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Keysight 81495A
Reference Receiver Module

KEYSIGHT TECHNOLOGIES

User's Guide

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NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to **www.keysight.com.**



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Subject Matter

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Printing History

New editions are complete revisions of the guide reflecting alterations in the functionality of the instrument. Updates are occasionally made to the guide between editions. The date on the title page changes when an updated guide is published. To find out the current revision of the guide, or to purchase an updated guide, contact your Keysight Technologies representative.

Control Serial Number: Edition 2 applies directly to all instruments.

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1 Getting Started

This chapter introduces the features of the Keysight 81495A Reference Receiver Module.

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Safety Considerations

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

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.

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**

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.

Initial Inspection

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.

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 Keysight Technologies Sales/Service Office.

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.).**

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Line Power Requirements

The Keysight 81495A Reference Receiver Module operate when installed in the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, and 8166A/B Lightwave Multichannel System.

Firmware Requirements

The Keysight 81495A Reference Receiver Module can only operate with more recent versions of the mainframe firmware.

To find the version of your firmware

1 Press *Config*.

2 Move to [About Mainframe], and press *Enter*.
The bottom line shows the firmware revision.

On a 8163A/B Lightwave Multimeter, you should have firmware V5.01 or greater.

On a 8164A/B Lightwave Measurement System, you should have firmware V5.01 or greater.

On a 8166A/B Lightwave Multichannel System, you should have firmware V5.01 or greater.

Operating Environment

The safety information in the 8163A/B Lightwave Multimeter, 8164A/B Lightwave Measurement System, and 8166A/B Lightwave Multichannel System User's Guide summarizes the operating ranges for the Keysight 81495A Reference Receiver Module. In order for these modules to meet specifications, the operating environment must be within the limits specified for the 8163B Lightwave Multimeter, 8164B Lightwave Measurement System, and 8166B Lightwave Multichannel System.

Storage and Shipment

This module can be stored or shipped at temperatures between
–40°C and +70°C. Protect the module from temperature extremes that may cause condensation within it.

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Environmental Information



This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/ electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as a "Monitoring and Control instrumentation" product.

Do not dispose in domestic household waste.

To return unwanted products, contact your local Keysight office, or see http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.

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Getting Started with the Receiver Module

What is a Reference Receiver Module

A Reference Receiver Module is an O/E converter that converts modulated optical signals, from a source like a transmitter, into an electrical signal with similar waveform and proportional signal amplitude.

It is designed to feed the return signal back to the BERT (Bit Error Ratio Tester) in testing transceiver loopback according to the IEEE 802.3ae and 10 GFC standards. As the transceiver output is optical, the signal is converted to the electrical domain with the 81495A Reference Receiver. The performance of this conversion has significant influence on the results of the loopback test. The 81495A reference receiver works perfectly with the N4917A Optical Transceiver Stress Test solution.

The 81495A reference receiver provides an integrated optical average power meter. This makes it fast and easy to verify the average optical power of the connected signal, thus avoiding problems with the test setup and the test results.

The Front Panel

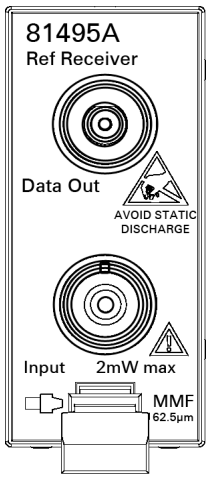


Figure 1 Front Panel of the Keysight Reference Receiver Module

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Data Out

The analog output is a 2.4 mm female RF connector on the front of the module. It outputs a voltage directly proportional to the strength of the optical signal at the optical input.

The analog signal is in the range between 0 and 0.4V, where 0V corresponds to no input signal, and 0.4V corresponds to an input signal power of around 1 mW.

The voltage at Data Out is typically in the range ±50mV with darkened Optical Input. To offset this voltage, follow the procedure in the chapter for Programming Information in the User's Guide.

The optical-to-electrical conversion ratio depends on the wavelength of the input signal and can be remotely queried for the three wavelength 850nm, 1310nm, and 1550nm; see "Query optical-to-electrical conversion ratio" in the SCPI Commands section of the document 81495-90A02.

CAUTION *To avoid electrical damage to the receiver, ensure zero-voltage and interference free common ground connection between 81495A and instruments attached to its Data Out connector.*

Connect the power plugs of the 816x mainframe housing the 81495A and of the instruments attached to Data Out to the same power outlet to minimize voltage differences of grounding and to minimize ground loop effects.

CAUTION *Always discharge the RF cable (using a temporary shorted connection between the center and outer conductors of the cable) before attaching to the receiver Data Out connector.*

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Optical Input

The optical input to the module requires a connector interface to match the connector type to the module. See “Accessories” chapter in the document 81495-90A02.

Straight Contact Connectors

The Keysight 81495A Reference Receiver Module is equipped with a straight contact optical input connector as standard.

Straight contact connectors help you maximise the power input.

CAUTION *Only use cables with straight connectors with the instrument.*

Using an angled contact connector can result in losses of 7dB or more.



Straight Contact
Connector Symbol

Figure 2 Straight Contact Connector Symbols

CAUTION *To avoid damage to the receiver; do not exceed the 2mW maximum safe input power to the optical input.*

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Programming Information

This chapter introduces the programming commands associated with the Keysight 81495A Reference Receiver Module.

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SCPI Commands

New Command Query optical-to-electrical conversion ratio

command:	**:SPECial[:PRIVATE]:PASSthru**<*SlotNr*>**:RUN?** ***'serx oegain'***
syntax:	:SPECial[:PRIVATE]:PASSthru<SlotNr>:RUN?
description:	Returns a list of up to five wavelength, gain pairs. Each pair is separated by a semi colon. "empty" is returned if no data is available.
parameters:	'serx oegain'
response:	The result is returned as an quoted string: "<wavelength1>,<gain1>[;<wavelength2>,<gain2>][;<wavelength3>,<gain3>][;<wavelength4>,<gain4>][;<wavelength5>,<gain5>]" or "empty"
example:	spec:pass1:run? 'serx oegain' ---> "8.5e-07,250;1.31e-06,410;1.55e-06,400"<END> which is equivalent to:

Wavelength	850 nm	1310 nm	1550 nm
O/E Converter Gain	250	410	400

Procedure for Adjusting Dark-Input Electrical Offset

Procedure for adjusting dark-input electrical offset:

The following remote control procedure can be used to adjust the voltage at the output when no optical signal is applied. Other applications for these SCPI commands are not currently documented. After reboot, this offset will be reset to the factory default setting.

Step 1: Set module to default state

command string:
spec:pass1:run? 'serx ignorecaldata 0'

command string:
spec:pass1:run? 'serx align'

Step 2: Measure offset voltage with darkened optical input (e.g. -0.03V)

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Step 3: Read current Target Value from module (marked blue)

command string:
spec:pass1:run? 'serx info'

sample response string from module:

target: caldata 1.090000, extern 0.000000; use caldata; do align

Step 4: Calculate new Target Value

new Target Value = current Target - (offset voltage * 0.5)

e.g. 1.09 - (- 0.03V * 0.5) = 1.105

Step 5: Set new Target Value

command string:
spec:pass1:run? 'serx target 1.105'

command string:
spec:pass1:run? 'serx align'

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3
Accessories

The Keysight 81495A Reference Receiver Module is available in various configurations for the best possible match to the most common applications.

This chapter provides information on the available options and accessories.

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Recommended Connector Interfaces

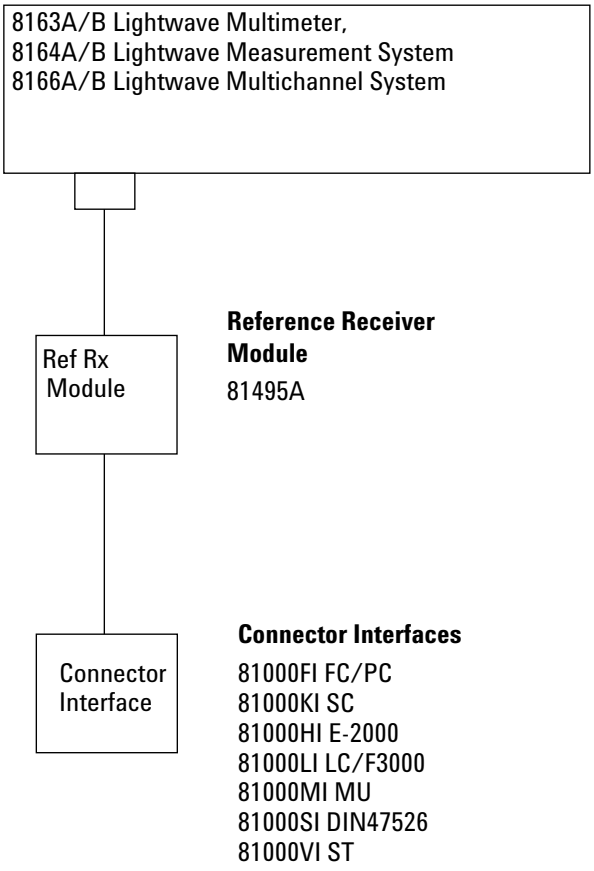


Figure 1 Recommended Connector Interfaces

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4
Specifications

Keysight 81495A Reference Receiver Module are produced to the ISO 9001 international quality system standard as part of Keysight's commitment to continually increasing customer satisfaction through improved quality control.

Specifications describe the module's warranted performance. Supplementary performance characteristics describe the module's non-warranted typical performance.

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

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Definition of Terms

Specification (guaranteed): describes a guaranteed product performance that is valid under the specified conditions. Specifications are based on a coverage factor[1] of 2 (unless otherwise stated), corresponding to a level of confidence of >95%.

Typical values (characteristics): a characteristic describing the product performance that is usually met but not guaranteed.

Generally, all specifications are valid at the stated operating and measurement conditions and settings, with uninterrupted line voltage.

