Keysight N4372E Lightwave Component Analyzer

User's Guide

KEYSIGHT TECHNOLOGIES

Notices

Manual Part Number

4372E-90B01

Edition

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CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

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1 Introduction

Documentation

The documentation for the Keysight N4372E Lightwave Component Analyzer (LCA) consists of the following:

- The documentation for the Keysight network analyzer. This documentation is on the hard disk of the network analyzer. Refer to it for using the network analyzer for electrical to electrical measurements, or for the configuration of the network analyzer.
- The documentation for the LCA Optical Receiver, the LCA Optical Transmitter, and the LCA Test Set Controller. Refer to this documentation for information on using the LCA together with the network analyzer, electrical to optical measurements, or for setting up your LCA.

General Safety Considerations

This product has been designed and tested in accordance with the standards listed on the manufacturer's Declaration of Conformity (see Declaration of Conformity on page 148), and has been supplied in a safe condition. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Safety symbols

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

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

Instrument markings

Instrument Marking	Description
	The instruction manual symbol. The product is marked with this warning symbol when it is necessary for the user to refer to the instructions in the manual.
	The laser radiation symbol. This warning symbol is marked on products which have a laser output.
	The Off-On symbols are used to mark the positions of the instrument power operating switch.
	The recycling symbol indicates the general ease with which the instrument can be recycled.
	The C-Tick mark is the certification mark of the Australian Communications Authority.
	The CE mark is the conformity marking of the European Community.
	The CSA mark is the certification mark of the Canadian Standards Association.

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

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

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

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

WARNING Using controls or adjustments or performing procedures other than those specified in the documentation supplied with your equipment can result in hazardous radiation exposure.

CAUTION This product complies with over-voltage Category II and Pollution Degree 2.

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

CAUTION

Install the instrument so that the power switch is readily identifiable and is easily reached by the operator. This is the instrument disconnecting device. It disconnects the mains circuit from the mains supply before other parts of the instrument. Alternatively, an externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.

CAUTION

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

CAUTION

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

CAUTION

The Keysight N4372E Lightwave Component Analyzer (LCA) complies with over-voltage category II and can operate from the single-phase AC power source that supplies between 100 V and 240 V at a frequency in the range 50 to 60 Hz. The maximum power consumption of the LCA is 40 VA with all options installed.

Refer to the documentation for your network analyzer for information on its line power requirements.

Line power connectors

In accordance with international safety standards, the instrument has a three-wire power cable. When connected to an appropriate AC power receptacle, this cable earths the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination.

WARNING

To avoid the possibility of injury or death, you must observe the following precautions before switching on the instrument.

- **Insert the power cable plug only into a socket outlet provided with a protective earth contact. Do not use an extension cord without a protective conductor. Using an extension cord without a protective conductor means the instrument is not earthed.**
- **Do not interrupt the protective earth connection intentionally.**
- **Do not remove protective covers. Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified service personnel.**
- **Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.**
- **Defective, damaged, or malfunctioning instruments must be returned to a Keysight Technologies Service Center.**

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

Laser Safety Information

WARNING

Please pay attention to the following laser safety warning:

Under no circumstances look into the end of an optical cable attached to the optical output when the instrument is switched on. The laser radiation can seriously damage your eyesight. Do not enable the laser when there is no fiber attached to the optical output connector. The optical output can be enabled by pressing the “active” button close to the optical output connector on the front panel of the module, by GUI, or by remote command. The optical output is emitting laser light when the green LED above the optical output, on the front panel of the instrument is lit. The built-in laser diode is active whenever the instrument is powered on, therefore disabling the output is not sufficient to establish eye safe conditions. The use of optical instruments with this product will increase eye hazard. The laser module has a built-in safety circuitry which will disable the optical output in the case of a fault condition. Refer servicing only to qualified and authorized personnel.

The laser sources specified by this table are classified according to IEC 60825-1:2014.

The laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated 2007, June 24.

Table 1 Laser Source Specification

	N4372E #100 N4372E #102 N4372E #E04	N4372E #101 N4372E #102 N4372E #E04
Laser type	DFB	DFB
Wavelength range	1310 ± 20 nm	1550 ± 20 nm
Max. CW output power of LCA*	< 36 mW	< 36 mW
Beam waist diameter	< 10 µm	< 10 µm
Numerical aperture	0.1	0.1
Laser class according to IEC 60825-1:2014	1M	1M
Max. permissible CW output power	300 mW	163 mW

** Max. CW output power is defined as the highest possible optical power that the laser source can produce at its output connector.*

Laser Safety Labels

Laser Class 1M Label

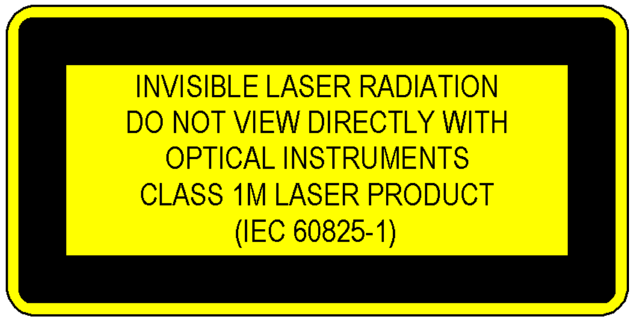
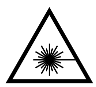


Figure 1 Laser Class 1M Label

A sheet of laser safety labels is included with the laser module. In order to meet the requirements of IEC 60825-1:2014, we recommend that you stick the laser safety labels, in your language, onto a suitable location on the outside of the instrument where they are clearly visible to anyone using the instrument.

Laser 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.



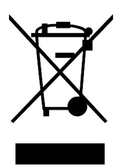
Hazardous laser radiation.

Invisible laser radiation.

Environmental information

This product is intended for indoor use only.

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.

Optical Test Set Front and Rear Panels

The figure displays the 4 - port PNA version, configured for single-ended measurements.

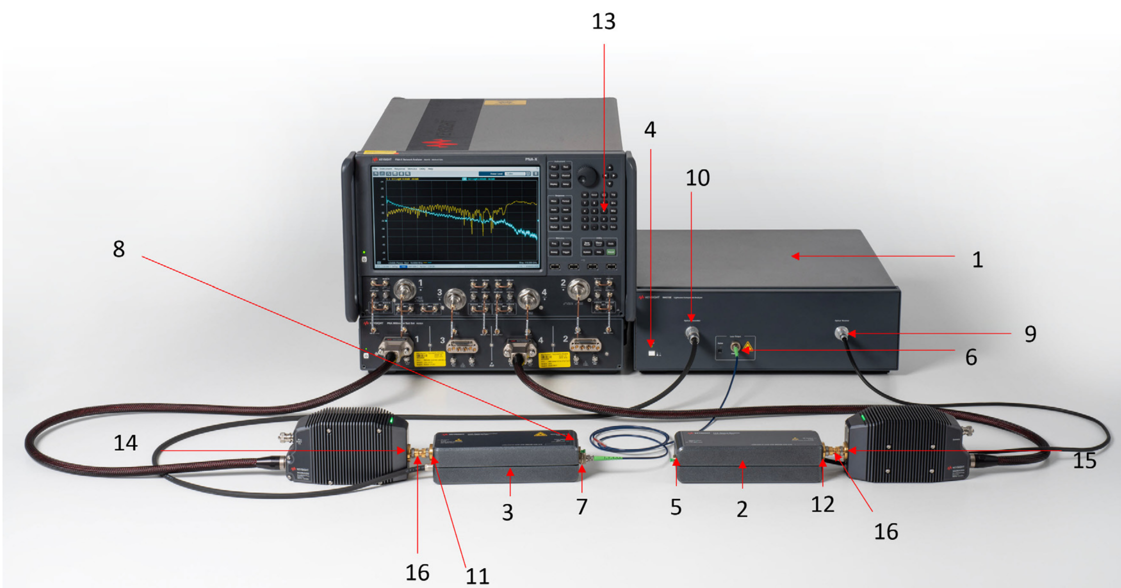


Figure 2 4 - port PNA version, configured for single-ended measurements

For further information on the front panel of the network analyzer, refer to the documentation supplied with the network analyzer.

1	LCA Test Set Controller	
2	LCA Optical Receiver	
3	LCA Optical Transmitter	
4	Power switch	Turns on the LCA Test Set Controller.
5	Optical Input of LCA Optical Receiver	Input port for the optical signal from the device under test. **CAUTION: Do not apply more than +14 dBm (maximum safe average input power).**

6	Laser output	Output port (CW) of the LCA's internal laser. Connect it to the input port of the LCA Optical Transmitter when the internal laser is to be used.
7	Laser input for LCA Optical Transmitter	Input port (CW) for laser signal, either from the LCA's internal laser or from an external laser.
8	Output of LCA Optical Transmitter	Output port (modulated) for the signal to the device under test.
9	Lemo socket for LCA Optical Receiver	Connect Lemo cable for power and control of LCA Optical Receiver.
10	Lemo socket for LCA Optical Transmitter	Connect Lemo cable for power and control of LCA Optical Transmitter.
11	Port A	RF input port of the LCA Optical Transmitter to connect to the PNA. **CAUTION: Do not apply any DC signal to this port.**
12	Port B	RF output port of the LCA Optical Receiver to connect to the PNA. **CAUTION: Do not apply any DC signal to this port.**
13	Function keys	Used to control the Lightwave Component Analyzer. Press the [Macro/Local] Utility button on the network analyzer to display the LCA function keys. ▪ LCA : Setup an LCA Measurement. ▪ Single : Perform a single sweep measurement with the current measurement setup. ▪ Continuous : Perform continuous sweep measurements with the current measurement setup. ▪ Optical Pwr. : Start the optical power meter. ▪ LCA Server : Start the LCA server (if not already running).
14	Network analyzer Port 1	This is an S parameter measurement port of the network analyzer. Depending on the S parameters of the measurement, this can be either an RF input or an RF output.
15	Network analyzer Port 4	This is an S parameter measurement port of the network analyzer. Depending on the S parameters of the measurement, this can be either an RF input or an RF output.
16	1mm rugged RF adapter	Connects port A/B of the LCA Optical Transmitter/Receiver to the network analyzer.

Rear Panel

Figure 3 Rear Panel

For information on the rear panel of the network analyzer, please refer to the documentation supplied with the network analyzer.

1	USB	The software on the network analyzer uses the USB port to control the LCA Test Set Controller.
2	Line power cable connector	Plug in your power cable here.

2 Setting Up the Instrument

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Unpacking the Lightwave Component Analyzer

Unpack your shipment.

- Inspect the shipping containers for damage.
- Inspect the instruments.
- Verify that you received the options and accessories that you ordered.

Keep the shipping containers and cushioning material until you have inspected the contents of the shipment for completeness and have checked the equipment mechanically and electrically.

