source	Agilent 8164A and Agilent 81680A #022	-	-	-	-		HP 8168E/F #022
Polarization Controller	HP 11698A	-	-	-	-		
Wavelength Independent Coupler (3 dB)	Special Tool	-	-	-	-		
Best IF Adapter	Special Tool	-	-	-	-		
Singlemode Fiber	Agilent 81101AC (2 each)	x	x	x	x		
	Agilent 81102SC (1 each)	x	x	x	x		
	Agilent 81109AC (1 each)	x	x	x	x		
	Agilent 8113PC (3 each)	x	x	x	x		
	Agilent 8113SC (1 each)	x	x	x	x		
Connector Adapters	Agilent 81000AA (1 each)	x	x	x	x		
Connector Interfaces	Agilent 81000AI (5 each)	x	x	x	x		
	Agilent 81000FI (3 each)	x	x	x	x		
	Agilent 81000SI (5 each)	x	x	x	x		
Plastic Cap	PN 5040-9351	x	x	x	x		
DIN Feedthrough	PN 1005-0255	x	x	x	x		

Legend:  
 - not applicable  
 x necessary  
 o optional

*Procedure" on page 55.*

MATCHING OIL. For cleaning, use the cleaning instructions given in "Cleaning Make sure that all optical connections are dry and clean. DO NOT USE INDEX

NOTE

The performance test given in this section includes the Accuracy Test, the Linearity Test, the Return Loss Test and the Noise Test. The performance test for the Agilent 81633A and Agilent 81634A also includes – as optional tests – the Relative Polarization Uncertainty and the Relative Interference Uncertainty Test. Perform each step in the order given, using the corresponding test equipment.

## Performance Test

Specifications are the performance characteristics of the instrument that is certified. These specifications, listed in "Specifications" on page 13, are the performance standards or limits against which the Agilent 81632A/3A/4A/5A can be tested. "Specifications" on page 13 also lists some supplemental characteristics of the Agilent 81632A/3A/4A/5A. Supplemental characteristics should be considered as additional information. Any changes in the specifications due to manufacturing changes, design, or traceability to the National Institute of Standards and Technology (NIST), will be covered in a manual change supplement, or revised manual. Such specifications supersede any that were previously published.

## Instrument Specification

If the Agilent 81632A/3A/4A/5A fails any performance test, return the instrument to the nearest Agilent Technologies/Sales/Service Office for repair.

## Test Failure

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 already familiar with the test procedures). The Test Record can also be used as a permanent record and may be reproduced without written permission from Hewlett-Packard.

## Test Record



- 1 Make sure that cable connector, detectors and adapters are clean.
- 2 Connect the equipment as shown in Figure 2. Instead of a HP 81554SM Laser Source you can also use a Agilent 81657A Laser Source. Ensure that the cables to and from the attenuator are fixed on the table and that both the optical head and the DUT are close together so that minimum cable movement is required when connecting the cable to the head or to the DUT.
- 3 Move to the Laser Source channel, move to the wavelength parameter, [λ], press *Enter*, select the lower wavelength source, and press *Enter*.

## Test Setup

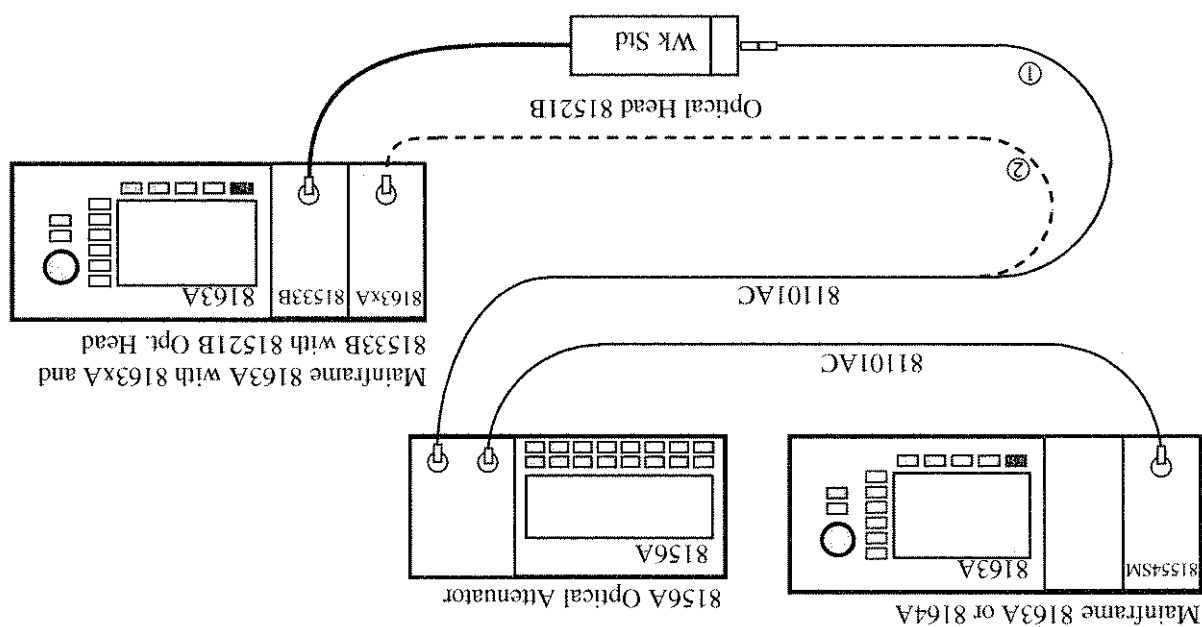
**NOTE** The linearity test must only be performed at either 1310 nm or 1550 nm. The accuracy test must be performed in the -20 dBm range at 10 μW at both 1310 nm and 1550 nm.

## Accuracy Test

Fix the optical cables that connect the laser source and Power Meter to the Agilent 8156A Attenuator. This ensures minimum cable movement during the tests.

- 7 Make sure the optical input of the Device Under Test (DUT), 8163xA, is not receiving any light by placing a plastic cap over the input. Move to the DUT Power Meter channel, press [Menu], move to <Zero>, press *Enter*.
  - 8 Ensure, that the Agilent 8156A output is disabled. Move to the reference Power Meter channel, 81532A, press [Menu], move to <Zero>, press *Enter*.
  - 9 Enable the Agilent 8156A output and change the attenuation until the reference Power Meter displays 10.00  $\mu$ W.
- a Move to the Power Meter channel.
  - b Move to the wavelength parameter, [A], press *Enter*, enter the wavelength of the laser source, and press *Enter*.
  - c Move to the calibration parameter, [CAL], press *Enter*, set the calibration parameter to zero, and press *Enter*.
  - d Move to the averaging time parameter, [AvgTime], press *Enter*, move to <500 ms>, and press *Enter*.
  - e Move to the power parameter, [P], press [Pwr unit], move to <Watt>, and press *Enter*.
- 6 Perform the following sub-procedure for both Power Meters:  
warm up for at least 20 minutes.
  - 5 Turn the instruments on, enable the laser source and allow the instruments to

Figure 2 Accuracy Test Setup



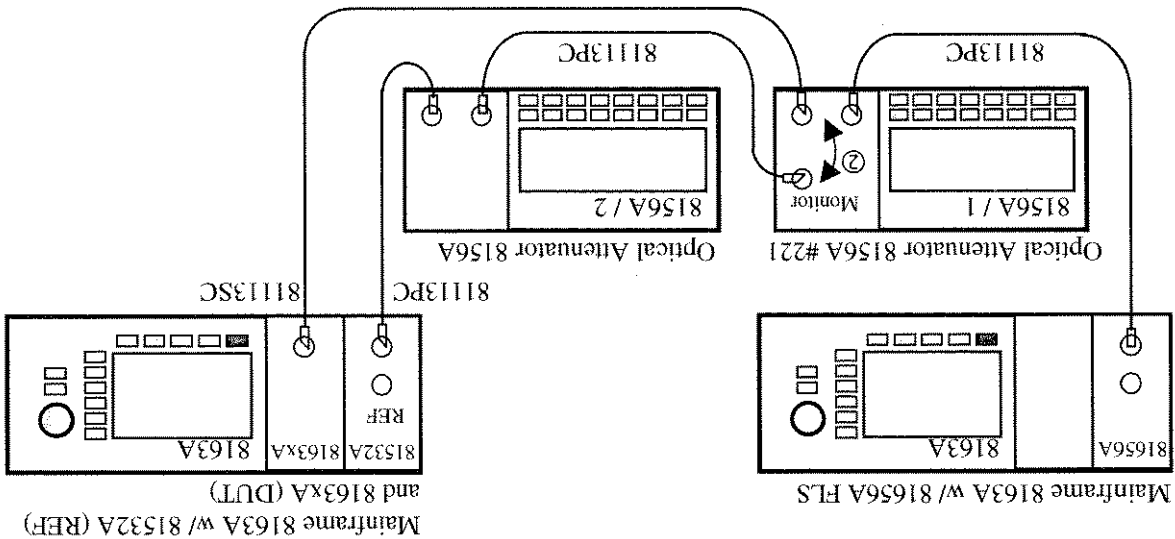
- 4 If you are using a Agilent 81657A Laser Source ensure to initialize the Agilent 8156A Optical Attenuator with 30 dB attenuation.