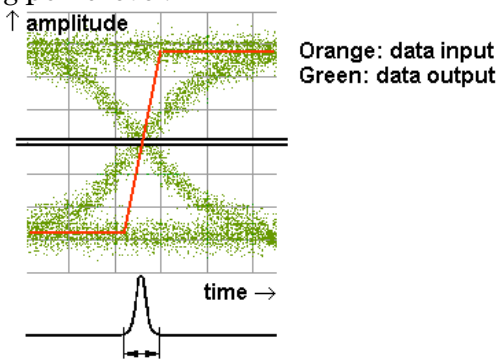
Averaging time (average power meter)

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).

Jitter (peak-peak) (RF out)

The variation of time intervals between successive falling or rising edges of the data output at constant frequency of the data input.

It is calculated as the peak to peak variation of the time interval between Reference Receiver electrical output edge 50% crossing point level.



Jitter p-p = full width of the histogram at the eye crossing point

Conditions: Conditions as specified

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Measurement: Using a suitable pattern generator, a reference transmitter and an optical/electrical sampling scope with pattern trigger capability and jitter analysis software. Measured with data pattern PRBS 2^{11}-1 and "pattern lock" (Keysight 86100C) enabled, 100 acquired waveforms and "BER" (Keysight 86100C) set to 10^{-3}.

Linearity (average power meter)

The linearity error E 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.

$$\text{Linearity} = \left(\frac{D_x/D_0}{P_x/P_0} - 1\right)100$$

if expressed in %, or

$$\text{Linearity} = 10\log\left(\frac{D_x/D_0}{P_x/P_0}\right)$$

if expressed in dB.

Conditions: Reference level 500 μW (-3 dBm). Power range and range setting as specified.

NOTE Ideally E = 0 %, respectively 0 dB.

Maximum safe input power (optical in)

The maximum peak input power that does not cause permanent change of the Reference Receiver's characteristics.

CAUTION *Applying a power beyond these limits may damage the Reference Receiver.*

Maximum linear input power (optical in)

The maximum peak input power where the decrease (compression) of the Reference Receiver's →*Optical-to-electrical conversion ratio* is below a specified limit.

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Conditions: Conditions as specified

Noise (2σ) (average power meter)

Twice the standard deviation of displayed power level over time with zero input power level (dark).

Conditions: Averaging time, observation time and wavelength as specified. Auto range enabled.

Operational data rate (optical in)

The non-return to zero (NRZ) data rate the Reference Receiver is designed for.

Optical-to-electrical conversion ratio (optical in)

The electrical output amplitude response of the Reference Receiver to an optical input power stimulus, calculated as the ratio *CR* of the electrical output voltage peak-to-peak amplitude in Volts to the input →*optical modulation amplitude* in Watt, expressed in V/W.

NOTE Optical-to-electrical conversion ratio expressed $dB_{V/W}$ is calculated as

$$20\log_{10}\left(\frac{CR}{1\,W/V}\right)$$

Conditions: High quality connectors in perfect condition. Other conditions as specified.

Measurement: Using a suitable pattern generator, a reference transmitter and an optical/electrical sampling scope with waveform and amplitude analysis software.

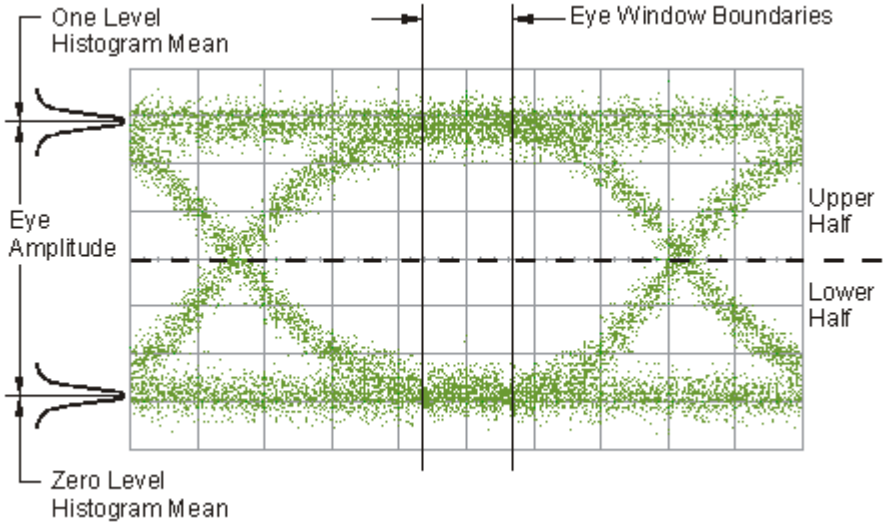
Optical modulation amplitude (OMA)

The difference between the “one” level average optical power P_1 (in Watt) and the “zero” level average optical power P_0 (in Watt), calculated as

$$OMA = P_1 - P_0$$

The power levels P_0 and P_1 are determined within the eye window boundaries. The eye window boundaries mark the central 20% range of the bit period.

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Measurement: Using a suitable pattern generator, a reference transmitter and an optical/electrical sampling scope with waveform and amplitude analysis software.

Opto-electrical modulation bandwidth (RF out)

The frequency range where the Reference Receiver's →*Optical-to-electrical conversion ratio* is above a specified limit.

Conditions: Response limit as specified. Other conditions as specified.

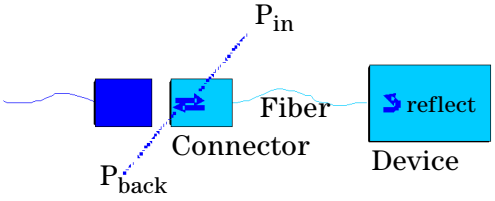
Output impedance nominal (RF out)

The nominal output impedance at the data output.

Return loss (optical in)

The ratio *RL* of the incident optical power in Watts to the reflected optical power, expressed in dB.

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

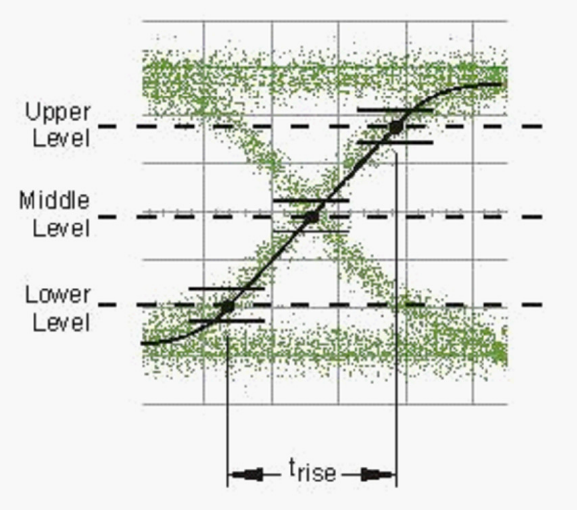


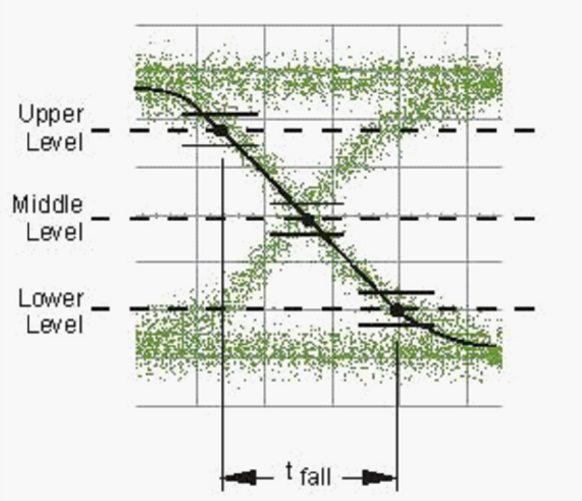
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Rise and fall time (RF out)

Rise time is the average transition time of the data output response on an (instantaneous) upward edge at the data input. Fall time is defined correspondingly at the downward edge.

The transition time is the average time (over repetitions) between the data output crossing the 20% level (lower) and crossing the 80% level (upper). Levels 0% and 100% are the average power levels of the zero level and the one level (at the crossing point, i.e. where the signal crosses the middle level).





Conditions: Conditions as specified.

Measurement: Using a suitable pattern generator, a reference transmitter and an optical/electrical sampling scope with waveform analysis software.

Power range (average power meter)

Specifies the range from the smallest input power that causes a significant change of the measured (displayed) power to the highest power the instrument is designed for to measure.

Condition: As specified.

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Measurement: The lower limit corresponds to power level at least 3 dB above the typical →*Noise (2σ)*. The upper limit is not measured (design value).

Total uncertainty (average power meter)

The power measurement uncertainty for a specified set of operating conditions, including noise and drift.

Conditions: As specified.

Wavelength range (optical in)

The wavelength range for which the power meter is calibrated and the internal optical-to-electrical converter is designed for.