The shipment should contain the following:

- 1x Network-Analyzer depending on the option selected
- 1x Millimeter-wave Test Set Controller depending on the option selected
- 2x, 3x or 4x Frequency extenders
- 1x N4372E LCA Test Set Controller
- 1x 8121-1242 USB cable
- 1x 0960-3245 Keyboard
- 1x 0960-3248 Mouse
- 1x 5972-3356 Calibration Report Notification
- 3x Local power cord
- 1x RoHS addendum for Photonic T&M Accessories
- 1x RoHS addendum for Photonic T&M products
- 1x N4372-90A05 Laser Safety Document
- 1x N4373-90159Virus Scan Result Information Sheet

Additional, option dependent shipping contents:

- -301 LCA for testing transmitters (E/O-Measurement)
  - N4372-67984/N4372-67985 LCA Optical Receiver 100 GHz/110 GHz
  - 5067-1395 f-f Adapter 1.0 mm
  - -021 straight connector
    - 1x N4373-87907 Patchcord SMF APC-PC 0.5 m
    - 1x 1005-0256 Feed-Thru
    - 1x 08154-61723 Connector Adapter FC

    - -022 angled connector
        - 1x N4373-87906 Patchcord SMF APC-APC 0.5 m
        - 1x 1005-1027 Feed-Thru
        - 1x 08154-61723 Connector Adapter FC
- -310 LCA for testing receivers (O/E-Measurements)
    - N4372E-010 Transmitter Operating Frequency 100 GHz
        - 1x N4372-67986 LCA Optical Transmitter 100 GHz
        - 1x 5067-1395 f-f Adapter 1.0 mm
    - N4372E-011 Transmitter Operating Frequency 100 GHz
        - 1x N4372-67987 LCA Optical Transmitter 110 GHz
        - 1x 5067-1395 f-f Adapter 1.0 mm
    - -021 straight connector
        - 2x 1005-0256 Feed-Thru
        - 1x N4372-87905 Patchcord PMF APC-APC 1.5 m
        - 2x N4372-87907 Patchcord PMF APC-PC 0.5 m
        - 3x 08154-61723 Connector Adapter FC
    - -022 angled connector
        - 2x 1005-1027 Feed-Thru
        - 1x N4372-87905 Patchcord PMF APC-APC 1.5 m
        - 2x N4372-87906 Patchcord PMF APC-APC 0.5 m
        - 3x 08154-61723 Connector Adapter FC

For Option -311, combine options –301 and -310

- -IK1 Interconnect Kit for 2 Port PNA with 3.5 mm Ports
    - N5292-60012
- -IK2 Interconnect Kit for 2 Port PNA with 2.4 mm or 1.85 mm Ports
    - N5292-60013
- -IK3 Interconnect Kit for 4 Port PNA with 3.5 mm Ports
    - N5292-60016
- -IK4 Interconnect Kit for 4 Port PNA with 2.4 mm or 1.85 mm Ports
    - N5292-60017
- Mounting Kit
    - 2x 2x 0403-1166 Adjustable Foot 65.0 mm
    - 6x 0515-0433 Screw Torx-T20 M4X0.7 8mm
    - 20x 0515-1269 Screw Torx-T20 M4X0.7 10mm

- 2x 0515-1619 Screw Torx-T20 M4X0.7 25mm
- 4x 0515-2317 Screw Torx-T15 M3.5X0.6 12mm
- 2x N4372-21214 Sidebar
- 2x N4372-40014 Trim Sidebar
- 2x N4373-25271 Bracket Adapter
- 1x N4373-25290 Bracket Rear Right
- 1x N4373-25291 Bracket Rear Left

Refer also to the contents list of the network analyzer.

If anything is missing or defective, contact your nearest Keysight Technologies sales office. If the shipment was damaged, contact the carrier, then contact the nearest Keysight Technologies sales office.

Mounting the Test Set and the Network Analyzer

Installing the Millimeter Wave Network Analyzer System

Install the Millimeter Wave Network Analyzer System as described in the Installation Guide for "N5290/1A PNA Series 2-Port and 4-Port Microwave Network Analyzer System" (part number N5292-90002). For more information, refer to the link:
http://literature.cdn.keysight.com/litweb/pdf/N5292-90002.pdf

Follow the steps below if you would like to mount the Millimeter Wave Network Analyzer System on top of the LCA Test Set Controller. You can skip these steps if you prefer to have the LCA Test Set Controller separate from the Millimeter Wave Network Analyzer System.

CAUTION **The Millimeter Wave Network Analyzer System and the LCA Test Set Controller can be assembled as one analyzer unit. Lifting this instrument requires two people using proper lifting techniques.**

Preparing the LCA Test Set Controller

1 Use a Torx T15 screwdriver and the screws 0515-2317 to mount the left and right bracket adapter N4373-25271 to the rear side of the test head.

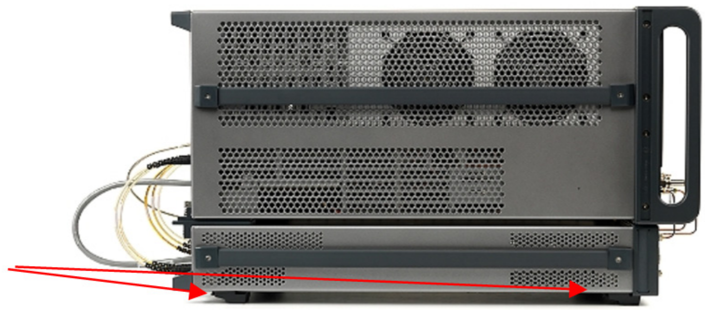
2 Use the screws 0515-0433 and a Torx T20 screwdriver to attach the brackets N4373-25290 and N4373-25291 to the right and left bracket adapter.

3 Turn the test head on its side and use a Pozidrive size 2 screwdriver to mount the adjustable feet 0403-1166 to the left and right brackets.

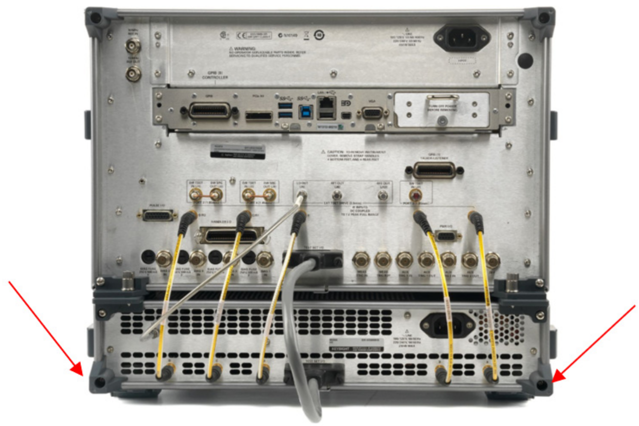
4 Turn the test head back to its normal position.

Preparing the Network Analyzer

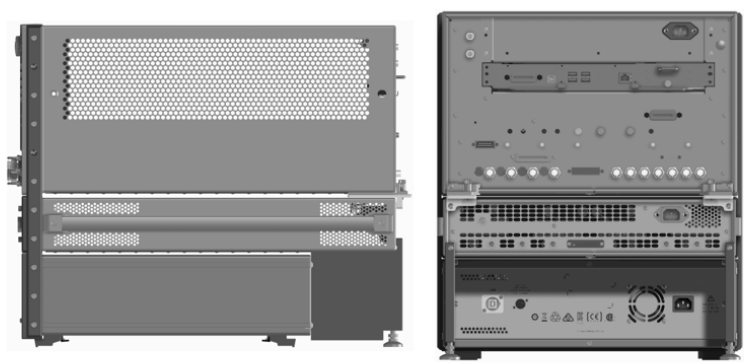
1 Unlock all four feet of the Millimeter Wave Network Analyzer System to remove them from the bottom. It is recommended to perform this step with at least two, better three, persons.



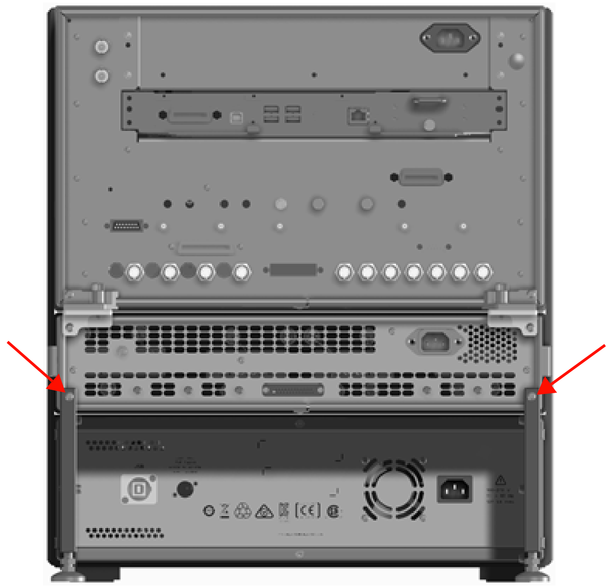
2 Using a Torx T20 screwdriver, remove the 2 lower rear feet from the rear panel of the Millimeter Wave Network Analyzer System.



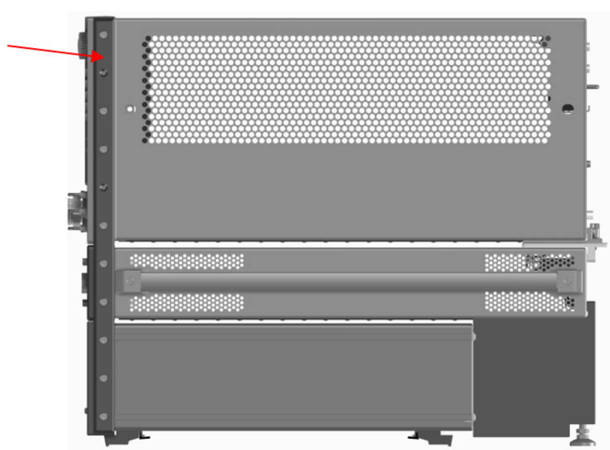
3 Place the Millimeter Wave Network Analyzer System on top of the LCA Test Set Controller and align it with the mounting slots of the rear brackets. It is recommended to perform this step with at least two, better three, persons.



4 Use a Torx T20 screwdriver and the screws 0515-1619 to connect Millimeter Wave Network Analyzer System and left and right rear brackets.

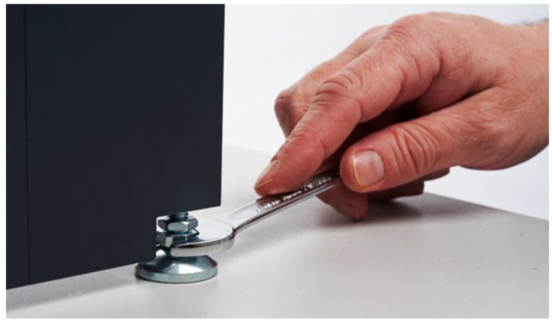


5 Use a Torx T20 screwdriver to attach the side bars N4372-21214 with the screws 0515-1269 to the left and right of the two instruments.



6 Attach the adhesive trim covers to the left- and right-side bars to cover the screws (optional).

7 Use a 13mm wrench to level the adjustable feet to the other feet of the test head. Use the upper nuts to lock the feet in place.



Setting up the Lightwave Component Analyzer

1 If you have option -301 or -311, plug the male Lemo connector of the LCA Optical Receiver (N4372-67984/N4372-67985) into the female Lemo receptacle on the LCA Test Set Controller.

NOTE **Do not plug other devices with the same Lemo connector into the LCA Test Set Controller. This might cause irreversible damage to the device and/or the LCA Test Set Controller.**

2 Attach the female to female rugged adapter to the electrical frequency extender-head on e.g. port 4 of the 110GHz Network Analyzer.

3 Screw the adapter finger-tight without rotating it.

4 Holding the adapter with a 12mm spanner wrench, use the 14mm torque wrench from the calibration kit (45 N-cm/4 lb-in, part number 8710-21813) to tighten the adapter.

5 Attach the other side of the female to female rugged adapter to the LCA Optical Receiver.

6 Repeat steps 3 and 4 to tighten the adapter.

7 If you have option -310 or -311, plug the male Lemo connector of the LCA Optical Transmitter (N4372-67986/N4372-67967) into the female Lemo receptacle on the LCA Test Set Controller.

8 Repeat steps 2 – 6 to connect the LCA Optical Transmitter with the network analyzer.

NOTE **The 1.0mm rugged RF adapter are part of the calibration for the LCA Optical Transmitter/Receiver. Do not change or lose them.**

CAUTION

Always rotate the nut and never the female to female adapter.

Rotating the adapter can damage the electrical interface of the adapter and the connector on the LCA Optical Receiver/Transmitter.

Avoid mechanical stress on the 1.0mm RF connection. Ensure that the RF connectors of the electrical frequency extender head and the LCA Optical Receiver/Transmitter are at the same height and longitudinally aligned when tightening the adapter.

If the height of the LCA Optical Receiver/Transmitter and the frequency extender head does not align, connecting the two will lead to stress on the 1.0mm RF connection. Adjust the height of the lower part by unscrewing the rubber feet until the height matches.

The LCA Optical Transmitter/Receiver must not be inverted during assembly or operation

Figure 4 LCA Optical Receiver and Test Set Controller connected to a Network Analyzer

Don't apply any DC or RF signal to the RF output of the LCA Optical Receiver. This might irreversibly damage the LCA Optical Receiver.