- 1 Make sure that cable connector, detectors and adapters are clean.
- 2 Make sure that you perform this test in a temperature-controlled environment with temperature fluctuations less than  $\pm 1^\circ\text{C}$ .
- 3 Setup the equipment as shown in Figure 3. Disable both attenuators and enable the laser source, where the source wavelength is chosen to 1550 nm. If you are using the 81657A, move to the wavelength parameter, [λ], press *Enter*, select the longer wavelength source (1550 nm nominally), and press *Enter*.

### Test Setup

- NOTE
- Do not turn the laser off during the measurement!
- Clean all connectors carefully before you start with the measurement!

Figure 3 Measurement Setup for Power Linearity



### Linearity Test

- 10 Connect the attenuator output cable to the DUT Power Meter. Note the power value returned from the DUT, [P], from the display and note the result in the test record.
- 11 Move to the Laser Source channel, move to the wavelength parameter, [λ], press *Enter*, select the longer wavelength source, and press *Enter*.
- 12 Repeat steps 4 to 10 at the second wavelength with the corresponding source.

- 4** Set the wavelength of both attenuators to the same wavelength as the laser source.
- 5** Perform the following sub-procedure for both Power Meters:
- a** Move to the Power Meter channel.
  - b** Move to the wavelength parameter, [W], press *Enter*, enter the wavelength of the laser source, and press *Enter*.
  - c** Move to the calibration parameter, [CAL], press *Enter*, set the calibration parameter to zero, and press *Enter*.
  - d** Move to the averaging time parameter, [AvgTime], press *Enter*, move to *<100 ms>*, and press *Enter*.
  - e** Move to the power parameter, [P], press [Pwr unit], move to *<dBm>*, and press *Enter*.
  - f** Press the [Menu] softkey and move to *<Number of digits>*, press *Enter*, move to *<3>*, press *Enter* and press [Close].
- 6** Initialize the two attenuators as follows:
- a** Set the attenuation of the 8156A #221 with Monitor Output (referred to as Atty1) to 0 dB.
  - b** Set the attenuation of the other 8156A (referred to as Atty2) to 35 dB.
- 7** Wait at least 15 minutes until the laser source is stabilized.
- 8** Perform the following sub-procedure for the reference Power Meter, 81532A:
- a** Press [Menu], move to *<Range mode>*, move to *<Manual>*, and press *Enter*.
  - b** Move to *<Range>*, press *Enter*, move to *<-40 dBm>*, press *Enter*, and press [Close].
- 9** Perform the following sub-procedure for the DUT, 8163xA:
- a** Press [Menu], move to *<Range mode>*, move to *<Manual>*, and press *Enter*.
  - b** Move to *<Range>*, press *Enter*, move to *<10 dBm>*, and press *Enter*.
  - c** Zero both Power Meters. Move to *<Zero all>* and press *Enter*.
- 10** Enable both attenuators.
- 11** Adjust the attenuation of Atty2 in order to achieve -37.2 dBm on the reference Power Meter.
- ### +10 dBm Range
- 12** Note both power readings as the first value in the test record, which is given at the end of the test descriptions (#1).
- Always include the three digits after the decimal point when you note a power reading.

## NOTE

- 33 On the DUT switch one range down to the -20 dBm range.  
record (#8).
- 32 Increase the attenuation of Atty1 by 10 dB and note the results in the test
- 31 Switch down to the previous range (-10 dBm) and note the values again (#7).
- 30 Switch one range up to the 0 dBm range and note the power readings (#6).
- 29 Enable Atty1.  
[Menu], move to <Zero all>, and press *Enter*.
- 28 Zero both Power Meters. On the 8163A with two installed power meters, press
- 27 Disable Atty1.

### -10 dBm Range

- 26 Decrease the attenuation of Atty2 by 10 dB in order to be on the upper limit of  
the -40 dBm range.
- 25 If necessary, adjust the attenuation of Atty1 in order to be on the upper limit of  
the range (i.e. -x7.y dBm).
- 24 Move to the channel of the DUT, 8163xA, press [Menu], move to <Range>,  
press *Enter*, move to <-10 dBm>, and press *Enter*.
- 23 Increase Atty1 by 10 dB and note the results in the test record (#5).
- 22 Switch down to the previous range (0dBm) and note the values again (#4).
- 21 Note both power readings (#3).
- 20 Switch one range up to the +10dBm range.
- 19 Enable Atty1.  
[Menu], move to <Zero all>, and press *Enter*.
- 18 Zero both Power Meters. On the 8163A with two installed power meters, press
- 17 Disable Atty1.

### 0 dBm Range

- 16 If necessary, adjust the attenuation of Atty2 in order to be on the upper limit of  
the -40 dBm range (i.e. -37.2 dBm).
- b Move to <Range>, press *Enter*, move to <0 dBm>, and press *Enter*.
- a Press [Menu], move to <Range mode>, move to <Manual>, and press  
*Enter*.
- 15 Perform the following sub-procedure for the DUT, 8163xA:
- 14 Note the InRange-values in the test record (#2)
- 13 Increase the attenuation of Atty1 until the power reading of the DUT shows  
about +2.8 dBm.

Information only		Your Entries				
n	Att1 / #221 [dB]	Att2 / #100 [dB]	DUT Range [dBm]	REF Power [dBm]	DUT Power [dBm]	Notes
1	0	24	10	-37,291	8,957	1. Value
2	6	24	10	-42,928	3,314	InRange
3	6	18	10	-37,299	3,317	RangeDisc / lower limit
4	6	18	0	-37,298	3,318	RangeDisc / upper limit
5	16	18	0	-47,280	-6,666	InRange

### Example: Measurement Results

46 Calculate the non-linearity using the formulas given in the test record.

### Calculation

Repeat step 33 to 39 until the power reading of the DUT shows -57.x dBm.

45 Decrease the attenuation of Att2 by 10 dB in order to be on the upper limit of the -40 dBm range.

44 On the DUT switch one range down. Adjust the attenuation of Att1, if necessary, so that the power displayed by the DUT is at the upper limit of the range, that is, -x7.y dBm.

43 Increase the attenuation of Att1 by 10 dB and note the results in the test record.

42 Switch one range down and note the power readings again.

41 Switch one range up and note both power readings.

40 Enable Att1.

39 Zero both Power Meters. On the 8163A with two installed power meters, press [Menu], move to <Zero all>, and press *Enter*.

38 Disable Att1.

### -20 dBm to -50 dBm Range

- Att2: the REF Power Meter shows a reading of -37.2 dBm.