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

References

(1) "Guide to the Expression of Uncertainty in Measurement" ("GUM"), BIPM, IEC, ISO et al. (1993)

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Reference Receiver Module Specifications

Data Input (Optical in)

Operational data rate		622Mb/s to 12.5Gb/s
Fiber type		Standard multi-mode 62.5 μm/ 125 μm
Wavelength range		750 nm to 1650 nm
Maximum safe input power		2 mW
Maximum linear input power[a]		-3 dBm
Noise equivalent power (rms)	λ = 850 nm	< 3.0 μW (typical)
	λ = 1310 nm	< 1.5 μW (typical)
Optical-to-electrical conversion ratio[b]	λ = 850 nm	> 250 V/W (typical)
	λ = 1310 nm	> 400 V/W (typical)
	λ = 1550 nm	> 350 V/W (typical)
Return loss	λ = 850 nm MM	> 14 dB (typical)
	λ = 1310 nm SM	> 27 dB (typical)
Maximum input voltage		< 2 V_{pp} from -2 V to 2 V
Nominal input impedance		50 Ω

a Compression < 1 dB

b OMA ⩽ 0.5 mW and average power ⩽ 0.3 mW

Data output (RF out)

Output impedance (nominal)	50 Ω
Opto-electrical modulation bandwidth[a]	DC to 9.3 GHz (typical)
Rise and fall time (20 to 80 %)	< 35 ps
Jitter[b]	< 20 ps

a -3dB decrease relative to 100 MHz

b Jitter of input signal < 10 ps

Optical average power meter (specifications valid at 850 nm, 1310 nm, 1550 nm)

Power range	-40 dBm to +5 dBm
Total uncertainty (-25 dBm to +2 dBm)[a]	< ± 0.5 dB (typical)

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Linearity (- 25 dBm to +2 dBm)[a]		< ± 0.05 dB (typical)
Noise (2σ)[b]	λ = 850 nm	< 35 nW
	λ = 1310 nm, 1550 nm	< 20 nW
Averaging time (selectable)		100 μs to 10 s

a NA . 0.24; within 5 min after zeroing, at constant temperature ±1K,
For 850 nm and 1550 nm: up to 0 dBm
For 1550 nm: add 0.05 dB above -3dBm

b 300 samples, averaging time 1 s, constant temperature ±1K

General specifications

Optical connector interface

Keysight universal adapter straight ferrule

RF connector interface

2.4mm female

Module size (H x W x D)

75 mm x 32 mm x 335 mm (2.8” x 2.3” x 13.2”)

Module weight

0.5 kg (1.1 lbs)

Warmup time

20 min

Operating temperature

+5° C to +40° C

Storage Temperature

- 40° C to +70° C

Humidity

15 % to 95 % relative humidity, non-condensing

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816xA/B Firmware revision

5.01 and higher

Recommended recalibration time

3 years

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5
Performance Tests

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KEYSIGHT TECHNOLOGIES

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Scope

This chapter describes the tests as defined for the product, that are performed either on each individual unit or on sample basis in the production line and where required in the service centers.

General conditions

Test environment conditions:

- Temperature: 20...28°C (if not stated differently).
- DUT warm-up time: > 30 Minutes

Related information

- "Definition of Terms" on page 18
- "Reference Receiver Module Specifications" on page 24

Parameters not tested

Parameters not tested because they are defined by firmware:

- Averaging time (selectable) (average power meter)

Parameters not tested because they are derived from component specs.:

- Maximum safe input power (optical in)
- Noise equivalent power (rms) (optical in)
- Output impedance
- Return Loss (optical in)
- Wavelength range (optical in)

Parameters not tested because they are design values:

- Operational data rate (optical in)

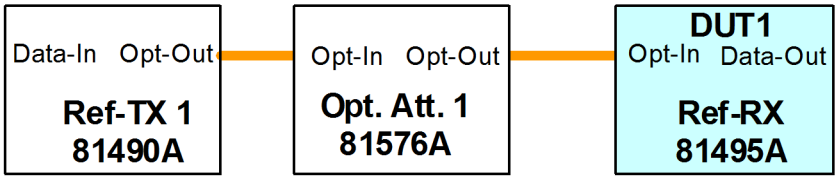
Parameter not tested because it are derived from typical "Noise" spec and upper power limit where the typical "Linearity" (add 3 dB) applies.

- Power range (average power meter)

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Linearity (average power meter)

Test setup and method



Orange lines: single mode fiber (9um)

Required equipment

Device	Required specifications	Comments (proposal)
LMS Mainframe	4-slot Firmware Rev. 5.01	Keysight 8164B
Reference Transmitter1	Wavelength 1310nm & 1550nm Single mode fiber interface	Keysight 81490A opt. 135
Optical Attenuator1 with 2 SM patchcords	Single mode fiber interface Insertion Loss < 2dB Accuracy +-0.1 dB. wavelength range: 1310, 1550nm] optical power monitor	Keysight 81576A (straight)

Test method:

Ref-TX1 serves as optical continuous wave stimulus by disconnected data input. Attenuator1 sets the power levels to DUT1. The monitor power meter of Attenuator1 serves as reference power meter.

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Test procedure

Verify Linearity

1. On optical attenuator 1, disable the the output.
2. On reference transmitter 1,
   a. Select laser 1 (for 1310nm).
   b. Query wavelength of selected laser 1310 nm.
   c. Enable the output.
3. On optical attenuator 1,
   a. Set power unit of monitor power meter to “Watt”.
   b. Set wavelength of monitor power meter to 1310 nm.
   c. Set the monitor power meter units to absolute units.
   d. Enable automatic power ranging of the monitor power meter.
   e. Set average time of monitor power meter to 1 s.
4. On the reference receiver under test, Set power unit of average power meter to “Watt”
5. On the reference receiver under test,
   a. Set the wavelength of the average power meter to 1310 nm.
   b. Set the average power meter units to absolute units.
   c. Enable automatic power ranging of the average power meter.
   d. Set average time of average power meter to 1 s.
6. On optical attenuator 1,
   a. Set the wavelength to 1310 nm.
   b. Set attenuation to 40.0 dB
7. On optical attenuator 1, zero the monitor power meter.
8. On the reference receiver under test, zero the average power meter.
9. On optical attenuator 1,
   a. Enable the output.
   b. Calculate and set attenuation for 6.8 dB, for the reference point (= -3dBm).
10. On optical attenuator 1, note the value for the monitor power, P_0, in Watt, in the test record.
11. On the reference receiver under test, note the value for the average power, D_0, in Watt, in the test record.

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12 For each of the values given in the test record (see "Page 4 of 10" on page 50)

a On optical attenuator 1, set the attenuation, and note the value for the monitor power, P_i, in Watt, in the test record.

b On the reference receiver under test, note the value for the average power, D_i, in Watt, in the test record.

13 When you have completed the test record, on optical attenuator 1, disable the output.

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Noise (2σ) (average power meter)

Test setup and method

See "Test setup and method" on page 29.

Test method:

Apply dark condition to the optical input of the DUT. Take a defined number of equidistant power readings using the internal logging data acquisition function of the LMS mainframe. Analyze the variation of power values.

Test procedure

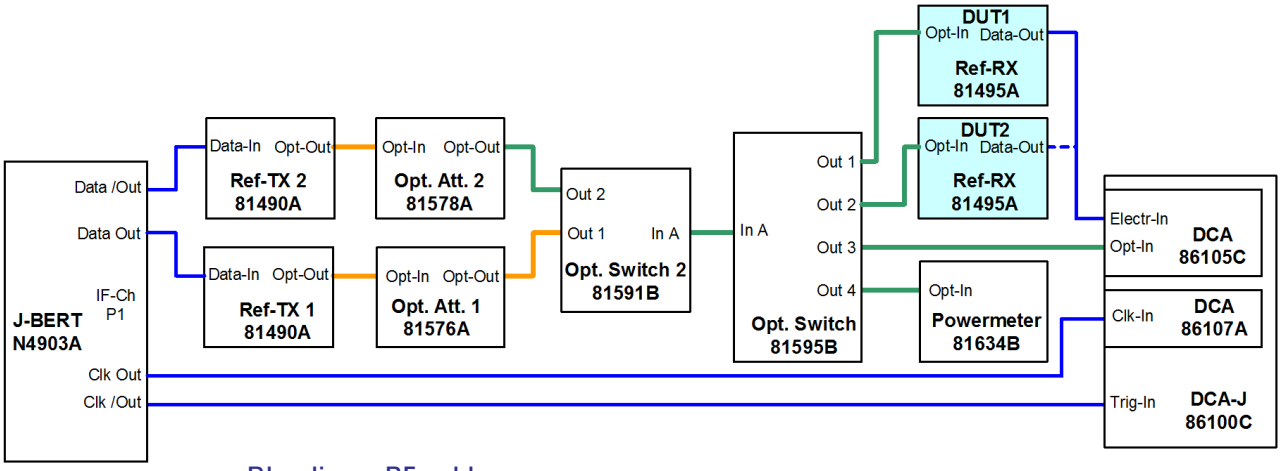
Verify Noise

1. On optical attenuator 1, disable the output.
2. On the reference receiver under test,
   a. Set the wavelength of average power meter to 850 nm.
   b. Execute a zero calibration of the average power meter.
   c. Enter the logging application.
   d. Set the number of samples to 300 and the averaging time to 1 s.
   e. Set the wavelength to 850 nm.
   f. Set the range mode to common and the power range to -20 dBm.
   g. Start measurement and wait till logging has completed.
   h. Note the standard deviation value from the analysis result screen in the test record.
   i. Exit the logging application.
3. Repeat from step 2 with wavelength settings of 1310 nm and 1550 nm.

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O-E conversion ratio, rise/fall time and jitter, maximum linear input power

Test method and setup



Blue lines: RF cable
Orange lines: single mode fiber (5um or 9um)
Green lines: multi mode fiber 62.5um.

Test method: The pattern generator generates a defined electrical signal which is fed directly to the Ref TX and converted into the optical signal. This optical signal is adjusted regarding power level and optical modulation amplitude by the following optical attenuator. The resulting stimulus signal is then fed to the optical switch which feeds the signal to the optical input of the sampling oscilloscope (DCA) for OMA adjustment, or to the optical power meter for referencing of the average power or to the DUT1 (respective DUT2) for verification of the named test parameters.

Finally, the (electrical) data output signal of the DUT is fed to the electrical input of the sampling scope for analysis of waveform and amplitude properties of the response signal.

The signal on the DUT is nearly single mode, though parts of the path are multi mode.