Don't apply any DC signal to the RF input of the LCA Optical Transmitter. This might irreversibly damage the LCA Optical Transmitter.

9 Remove the dust cap from the optical output.

10 Remove the dust caps from the SMF optical patch cord (Option 021: N4373-87907, Option 022: N4373-87906).

11 Connect the optical patch cord to the optical input of the LCA Optical Receiver.

12 Remove the dust caps from the PMF optical patch cord (N4372-87905).

13 Connect the optical patch cord to the laser output of the LCA Test Set controller and the laser input of the LCA Optical Transmitter.

14 Remove the dust caps from the PMF optical patch cord.

15 Connect the optical patch cord to the optical output of the LCA Optical Transmitter.

CAUTION Always use optical patch cords to connect to your DUT. This protects the connectors of the LCA Optical Receiver/Transmitter, by minimizing the number of connector changes.

CAUTION Make sure to connect only matching connector types to the LCA Optical Receiver/Transmitter: connecting a straight connector to an angled port, or vice versa, will damage both interfaces.

CAUTION Before you connect any fiber-optic cable to the Lightwave Component Analyzer, please ensure it has been properly cleaned.

Fiber-optic connectors are easily damaged when connected to dirty or damaged cables and accessories. Improper cleaning or handling may lead to expensive instrument repairs, damaged cables, or compromised measurements.

16 On the rear, connect the network analyzer to the LCA Test Set Controller using the supplied USB cable.

17 Connect the power cables.

18 Continue with Performance Quick Check on page 39 or Starting the Lightwave Component Analyzer on page 50.

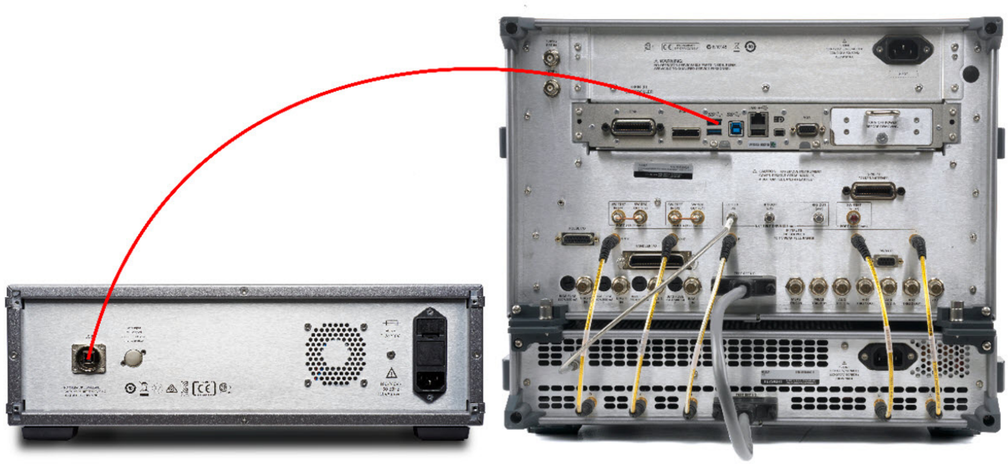


Figure 5 USB-connection between the LCA Test Set Controller and the Network Analyzer

3 Performance Quick Check

This chapter shows how to:

- Verify the optical and electrical connections to the N4372E Lightwave Component Analyzer.
- Verify the performance of your N4372E Lightwave Component Analyzer.
- Trouble shoot, if you think there may be a malfunction.

Preparation

1. Turn on the network analyzer and the LCA Test Set controller.
2. Allow the LCA Test Set Controller and the network analyzer to warm up (60 minutes after the LCA software has been started).
3. If it is not already started, start the network analyzer application.

Consult the documentation supplied with the network analyzer if you need help with this step.

NOTE

Most performance problems are caused by damaged or dirty electrical or optical connectors.

Before starting the performance verification procedure, make sure all electrical and optical connectors are in excellent condition.

For more information on cleaning procedures see Cleaning on page 114 for information on cleaning optical connections, and to the user guide of the network analyzer for information on cleaning electrical connections.

Network analyzer settings and electrical calibration

1. On the network analyzer make the following settings:
   - Start Frequency: 10 MHz, Stop Frequency: 110 GHz
   - Number of points: 11000
   - IF bandwidth: 2000 Hz
   - Averages: 1
   - RF output power: -15 dBm
2. Select “Stepped sweep - sweep moves in discrete steps”.
3. Calibrate the network analyzer electrically.
   a Make sure the LCA has been returned to the electrical measurement mode as described in Returning to Electrical Measurements on page 69.

NOTE

To meet the technical specifications, you must use the calibration kit.

b Proceed with the electrical calibration as described in Calibrating the Network Analyzer before Measurements on page 50.

It is recommended to use an 85059B Calibration Kit for calibrating the Network Analyzer.

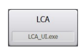
It is recommended to use a ruggedized 1.0 mm (f) to ruggedized 1.0 mm (f) adapter (Y1900D) or 1.0 mm test port cable (11500J) for the THRU-calibration.

Verifying your Electrical Calibration

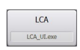
Passing this test ensures that the electrical calibration is within expected performance.

1 Follow the steps in the sections Preparation on page 40 and Network analyzer settings and electrical calibration on page 40.

2 Connect female to female rugged 1.0mm adapter (Y1900D) between port 1 and port 2/port4 (depending on the configuration) of the 110 GHz Network analyzer.

3 Press the [Macro/Local utility] button until the Macro 1 group is highlighted and you see 

.

4 Click 

to start the LCA measurement setup.

5 Select the “EE Measurement” tab.

6 Click 

.

7 Make a corrected measurement with the network analyzer.

8 Inspect the results.

- Electrical return loss S11 should be similar to S22/S44 (depending on the configuration).
- Both curves should be below -20 dB over the full measurement range, with only low frequency dependence.
- Transmission loss S12/S14 (depending on the configuration) should be similar to S21/S41 (depending on the configuration).
- Both curves should be within +0.1 dB to -0.6 dB over the full measurement range, with only low frequency dependence.

If the results differ from the expected values, do the following:

- Visually inspect all RF connectors. If an electrical connector seems to be damaged, contact Keysight for repair or replacement.

- Clean the RF connectors on the calibration kit and on the test port. Make sure the connection to the network analyzer of the two 1.00 mm female-female rugged connector is tight.

Perform a new electrical calibration and retest. If the problem persists, contact Keysight for support.

Verifying the Optical Connections and Optical CW Operation

Passing these tests ensures that the transmitter and receiver are within expected optical CW performance.

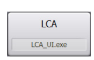
1. Follow the steps in the sections Preparation on page 40 and Network analyzer settings and electrical calibration on page 40.
2. If you have option -311 and -021:

   Connect the two straight-angled optical patch cords (N4373-87907) to the optical output of the LCA Optical Transmitter and input of the LCA Optical Receiver. Note that the angled connector must be attached to the optical test set.
   Use the FC/PC adapter (1005-0256) to connect the straight ends of the optical patch cords.

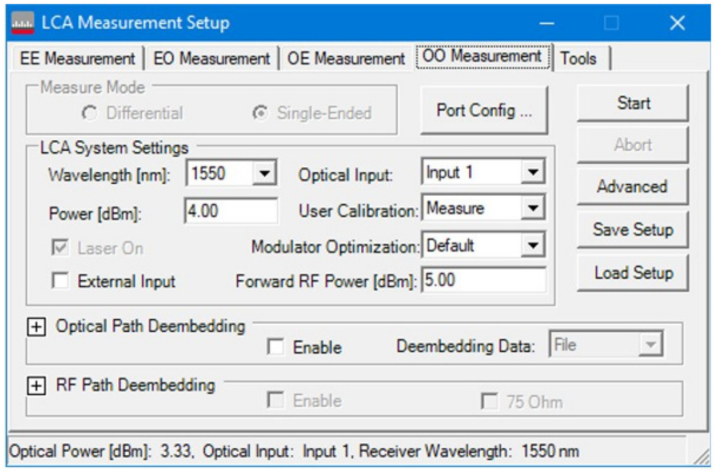
   If you have option -311 and -022:

   Connect the angled-angled optical patch cords (N4373-87906) to the optical output of the LCA Optical Transmitter and input of the LCA Optical Receiver.

   Use the FC/APC through adapter (1005-1027) to connect the ends of the optical patch cords.
3. Press the [Macro/Local] utility button until the Macro 1 group is highlighted and you see 

.
4. Press 

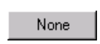
to start the LCA measurement setup.
5. Select the OO measurement tab.



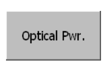
6 Set the following parameters:

- If you have option 102 (Dual wavelength 1310 nm, 1550 nm), select the appropriate wavelength for your DUTs.
- Laser power: +3 dBm
- Optical input: Input 1
- User Calibration: None
- Forward RF Power: 0 dBm

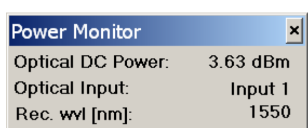
7 Click 

, then 

to set the output power.

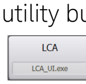
8 Press 

to start optical power meter application.



9 Read the optical power from the power meter application.

The readout should be +3 dBm ± 0. 5 dB.

10 Press the [Macro/Local] utility button until the Macro 1 group is highlighted and you see 

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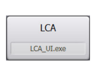
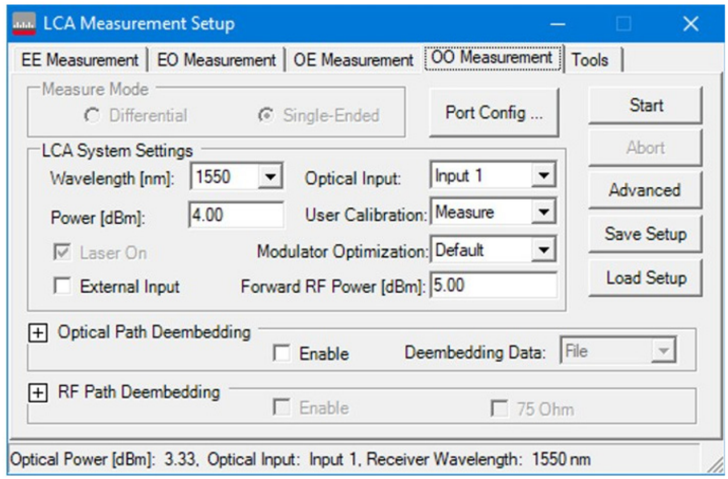
11 Press 

to start the LCA measurement setup.

12 Select the OO measurement tab.



13 Set the following parameters:

- If you have option 102 (Dual wavelength 1310 nm, 1550 nm), select the appropriate wavelength for your DUTs.
- Laser power: -1 dBm
- Optical input: Input 1
- User Calibration: None
- Forward RF Power: 0 dBm

14 Click Start, then None to set the output power.

15 Press Optical Pwr. to start optical power meter application.

16 Read the optical power from the power meter application.

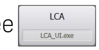
The readout should be -1 dBm ± 0. 5 dB

17 If you have option -301 and -021:

Connect the straight-angled optical patch cord (N4373-87907) to the optical output of an external laser, with 1310 nm or 1550 nm wavelength and known output power, and input of the LCA Optical Receiver. Note that the angled connector must be attached to the optical test set.

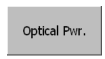
18 If you have option -301 and -022:

Connect the angled-angled optical patch cords (N4373-87906) to the optical output of an external laser, with 1310 nm or 1550 nm wavelength and known output power, and input of the LCA Optical Receiver.

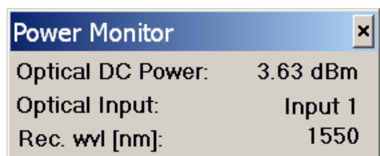
19 Press the [Macro/Local] utility button until the Macro 1 group is highlighted and you see 

.

20 Select the tools measurement tab and enter the wavelength of the external laser for the receiver.

21 Press 

to start optical power meter application.



22 Read the optical power from the power meter application.

The readout should be the power of the external laser ± 0. 5 dB.