- Att1: DUT Power Meter shows a reading of -17.2 dBm and

37 Adjust the attenuation of both attenuators in the following order:

36 Enable Att1 again.

35 Set the attenuation of Att1 to 15 dB and of Att2 to 35 dB.

34 Disable Att1 and switch the output with the monitor output.

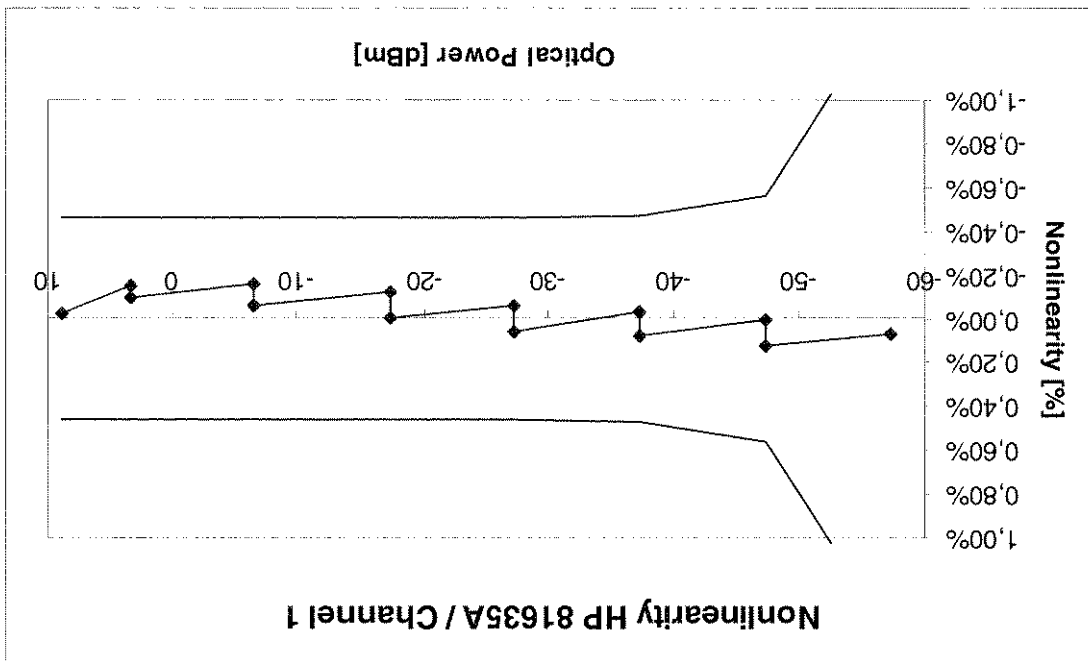
### Change Setup

### Calculations

n	Ref/R [mW]	DUT/D [mW]	Relation1/A $= R_{n+1}/R_n$	Relation2/B $= D_n/D_{n+1}$	Non-Linearity $= A^n * R_n (N^{n+1} + 1) - 1$ [⊕] [%]
1	1,86612E-04	7,86448E+00	2,73049E-01	3,66708E+00	-0,02
2	5,09542E-05	2,14462E+00	9,99724E-01	9,99701E-01	-0,15
3	1,86312E-04	2,14640E+00	1,00434E-01	9,99630E+00	-0,09
4	1,86260E-04	2,14704E+00	1,00157E-01	9,99079E+00	-0,06
5	1,87068E-05	2,15501E-01	9,99540E-01	9,99471E-01	-0,16
6	1,86256E-04	2,15561E-01	1,00157E-01	9,99471E-01	-0,16
7	1,86170E-04	2,15675E-01	1,00157E-01	9,99079E+00	-0,06
8	1,86462E-05	2,15874E-02	9,99540E-01	9,99240E-01	-0,12
9	1,86110E-04	1,85298E-02	9,99540E-01	9,99240E-01	-0,12
10	1,86024E-04	1,85439E-02	Reference Level		
11	1,86518E-05	1,85819E-03	9,97356E+00	1,00205E-01	-0,06
12	1,86973E-04	1,85708E-03			

n	Information only					Your Entries	
	Att1 / #221 [dB]	Att2 / #100 [dB]	DUT Range [dBm]	REF Power [dBm]	DUT Power [dBm]	Notes	
6	16	8	0	-37,301	-6,664	RangeDisc / lower limit	
7	16	8	-10	-37,299	-6,662	RangeDisc / upper limit	
8	26	8	-10	-47,294	-16,658	InRange	
9	7,7	35,7	-10	-37,304	-17,321	RangeDisc / lower limit	
10	7,7	35,7	-20	-37,302	-17,318	RangeDisc / upper limit	
11	17,7	35,7	-20	-47,293	-27,309	InRange	
12	17,7	25,7	-20	-37,285	-27,312	RangeDisc / lower limit	
13	17,7	25,7	-30	-37,282	-27,309	RangeDisc / upper limit	
14	27,7	25,7	-30	-47,280	-37,308	InRange	
15	27,7	15,7	-30	-37,278	-37,306	RangeDisc / lower limit	
16	27,7	15,7	-40	-37,276	-37,304	RangeDisc / upper limit	
17	37,7	15,7	-40	-47,277	-47,306	InRange	
18	37,7	5,7	-40	-37,274	-47,301	RangeDisc / lower limit	
19	37,7	5,7	-50	-37,271	-47,298	RangeDisc / upper limit	
20	47,7	5,7	-50	-47,270	-57,298	InRange	

Figure 4 Linearity Test



$$NL_n = \begin{cases} A_n/B_n \cdot (NL_{n+1} + 1) - 1 & \text{for } n < 10 \\ A_n/B_n \cdot (NL_{n-1} + 1) - 1 & \text{for } n > 10 \end{cases}$$

NOTE ①: The Nonlinearity is calculated recursively using n=11 as reference point. The formula is:

Conversion [dBm] → [mW]	Calculation as given			Calculation as given	
n	Ret / R [mW]	DUT / D [mW]	Relation1 / A $= R_{n+1}/R_n$	Relation2 / B $= D_n/D_{n+1}$	Non-Linearity $= A_n \cdot B_n \cdot (NL_{n+1} + 1) - 1$ ① [%]
13	1.86857E-04	1.85810E-03	1.00062E+00	1.00055E+00	0.06
14	1.87068E-05	1.85849E-04	9.98872E+00	1.00021E-01	-0.03
15	1.87245E-04	1.85935E-04			
16	1.87150E-04	1.86050E-04	1.00051E+00	1.00062E+00	0.08
17	1.87206E-05	1.85973E-05	9.99701E+00	9.99586E-02	0.01
18	1.87443E-04	1.86149E-05			
19	1.87333E-04	1.86264E-05	1.00058E+00	1.00062E+00	0.13
20	1.87495E-05	1.86312E-06	9.99148E+00	1.00025E-01	0.07



- 1 Connect the equipment as shown in Figure 5-1. Alternatively, you can use a clean and undamaged straight fiber end as a reference reflector.
- 2 Move to the fixed wavelength Laser Source channel, select [Menu] and set the `<Modulation src 15xx.xnm>` to `<Coherence Cnt>`. Ensure, that you set the modulation of the upper wavelength source if you are using a Agilent 81657A Laser Source.
- 3 Set the attenuation of the Agilent 8156A optical attenuator to 10.0 dB at the wavelength given by the source module and enable the output of the attenuator.
- 4 Set the averaging time of the Return Loss Module to 1s by pressing *Param* and set the wavelength to the wavelength of the Laser Source.
- 5 Zero the Return Loss Module.
- 6 Select the reference parameter, R, by pressing *Param* and set this to 0.18 dB (in case of a straight fiber end as reflector, set the reference to 14.7 dB).
- 7 Enable the source output and press *Disp*→*Ref* for the Return Loss Module.
- 8 Select the termination parameter T by pressing *Param*.

## Return Loss Test

- 1 Insert the device under test, a 8163xA Power Sensor, into a slot of the 8163A mainframe. Make sure the optical input of the Device Under Test (DUT), 8163xA, is not receiving any light by placing a plastic cap over the input. Move to the DUT Power Meter channel, press [Menu], move to `<Zero>`, and press *Enter*.
- 2 Press *Appl*, move to `<Stability>`, and press *Enter*. The Stability Setup Screen appears.
- 3 Ensure, that the correct channel is selected in the upcoming Module Selection box.
- 4 Press [Menu] to access the Logging application menu screen.
- 5 Move to `<Pwr unit>`, press *Enter*, move to `<W>`, and press *Enter*.
- 6 Move to `<AvgTime>`, press *Enter*, move to `<1 s>`, and press *Enter*.
- 7 Move to `<Range mode>`, press *Enter*, move to `<Auto>`, and press *Enter*, and press [Close].
- 8 Press the [Parameter] softkey, move to [TotalTime], press *Enter*, set the total time to 00:05:00, which is 5 minutes, and press *Enter*.
- 9 Press the [Measure] softkey to start the measurement.
- 10 After the stability application has finished, press the [Analysis] softkey, press the [more] softkey, and note  $[\Delta P]$  as the noise value in the test record.

## Noise Test

Below, you will find the test setup to verify the relative uncertainty due to polarization of the sensor module. Generally, during this measurement-procedure the tunable laser source is swept through a predefined wavelength range. After every wavelength step, a single PDL-measurement is made, where the polarization controller generates all different polarization states. The highest PDL

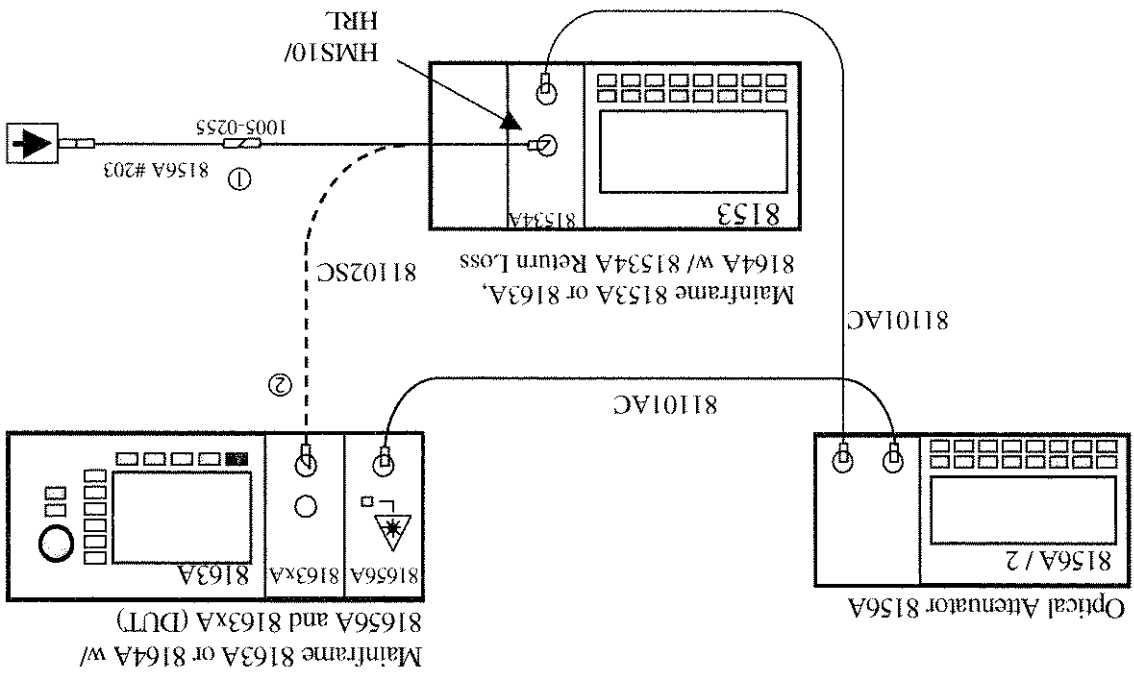
The performance test "Relative Uncertainty due to Polarization" is optional, since the polarization is given with the production of the unit by mechanical and optical cavities and stays unchanged by normal use of the sensor module.