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Required equipment

Device	Required specifications	Comments (proposal)
LMS Mainframe	4-slot Firmware Rev. 5.01	Keysight 8164B
Reference Transmitter1	Wavelength 1310nm & 1550nm Single mode fiber interface	Keysight 81490A opt. 135
Optical Attenuator1 with 2 SM patchcords	Single mode fiber interface Insertion Loss < 2dB Accuracy +-0.1 dB. wavelength range: 1310, 1550nm] optical power monitor	Keysight 81576A (straight)
Pattern Generator with 1 RF cable 2.4mm (male-male).	Data rate: 150 Mb/s to 12.5 Gb/s Data amplitude: 0.1V to 1.8V Data pattern: PRBS (2^7 to 2^15), & user defined. Jitter Compliance Suite Cable Gore P/N EM0CJ0CJ016.0 or EM0CJ0CJ024.0	N4903A #C13, #J20, #J10, #J12
Reference Transmitter2	Wavelength 850nm Standard single mode fiber (9/125) interface	Keysight 81490A opt. 085 [special]
Optical Attenuator2 with 2 SM patchcords	Single mode or multi mode fiber interface Insertion Loss < 2dB Accuracy +-0.2 dB. wavelength range: 850nm	Keysight 81578A opt. 050 or opt. 062
Optical Switch1	1 Input, 4 output ports Multimode 62.5u fiber interface 850nm, 1310, 1550nm	Keysight 81595B #062
Optical Switch2	1 Input, 2 output ports Multimode 62.5u fiber interface 850nm, 1310, 1550nm	81591B #062 or Keysight 81595B #062
Optical Power Meter	Wavelength range 850, 1310, 1550nm Power Range -40 dBm to +10dBm Abs. uncertainty <= +-5.0 % Linearity <= +-0.57% (+-0.025 dB). Multimode 62.5u fiber interface	Keysight 81634B
Sampling Scope Mainframe	Sampling Scope with pattern trigger capability jitter analysis SW, waveform analysis SW, amplitude analysis SW	86100C #001, #200, #201, #300

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Device	Required specifications	Comments (proposal)
Optical/Electrical Sampling Module (DCA)	Multimode 62.5u fiber interface wavelength range: 850nm,1310, 1550nm Optical sampling bandwidth > 8GHz Electrical sampling bandwidth > 20GHz	Keysight 86105C #200 or 300
Precision Time Base Module	Trigger bandwidth: 2.5 to 15 GHz Jitter: < 280fs	Keysight 86107A #010

Test procedure

Calibrate Optical Modulation Amplitude at 850 nm

1. Reset all instruments.
2. On optical attenuator 1, disable the output.
3. On optical attenuator 2, enable the output.
4. On the optical power meter,
   a. Set the average time 1 s.
   b. Set the power unit to “dBm”.
5. On optical switch 1, route path to A -> 3 (connect to the DCA).
6. On optical switch 2, route path to A -> 2 (connect to attenuator 2).
7. On optical attenuator 2, set the attenuation to 9.5 dB.
8. On the J-BERT, set the data pattern to PRBS 2^{11}-1.
9. On the DCA mainframe,
   a. Enable the optical channel.
   b. Set trigger bandwidth to Divided Mode.
   c. Disable the pattern-lock.
   d. Set the threshold definition to 20% - 50% - 80%.
   e. Disable the Acquisition Limit Testing.
   f. Set BER for total interference and jitter 10^{-3}.
   g. Turn off the internal low-pass filter of the optical channel.
   h. Turn off ER-correction of the optical channel.
   i. Disable the electrical channel.
   j. Set the bandwidth of the electrical channel to HIGH.
   k. Turn off ER-correction of the electrical channel.

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10 On reference transmitter 2,

- **a** Select laser 1 (850 nm).
- **b** Enable the output.

11 On optical attenuator 2, set the wavelength to 850 nm.

12 On the optical power meter, set the wavelength to 850 nm.

13 On the DCA mainframe,

- **a** Set the wavelength of the optical channel to USER.
- **b** Set the data rate of the Precision Timebase to 12.5Gb/s.

14 On the J-BERT,

- **a** Set the data rate to 12.5Gb/s.
- **b** Set the data amplitude to 1.8 V.

15 On reference transmitter 2, recalibrate the transmitter.

16 On optical switch 1, route path to A -> 4 (connect to the poaer meter).

17 On the optical power meter,

- **a** Wait 5 s for auto-scaling.
- **b** Note the optical power 'P_{act}', in the test record in dBm.

18 On optical attenuator 2, calculate and set the attenuation to a_{new}, as calculated in the test record.

19 On the optical power meter,

- **a** Wait 5 s for auto-scaling.
- **b** Note the optical power, P_{ref}, in the test record in dBm and convert to Watt.

20 On optical switch 1, route path to A -> 3 (connect to the DCA).

21 On the DCA mainframe,

- **a** Initiate the calibration of optical channel.
- **b** Query the execution of the calibration step.

22 On optical attenuator 2, disable the output.

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23 On the DCA mainframe,
   a Continue with the next calibration step.
   b Query the execution of the calibration step.
   c Enter the optical wavelength (850 nm).
   d Enter the optical power P_{ref}.
   e Continue with next calibration step.
   f Query the execution of the calibration step.
24 On optical attenuator 2, enable the output.
25 On the DCA mainframe,
   a Continue with the next calibration step.
   b Query the execution of the calibration step.
   c Enable the Precision Timebase.
   d Select Eye/Mask Measurement Mode.
26 On reference transmitter 2, adjust the operating point until the crossing point is at 50% ± 1%.
27 On the DCA mainframe,
   a Execute an auto-scale.
   b Run the measurement. Wait 16 s.
   c Note the modulation amplitude, OMA_{act}, in the test record, in dBm
28 On optical attenuator 2, calculate and set the attenuation to a_{nom} as calculated in the test record.

Verify reference receiver at 850 nm

1 On the DCA mainframe,
   a Disable the optical channel.
   b Enable the electrical channel
2 On the reference receiver under test,
   a Set the average time for the average power meter to 0.2 s.
   b Set the wavelength of the average power meter to 850 nm.
3 On optical switch 2, route path to A -> 2 (connect to attenuator 2).
4 On optical attenuator 1, disable the output.
5 On optical attenuator 2, enable the output.

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6 On optical switch 1, route path to A -> x (, where x is 1 for DUT1, or 2 for DUT2).

7 On optical attenuator 1, calculate and set test attenuation, $a_{\text{test,}}$ for OMA_{ver} = OMA_{nom} = 0.5mW, as indicated in the test record.

8 On the DCA mainframe,

- **a** Enable Acquisition Limit Testing, with the number of waveforms set to 100.
- **b** Disable the optical channel.
- **c** Enable the electrical channel.
- **d** Select the Eye/Mask Measurement Mode.
- **e** Disable the pattern-lock.
- **f** Execute an auto-scale.
- **g** Run the measurement. Wait 16 s.
- **h** Note the value for the electrical eye amplitude in the test record.
- **i** Note the value for the rise time in the test record.
- **j** Note the value for the fall time in the test record.
- **k** Select Jitter Measurement Mode.
- **l** Clear the display.
- **m** Enable pattern-lock.
- **n** Run the measurement. Wait 18 s.
- **o** Note the value for the Total Jitter in the test record.
- **p** Select Eye/Mask Measurement Mode.
- **q** Disable the pattern-lock.

9 On optical attenuator 1, calculate and set test attenuation, $a_{\text{test,}}$ for OMA_{ver} = 0.1 mW, OMA_{nom} = 0.5mW, as indicated in the test record.

10 Repeat step 8.

Calibrate and Verify Optical Modulation Amplitude at 1310 nm or 1550 nm

Both calibration and verification should be performed first at 1310 nm, and then repeated for 1550 nm.

Calibration: 1Reset all instruments.

2 On optical attenuator 1, enable the output.

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3 On optical attenuator 2, disable the output.

4 On the optical power meter,

   a Set the average time 1 s.

   b Set the power unit to “dBm”.

5 On optical switch 1, route path to A -> 3 (connect to the DCA).

6 On optical switch 2, route path to A -> 1 (connect to attenuator 1).

7 On optical attenuator 1,

   a Set the attenuation to 9.5 dB.

   b Set the average time of the monitor power meter to 1 s.

   c Set the power unit of the monitor power meter to “dBm”

8 On the J-BERT, set the data pattern to PRBS 2^{11}-1.

9 On the DCA mainframe,

   a Enable the optical channel.

   b Set trigger bandwidth to Divided Mode.

   c Disable the pattern-lock.

   d Set the threshold definition to 20% - 50% - 80%.

   e Disable the Acquisition Limit Testing.

   f Set BER for total interference and jitter 10^{-3}.

   g Turn off the internal low-pass filter of the optical channel.

   h Turn off ER-correction of the optical channel.

   i Disable the electrical channel.

   j Set the bandwidth of the electrical channel to HIGH.

   k Turn off ER-correction of the electrical channel.

10 On reference transmitter 1,

   a Select laser 1 (1310 nm) or laser 2 (1550 nm).

   b Enable the output.

11 On optical attenuator 2, set the wavelength to 1310 nm or 1550 nm.

12 On the optical power meter, set the wavelength to 1310 nm or 1550 nm.

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13 On the DCA mainframe,

- **a** Set the wavelength of the optical channel to USER.
- **b** Set the data rate of the Precision Timebase to 12.5Gb/s.

14 On the J-BERT,

- **a** Set the data rate to 12.5Gb/s.
- **b** Set the data amplitude to 0.85 V, if you are at 1310 nm, or 1.0V if you are at 1550 nm.

15 On reference transmitter 1, recalibrate the transmitter.

16 On optical switch 1, route path to A -> 4 (connect to the poaer meter).

17 On the optical power meter,

- **a** Wait 5 s for auto-scaling.
- **b** Note the optical power 'P_{act}', in the test record in dBm.

18 On optical attenuator 1,

- **a** Set the power offset value to 0.0 dB.
- **b** Note the optical power 'P_{mon}', in the test record in dBm.
- **c** Calculate and set the new power offset value to P_{off}, as calculated in the test record.
- **d** Set the power unit of the monitor power meter to "Watt"
- **e** Set the output power value to 0.2mW.
- **f** Enable power control mode. Wait 5 s for power control mode to settle.
- **g** Disable power control mode.
- **h** Note the optical power, P_{ref}, in the test record in Watts.

19 On optical switch 1, route path to A -> 3 (connect to the DCA).

20 On the DCA mainframe,

- **a** Initiate the calibration of optical channel.
- **b** Query the execution of the calibration step.

21 On optical attenuator 1, disable the output.

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22 On the DCA mainframe,

- **a** Continue with the next calibration step.
- **b** Query the execution of the calibration step.
- **c** Enter the optical wavelength (1310 nm or 1550 nm).
- **d** Enter the optical power P_{ref}.
- **e** Continue with next calibration step.
- **f** Query the execution of the calibration step.

23 On optical attenuator 1, enable the output.

24 On the DCA mainframe,

- **a** Continue with the next calibration step.
- **b** Query the execution of the calibration step.
- **c** Enable the Precision Timebase.
- **d** Select Eye/Mask Measurement Mode.