If the results are not as expected

- Try cleaning the optical connectors as described in Cleaning on page 114.
- With the laser switched off, inspect all optical connectors with a microscope.
  - If the connectors on the N4373E Lightwave Component Analyzer seem to be damaged contact Keysight for repair.
  - If the connectors on the patch cord seem to be damaged contact Keysight for replacements.
- Using an external optical power meter, you can verify that there is an optical signal at the optical connection on the transmitter side.

If the problem persists, contact Keysight for support.

Verifying the Electrical Connection and Electro-optical Operation

The following tests ensure that the internal transmitter and receiver of the Lightwave Component Analyzer operate as expected.

1 Follow the steps in the sections Preparation on page 40 and Network analyzer settings and electrical calibration on page 40.

2 On the network analyzer make the following settings:
   - IF bandwidth: 300 Hz
   - Select “Reduce IF BW at Low Frequencies”.

3 If you have option -311 and -021:

   Connect the two straight-angled optical patch cords (N4373-87907) to the optical output of the LCA Optical Transmitter and input of the LCA Optical Receiver. Note that the angled connector must be attached to the optical test set.

   Use the FC/PC adapter (1005-0256) to connect the straight ends of the optical patch cords.

   If you have option -311 and -022:

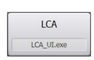
   Connect the angled-angled optical patch cords (N4373-87906) to the optical output of the LCA Optical Transmitter and input of the LCA Optical Receiver.

   Use the FC/APC through adapter (1005-1027) to connect the ends of the optical patch cords.

4 Connect the two supplied flexible test port cables to the RF ports of the Lightwave Component Analyzer test set.

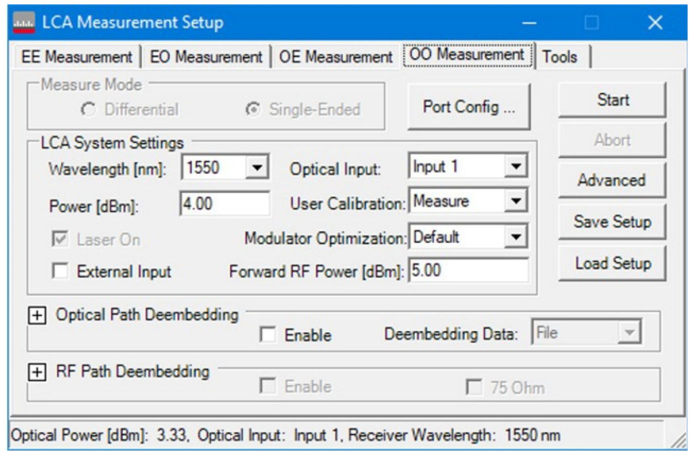
5 Press the [Macro/Local] utility button until the Macro 1 group is highlighted and you see 

.

6 Press 

to start the LCA measurement setup.

7 Select the OO measurement tab.



8 Set the following parameters:

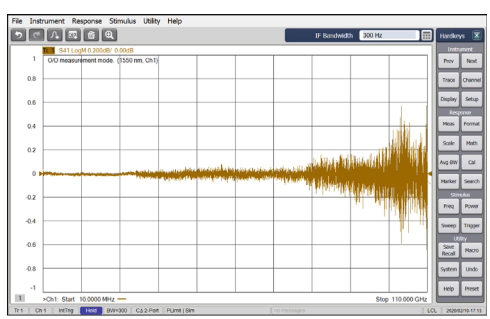
- If you have option 102 (Dual wavelength 1310 nm, 1550 nm), select the appropriate wavelength for your DUTs.
- Laser power: +3 dBm
- User Calibration: None
- Forward RF Power: 0 dBm

9 Click **Start**, then **Single** to set the output power.

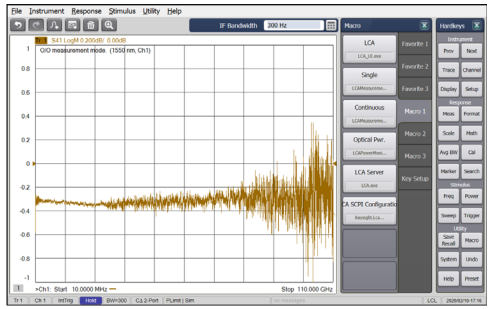
10 Right click the measurement trace, and select “Autoscale All” in the context menu.

At the end of the measurement, there should be a flat trace.

An ideal trace might look like this:



Please note, though, that this trace is also within specifications:



If the results are not as expected;

- Inspect the electrical connectors on the N4372E Lightwave Component Analyzer and on the ruggedized 1.0 mm (f) to ruggedized 1.0 mm (f) adapter visually.
  If electrical connectors seem to be damaged, contact Keysight for repair or replacement.
- Clean the electrical connectors on the N4372E Lightwave Component Analyzer and on the ruggedized 1.0 mm (f) to ruggedized 1.0 mm (f) adapter.
- Make sure the connection to the network analyzer of the two flexible test port cables are tight.

Perform a new electrical calibration and retest.

If the problem persists, contact Keysight for support.

If you have option 102 (Dual wavelength 1310 nm, 1550 nm), and you are testing at both wavelengths, repeat the performance quick check for the second wavelength.

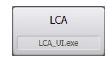
4 Making Measurements

Starting the Lightwave Component Analyzer

1 Turn on the network analyzer and the LCA Test Set Controller.

2 Allow the LCA Test Set Controller to warm up. Both the LCA Test Set Controller and the network analyzer need to stabilize their internal temperature for at least 60 minutes after the LCA software has been started.

3 If it did not start automatically, click on the icon on the desktop to start the network analyzer application.

4 If it is not already running, start the LCA server by pressing 

, or by clicking the LCA server icon on the desktop. See The LCA Function Keys on page 78 for information on displaying the LCA function keys.

Calibrating the Network Analyzer before Measurements

About measurements

- Always make sure that, “Stepped sweep - sweep moves in discrete steps” is selected in the sweep setup menu on the network analyzer.
- To get the best S/N ratio for your measurements, use the highest RF power your network analyzer can output without showing a “source unlevelled” error. This can be more than the maximum specified output power of the network analyzer.
- Decreasing the IF bandwidth improves the S/N ratio of the measurement. However, doing so increases the calibration and measurement times, so a suitable IF bandwidth should be selected.

  It is recommended to use an IF bandwidth of 5 kHz or narrower.
- Apply appropriate averaging or smoothing for your application.
- Always perform an electrical calibration of the network analyzer or load an existing calibration set before making measurements.
- Before starting the electrical calibration of the network analyzer, make sure that the LCA is in EE measurement mode.
- For electrical calibration use the default RF power for EE measurement mode.
- After completing the electrical calibration, do not alter the IF bandwidth, start frequency, stop frequency, measurement point number or other settings. You may get measurement errors if you change any of those parameters.

- For additional information, please refer to "Optimize a measurement" and "Calibrate a measurement" in the documentation of the network analyzer.

Electrical calibration for single-ended measurements

To ensure the specified performance of the LCA, you need to perform a full two-port electrical calibration.

NOTE **When in EO measurement mode, you need to return to EE measurement mode first before you can perform an electrical calibration.**

Calibrate before you start using the Lightwave Component Analyzer application. Alternatively, return to EE measurement mode, as described in Returning to Electrical Measurements on page 69, to calibrate. For calibrating the Lightwave Component Analyzer using calibration kit, follow these steps:

1. Set your measurement parameters.
2. From the “Calibration” menu, select “Other Cals” -> “Smart Cal”.
3. Select "2 Port Cal".
4. On two-port network analyzers, select port 2 as "selected 2nd port". On 4-port network analyzers, select port 4 as "selected 2nd port". If you plan to use other ports for your measurements, select them for the calibration and later in the LCA software port configuration window. For more information, refer to Selecting Port Configuration on page 83.
5. Follow the instruction for further steps shown on the Network Analyzer.
6. After the calibration has been completed, save the calibration file.

NOTE **It is recommended to use the 6 mm and 14 mm torque wrenches (Keysight part number 8710-2812 and 8710-2813, 45 N-cm/4 lb-in) and a 12mm wrench to tighten all RF connections during the calibration.**

Electrical calibration for differential OE measurements

To ensure the specified performance of the LCA, you should perform a full three- port electrical calibration. See the Keysight website for applicable calibration kits.

If you want to perform an OE user calibration (see page 61 for details), we recommend executing a full four-port calibration, or a two-port calibration between network analyzer ports 1 and 4, in addition to the three-port calibration (see Electrical calibration for single-ended measurements on page 51).

Calibrate before you start using the Lightwave Component Analyzer application. Alternatively, return to EE measurement mode, as described in Returning to Electrical Measurements on page 69, to calibrate.

NOTE It is recommended to use the 6 mm and 14 mm torque wrenches (Keysight part number 8710-2812 and 8710-2813, 45 N-cm/4 lb-in) and a 12 mm wrench to tighten all RF connections during the calibration

Electrical calibration for differential EO measurements

Calibrate before you start using the Lightwave Component Analyzer application. Alternatively, return to the EE measurement mode, as described in Returning to Electrical Measurements on page 69, to calibrate. For calibrating the Lightwave Component Analyzer using an automated electrical calibration module, follow these steps:

1 Set your measurement parameters.

2 From the “Calibration” menu, select “Smart Cal”.

3 Select “3 Port Cal”.

4 Select 3 Port Cal Configuration according to the planned port configuration for EO measurement and click the “Next” button.

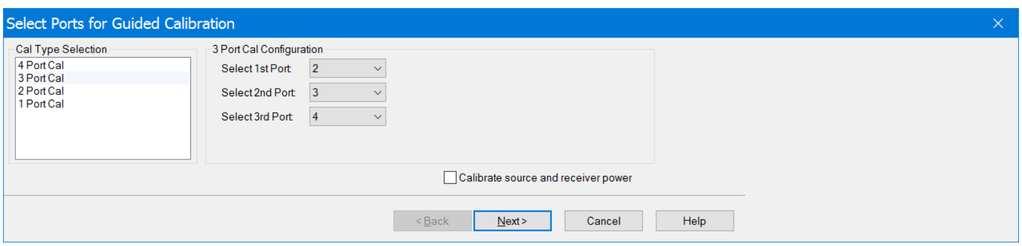


Figure 6 Port-configuration for the 3 port calibration

5 Select DUT connectors and the Cal Kits (e.g. “1.0mm female” and “85059B”).

6 Follow the instructions for further steps shown on the Network Analyzer.

7 After the calibration has been completed, save the calibration file for later reuse.

Measuring Opto-Electrical (OE) devices

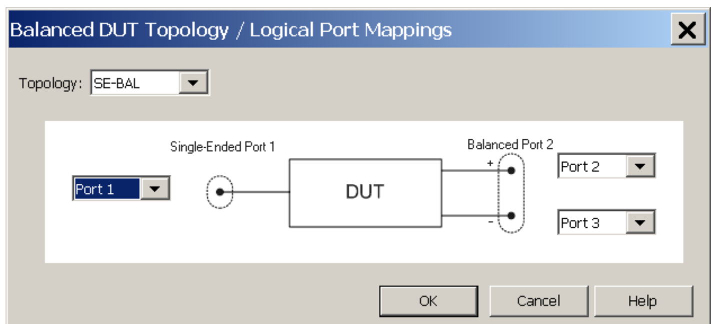
Always perform an electrical calibration of the network analyzer or load an existing calibration set before you make a measurement.

Options -310 or -311 are required to perform OE measurements.

For standard measurements, see Electrical calibration for single-ended measurements on page 51.

For differential measurements, see Electrical calibration for differential OE measurements on page 52.

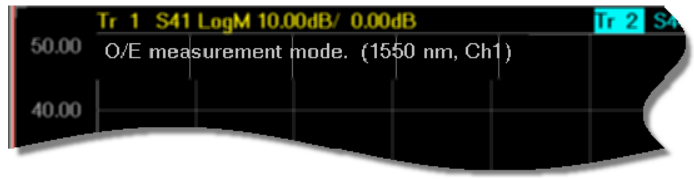
For differential OE measurements the single-ended (SE), logical port 1 is assigned to physical port 1 and the balanced (BAL), logical port 2 is assigned to the physical ports 2 and 3.