NOTE

## Relative Uncertainty due to Polarization (Optional Test)

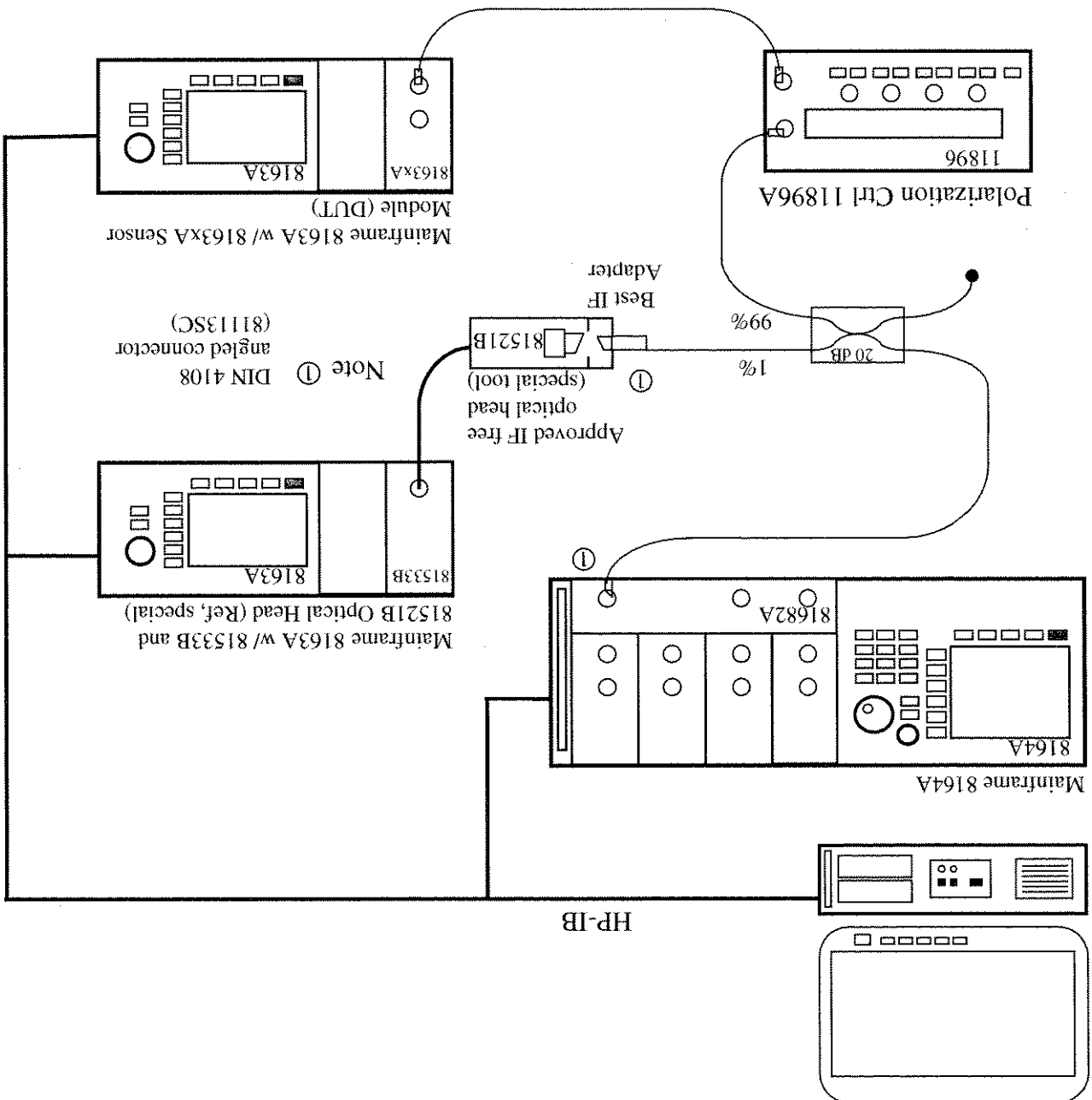
13 Note the result as the return loss of the sensor module into the test record.

Figure 5 Return Loss Measurement Setup



- 9 Disconnect the Agilent 81102SC and the Agilent 8156A #203 patchcords from each other.
- 10 Press  $Disp \rightarrow Ref$  for the Return Loss Module.
- 11 Ensure, that the termination parameter T at the Return Loss Module shows a reading of more than 50dB.
- 12 Connect the DIN-connector of the 81102SC patchcord to the sensor module as shown in Figure 5/②.

Figure 6 Measurement Setup for PDL Test



value is taken as the "relative uncertainty due to polarization". The low output power path of the coupler is used to monitor the power stability of the setup.

## Relative Uncertainty due to Interference (Optional Test)

### NOTE

The performance test "Relative Uncertainty due to Interference" is optional, since the interference is given with the production of the unit by mechanical and optical cavities and stays unchanged by normal use of the sensor module.

Below, you will find the test setup to verify the relative uncertainty due to interference of the sensor module. In order to perform the relative uncertainty due to interference test, it is mandatory to use two mainframes, since the time difference between measurement A and B for a specific wavelength point has to be at most 2 ms. Due to this short measurement interval, the performance test of the relative uncertainty due to interference can only be using computer control.

Theoretically, both Power Meters are monitoring the power ratio over the variable wavelength in a predefined range as shown in Figure 8. Ensure that the tunable laser source is mode-hop free in the tested wavelength range.