25 On reference transmitter 1, adjust the operating point until the crossing point is at 50% ± 1%.

26 On the DCA mainframe,

- **a** Execute an auto-scale.
- **b** Run the measurement. Wait 16 s.
- **c** Note the modulation amplitude, OMA_{act}, in the test record, in dBm

27 On optical attenuator 1,

- **a** Note the value for the current attenuation, a_{act}, in the test record, in dB.
- **b** Calculate and set the attenuation to a_{nom} as calculated in the test record.

28 On reference transmitter 1,

- **a** Select laser 2 (1550 nm).
- **b** Enable the output.

Verification: **1**On the DCA mainframe,

- **a** Disable the optical channel.
- **b** Enable the electrical channel

2 On the reference receiver under test,

- **a** Set the average time for the average power meter to 0.2 s.
- **b** Set the wavelength of the average power meter to 1310 nm or 1550 nm.

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3 On optical switch 2, route path to A -> 2 (connect to attenuator 2).

4 On optical attenuator 1, enable the output.

5 On optical attenuator 2, disable the output.

6 On optical switch 1, route path to A -> x (, where x is 1 for DUT1, or 2 for DUT2).

7 On optical attenuator 1, calculate and set test attenuation, $a_{\text{test,}}$ for $\text{OMA}_{\text{ver}} = \text{OMA}_{\text{nom}} = 0.5\text{mW}$, as indicated in the test record.

8 On the DCA mainframe,

- **a** Enable Acquisition Limit Testing, with the number of waveforms set to 100.
- **b** Disable the optical channel.
- **c** Enable the electrical channel.
- **d** Select the Eye/Mask Measurement Mode.
- **e** Disable the pattern-lock.
- **f** Execute an auto-scale.
- **g** Run the measurement. Wait 16 s.
- **h** Note the value for the electrical eye amplitude in the test record.
- **i** Note the value for the rise time in the test record.
- **j** Note the value for the fall time in the test record.
- **k** Select Jitter Measurement Mode.
- **l** Clear the display.
- **m** Enable pattern-lock.
- **n** Run the measurement. Wait 18 s.
- **o** Note the value for the Total Jitter in the test record.

9 On optical attenuator 1, calculate and set test attenuation, $a_{\text{test,}}$ for $\text{OMA}_{\text{ver}} = 0.1$ mW, $\text{OMA}_{\text{nom}} = 0.5\text{mW}$, as indicated in the test record.

10 Repeat step 8.

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Opto-electrical modulation bandwidth (data output)

Measured using a Keysight N4375B (Option 100 or 102) 20 GHz Single-Mode, 1310 nm Lightwave Component Analyzer.

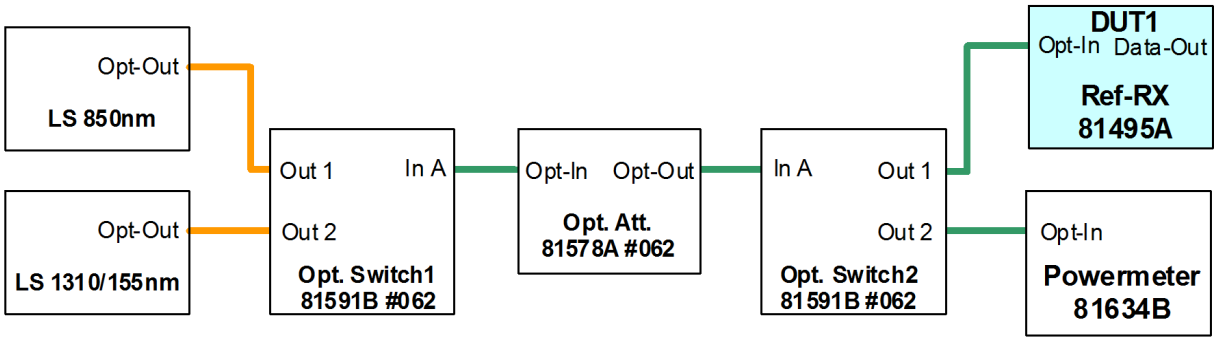
1. Set
   - Frequency range: 0.01 GHz to 20 GHz
   - Number of measurement points: 2000 (0.01 GHz step size)
   - IFBW: 100 Hz
   - Tested wavelength: 1310 nm
   - Optical output power: -2.0 dBm
   - Reference frequency : 100 MHz
2. Measure the responsivity S21 data in “dB”.
3. Store the measurement data in “s2p” Format.
4. Determine the first frequency above reference frequency where the responsivity falls 3 dB below the value at reference frequency.

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Total uncertainty (average power meter)

Test setup and method

The power at selected wavelength from fixed laser sources set to the working point using an attenuator and measured with a reference power meter.



Orange lines: single mode fiber (9 um)
Green lines: multi mode fiber 62.5 um.

Required equipment

Device	Required specifications	Comments (proposal)
LMS Mainframe 1 and 2	4-slot Firmware Rev. 5.01	Keysight 8164B
Laser source 850nm	Output power > 1 mW Wavelength 850nm Single mode fiber interface Wavelength uncertainty <1 nm	Keysight 81655A opt. E01 or Keysight 81490A opt. 085 (special)
Laser source 1310 / 1550nm	Output power > 1 mW Wavelength 1310nm & 1550nm Single mode fiber interface Wavelength uncertainty <1 nm	81654A or Keysight 81490A opt. 135
Optical Attenuator	Multimode 62.5μ fiber interface Insertion Loss < 2dB IL known, +-0.2 dB. Wavelength range: 800 to 1650nm	Keysight 81578A opt. 062
Optical Switch1	1 Input, 2 output ports Multimode 62.5u fiber interface	81591B #062

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Device	Required specifications	Comments (proposal)
Optical Switch2	1 Input, 2 output ports Multimode 62.5u fiber interface	81591B #062
Optical Power Meter	Wavelength range 800nm to 1650nm Power Range -40 dBm to +10dBm Abs. uncertainty < +-5 % Multimode 62.5u fiber interface	Keysight 81634B

Test procedure

Verify Abs. power uncertainty

1. On the reference receiver under test,
   a. Set the power unit of the average power meter to “Watt”.
   b. Set average time of average power meter to 0.2 s.
2. On the optical power meter,
   a. Set power unit to “Watt”.
   b. Set the average time to 0.2 s.
3. On the optical attenuator,
   a. Set wavelength to 850 nm.
   b. Disable the output.
4. On the optical power meter, execute a zero calibration.
5. On the reference receiver under test, execute a zero calibration of the average power meter.
6. On the optical attenuator, enable the output.
7. On optical switch 1, Route path to A -> 1 (connect to laser source with 850 nm).
8. If necessary, on the laser source: select the wavelength (1310 nm or 1550 nm).
9. On optical switch 2, Route path to A -> 2 (connect to the optical power meter).
10. On the laser source, enable the output.
11. On the optical power meter, set the wavelength to the wavelength of the laser source.
12. On the reference receiver under test, , set the wavelength of the average power meter to the wavelength of the laser source.
13. On the optical attenuator, set the attenuation to 0.0 dB.
14. On the optical power meter, note the power, P_{act}, in Watts.

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15 On the optical attenuator: Calculate and set attenuation, a_{set}, as indicated in the test record.

16 On the optical power meter, note the power in the test record, in Watts.

17 On optical switch 2, route path to A -> 1.

18 On the reference receiver under test, note the power in the test record, in Watts.

19 On the laser source, disable the output.

20 On the optical attenuator, disable the output.

21 On optical switch 1, route path to A -> 2.
Note: both 1310 nm and 1550 nm are on the same laser. Do not advance the optical switch until you have measured at both of these wavelengths).

22 Repeat the procedure from step 8 for each wavelength.

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Keysight 81495A Performance Test Record

Page 1 of 10

Report No. _____ Date: _____

Test Facility _____

Customer: _____

Tested by: _____

Device Under Test

Mainframe

Product No. _____

Serial No. _____

Firmware Rev. _____

81495A Reference Reciever Module

Serial No. _____

Firmware Rev. _____

Conditions

Ambient temperature _____ °C

Relative humidity _____ %

Line frequency _____ Hz

Special Notes: _____

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Page 2 of 10 **Test equipment**

Report No. _____ Date: _____

Linearity, Noise, O-E conversion ratio, rise/fall time, jitter and manual linear input power test equipment

#	Description	Model No.	Trace No.	Calibration due date
1	LMS Mainframe			/ /
2	Reference Transmitter1			/ /
3	Optical Attenuator1 with 2 SM patchcords			/ /
4	Pattern Generator with 1 RF cable 2.4mm (male-male).			/ /
5	Reference Transmitter2			/ /
6	Optical Attenuator2 with 2 SM patchcords			/ /
7	Optical Switch1			/ /
8	Optical Switch2			/ /
9	Optical Power Meter			/ /
10	Sampling Scope Mainframe			/ /
11	Optical/Electrical Sampling Module (DCA)			/ /
12	Precision Time Base Module			/ /
13	Optical Attenuator			/ /
14	Sampling Scope Mainframe			/ /
15	Optical Sampling Module			/ /
16	Precision Time Base Module			/ /

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Page 3 of 10 **Test equipment (continued)**

Report No. _____ Date: _____

Opto-electrical modulation bandwidth test equipment

#	Description	Model No.	Trace No.	Calibration due date
1	N4375B 20 GHz Single-Mode Lightwave Component Analyzer	_____	_____	_____ / _____ / _____

Total uncertainty test equipment

#	Description	Model No.	Trace No.	Calibration due date
1	LMS Mainframe 1 and 2	_____	_____	_____ / _____ / _____
2	Laser source 850nm	_____	_____	_____ / _____ / _____
4	Laser source 1310 / 1550nm	_____	_____	_____ / _____ / _____
6	Optical Attenuator	_____	_____	_____ / _____ / _____
7	Optical Switch1	_____	_____	_____ / _____ / _____
8	Optical Switch2	_____	_____	_____ / _____ / _____
9	Optical Power Meter	_____	_____	_____ / _____ / _____

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Page 4 of 10 **Linearity (average power meter) results**