For OE measurements, the LCA sets up traces for S22, S21, S33, S31 by default.

For more information, see Differential Measurements (applies to 4-port PNA only) on page 104.

Before you make your first opto-electrical measurement, you must initialize the OE measurement. You can see which measurement is currently initialized at the top left of the trace screen.



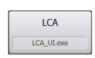
If you have already initialized the OE measurement, you can connect your device under test and make the measurement by pressing 

or 

.

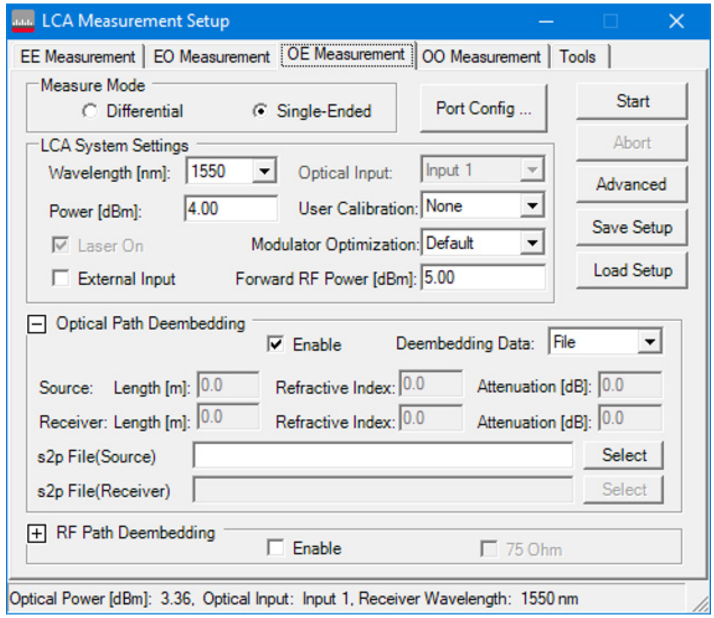
Please refer to the user’s guide and online help of the network analyzer for further information.

Initializing the OE measurement

1 Press 

.

2 Select the “OE Measurement” tab.



3 If necessary, select a Differential or Single-Ended Measure Mode, depending on the type of your DUT.

4 Select the wavelength at which you are testing.

If you want to use external laser sources, select the optional External Input, and enter the wavelength of the external source.

5 Set the power of the laser to be applied to the test circuit.

If you are using the external source input, enter the value for the power emitted by the LCA Optical Transmitter output port. (Use an external power meter, or the LCA power meter to measure the optical power). The optical power is also displayed at the bottom of the LCA measurement setup screen.

6 If you are running measurements in an unstable environment, or need extra accuracy or long term stability, make sure to select “EverySweep” or “Continuous” (recommended) for Modulator Optimization.

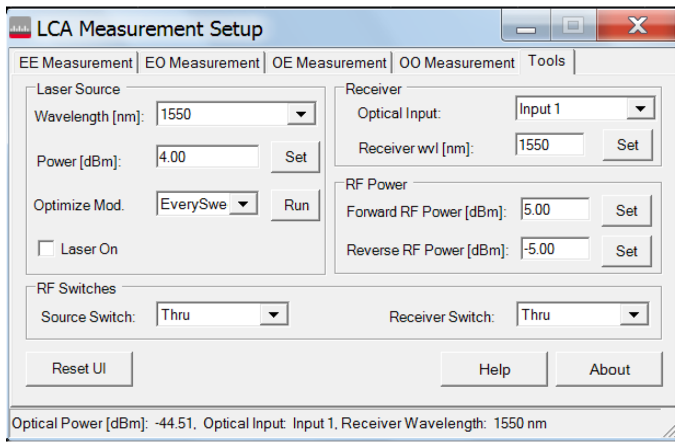
Note that, optimizing every sweep adds about 1 second to each measurement.

"Continuous" modulator bias optimization superimposes a 10 kHz pilot tone onto the signal. This improves the short and long term stability of the modulator operating point.

The pilot tone will affect measurements with IF bandwidth settings of the network analyzer > 5 kHz.

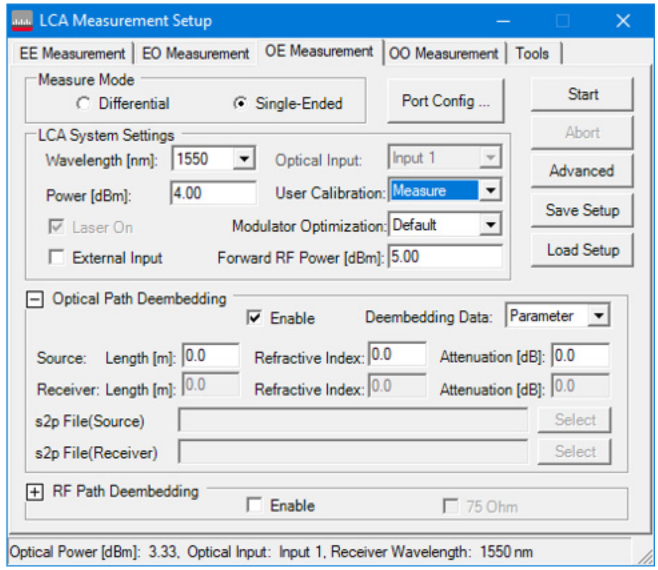
For IF bandwidth settings of the network analyzer > 10 kHz we recommend setting modulator bias optimization to "Every Sweep" or "Once". It is recommended to include a “User Calibration” in your setup (see the section “User Calibration” under LCA System Settings on page 85) if you are not using “Continuous” modulator bias optimization.

The system is calibrated with a default setting. You can determine the default setting by going to the "Tools" page, choosing “Reset UI”, and pressing “Run”.

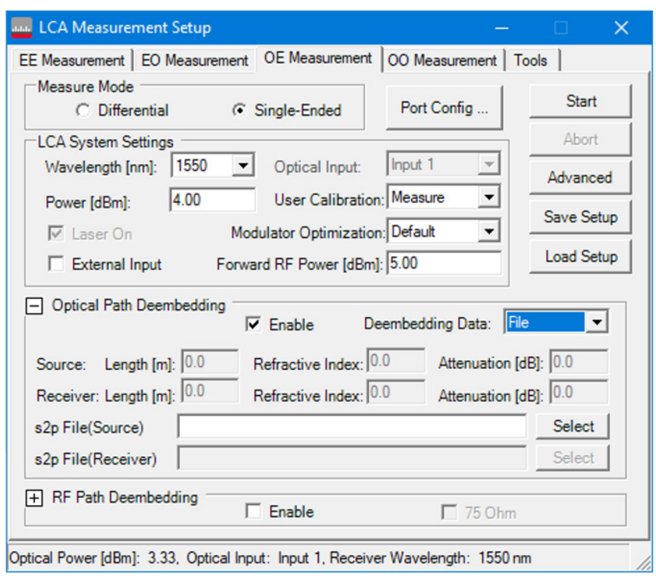


7 If you need to deembed optical components, such as attenuators, fiber optic cables or splitters, located between the laser output and your device under test, open and enable the “Optical Path Deembedding”.

Here you can enter the parameters of the optical path directly.

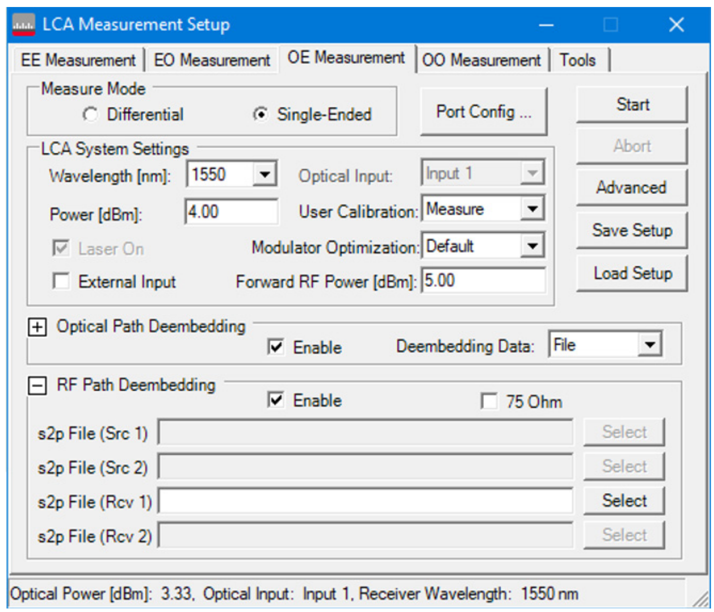


If you already have an .s2p file for your device, set "Deembedding Data" to "File" and enter or select the .s2p file name.



- For accurate measurements, you can also perform a user calibration. To do so, remove the DUT and close the optical path again. Then set "User Calibration" to "Measure" to perform a measurement of the optical path. Alternatively, select "Load" to recall an existing calibration.

8 If you need to deembed electrical components, such as RF cables, waveguide or other adapters, or probe heads, located between the device under test and the input port, open and enable the "RF Path Deembedding".



Enter or select the file name.

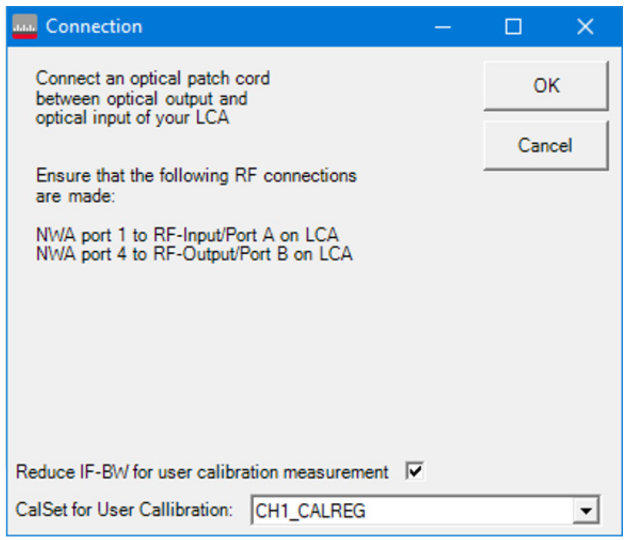
9 Select the appropriate type of user calibration for your measurement:

- In many cases, a User Calibration is not needed, so select "None". The LCA measures to specifications under the standard conditions.
- The frequency dependent transmission behavior of optical transmitters cannot be characterized as accurately as the behavior of receivers. So for improved results at lower frequencies, select “Measure”.
- If you want to reuse an existing user calibration, select “Load”, and select the calibration file from the Windows Explorer window.

NOTE Optical and electrical path deembedding is not applied during a user calibration.

10 Click **Start** to start the measurement preparation.

If "User Calibration" mode is set to "Measure" the following screen is displayed:



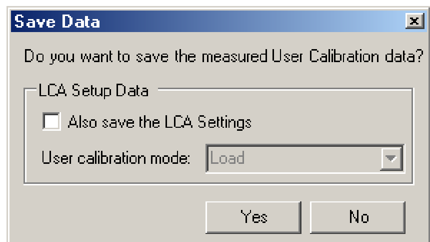
a A user calibration requires a valid electrical calibration between at least two ports of network analyzers. If you want to use a different electrical calibration for the user calibration measurement and for the DUT measurement, "Electrical Calibration" can be used as the user calibration measurement in the "CalSet for User Calibration" combo box. If you have performed a four-port electrical calibration before, use this one, otherwise select the corresponding two-port calibration. The selected electrical calibration will only be used for the user calibration measurement. Afterwards the LCA returns to the currently activated electrical calibration for the DUT measurements. The currently activated electrical calibration is preselected in the "CalSet for User Calibration" combo box. This preselection is fine and you have nothing to do if the same electrical calibration is used for the user calibration measurement and for the DUT measurement.

b Select “Reduce IF-BW for user calibration measurement” to reduce noise on the user calibration data. The default bandwidth reduction factor is defined in the LCAConfig.xml file.

c Click 

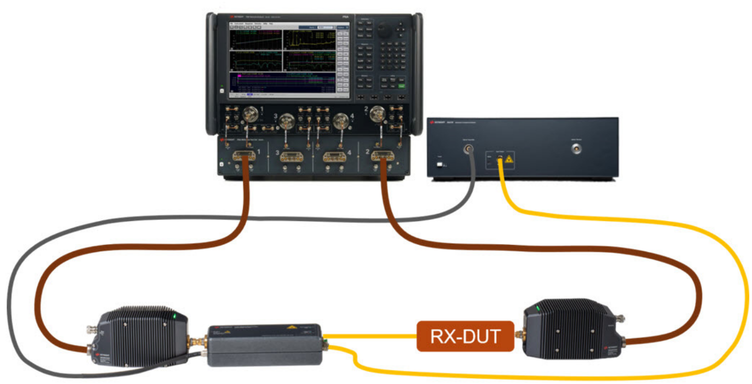
to proceed.

d Choose whether you want to save the calibration data for later use.