Figure 7 Setup for Relative Uncertainty due to Interference Measurement

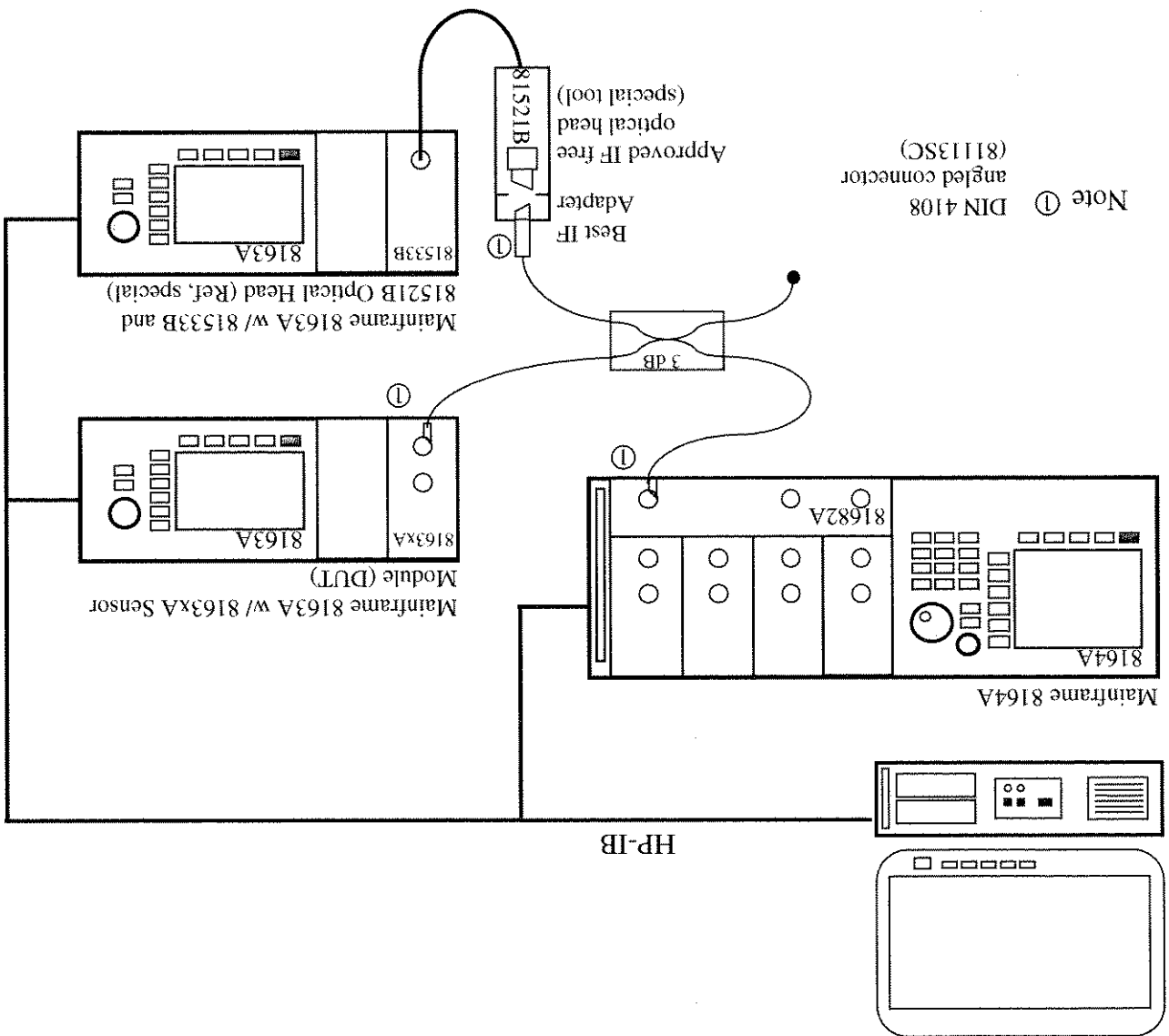
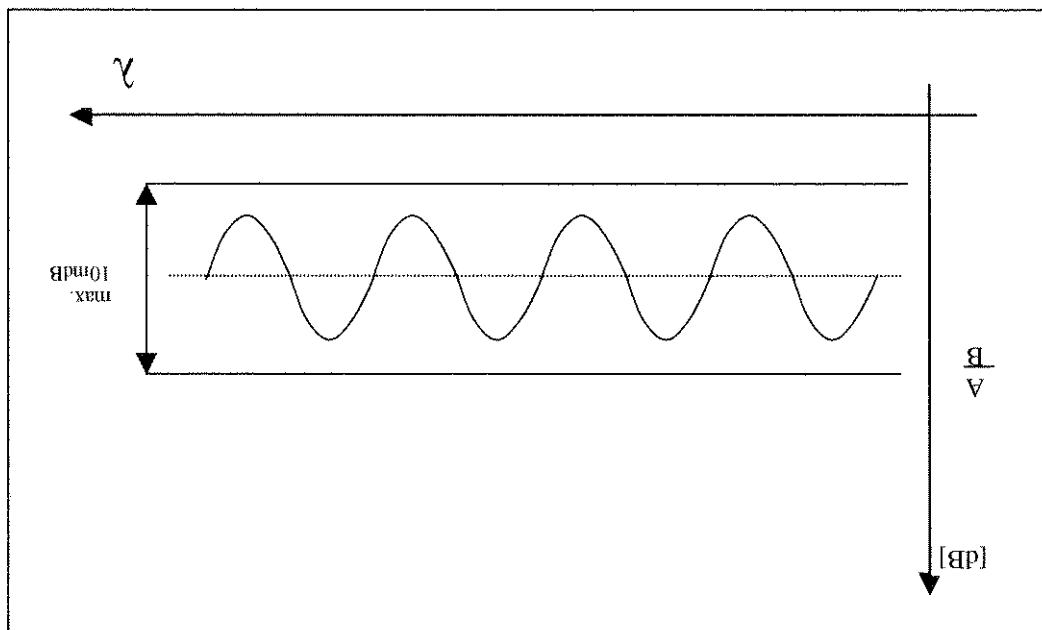


Figure 8 Interference Ripple



**Performance Test for the Agilent 81632A**

Page 1 of 3

Model	Agilent 81632A Sensor Module
Serial No.	
Options	
Firmware Rev.	
Test Facility	
Performed by	
Special Notes	

Date	
Ambient Temperature	°C
Relative Humidity	%
Line Frequency	Hz
Customer	
Report No	

Accessories		Product #		Trace No		Cal. Due Date	
1a1	Lightwave Multimeter (Std.)	Agilent 8163A					
1a2	Lightwave Multimeter (DUT)	Agilent 8163A					
1b	TLS Mainframe	Agilent 8164A					
2a1	CW High Power Laser Source	Agilent 81655A					
2a2	CW High Power Laser Source	Agilent 81656A					
2b	CW Dual High Power Laser Source	Agilent 81657A					
3	CW Dual Laser Source	HP 81554SM					
4a1	Opt. Head Interface Module	HP 81533B					
4a2	Optical Head, Reference	HP 81521B					
5	Sensor Module	HP 81532A					
6	Optical Attenuator	Agilent 8156A #221					
7a	Optical Attenuator	Agilent 8156A #101					
7b	Optical Attenuator	HP 8157A					
7c	Optical Attenuator	HP 8158B #002					
8	Return Loss Module	HP 81534A					
9							
10							
11							
12							
Singlemode Fibers		81101AC	2	81102SC	1	81109AC	1
Connector Interfaces		81113PC	3	81000AI	3	81000SI	5
Connector Adapters		81000AA	1				
Backreflector Kit		8156A #203	1				

Test Equipment Used

Performance Test for the Agilent 81632A

Page 2 of 3



Model Agilent 81632A Sensor Module

Report No. \_\_\_\_\_

Date \_\_\_\_\_

Min. Spec. Result Max. Spec. Measurement Uncertainty

I Accuracy Test [µW]

measured at \_\_\_\_\_ mm Output Power 9.64 µW 10.36 µW

(1310nm)

measured at \_\_\_\_\_ mm Output Power 9.64 µW 10.36 µW

(1550nm)

II Linearity Test For Calculations you may want to use the appropriate sheet

Range P<sub>DUT</sub> [dBm] P<sub>DUT</sub> [dBm] Loss [%]

+10	+9	<± 0.93 %
+10	+3	<± 0.46 %
0	+3	<± 0.46 %
0	-7	<± 0.46 %
-10	-7	<± 0.46 %
-10	-17	<± 0.46 %
-20*	-17*	0.0
-20	-27	<± 0.46 %
-30	-27	<± 0.46 %
-30	-37	<± 0.47 %
-40	-37	<± 0.47 %
-40	-47	<± 0.56 %
-50	-47	<± 0.56 %
-50	-57	<± 1.46 %

III Noise Test

Return Loss Test

40 dB >

[dB]

[pW]

< 20 pW



**Performance Test for the Agilent 81633A**

Page 1 of 3

Model	Agilent 81633A Sensor Module
Serial No.	_____
Options	_____
Firmware Rev.	_____
Test Facility	_____
Performed by	_____
Special Notes	_____ _____ _____ _____ _____ _____ _____ _____

Date	_____
Ambient Temperature	_____ °C
Relative Humidity	_____ %
Line Frequency	_____ Hz
Customer	_____
Report No	_____

Accessories		Product #		Product #		Product #	
1a1	Lightwave Multimeter (Std.)	Agilent	8163A				
1a2	Lightwave Multimeter (DUT)	Agilent	8163A				
1b	TLS Mainframe	Agilent	8164A				
2a1	CW High Power Laser Source	Agilent	81655A				
2a2	CW High Power Laser Source	Agilent	81656A				
2b	CW Dual High Power Laser Source	Agilent	81657A				
3	CW Dual Laser Source	HP	81554SM				
4a1	Opt. Head Interface Module	HP	81533B				
4a2	Optical Head, Reference	HP	81521B				
5	Sensor Module	HP	81532A				
6	Optical Attenuator	Agilent	8156A #221				
7a	Optical Attenuator	Agilent	8156A #101				
7b	Optical Attenuator	HP	8157A				
7c	Optical Attenuator	HP	8158B #002				
8	Return Loss Module	HP	81534A				
9							
10							
11							
12							
Singlemode Fibers		2	81101AC	1	81102SC	1	81109AC
Connector Interfaces		5	81000AI	3	81000FI	5	81000SI
Connector Adapters		1	81000AA				
Backreflector Kit		1	8156A #203				

Model Agilent 81633A Sensor Module Report No. \_\_\_\_\_ Date \_\_\_\_\_

Test No. Test Description Min. Spec. Result Max. Spec. Measurement Uncertainty

I	Accuracy Test	[ $\mu$ W]	Result	Max. Spec.	Measurement Uncertainty
	measured at _____ nm (1310nm) Output Power		9.69 $\mu$ W	10.31 $\mu$ W	
	measured at _____ nm (1550nm) Output Power		9.69 $\mu$ W	10.31 $\mu$ W	