Report No. _____ Date: _____

Attenuation	6.8dB	**P_0**	_____ W	**D_0**	_____ W

Attenuation	**P_i**	**D_i**	**Nonlinearity[a]**
0.8dB	_____ W	_____ W	_____ dB
1.8dB	_____ W	_____ W	_____ dB
2.8dB	_____ W	_____ W	_____ dB
3.8dB	_____ W	_____ W	_____ dB
4.8dB	_____ W	_____ W	_____ dB
5.8dB	_____ W	_____ W	_____ dB
6.8dB	_____ W	_____ W	_____ dB
7.8dB	_____ W	_____ W	_____ dB
8.8dB	_____ W	_____ W	_____ dB
9.8dB	_____ W	_____ W	_____ dB
10.8dB	_____ W	_____ W	_____ dB
11.8dB	_____ W	_____ W	_____ dB
12.8dB	_____ W	_____ W	_____ dB
13.8dB	_____ W	_____ W	_____ dB
14.8dB	_____ W	_____ W	_____ dB
15.8dB	_____ W	_____ W	_____ dB
Limit			**< ± 0.05 dB**

Attenuation	**P_i**	**D_i**	**Nonlinearity[a]**
16.8dB	_____ W	_____ W	_____ dB
17.8dB	_____ W	_____ W	_____ dB
18.8dB	_____ W	_____ W	_____ dB
19.8dB	_____ W	_____ W	_____ dB
20.8dB	_____ W	_____ W	_____ dB
21.8dB	_____ W	_____ W	_____ dB
22.8dB	_____ W	_____ W	_____ dB
23.8dB	_____ W	_____ W	_____ dB
24.8dB	_____ W	_____ W	_____ dB
15.8dB	_____ W	_____ W	_____ dB
16.8dB	_____ W	_____ W	_____ dB
27.8dB	_____ W	_____ W	_____ dB
28.8dB	_____ W	_____ W	_____ dB
29.8dB	_____ W	_____ W	_____ dB
30.8dB	_____ W	_____ W	_____ dB
Limit			**< ± 0.05 dB**

a $$\text{Nonlinearity} = 10\log_{10}\left(\frac{D_i/D_0}{P_i/P_0}\right)$$

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Page 5 of 10 **Noise (2σ) (average power meter)results**

Report No. Date:

Wavelength	σ	Noise[a]
850 nm	_____ nW	_____ nW
Limit		**< 35 nW**

Wavelength	σ	Noise[a]
1310 nm	_____ nW	_____ nW
Limit		**< 20 nW**

Wavelength	σ	Noise[a]
1550 nm	_____ nW	_____ nW
Limit		**< 20 nW**

a $\text{Noise}_{\lambda} = 2\sigma(P_{\text{logging}_\lambda}(300)[W]) = 2 \times \text{noted value}$

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Page 6 of 10 **O-E conversion ratio, rise/fall time and jitter, maximum linear input power (850 nm)**

Report No. _____ Date: _____

Wavelength	P_{act}	α_{new} [a]	P_{ref}		OMA_{act}	α_{nom} [b]
850 nm	_____ dBm	_____ dB	_____ dBm	_____ W	_____ dBm	_____ dB

a $\alpha_{new} = P_{act} - P_{cal_0}$ + setting attenuator 2, where P_{cal_0} is the DCA reference calibration power at this wavelength (0.4 mW)
$= P_{act}$ +3.98 dBm + 9.5 dB

b $\alpha_{nom} = OMA_{act} - OMA_{nom} + \alpha_{new}$, where OMA_{nom} is the nominal OMA (0.5 mW)
$= OMA_{act}$ + 3 dBm + α_{new}

Wavelength	OMA_{ver}	Test attenuation, α_{test} [a]					
850 nm	0.5 mW (-3 dBm)	_____ dB					
	Electrical Eye Amplitude	**O/E conversion ratio[b]**	**Rise Time**	**Corrected Rise Time[c]**	**Fall Time**	**Corrected Fall Time[c]**	**Total Jitter**
	_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
	Limits	**> 250 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**
	OMA_{ver}	**Test attenuation, α_{test} [a]**					
	0.1 mW (-10 dBm)	_____ dB					
	Electrical Eye Amplitude	**O/E conversion ratio[b]**	**Rise Time**	**Corrected Rise Time[c]**	**Fall Time**	**Corrected Fall Time[c]**	**Total Jitter**
	_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
	Limits	**> 250 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**
	Nonlinearity of the O/E conversion ratio[d]						
	_____ dB						
	Limits	**< 1.0 dB**					

a $\alpha_{test} = OMA_{nom} - OMA_{ver}$ [dBm] + α_{nom}, where OMA_{nom} is the nominal OMA (0.5 mW)
$= -3$ dBm - OMA_{ver} [dBm] + α_{nom}

b Optical-to electrical conversion ratio [V/W] = Electrical Eye Amplitude [V] / OMA_{ver} [W]

c Corrected Rise/Fall Time = SQRT($(\text{Rise/Fall Time})^2 - T^2_{DCA_intr}$), where T_{DCA_intr} is the worst case intrisic rise/fall time for the DCA (86105)
$= SQRT((\text{Rise/Fall Time})^2 - 15.91^2)$

d Nonlinearity of O/E conversion factor = $10 \log_{10}$((O/E Conversion ratio @ 0.5 mW) / (O/E Conversion ratio @ 0.1 mW))

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Page 7 of 10 **O-E conversion ratio, rise/fall time and jitter, maximum linear input power (1310 nm) results**

Report No. _____ Date: _____

Wavelength	P_{act}	P_{mon}	P_{off} [a]	P_{ref}
1310 nm	_____ dBm	_____ dB	_____ dB	_____ dBm

OMA_{act}	α_{act}	α_{nom} [b]
_____ dBm	_____ dB	_____ dB

a $P_{off} = P_{mon} - P_{act}$

b $\alpha_{nom} = OMA_{act} - OMA_{nom} + \alpha_{act}$, where OMA_{nom} is the nominal OMA (0.5 mW)
$= OMA_{act}$ +3 dBm + α_{act}

Wavelength	OMA_{ver}	Test attenuation, α_{test} [a]
1310 nm	0.5 mW (-3 dBm)	_____ dB

Electrical Eye Amplitude	O/E conversion ratio [b]	Rise Time	Corrected Rise Time [c]	Fall Time	Corrected Fall Time [c]	Total Jitter
_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
Limits	**> 400 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**

OMA_{ver}	Test attenuation, α_{test} [a]
0.1 mW (-10 dBm)	_____ dB

Electrical Eye Amplitude	O/E conversion ratio [b]	Rise Time	Corrected Rise Time [c]	Fall Time	Corrected Fall Time [c]	Total Jitter
_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
Limits	**> 400 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**

Nonlinearity of the O/E conversion ratio [d]
_____ dB
Limits **< 1.0 dB**

a $\alpha_{test} = OMA_{nom} - OMA_{ver}$ [dBm] + α_{nom}, where OMA_{nom} is the nominal OMA (0.5 mW)
$=$ -3 dBm - OMA_{ver} [dBm] + α_{nom}

b Optical-to electrical conversion ratio [V/W] = Electrical Eye Amplitude [V] / OMA_{ver} [W]

c Corrected Rise/Fall Time = SQRT($(\text{Rise/Fall Time})^2 - T^2_{DCA_intr}$), where T_{DCA_intr} is the worst case intrisic rise/fall time for the DCA (86105)
$=$ SQRT($(\text{Rise/Fall Time})^2 - 15.91^2$)

d Nonlinearity of O/E conversion factor = 10 $\log_{10}$((O/E Conversion ratio @ 0.5 mW) / (O/E Conversion ratio @ 0.1 mW))

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Page 8 of 10 **O-E conversion ratio, rise/fall time and jitter, maximum linear input power (1550 nm) results**

Report No. _____ Date: _____

Wavelength	P_{act}	P_{mon}	P_{off} [a]	P_{ref}
1550 nm	_____ dBm	_____ dB	_____ dB	_____ dBm

OMA_{act}	α_{act}	α_{nom} [b]
_____ dBm	_____ dB	_____ dB

a $P_{off} = P_{mon} - P_{act}$

b $\alpha_{nom} = OMA_{act} - OMA_{nom} + \alpha_{act}$, where OMA_{nom} is the nominal OMA (0.5 mW)
$= OMA_{act}$ +3 dBm + α_{act}

Wavelength	OMA_{ver}	Test attenuation, α_{test} [a]					
1550 nm	0.5 mW (-3 dBm)	_____ dB					
	Electrical Eye Amplitude	**O/E conversion ratio[b]**	**Rise Time**	**Corrected Rise Time[c]**	**Fall Time**	**Corrected Fall Time[c]**	**Total Jitter**
	_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
	Limits	**> 350 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**
	OMA_{ver}	**Test attenuation, α_{test} [a]**					
	0.1 mW (-10 dBm)	_____ dB					
	Electrical Eye Amplitude	**O/E conversion ratio[b]**	**Rise Time**	**Corrected Rise Time[c]**	**Fall Time**	**Corrected Fall Time[c]**	**Total Jitter**
	_____ V	_____ V/W	_____ ps	_____ ps	_____ ps	_____ ps	_____ ps
	Limits	**> 350 V/W**		**< 35 ps**		**< 35 ps**	**< 20 ps**
	Nonlinearity of the O/E conversion ratio[d]						
		_____ dB					
	Limits	**< 1.0 dB**					

a $\alpha_{test} = OMA_{nom} - OMA_{ver}$ [dBm] + α_{nom}, where OMA_{nom} is the nominal OMA (0.5 mW)
$=$ -3 dBm - OMA_{ver} [dBm] + α_{nom}

b Optical-to electrical conversion ratio [V/W] = Electrical Eye Amplitude [V] / OMA_{ver} [W]

c Corrected Rise/Fall Time = SQRT((Rise/Fall Time)^2 - $T^2_{DCA_intr}$), where T_{DCA_intr} is the worst case intrisic rise/fall time for the DCA (86105)
$=$ SQRT((Rise/Fall Time)^2 - 15.91^2)

d Nonlinearity of O/E conversion factor = 10 $\log_{10}$((O/E Conversion ratio @ 0.5 mW) / (O/E Conversion ratio @ 0.1 mW))