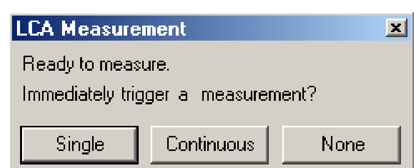


Making single-ended OE measurements

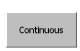
1 Connect your device under test as illustrated below:



2 When the following message is displayed, click "Single" or "Continuous" to start the first measurement.



To make further measurements with these settings, press 

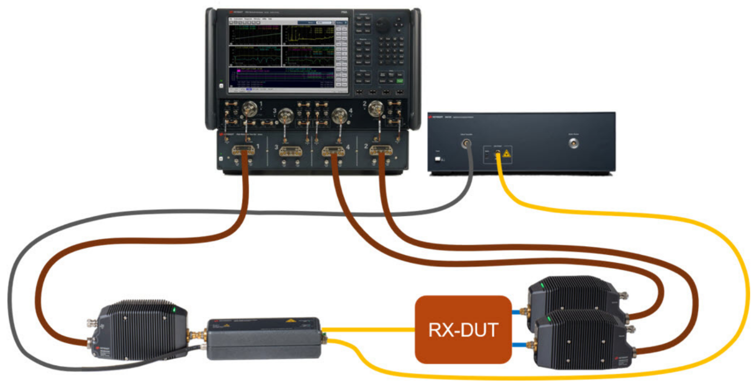
or 

to start the measurement.

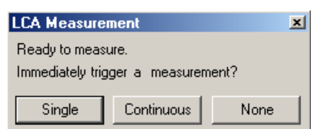
For information on further parameters, refer to User Interface Reference on page 77.

Making differential OE measurements (applies to 4-port PNA only)

1 Connect your device under test.



2 When the following message is displayed, select "Single" or "Continuous" to start the first measurement:



3 To make further measurements with these settings, press click 

or 

to start the measurement.

For information on further parameters, refer to User Interface Reference on page 77.

Measuring Electro-Optical (EO) Devices

Always perform an electrical calibration of the network analyzer or load an existing calibration file before you make a measurement.

Options -301 or -311 are required to perform EO measurements.

For standard measurements, see Electrical calibration for single-ended measurements on page 51.

For differential measurements, see Electrical calibration for differential EO measurements on page 53.

For differential EO measurements, the single-ended (SE), logical port 1 is assigned to physical port 4 and the balanced (BAL), logical port 2 is assigned to physical ports 2 and 3.

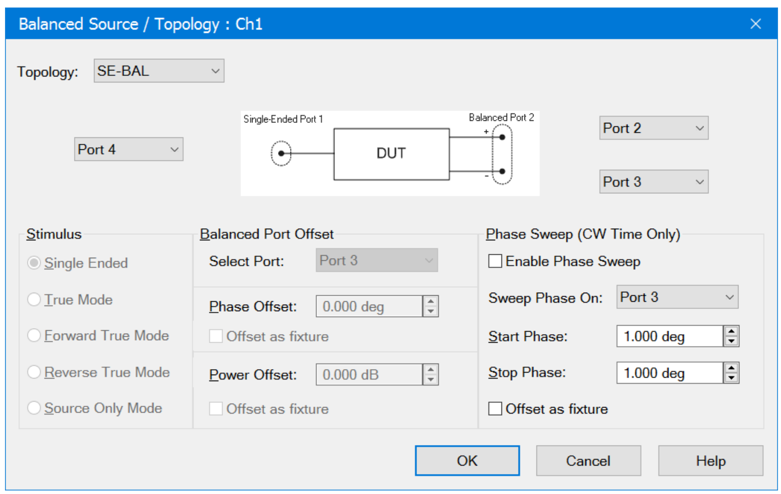


Figure 7 Topology configuration for differential measurements

For EO measurements the LCA sets up traces for S22, S42, S33, S43 by default. For more information, see Differential on page 85.

Before you make your first electro-optical measurement, you must switch to EO measurement mode. You can see which measurement is currently initialized at the top left of the trace screen.

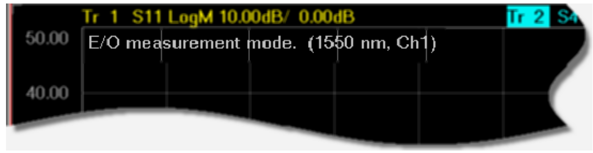


Figure 8 Indicator that the LCA is in EO-measurement mode

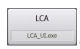
If you have already initialized the EO measurement, you can connect your device under test and start the measurement by pressing 

or 

.

Please refer to the user’s guide and online help of the network analyzer for further information.

Initializing the EO measurement

1 Press 

.

2 Select the “EO Measurement” tab (only available for options -310 or -311).

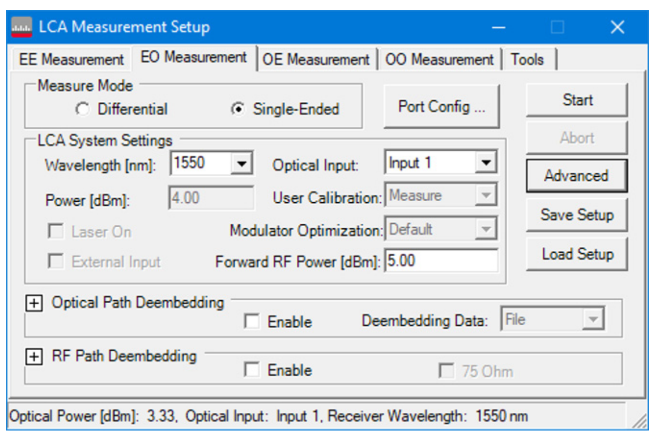


Figure 9 Graphical user interface of the LCA software

3 On a 4-port LCA, select Differential or Single-Ended Measure Mode, depending on the type of your DUT.

4 Select or enter the wavelength at which you are testing.

5 If you need to deembed optical components, such as attenuators, fiber optic cables or splitters, located between your device under test and the optical input, open and enable “Optical Path Deembedding”.

Here you can enter the parameters of the optical path directly

6 If you need to deembed electrical components, such as RF cables, waveguide or other adapters, or probe heads, located between the output port and your device under test, open and enable the “RF Path Deembedding”.

7 If you are using a 75 Ohm minimum loss pad, enable the RF Path Deembedding, and make sure 75 Ohm is selected.

Enter or select the file with the characterization of the minimum loss pad.

8 Click 

to start the measurement preparation.

Making single-ended EO measurements

1 Connect your device under test.

Figure 10 Schematic measurement setup for single-ended EO measurements

2 When the following message is displayed, select "Single" or "Continuous" to start the first measurement.

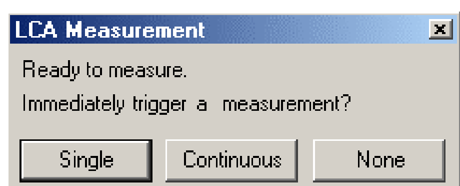
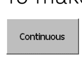


Figure 11 Window to trigger LCA measurements

3 To make further measurements with these settings, press 

or 

to start the measurement.

For information on further parameters, refer to User Interface Reference on page 77.

Making differential EO measurements

1 Connect your device under test.

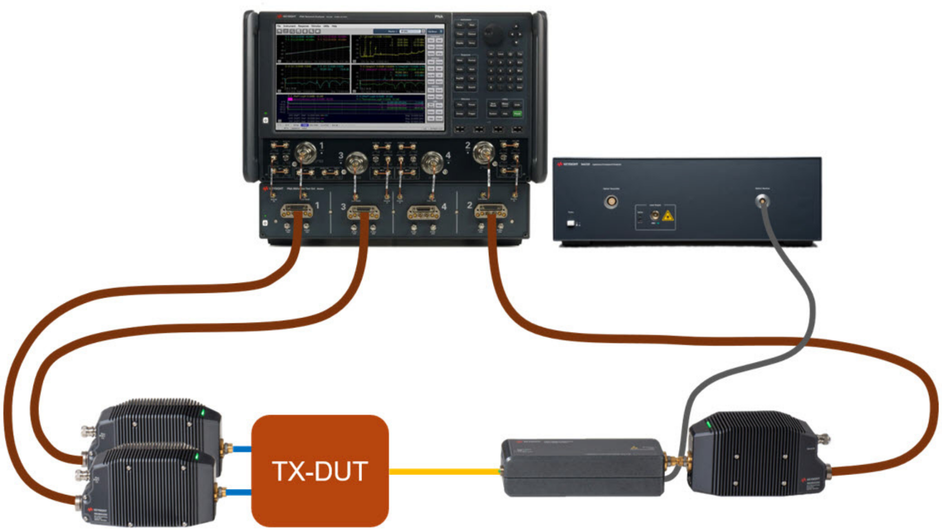


Figure 12 Schematic measurement setup for differential EO measurements

2 When the following message is displayed, select “Single” or “Continuous” to start the first measurement.

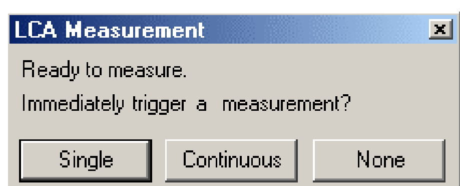
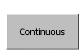


Figure 13 Window to trigger LCA measurements

3 To make further measurements with these settings, press 

or 

to start the measurement.

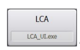
For information on further parameters, refer to User Interface Reference on page 77.

Returning to Electrical Measurements

Before you measure purely electrical devices with the network analyzer, or perform an electrical calibration, you need to switch to "EE Measurement" mode.

Initializing the EE Measurement as described here removes all the fixturing information in the network analyzer that is specific to the LCA. Also, the RF power on all ports is set to the power specified for “Reverse RF Power [dBm]".

NOTE **The recommended settings for Forward and Reverse RF power depend on the type of your network analyzer. See** **RF Power on page 90.**

1 Press 
.

2 Make sure the “EE Measurement” tab is selected.

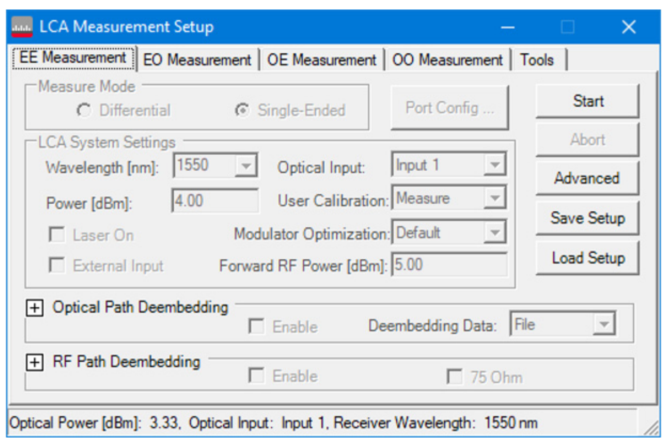


Figure 14 Graphical user interface of the LCA software

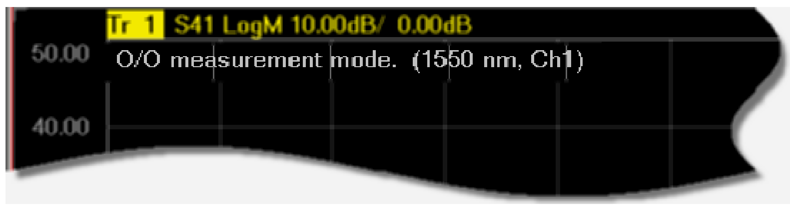
3 Click 
.