For Calculations you may want to use the appropriate sheet

II Linearity Test

Range	$P_{DUT}$ [dBm]	$P_{DUT}$ [dBm]	Loss [%]
+10	+9	_____	< $\pm$ 0.35 %
+10	+3	_____	< $\pm$ 0.35 %
0	+3	_____	< $\pm$ 0.35 %
0	-7	_____	< $\pm$ 0.35 %
-10	-7	_____	< $\pm$ 0.35 %
-10	-17	_____	< $\pm$ 0.35 %
-20*	-17*	Reference	0.0
-20	-27	_____	< $\pm$ 0.35 %
-30	-27	_____	< $\pm$ 0.35 %
-30	-37	_____	< $\pm$ 0.35 %
-40	-37	_____	< $\pm$ 0.35 %
-40	-47	_____	< $\pm$ 0.36 %
-50	-47	_____	< $\pm$ 0.36 %
-50	-57	_____	< $\pm$ 0.45 %

III Noise Test

< 2 pW

IV Return Loss Test

55 dB >

(V) Relative Uncertainty due to Polarization

Maximum difference in interval

1550 nm - 1560 nm / 0.1 nm step;  $\Delta P$

(VI) Relative Uncertainty due to Interference

Maximum difference in interval

1500 nm - 1560 nm / 2 pm step;  $\Delta P$

> 0.01 dB

[dB]

[dB]

[dB]

[pW]

Loss [%]

$P_{DUT}$  [dBm]

$P_{DUT}$  [dBm]

Range



**Performance Test for the Agilent 81634A**

Page 1 of 3

Model	Agilent 81634A Sensor Module
Serial No.	_____
Options	_____
Firmware Rev.	_____
Test Facility	_____
Performed by	_____
Special Notes	_____ _____ _____ _____ _____ _____ _____ _____ _____ _____
Date	_____
Ambient Temperature	_____ °C
Relative Humidity	_____ %
Line Frequency	_____ Hz
Customer	_____
Report No	_____

Performance Test for the Agilent 81634A		Test Equipment Used	
Page 2 of 3		Page 2 of 3	
Description	Model No.	Trace No	Cal. Due Date
1a1 Lightwave Multimeter (Std.)	Agilent 8163A		
1a2 Lightwave Multimeter (DUT)	Agilent 8163A		
1b TLS Mainframe	Agilent 8164A		
2a1 CW High Power Laser Source	Agilent 81655A		
2a2 CW High Power Laser Source	Agilent 81656A		
2b CW Dual High Power Laser Source	Agilent 81657A		
3 CW Dual Laser Source	HP 81554SM		
4a1 Opt. Head Interface Module	HP 81533B		
4a2 Optical Head, Reference	HP 81521B		
5 Sensor Module	HP 81532A		
6 Optical Attenuator	Agilent 8156A #221		
7a Optical Attenuator	Agilent 8156A #101		
7b Optical Attenuator	HP 8157A		
7c Optical Attenuator	HP 8158B #002		
8 Return Loss Module	HP 81534A		
9			
10			
11			
12			
Accessories	# Product	# Product	# Product
Singlemode Fibers	2 81101AC	1 81102SC	1 81109AC
Connector Interfaces	5 81000AI	3 81000FI	5 81000SI
Connector Adapters	1 81000AA		
Backreflector Kit	1 8156A #203		



Model Agilent 81634A Sensor Module

Report No. \_\_\_\_\_

Date \_\_\_\_\_

<b>Test No.</b>	<b>Test Description</b>	<b>Min. Spec.</b>	<b>Result</b>	<b>Max. Spec.</b>	<b>Measurement Uncertainty</b>
-----------------	-------------------------	-------------------	---------------	-------------------	--------------------------------

**I Accuracy Test**

measured at _____ nm	(1310nm)	Output Power	9.69 $\mu$ W	_____	10.31 $\mu$ W
measured at _____ nm	(1550nm)	Output Power	9.69 $\mu$ W	_____	10.31 $\mu$ W

**II Linearity Test**

For Calculations you may want to use the appropriate sheet

<b>Range</b>	<b><math>P_{DUT}</math> [dBm]</b>	<b><math>P_{DUT}</math> [dBm]</b>	<b>Loss [%]</b>
--------------	-----------------------------------	-----------------------------------	-----------------

+10	+9	_____	<math>\pm 0.35\%</math>
+10	+3	_____	<math>\pm 0.35\%</math>
0	+3	_____	<math>\pm 0.35\%</math>
0	-7	_____	<math>\pm 0.35\%</math>
-10	-7	_____	<math>\pm 0.35\%</math>
-10	-17	_____	<math>\pm 0.35\%</math>
-20*	-17*	Reference	0.0
-20	-27	_____	<math>\pm 0.35\%</math>
-30	-27	_____	<math>\pm 0.35\%</math>
-30	-37	_____	<math>\pm 0.35\%</math>
-40	-37	_____	<math>\pm 0.35\%</math>
-40	-47	_____	<math>\pm 0.35\%</math>
-50	-47	_____	<math>\pm 0.35\%</math>
-50	-57	_____	<math>\pm 0.36\%</math>

**III Noise Test**

\_\_\_\_\_ [pW] <math>< 2\text{ pW}</math>

**IV Return Loss Test**

\_\_\_\_\_ [dB] 55 dB <

**(V) Relative Uncertainty due to Polarization**

\_\_\_\_\_ [dB]

\_\_\_\_\_ [dB] <math>< 0.01\text{ dB}</math>

**(VI) Relative Uncertainty due to Interference**

\_\_\_\_\_ [dB]

\_\_\_\_\_ [dB] <math>< 0.01\text{ dB}</math>

Maximum difference in interval  
1500 nm - 1560 nm / 2 pm step;  $\Delta P$

Maximum difference in interval  
1550 nm - 1560 nm / 0.1 nm step;  $\Delta P$



**Performance Test for the Agilent 81635A**

Page 1 of 3

Model	Agilent 81635A Sensor Module	Date	_____
Serial No.	_____	Ambient Temperature	_____ °C
Options	_____	Relative Humidity	_____ %
Firmware Rev.	_____	Line Frequency	_____ Hz
Test Facility	_____	Customer	_____
Performed by	_____	Report No	_____
Special Notes	_____ _____ _____ _____ _____ _____ _____ _____		

Performance Test for the Agilent 81635A		Test Equipment Used	
Page 2 of 3			
1a1	Lightwave Multimeter (Std.)	Agilent 8163A	
1a2	Lightwave Multimeter (DUT)	Agilent 8163A	
1b	TLS Mainframe	Agilent 8164A	
2a1	CW High Power Laser Source	Agilent 81655A	
2a2	CW High Power Laser Source	Agilent 81656A	
2b	CW Dual High Power Laser Source	Agilent 81657A	
3	CW Dual Laser Source	HP 81554SM	
4a1	Opt. Head Interface Module	HP 81533B	
4a2	Optical Head, Reference	HP 81521B	
5	Sensor Module	HP 81532A	
6	Optical Attenuator	Agilent 8156A #221	
7a	Optical Attenuator	Agilent 8156A #101	
7b	Optical Attenuator	HP 8157A	
7c	Optical Attenuator	HP 8158B #002	
8	Return Loss Module	HP 81534A	
9			
10			
11			
12			
<b>Accessories</b>			
		#	Product
	Lightmode Fibers	2	81101AC
		1	81102SC
		1	81109AC
	Connector Interfaces	5	81000AI
		3	81000FI
		5	81000SI
	Connector Adapters	1	81000AA
	Backreflector Kit	1	8156A #203

Model Agilent 81632A Sensor Module

Report No. \_\_\_\_\_

Date \_\_\_\_\_

Min. Spec. Result Max. Spec. Measurement Uncertainty

I Accuracy Test  $\mu W$

measured at \_\_\_\_\_ nm Output Power 9.64  $\mu W$  10.36  $\mu W$

(1310nm)

measured at \_\_\_\_\_ nm Output Power 9.64  $\mu W$  10.36  $\mu W$

(1550nm)

II Linearity Test For Calculations you may want to use the appropriate sheet

Range  $P_{DUT}$  [dBm]  $P_{DUT}$  [dBm] Loss [%]

+10 +9 <math>\pm 0.93\%</math>

+10 +3 <math>\pm 0.46\%</math>

0 +3 <math>\pm 0.46\%</math>

0 -7 <math>\pm 0.46\%</math>

-10 -7 <math>\pm 0.46\%</math>

-10 -17 <math>\pm 0.46\%</math>

-20\* -17\* Reference

-20 -27 <math>\pm 0.46\%</math>

-30 -27 <math>\pm 0.46\%</math>

-30 -37 <math>\pm 0.47\%</math>

-40 -37 <math>\pm 0.47\%</math>

-40 -47 <math>\pm 0.56\%</math>

-50 -47 <math>\pm 0.56\%</math>

-50 -57 <math>\pm 1.46\%</math>

III Noise Test [pW]

<math>> 20\text{ pW}</math>

IV Return Loss Test [dB]

<math>40\text{ dB}</math>

## Calculation Sheet for Linearity Measurement

		Calculation as given		Calculation as given	
n	Ref / R	DUT / D	Relation1 / A	Relation2 / B	Non-Linearity
	[mW]	[mW]	$= R_{n+1}/R_n$	$= D_n/D_{n+1}$	$= A_n * B_n (NL_{n+1} + 1) - 1$ ① [%]
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

# Cleaning Procedure

---

**WARNING**

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

**WARNING**

In general, *whenever possible use physically contacting connectors, and dry connections*. Clean the connectors, interfaces and bushings carefully each time after use.