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Page 9 of 10 **Opto-electrical modulation bandwidth (data output)**

Report No. Date:

Results

-3dB Frequency	Bandwidth[a]
_____ GHz	_____ GHz
Limit	**> 9.3 GHz**

a Bandwidth = -3 dB frequency
= frequency(S21(f=100 MHz) - 3 dB)

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Page 10 of 10 **Total uncertainty (average power meter) results**

Report No. _____ Date: _____

Wavelength	**P_{act}**	**α_{set} [a]**		
850 nm	_____ W _____ dBm	_____ dB		
	Power measured on the power meter	**Power measured on the reference receiver**	**Absolute Power Uncertainty [b]**	
	_____ W	_____ W	_____ dB	
Wavelength	**P_{act}**	**α_{set} [a]**	**Limit**	**< ± 0.05 dB**
1310 nm	_____ W _____ dBm	_____ dB		
	Power measured on the power meter	**Power measured on the reference receiver**	**Absolute Power Uncertainty [b]**	
	_____ W	_____ W	_____ dB	
Wavelength	**P_{act}**	**α_{set} [a]**	**Limit**	**< ± 0.05 dB**
1550 nm	_____ W _____ dBm	_____ dB		
	Power measured on the power meter	**Power measured on the reference receiver**	**Absolute Power Uncertainty [b]**	
	_____ W	_____ W	_____ dB	

a $\alpha_{set} = P_{act}$ [dBm] - $P_{nominal_reference}$ [dBm], where $P_{nominal\ reference}$ is 0.5mW = P_{act} + 3 dBm

b $APU[dB] = 10\log_{10}(P_{power_meter}[W] / P_{ref_rx}[W])$

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6
Cleaning Information

The following Cleaning Information contains some general safety precautions, which must be observed during all phases of cleaning. Consult your specific optical device manuals or guides for full information on safety matters.

Please try, whenever possible, to use physically contacting connectors, and dry connections. Clean the connectors, interfaces, and bushings carefully after use.

If you are unsure of the correct cleaning procedure for your optical device, we recommend that you first try cleaning a dummy or test device.

Keysight Technologies assume no liability for the customer's failure to comply with these requirements.

Cleaning Instructions for this Instrument

This Cleaning Information applies to a number of different types of Optical Equipment.

"How to clean instruments with a physical contact interface" on page 72 is particularly relevant to this module.

Safety Precautions 58
Why is it important to clean optical devices? 59
What do I need for proper cleaning? 60
Preserving Connectors 66
Cleaning Instructions 67
Other Cleaning Hints 79

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Safety Precautions

Please follow the following safety rules:

- Do not remove instrument covers when operating.
- Ensure that the instrument is switched off throughout the cleaning procedures.
- Use of controls or adjustments or performance of procedures other than those specified may result in hazardous radiation exposure.
- Make sure that you disable all sources when you are cleaning any optical interfaces.
- Under no circumstances look into the end of an optical device attached to optical outputs when the device is operational. The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.
- 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.
- Do not install parts or perform any unauthorized modification to optical devices.
- Refer servicing only to qualified and authorized personnel.

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Why is it important to clean optical devices?

In transmission links optical fiber cores are about 9 μm (0.00035") in diameter. Dust and other particles, however, can range from tenths to hundredths of microns in diameter. Their comparative size means that they can cover a part of the end of a fiber core, and as a result will reduce the performance of your system.

Furthermore, the power density may burn dust into the fiber and cause additional damage (for example, 0 dBm optical power in a single mode fiber causes a power density of approximately 16 million W/m^2). If this happens, measurements become inaccurate and non-repeatable.

Cleaning is, therefore, an essential yet difficult task. Unfortunately, when comparing most published cleaning recommendations, you will discover that they contain several inconsistencies. In this section, we want to suggest ways to help you clean your various optical devices, and thus significantly improve the accuracy and repeatability of your lightwave measurements.

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What do I need for proper cleaning?

Some Standard Cleaning Equipment is necessary for cleaning your instrument. For certain cleaning procedures, you may also require certain Additional Cleaning Equipment.

Standard Cleaning Equipment

Before you can start your cleaning procedure you need the following standard equipment:

- Dust and shutter caps
- Isopropyl alcohol
- Cotton swabs
- Soft tissues
- Pipe cleaner
- Compressed air

Dust and shutter caps

All of Keysight Technologies' lightwave instruments are delivered with either laser shutter caps or dust caps on the lightwave adapter. Any cables come with covers to protect the cable ends from damage or contamination.

We suggest these protective coverings should be kept on the equipment at all times, except when your optical device is in use. Be careful when replacing dust caps after use. Do not press the bottom of the cap onto the fiber too hard, as any dust in the cap can scratch or pollute your fiber surface.

If you need further dust caps, please contact your nearest Keysight Technologies sales office.

Isopropyl alcohol

This solvent is usually available from any local pharmaceutical supplier or chemist's shop.

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If you use isopropyl alcohol to clean your optical device, do not immediately dry the surface with compressed air (except when you are cleaning very sensitive optical devices). This is because the dust and the dirt is solved and will leave behind filmy deposits after the alcohol is evaporated. You should therefore first remove the alcohol and the dust with a soft tissue, and then use compressed air to blow away any remaining filaments.

If possible avoid using denatured alcohol containing additives. Instead, apply alcohol used for medical purposes.

Never drink this alcohol, as it may seriously damage to your health.

Do not use any other solvents, as some may damage plastic materials and claddings. Acetone, for example, will dissolve the epoxy used with fiber optic connectors. To avoid damage, only use isopropyl alcohol.

Cotton swabs

We recommend that you use swabs such as Q-tips or other cotton swabs normally available from local distributors of medical and hygiene products (for example, a supermarket or a chemist's shop). You may be able to obtain various sizes of swab. If this is the case, select the smallest size for your smallest devices.

Ensure that you use natural cotton swabs. Foam swabs will often leave behind filmy deposits after cleaning.

Use care when cleaning, and avoid pressing too hard onto your optical device with the swab. Too much pressure may scratch the surface, and could cause your device to become misaligned. It is advisable to rub gently over the surface using only a small circular movement.

Swabs should be used straight out of the packet, and never used twice. This is because dust and dirt in the atmosphere, or from a first cleaning, may collect on your swab and scratch the surface of your optical device.

Soft tissues

These are available from most stores and distributors of medical and hygiene products such as supermarkets or chemists' shops.

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We recommend that you do not use normal cotton tissues, but multi-layered soft tissues made from non-recycled cellulose. Cellulose tissues are very absorbent and softer. Consequently, they will not scratch the surface of your device over time.

Use care when cleaning, and avoid pressing on your optical device with the tissue. Pressing too hard may lead to scratches on the surface or misalignment of your device. Just rub gently over the surface using a small circular movement.

Use only clean, fresh soft tissues and never apply them twice. Any dust and dirt from the air which collects on your tissue, or which has gathered after initial cleaning, may scratch and pollute your optical device.

Pipe cleaner

Pipe cleaners can be purchased from tobacconists, and come in various shapes and sizes.The most suitable one to select for cleaning purposes has soft bristles, which will not produces scratches.

There are many different kinds of pipe cleaner available from tobacco nists.

The best way to use a pipe cleaner is to push it in and out of the device opening (for example, when cleaning an interface). While you are cleaning, you should slowly rotate the pipe cleaner.

Only use pipe cleaners on connector interfaces or on feed through adapters. Do not use them on optical head adapters, as the center of a pipe cleaner is hard metal and can damage the bottom of the adapter.

Your pipe cleaner should be new when you use it. If it has collected any dust or dirt, this can scratch or contaminate your device.

The tip and center of the pipe cleaner are made of metal. Avoid accidentally pressing these metal parts against the inside of the device, as this can cause scratches.

Compressed air

Compressed air can be purchased from any laboratory supplier.

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It is essential that your compressed air is free of dust, water and oil. Only use clean, dry air. If not, this can lead to filmy deposits or scratches on the surface of your connector. This will reduce the performance of your transmission system.

When spraying compressed air, hold the can upright. If the can is held at a slant, propellant could escape and dirty your optical device. First spray into the air, as the initial stream of compressed air could contain some condensation or propellant. Such condensation leaves behind a filmy deposit.

Please be friendly to your environment and use a CFC-free aerosol.

Additional Cleaning Equipment

Some Cleaning Procedures need the following equipment, which is not required to clean each instrument:

- Microscope with a magnification range about 50X up to 300X
- Ultrasonic bath
- Warm water and liquid soap
- Premoistened cleaning wipes
- Polymer film
- Infrared Sensor Card

Microscope with a magnification range about 50X up to 300X

A microscope can be found in most photography stores, or can be obtained through or specialist mail order companies. Special fiber-scopes are available from suppliers of splicing equipment.

Ideally, the light source on your microscope should be very flexible. This will allow you to examine your device closely and from different angles.

A microscope helps you to estimate the type and degree of dirt on your device. You can use a microscope to choose an appropriate cleaning method, and then to examine the results. You can also use your microscope to judge whether your optical device (such as a connector) is severely scratched and is, therefore, causing inaccurate measurements.

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Ultrasonic bath

Ultrasonic baths are also available from photography or laboratory suppliers or specialist mail order companies.

An ultrasonic bath will gently remove fat and other stubborn dirt from your optical devices. This helps increase the life span of the optical devices.

Only use isopropyl alcohol in your ultrasonic bath, as other solvents may cause damage.

Warm water and liquid soap

Only use water if you are sure that there is no other way of cleaning your optical device without causing corrosion or damage. Do not use hot water, as this may cause mechanical stress, which can damage your optical device.

Ensure that your liquid soap has no abrasive properties or perfume in it. You should also avoid normal washing up liquid, as it can cover your device in an iridescent film after it has been air dried.

Some lenses and mirrors also have a special coating, which may be sensitive to mechanical stress, or to fat and liquids. For this reason we recommend you do not touch them.

If you are not sure how sensitive your device is to cleaning, please contact the manufacturer or your sales distributor.