Measuring Optical-Optical (OO) Devices

Always perform an electrical calibration of the network analyzer or load an existing calibration set before you make a measurement. For standard measurements, see Electrical calibration for single-ended measurements on page 51.

Option -311 is required to perform OO measurements.

Before you make your first optical-optical measurement, you must switch to OO measurement mode. You can see which measurement is currently initialized at the top left of the trace screen.



If you have already initialized the OO measurement, you can connect your device under test and start the measurement by pressing 

or 

.

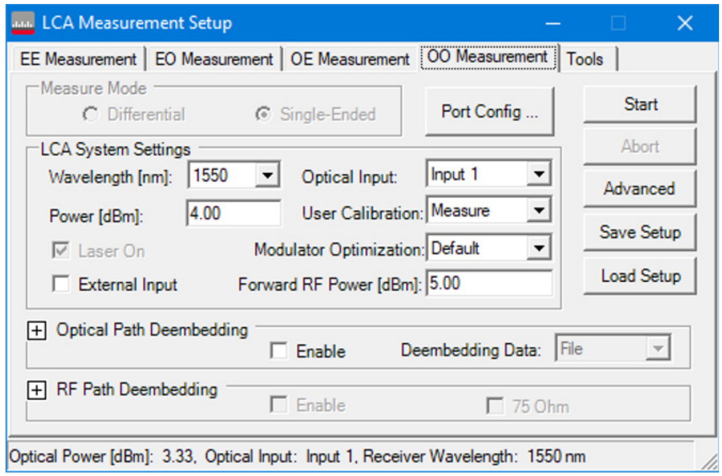
Please refer to the user's guide and online help of the network analyzer for further information.

Initializing the OO measurement

1 Click 

.

2 Select the “OO Measurement” tab.



3 Select the wavelength at which you are testing.

If you want to use external laser sources, select the optional External Input, and enter the wavelength of the external source.

4 Set the power of the laser to be applied to the test circuit.

If you are using the external source input, enter the value for the power emitted by the LCA optical output port. (Use an external power meter, or the LCA power meter to measure the optical power).

5 If you are running measurements in an unstable environment, or need extra accuracy or long term stability, make sure to select “EverySweep” or “Continuous” (recommended) for Modulator Optimization.

Please note, optimizing every sweep adds about 1 second to each measurement.

"Continuous" modulator bias optimization superimposes a 10 kHz pilot tone onto the signal. This improves the short and long term signal stability of the modulator operating point.

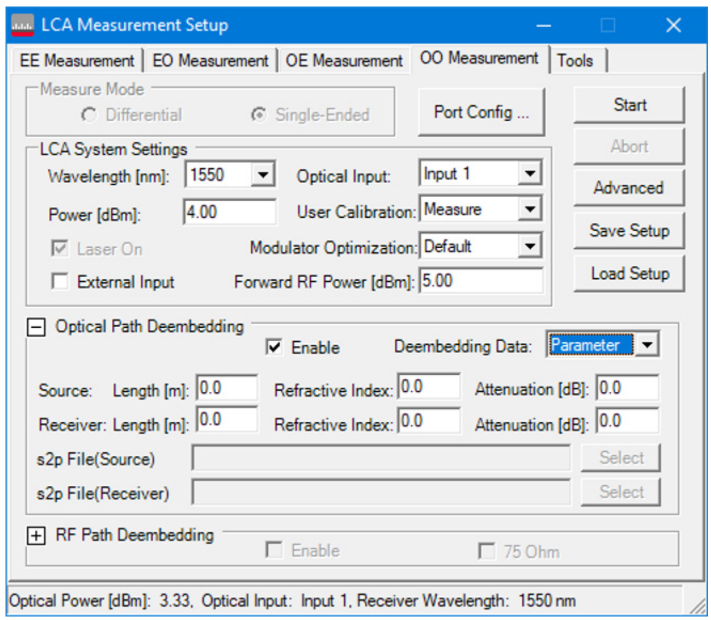
The pilot tone will affect measurements with IF bandwidth settings of the network analyzer > 5 kHz.

For IF bandwidth settings of the network analyzer > 10 kHz we recommend setting modulator bias optimization to "Every Sweep" or "Once". Not using “Continuous” modulator bias optimization affects the accuracy of the internal transmitter calibration. We recommend you include a “User Calibration” in your setup (see the section “User Calibration” under LCA System Settings on page 85) if you are not using “Continuous” modulator bias optimization.

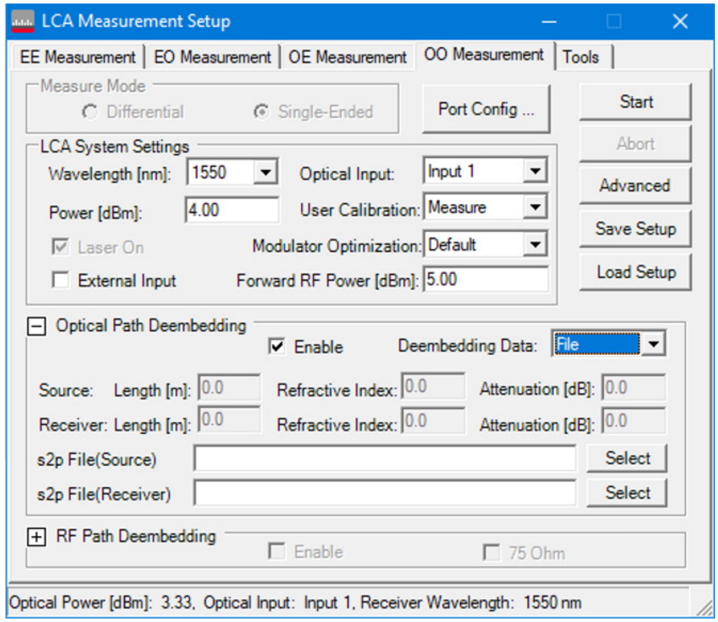
The system is calibrated with a default setting. You can determine the default setting by going to the “Tools” page, choosing “Default”, and pressing “Run”.

6 If you need to deembed optical components, such as attenuators, fiber optic cables or splitters, located between the laser output and your device under test, open and enable the “Optical Path Deembedding”.

Here you can enter the parameters of the optical path directly.



If you already have an .s2p file for your device, set "Deembedding Data" to "File" and enter or select the .s2p file name.



7 Select the appropriate type of user calibration for your measurement:

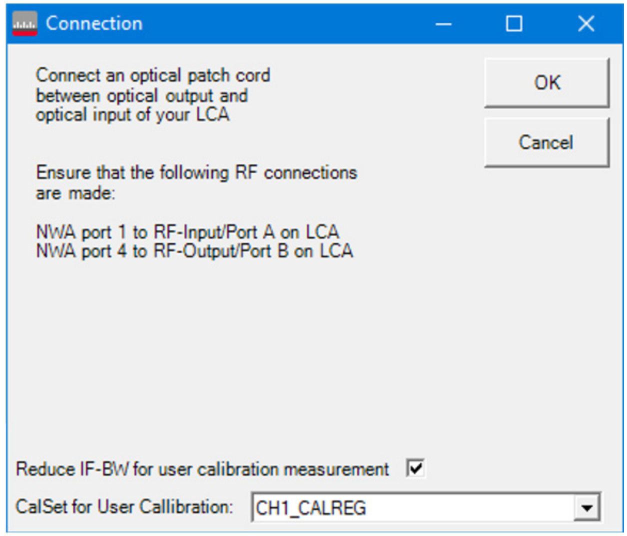
- In many cases, a User Calibration is not needed, so select "None". The LCA measures to specifications under the standard conditions.
- The frequency dependent transmission behavior of optical transmitters cannot be characterized as accurately as the behavior of receivers. So for improved results at lower frequencies, select “Measure”.
- If you want to reuse an existing user calibration, select “Load”, and select the calibration file from the Windows Explorer window.

NOTE Optical and electrical path deembedding is not applied during a user calibration.

8 Click 

to start the measurement preparation.

If "User Calibration" mode is set to "Measure" the following screen is displayed:

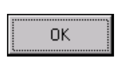


a If you want to use a different electrical calibration for the user calibration measurement and for the DUT measurement, "Electrical Calibration" can be used as the user calibration measurement in the "CalSet for User Calibration" combo box.

This electrical calibration will only be used for the “user calibration” measurements. Afterwards the LCA returns to the currently activated electrical calibration for the DUT measurements.

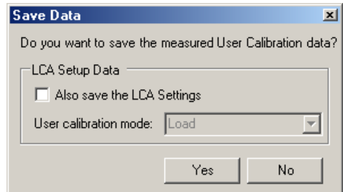
The currently activated electrical calibration is preselected in the "CalSet for User Calibration" combo box. This preselection is fine and you have nothing to do if the same electrical calibration is used for the user calibration measurement and for the DUT measurement.

b Select “Reduce IF-BW for user calibration measurement” to reduce noise on the user calibration data. The default bandwidth reduction factor is defined in the LCAConfig.xml file.

c Click 

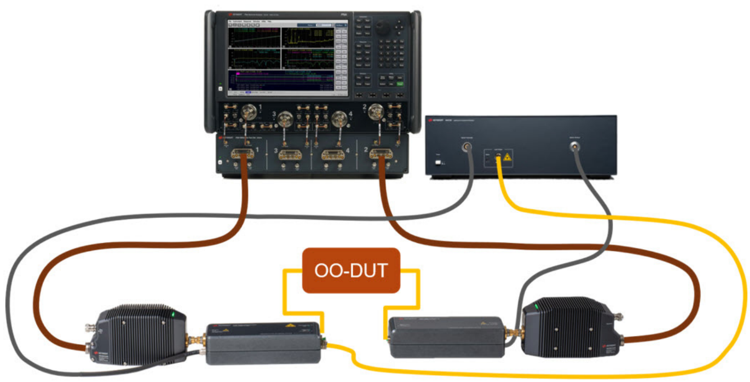
to proceed.

d Choose whether you want to save the calibration data for later use.

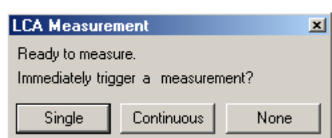


Making OO measurements

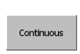
1 Connect your device under test.



2 When the following message is displayed, select "Single" or "Continuous" to start the first measurement.



3 To make further measurements with these settings, press 

or 

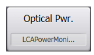
to start the measurement.

For information on further parameters, please refer to User Interface Reference on page 77.

Aborting a Measurement

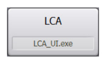
In some cases it can become difficult to abort continuous measurements by pressing the "Continuous" or "Single" button, since the network analyzer does not react to the keypad during measurements. Abort the measurement with the "Abort Measurement" button in the LCA Server window.

Measuring Optical Power

Press 

to measure the average optical power (requires option -301 or -311).

The optical power meter uses either the same Optical Input as the most recent measurement setup, or the input specified on the “Tools” tab. To set the optical input using the “Tools” tab, follow these steps:

1 Press 

.
2 Select Input 2 as the Optical Input under Receiver on the “Tools” tab.
3 Under Receiver on the “Tools” tab, specify the receiver wavelength.

NOTE **The optical power is also displayed at the bottom of LCA measurement setup screen.**

5 User Interface Reference

KEYSIGHT TECHNOLOGIES

The LCA Function Keys

1 If the LCA server is running, but the function keys are not displayed, press the [Macro/Local] Utility key until Macro 1 group is shown:

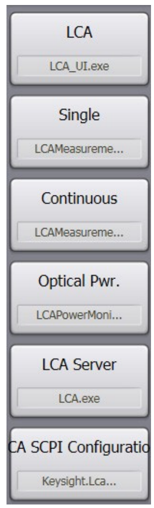
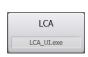
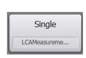
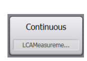


Figure 15 Available macro-buttons on the network analyzer to control the LCA

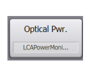
- 

: Brings the LCA user interface to the foreground, to setup an LCA measurement.
- 

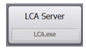
: Perform a single sweep measurement with the current measurement setup.