Make sure to disable all sources when you are cleaning any optical interfaces. Under no circumstances look into the end of an optical cable attached to the optical output when the device is operational.

The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.



# The Cleaning Kit

A full cleaning kit contains the following items:

## Isopropyl alcohol

This is usually available from pharmaceutical suppliers or chemists.

If possible, use alcohol supplied for medical purposes, rather than impure alcohol or alcohol with additives.

Do not use other solvents as some can damage plastic materials and claddings. For example, Acetone dissolves the adhesives used in fiber optic devices.

Never drink this alcohol as this can lead to blindness or other serious damage to your health.

## Cotton-swabs

Use swabs such as Q-tips or other cotton-swabs. These are typically available from local distributors of medical or hygiene products (such as supermarkets or pharmacies).

### NOTE

If you are cleaning connector interfaces or adapters, the diameter of the cotton swab is important. Cotton swabs for babies normally have a smaller diameter.

Do not use foam swabs, as these can leave filmy deposits on the surface you are cleaning.

Store your cotton-swabs carefully and never reuse them. Dust and dirt from the air or from previous cleaning, can scratch or dirty your optical device.

## Soft-tissues

These are available from most stores and distributors of medical and hygiene products (such as supermarkets or pharmacies).

Use multi-layer tissues made from non-recycled cellulose. These are more absorbent and softer than other types and they do not scratch the surface of your device.

Store your soft-tissues carefully and never reuse them, as dust and dirt from the air or from previous cleaning can scratch and dirty your optical device.

### CAUTION

### CAUTION

### WARNING

### CAUTION

To examine devices you also require:

**Microscope**

Select a microscope with a magnification range of between 50X and 300X. These should be available from photographic stores or laboratory suppliers.

Ensure that the light source of the microscope is flexible. This helps you to examine your device closely and from different angles.

A microscope allows you to determine the type of dirt on your device and its extent. Then you can choose the correct cleaning procedure and later to examine the results of cleaning. With a microscope you can also determine if your optical device is scratched.

## Other Cleaning Tools

This is available from laboratory suppliers.

It is essential that your compressed air is free of dust, water and oil. Only use clean, dry air. If you do not, it can lead to filmy deposits or scratches.

When using compressed air from a can,

- Hold the can upright. A slant can cause propellant to escape with the compressed air and dirty your optical device.
- Spray the first couple of seconds into the air, as the first stream of compressed air can contain condensation or propellant. Any condensation produces a filmy deposit.

If you are using compressed air from a can, you should select one with a CFC-free propellant, for the sake of the environment.

## Compressed Air

These are available from tobacco shops.

Ensure that the bristles of the pipe-cleaner are soft, so that they do not scratch your device during cleaning.

Store your pipe-cleaner carefully and never reuse them as dust and dirt from the air or from previous cleaning can scratch and dirty your optical device.

## Pipe-cleaner

**CAUTION**

Some lens cleaning papers and cleaning kits available, for example, in photographic stores are not suitable for cleaning fiber optic devices. To be sure, please ask the salesperson or the manufacturer.

## Lens Cleaning Paper

This is typically available from laboratory suppliers. With this card you can qualitatively check the uniformity of your emitted laser light, because when the laser light is projected onto the sensor card it becomes visible.

## Infrared sensor card

This is typically available from professional photographic stores or laboratory suppliers. Polymer film is very gentle on optical surfaces and is particularly good for cleaning extremely sensitive devices such as mirrors.

## Polymer film

These are tissues that are moistened with isopropyl alcohol.

## Premoistened cleaning wipes

Use water only if you are sure that your optical device will not corrode or be damaged. Do not use hot water, as this can lead to mechanical stress that can damage your optical device. Ensure that your liquid soap has no abrasive properties or perfume in it, as these can scratch or damage your optical device. Do not use normal washing-up liquid, as it can leave behind an iridescent film.

## Warm water and liquid soap

These are typically available from photographic stores or laboratory suppliers. An ultrasonic bath very gently removes greasy and other stubborn dirt from optical devices. Only use an ultrasonic bath with isopropyl alcohol, as other solvents can damage or dirty your optical device.

## Ultrasonic bath

Use a dry and very soft cotton tissue to clean the instrument housing and the keypad. Do not open the instrument as there is a danger of electric shock, or electrostatic discharge. Opening the instrument can cause damage to sensitive components, and in addition your warranty will be voided.

## Cleaning Instrument Housings

Where it is possible, do not use immersion oil or other index matching compounds with your device. They are liable to impair and dirty the surface of the device. In addition, the characteristics of your device can be changed and your measurement results affected.

### Immersion Oil and Other Index Matching Compounds

All of Agilent Technologies' sighthwave instruments and accessories are shipped with either laser shutter caps or dust caps. If you need additional or replacement dust caps, contact your nearest Agilent Technologies Sales/Service Office.

Keep the caps on the equipment always when it is not in use. When you have finished cleaning, put the dust cap back on, or close the shutter cap if the equipment is not going to be used immediately. Be careful when replacing dust caps after use. Do not press the bottom of the cap onto the fiber as any dust in the cap can scratch or dirty your fiber surface.

### Dust Caps and Shutter Caps

Before you make any connection you must ensure that all cables and connectors are clean. If they are dirty, use the appropriate cleaning procedure. When inserting the ferrule of a patchcord into a connector or an adapter, make sure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise you will rub the fiber end against an unsuitable surface, producing scratches and dirt deposits on the surface of your fiber.

### Making Connections

Listed below are some hints on how best to keep your connectors in the best possible condition.

## Preserving Connectors

# Cleaning Procedures

If you are unsure about the correct cleaning procedure for your device or if you are unsure whether the procedure given here is suitable for your device, check with the manufacturer or sales distributor, or try the procedure on a dummy or test device first.

## Cleaning Cable Connectors

Cleaning connectors is difficult as the core diameter of a singlemode fiber is only about 9 µm. This generally means you cannot see streaks or scratches on the surface. To be certain of the condition of the surface of your connector and to check it after cleaning, you need a microscope.

In the case of scratches, or of dust that has been burnt onto the surface of the connector, you may have no option but to polish the connector. This depends on the degree of dirtiness, or the depth of the scratches. This is a difficult procedure and should only be performed by skilled personal, and as a last resort as it wears out your connector.

Never look into the end of an optical cable that is connected to an active source.

To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the output of the connector. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

## Preferred Procedure

- 1 Clean the connector by rubbing a new, dry cotton-swab over the surface using a small circular movement.
- 2 Blow away any remaining lint with compressed air.

## Procedure for Stubborn Dirt

Use this procedure particularly when there is greasy dirt on the connector:

- 1 Moisten a new cotton-swab with isopropyl alcohol.
- 2 Clean the connector by rubbing the cotton-swab over the surface using a small circular movement.
- 3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
- 4 Blow away any remaining lint with compressed air.

## WARNING

**CAUTION**

Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the interface.  
Do not use pipe-cleaners on optical head adapters, as the hard core of normal pipe-cleaners can damage the bottom of an adapter.

**Cleaning Connector Interfaces**

- 4 Blow away any remaining lint with compressed air.
  - 3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
  - 2 Clean the adapter by rubbing the cotton-swab over the surface using a small circular movement.
  - 1 Moisten a new cotton-swab with isopropyl alcohol.
- Use this procedure particularly when there is greasy dirt on the adapter:

**Procedure for Stubborn Dirt**

- 2 Blow away any remaining lint with compressed air.
- 1 Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.

**Preferred Procedure**

Some adapters have an anti-reflection coating on the back to reduce back reflection. This coating is extremely sensitive to solvents and mechanical abrasion. Extra care is needed when cleaning these adapters.

**CAUTION****Cleaning Connector Adapters**

- 3 Blow away any remaining lint with compressed air.
  - 2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
  - 1 Hold the tip of the connector in the bath for at least three minutes.
- The better, more gentle, but more expensive cleaning procedure is to use an ultrasonic bath with isopropyl alcohol.

**An Alternative Procedure**

- 1 Clean the adapter by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.