Premoistened cleaning wipes

Use pre-moistened cleaning wipes as described in each individual cleaning procedure. Cleaning wipes may be used in every instance where a moistened soft tissue or cotton swab is applied.

Polymer film

Polymer film is available from laboratory suppliers or specialist mail order companies.

Using polymer film is a gentle method of cleaning extremely sensitive devices, such as reference reflectors and mirrors.

Infrared Sensor Card

Infrared sensor cards are available from laboratory suppliers or specialist mail order companies.

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With this card you are able to control the shape of laser light emitted. The invisible laser beam is projected onto the sensor card, then becomes visible to the normal eye as a round spot.

Take care never to look into the end of a fiber or any other optical component, when they are in use. This is because the laser can seriously damage your eyes.

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Preserving Connectors

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

Making Connections 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.

Dust Caps and Shutter Caps 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.

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.

Always keep the caps on the equipment when it is not in use.

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

Immersion Oil and Other Index Matching Compounds Wherever 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.

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Cleaning Instructions

Cleaning Instrument Housings

Use a dry and very soft cotton tissue to clean the instrument housing and the keypad. Do not open the instruments 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.

Which Cleaning Procedure should I use ?

Light dirt

If you just want to clean away light dirt, observe the following procedure for all devices:

- Use compressed air to blow away large particles.
- Clean the device with a dry cotton swab.
- Use compressed air to blow away any remaining filament left by the swab.

Heavy dirt

If the above procedure is not enough to clean your instrument, follow one of the procedures below. Please consult *"Cleaning Instructions for this Instrument" on page 57* for the procedure relevant for this instrument.

If you are unsure of how sensitive your device is to cleaning, please contact the manufacturer or your sales distributor

How to clean connectors

Cleaning connectors is difficult as the core diameter of a single-mode 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.

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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 a skilled person, and as a last resort as it wears out your connector.

WARNING 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 projected onto the card and becomes visible as a small circular spot.

Preferred Procedure

Use the following procedure on most occasions.

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 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.

An Alternative Procedure

A better, more gentle, but more expensive cleaning procedure is to use an ultrasonic bath with isopropyl alcohol.

1. Hold the tip of the connector in the bath for at least three minutes.

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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 any remaining lint with compressed air.

How to clean connector adapters

CAUTION *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.*

Preferred Procedure

Use the following procedure on most occasions.

1 Clean the adapter 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 when there is greasy dirt on the adapter:

1 Moisten a new cotton swab with isopropyl alcohol.

2 Clean the adapter 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.

How to clean connector interfaces

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.

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Preferred Procedure

Use the following procedure on most occasions.

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.

2 Then clean the interface by rubbing a new, dry cotton swab over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

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

1 Moisten a new pipe cleaner 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.

3 Moisten a new cotton swab with isopropyl alcohol.

4 Clean the interface by rubbing the cotton swab over the surface using a small circular movement.

5 Using a new, dry pipe cleaner, and a new, dry cotton swab remove the alcohol, any dissolved sediment and dust.

6 Blow away any remaining lint with compressed air.

How to clean bare fiber adapters

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

CAUTION *Never use any kind of solvent when cleaning a bare fiber adapter as solvents can:*

- *Damage the foam inside some adapters.*
- *Deposit dissolved dirt in the groove, which can then dirty the surface of an inserted fiber.*

Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

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Procedure for Stubborn Dirt

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

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.

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

2 Clean the adapter by rubbing a new, dry cotton swab over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

How to clean lenses

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.

Preferred Procedure

Use the following procedure on most occasions.

1 Clean the lens 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 when there is greasy dirt on the lens:

1 Moisten a new cotton swab with isopropyl alcohol.

2 Clean the lens by rubbing the cotton swab over the surface using a small circular movement.

3 Using a new, dry cotton swab remove the alcohol, any dissolved sediment and dust.

4 Blow away any remaining lint with compressed air.

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How to clean instruments with a fixed connector interface

CAUTION *Only use clean, dry compressed air. Make sure that the air is free of dust, water, and oil. If the air that you use is not clean and dry, this can lead to filmy deposits or scratches on the surface of your connector interface. This will degrade the performance of your transmission system.*

Never try to open the instrument and clean the optical block by yourself, because it is easy to scratch optical components, and cause them to become misaligned.

You should only clean instruments with a fixed connector interface when it is absolutely necessary. This is because it is difficult to remove any used alcohol or filaments from the input of the optical block.

It is important, therefore, to keep dust caps on the equipment at all times, except when your optical device is in use.

If you do discover filaments or particles, the only way to clean a fixed connector interface and the input of the optical block is to use compressed air.

If there are fluids or fat in the connector, please refer the instrument to the skilled personnel of Keysight's service team.

How to clean instruments with an optical glass plate

Some instruments, for example, the optical heads from Keysight Technologies have an optical glass plate to protect the sensor. Clean this glass plate in the same way as optical lenses (see *"How to clean lenses" on page 71*).

How to clean instruments with a physical contact interface

Remove any connector interfaces from the optical output of the instrument before you begin the cleaning procedure.

Cleaning interfaces is difficult as the core diameter of a single-mode fiber is only about 9 μm. 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.

WARNING **Never look into an optical output, because this can seriously damage your eyesight.**

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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 projected onto the card and becomes visible as a small circular spot.

Preferred Procedure

Use the following procedure on most occasions.

1 Clean the interface 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 when there is greasy dirt on the interface:

1 Moisten a new cotton swab with isopropyl alcohol.

2 Clean the interface 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.

How to clean instruments with a recessed lens interface

WARNING **For instruments with a deeply recessed lens interface (for example the Keysight 81633A and 81634A Power Sensors) do NOT follow this procedure. Alcohol and compressed air could damage your lens even further.**

Keep your dust and shutter caps on when your instrument is not in use. This should prevent it from getting too dirty. If you must clean such instruments, please refer the instrument to the skilled personnel of Keysight's service team.

Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.
If this is not sufficient, then

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2 Clean the interface by rubbing a new, dry cotton swab over the surface using a small circular movement.

3 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure when there is greasy dirt on the interface, and using the preferred procedure 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:

1 Moisten a new cotton swab with isopropyl alcohol.

2 Clean the interface 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.

How to clean optical devices which are sensitive to mechanical stress and pressure

Some optical devices, such as the Keysight 81000BR Reference Reflector, which has a gold plated surface, are very sensitive to mechanical stress or pressure. Do not use cotton swabs, soft tissues or other mechanical cleaning tools, as these can scratch or destroy the surface.

Preferred Procedure

Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

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.

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.

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2 Remove the film and any dirt with special adhesive tapes.

Alternative Procedure

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 any part of 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.

How to clean metal filters or attenuator gratings

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.

Preferred Procedure

Use the following procedure on most occasions.

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

Procedure for Stubborn Dirt

Do not use an ultrasonic bath as this can damage your device.

Use this procedure when there is greasy dirt on the device:

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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Additional Cleaning Information

The following cleaning procedures may be used with other optical equipment:

- How to clean bare fiber ends
- How to clean large area lenses and mirrors

How to clean bare fiber ends

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. You make a new cleave. To do this:

1 Strip off the cladding.

2 Take a new soft tissue and moisten it with isopropyl alcohol.

3 Carefully clean the bare fiber with this tissue.

4 Make your cleave and immediately insert the fiber into your bare fiber adapter in order to protect the surface from dirt.

How to clean large area lenses and mirrors

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.

Preferred Procedure Use the following procedure on most occasions.

1 Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt Use this procedure when there is greasy dirt on the lens:

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CAUTION *Only use water if you are sure that there is no other way of cleaning your optical device without causing corrosion or damage.*

Only use water if you are sure that there is no other way of cleaning your optical device without causing corrosion or damage. Do not use hot water, as this may cause mechanical stress, which can damage your optical device.

Ensure that your liquid soap has no abrasive properties or perfume in it. You should also avoid normal washing up liquid, as it can cover your device in an iridescent film after it has been air dried.

Some lenses and mirrors also have a special coating, which may be sensitive to mechanical stress, or to fat and liquids. For this reason we recommend you do not touch them.

If you are not sure how sensitive your device is to cleaning, please contact the manufacturer or your sales distributor.

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.

Alternative Procedure A 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.

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.

Alternative Procedure B If your lens is sensitive to water then:

1 Moisten the lens or the mirror with isopropyl alcohol.

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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.

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Other Cleaning Hints

Selecting the correct cleaning method is an important element in maintaining your equipment and saving you time and money. This Appendix highlights the main cleaning methods, but cannot address every individual circumstance.

This section contain some additional hints which we hope will help you further. For further information, please contact your local Keysight Technologies representative.

Making the connection

Before you make any connection you must ensure that all lightwave cables and connectors are clean. If not, then use the appropriate cleaning methods.

When you insert the ferrule of a patchcord into a connector or an adapter, ensure that the fiber end does not touch the outside of the mating connector or adapter. Otherwise, the fiber end will rub up against something which could scratch it and leave deposits.

Lens cleaning papers

Some special lens cleaning papers are not suitable for cleaning optical devices like connectors, interfaces, lenses, mirrors and so on. To be absolutely certain that a cleaning paper is applicable, please ask the salesperson or the manufacturer.

Immersion oil and other index matching compounds

Do not use immersion oil or other index matching compounds with optical sensors equipped with recessed lenses. They are liable to dirty the detector and impair its performance. They may also alter the property of depiction of your optical device, thus rendering your measurements inaccurate.

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Cleaning the housing and the mainframe

When cleaning either the mainframe or the housing of your instrument, only use a dry and very soft cotton tissue on the surfaces and the numeric pad.

Never open the instruments as they can be damaged. Opening the instruments puts you in danger of receiving an electrical shock from your device, and renders your warranty void.

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Warranty Information

All system warranties and support agreements are dependent upon the integrity of the Keysight 81495A Reference Receiver Module. Any modification of the system software or hardware will terminate any obligation that Keysight Technologies may have to the purchaser. Please contact your local Keysight field engineer before embarking in any changes to the system.

System

Included in the sales price is a one-year warranty. In addition to the one-year warranty, extended warranty periods, on-site troubleshooting, reduced response times and increased coverage hours can be negotiated under a separate support agreement and will be charged at an extra cost.

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