Be careful when using pipe-cleaners, as the core and the bristles of the pipe-cleaner are hard and can damage the adapter.

Use this procedure particularly when there is greasy dirt on the adapter:

### Procedure for Stubborn Dirt

- 1 Blow away any dust or dirt with compressed air.

### Preferred Procedure

Never use any kind of solvent when cleaning a bare fiber adapter as solvents can damage the foam inside some adapters. They can deposit dissolved dirt in the groove, which can then dirty the surface of an inserted fiber.

Bare fiber adapters are difficult to clean. Protect from dust unless they are in use.

## Cleaning Bare Fiber Adapters

- 6 Blow away any remaining lint with compressed air.
- 5 Using a new, dry pipe-cleaner, and a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.
- 4 Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
- 3 Moisten a new cotton-swab with isopropyl alcohol.
- 2 Clean the interface by pushing and pulling the pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.
- 1 Moisten a new pipe-cleaner with isopropyl alcohol.

Use this procedure particularly when there is greasy dirt on the interface:

### Procedure for Stubborn Dirt

- 3 Blow away any remaining lint with compressed air.
- 2 Then clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
- 1 Clean the interface by pushing and pulling a new, dry pipe-cleaner into the opening. Rotate the pipe-cleaner slowly as you do this.

### Preferred Procedure

**CAUTION**

**CAUTION**

- 4 Blow away any remaining lint with compressed air.
  - 3 Using a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.  
circular movement.
  - 2 Clean the lens by rubbing the cotton-swab over the surface using a small circular movement.
  - 1 Moisten a new cotton-swab with isopropyl alcohol.
- Use this procedure particularly when there is greasy dirt on the lens:

### Procedure for Stubborn Dirt

- 2 Blow away any remaining lint with compressed air.  
small circular movement.
- 1 Clean the lens by rubbing a new, dry cotton-swab over the surface using a small circular movement.

### Preferred Procedure

Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings. Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little alcohol as possible, as it can get between the lenses and in doing so can change the properties of projection.

## Cleaning Lenses

- 4 Make your cleave and immediately insert the fiber into your bare fiber adapter in order to protect the surface from dirt.
- 3 Carefully clean the bare fiber with this tissue.
- 2 Take a new soft-tissue and moisten it with isopropyl alcohol.
- 1 Strip off the cladding.

You make a new cleave. To do this:  
Bare fiber ends are often used for splices or, together with other optical components, to create a parallel beam. The end of a fiber can often be scratched.

## Cleaning Bare Fiber Ends

- 3 Blow away any remaining lint with compressed air.  
small circular movement.
- 2 Clean the adapter by rubbing a new, dry cotton-swab over the surface using a small circular movement.



- 1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.
  - 2 Remove the film and any dirt with special adhesive tapes.
- To clean lenses that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

### Alternative Procedure A

- 1 Moisten the lens or the mirror with water.
- 2 Put a little liquid soap on the surface and gently spread the liquid over the whole area.
- 3 Wash off the emulsion with water, being careful to remove it all, as any remaining streaks can impair measurement accuracy.
- 4 Take a new, dry soft-tissue and remove the water, by rubbing gently over the surface using a small circular movement.
- 5 Blow away remaining lint with compressed air.

Only use water if you are sure that your device does not corrode. Do not use hot water as this can lead to mechanical stress, which can damage your device. Make sure that your liquid soap has no abrasive properties or perfume in it, because they can scratch and damage your device. Do not use normal washing-up liquid as sometimes an iridescent film remains.

Use this procedure particularly when there is greasy dirt on the lens:

### Procedure for Stubborn Dirt

- 1 Blow away any dust or dirt with compressed air.

### Preferred Procedure

Some mirrors, as those from a monochromator, are very soft and sensitive. Therefore, never touch them and do not use cleaning tools such as compressed air or polymer film. Some lenses have special coatings that are sensitive to solvents, grease, liquid and mechanical abrasion. Take extra care when cleaning lenses with these coatings. Lens assemblies consisting of several lenses are not normally sealed. Therefore, use as little liquid as possible, as it can get between the lenses and in doing so can change the properties of projection.

**CAUTION**

## Cleaning Large Area Lenses and Mirrors

To assess the projection of the emitted light beam you can use an infrared sensor card. Hold the card approximately 5 cm from the interface. The invisible emitted light is project onto the card and becomes visible as a small circular spot.

sight.

Never look into an optical output, because this can seriously damage your eye.

## WARNING

Remove any connector interfaces from the optical output of the instrument before you start the cleaning procedure. Cleaning interfaces is difficult as the core diameter of a singlemode fiber is only about 9  $\mu\text{m}$ . This generally means you cannot see streaks or scratches on the surface. To be certain of the degree of pollution on the surface of your interface and to check whether it has been removed after cleaning, you need a microscope.

## Cleaning Physical Contact Interfaces

Some instruments, for example, the optical heads from Agilent Technologies have an optical glass plate to protect the sensor. Clean this glass plate in the same way as optical lenses (see "*Cleaning Lenses*" on page 64).

## Cleaning Optical Glass Plates

If there is dust on the interface, try cleaning it using compressed air. If there is fluid or greasy dirt on the interface then contact Agilent Technologies, so that trained personnel can open the instrument and do the cleaning. Never open the instrument to clean the optical block yourself, because the optical components can be easily scratched or misaligned.

Generally, avoid cleaning this kind of interface, because it is difficult to remove any used alcohol or lint from the input of the optical block. Keep the dust caps on the interfaces unless it is in use.

## Cleaning Fixed Connector Interfaces

- 1 Moisten the lens or the mirror with isopropyl alcohol.
- 2 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
- 3 Blow away remaining lint with compressed air.

If your lens is sensitive to water then:

## Alternative Procedure B

Some optical devices, such as the Agilent 8100BR Reference Reflector, which has a gold plated surface, are very sensitive to mechanical stress or pressure. Do

## Cleaning Fragile Optical Devices

- 4 Blow away any remaining lint with compressed air.
- 3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
- 2 Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
- 1 Moisten a new cotton-swab with isopropyl alcohol.

Use this procedure particularly when there is greasy dirt on the interface, and using the procedure for light dirt is not sufficient. Using isopropyl alcohol should be your last choice for recessed lens interfaces because of the difficulty of cleaning out any dirt that is washed to the edge of the interface:

### Procedure for Stubborn Dirt

- 3 Blow away any remaining lint with compressed air.
- 2 Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.
- 1 Blow away any dust or dirt with compressed air. If this is not sufficient, then

### Preferred Procedure

## Cleaning Recessed Lens Interfaces

- 4 Blow away any remaining lint with compressed air.
- 3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.
- 2 Clean the interface by rubbing the cotton-swab over the surface using a small circular movement.
- 1 Moisten a new cotton-swab with isopropyl alcohol.

Use this procedure particularly when there is greasy dirt on the interface:

### Procedure for Stubborn Dirt

- 2 Blow away any remaining lint with compressed air.
- 1 Clean the interface by rubbing a new, dry cotton-swab over the surface using a small circular movement.

### Preferred Procedure

Do not use an ultrasonic bath as this can damage your device.  
Use this procedure particularly when there is greasy dirt on the device:

### Procedure for Stubborn Dirt

**Preferred Procedure**

- 1 Use compressed air at a distance and with low pressure to remove any dust or lint.

This kind of device is extremely fragile. A misalignment of the grating leads to inaccurate measurements. Never touch the surface of the metal filter or attenuator grating. Be very careful when using or cleaning these devices. Do not use cotton-swabs or soft-tissues, as there is the danger that you cannot remove the lint and that the device will be destroyed by becoming mechanically distorted.

### Cleaning Metal Filters or Attenuator Gratings

For these types of optical devices you can often use an ultrasonic bath with isopropyl alcohol. Only use the ultrasonic bath if you are sure that it won't cause any damage anything to the device.

- 1 Put the device into the bath for at least three minutes.
- 2 Blow away any remaining liquid with compressed air.

If there are any streaks or drying stains on the surface, repeat the cleaning procedure.

### Alternative Procedure

- 1 Put the film on the surface and wait at least 30 minutes to make sure that the film has had enough time to dry.
- 2 Remove the film and any dirt with special adhesive tapes.

To clean devices that are extremely sensitive to mechanical stress or pressure you can also use an optical clean polymer film. This procedure is time-consuming, but you avoid scratching or destroying the surface.

### Procedure for Stubborn Dirt

**Preferred Procedure**

- 1 Blow away any dust or dirt with compressed air.

not use cotton-swabs, soft-tissues or other mechanical cleaning tools, as these can scratch or destroy the surface.

- 1** Put the optical device into a bath of isopropyl alcohol, and wait at least 10 minutes.
- 2** Remove the fluid using compressed air at some distance and with low pressure. If there are any streaks or drying stains on the surface, repeat the whole cleaning procedure.



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