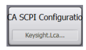
  Pressing this function key when a single or continuous measurement is running, stops this measurement, and starts a new single sweep measurement.
- 

: Perform continuous measurement sweeps with the current measurement setup.

  Pressing this function key during a single or continuous measurement, stops the measurement.
- 

: Start the optical power monitor. This uses the current measurement setup to determine the wavelength and the optical input for which the average optical power is measured.

- 

: If it is not already running, this starts the LCA server. If it is already running, it brings the server to the foreground.
- 
: With the LCA SCPI Configurator you can configure the SCPI connection interface (socket or USB) and start or stop the SCPI interface.

  The LCA SCPI Interface does not start automatically. To enable control of the LCA using SCPI commands you have to start the LCA SCPI interface manually.

  To launch the LCA SCPI Configurator, you may either press the "LCA SCPI Configuration" button in the network analyzer GUI macro list under "Utilities", or use the shortcut "LCA SCPI Configuration" which you can find on the desktop or in the program menu.

For information on further function keys, please refer to the documentation supplied with the network analyzer.

NOTE

After completing the “LCA Measurement Setup” step, the network analyzer is ready for DUT measurements.

Because the receiver responsivity depends on the optical power, you should start the DUT measurements with the LCA “Single” or “Continuous” macros.

These macros perform an optical power measurement prior to each measurement sweep. This achieves the highest accuracy in EO measurements.

If you do not need this accuracy, you can also start the DUT measurements with the network analyzer's trigger functions.

In some cases it can become difficult to abort continuous measurements by pressing the "Continuous" or "Single" button, since the network analyzer does not react to the keypad during measurements. In that case, abort the measurement with the "Abort Measurement" button in the LCA Server window.

Default and Advanced Measurement Parameters

Use the default parameters for EO measurements of devices with a simple stimulus and response path. This includes devices like sources, receivers or amplifiers.

Use the advanced parameters for more comprehensive control of your measurements.

Saving and Loading Setups

Saving setups

A setup contains the current state of the LCA user interface and optionally also the current state of the network analyzer. Setups are stored as XML-files or as compressed XML-files.

The settings on the “Tools” tab are not saved in the setup, since the settings shown on this tab always reflect the current state of the LCA hardware. After loading the setup the LCA system is configured to press “Start” from the LCA user interface.

There are two ways of saving setups.

First saving method

Click Save Setup to save the current setup.

- If user calibration mode is set to “Measure” (only possible for OE and OO measurements), you are asked to specify the electrical calibration set to be saved with the setup.

  This is the electrical calibration set to be used during user calibration measurements.

  Only a link to the electrical calibration set is saved, not the calibration data itself.

  For more details, see Measuring Opto-Electrical (OE) devices on page 54 or Measuring Optical-Optical (OO) Devices on page 70.

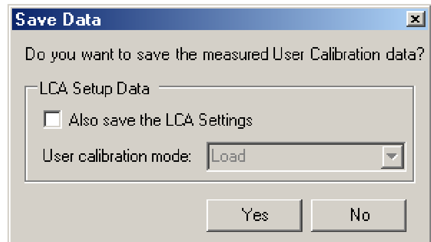
- If User Calibration is set to “Load” (only possible for OE and OO measurements), you will be asked to specify which user calibration file should be loaded.

  The filename of the calibration data is saved with the setup, not the calibration data itself.

  For more details, see Measuring Opto-Electrical (OE) devices on page 54 or Measuring Optical-Optical (OO) Devices on page 70.

Second saving method

After initializing with the User Calibration mode set to “Measure”, you are asked if you want to save the user calibration data and/or the LCA Setup.



Check “Also save the LCA Setup” if you want to save the LCA setup. Then choose between “Load” and “Measure” to specify the user calibration mode to save with the setup.

- If you selected “Load”, the “No” button is disabled to force you to store the measured user calibration data.

  After you press “Yes”, you are asked to specify the filename for the user calibration data and the filename of the LCA setup.

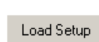
  Only the filename of the user calibration data is saved with the setup.

- If you selected “Measure”, it is also possible to press the “No” button. In this case only the LCA setup is saved.

  If you press “Yes”, you are asked for the filename of the LCA setup. The name of the electrical calibration set just used for this user calibration measurement will be saved in the LCA setup.

Before the LCA saves the setup, it asks you whether you want to save the network analyzer state with your LCA setup.

Loading setups

Click 

to retrieve an existing setup.

- After loading a setup with user calibration mode set to “Measure”, the electrical calibration set specified in this setup is preselected in the optical connection dialog shown during OE or OO initialization.

  This is different to the behavior when doing OE or OO initialization without loading a setup.

  For more details, see Measuring Opto-Electrical (OE) devices on page 54 or Measuring Optical-Optical (OO) Devices on page 70.

- After loading a setup with user calibration mode set to “Load”, the specified calibration file is preselected in the load dialog asking you for the calibration data file during OE or OO initialization.

For more details, see Measuring Opto-Electrical (OE) devices on page 54 or Measuring Optical-Optical (OO) Devices on page 70.

The Measurement Parameters

Measure Mode

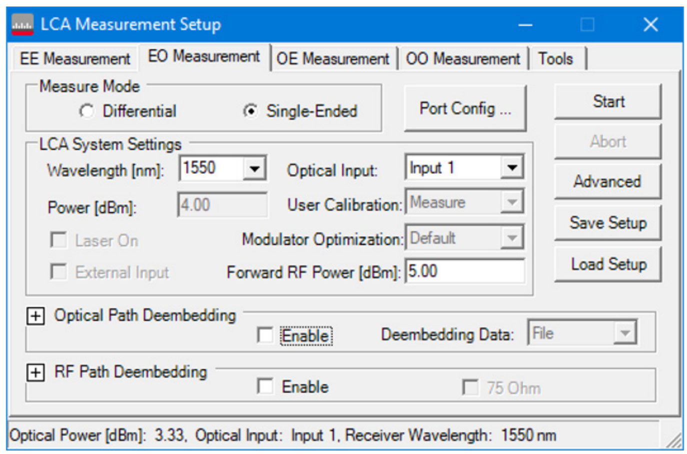


Figure 16 Graphical user interface of the LCA software

A 2-port network analyzer can only support single-ended measurements. Selecting the Measure Mode is only possible if you have a 4-port network analyzer.

Selecting Port Configuration

Pressing the Port Config ... button opens a dialog which allows you to select the network analyzer ports to be used for the LCA Optical Transmitter/Receiver as well as the DUT. Once open, the dialog shows the current port configuration as it is configured on the LCA server. The LCA server stores specific port configurations for EO-, OE- and OO-measurements.

The assignment of source and receiver to either DUT or LCA in the configuration table depends on which measurement tab the dialog was opened from.

If ‘Single-Ended’ measurement is selected, two columns are shown where you can select which port is connected to the source and which one is connected to the receiver.

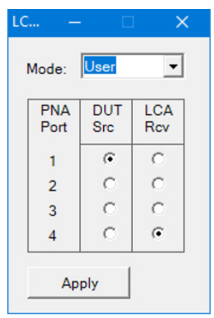


Figure 17 Single-Ended EO-measurement

If ‘Differential’ measurement is selected, three columns are shown. Here it can be selected which ports to use on the differential side and which port is connected to the LCA Optical Transmitter or Receiver.

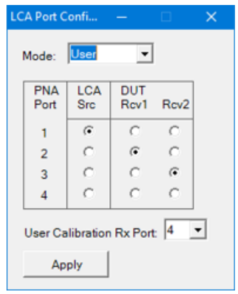


Figure 18 Differential OE-measurement

The port configuration can only be changed when ‘User’ is selected in the ‘Mode’ listbox. If ‘Default’ is selected, the factory default port configuration is used. ‘True Mode’ is only available in combination with ‘Differential’ measurements. If ‘True Mode’ is selected, a port configuration is shown which allows true mode differential measurements on the network analyzer. See network analyzer documentation for information about true mode differential measurements.

For differential OE measurements, the network analyzer port to be used for the user calibration measurement can be selected independently. If one of the differential ports is selected, only a 3-port electrical calibration is required. With the configuration shown above, a 4-port electrical calibration would be required.

After pressing the ‘Apply’ button, the currently selected configuration is written to the LCA server.

The ‘Apply’ button is only enabled when a valid configuration is selected.

Invalid configurations:

- Duplicate port assignment: The same NWA port is used as source and transmitter port.
- Second differential port has the same or a lower port number than the first differential port.
- The Receiver-port for the user calibration is the same as the port for the LCA Optical Transmitter.

Differential

If you select this mode, means the LCA uses a differential electrical input or output for this measurement.

Whether the differential signal is the input to the DUT or the output from the DUT, this uses ports 2 and 3 of a 4- port network analyzer.

Single-Ended

If you select this mode, the LCA uses a single-ended electrical input or output for this measurement.

LCA System Settings

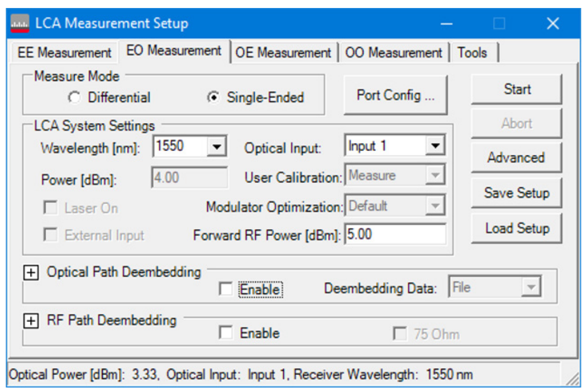


Figure 19 Graphical user interface of the LCA software

Wavelength (nm)

- If you have not selected to use the optional External Input, select the wavelength of the laser source and the optical power meter use for measurements.
- If you have selected to use the External Input, you can enter the wavelength of the external source here. This wavelength is used by the optical power meter.

Optical Path Deembedding

Enable

Select if you want the LCA to compensate for the optical connections to the DUT.

Deembedding Data

Select how you want to specify the characteristics of the optical path.

- **Parameter** lets you characterize the source or receiver optical path by its length and refractive index, and attenuation.

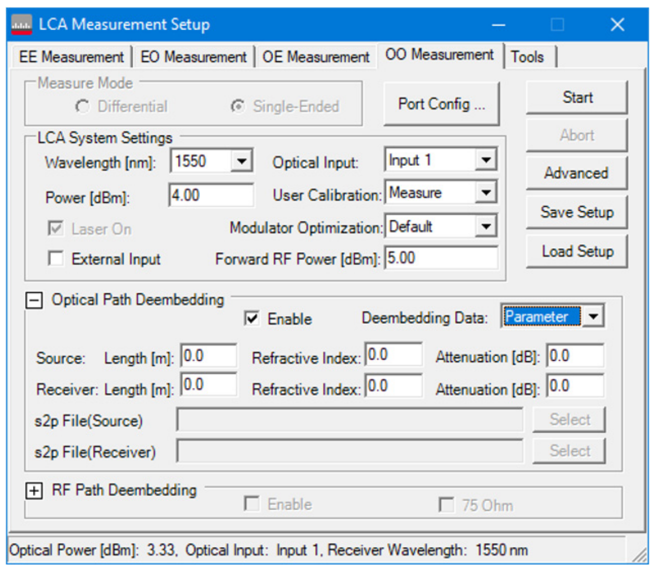


Figure 20 Graphical user interface of the LCA software with enabled optical path deembedding based on optical parameters

- **Length (m)** and **Refractive Index** can only be used together. That is, you cannot give a value just for the refractive index or just the length.

  The value for the Refractive Index of a single-mode fiber is typically 1.467 at 1310 nm and 1.468 at 1550 nm.

  The value for the Refractive Index of a graded index multi-mode fiber is 1.49 for 62.5 µm at 850 nm, 1.475 for 50 µm at 850 nm and 1.465 for 50 µm at 1300 nm.

- **Attenuation (dB)** can be used alone, or with the values for length and refractive index.
- **File** lets you use the results of a measurement of the optical path to characterize the source or receiver optical path.

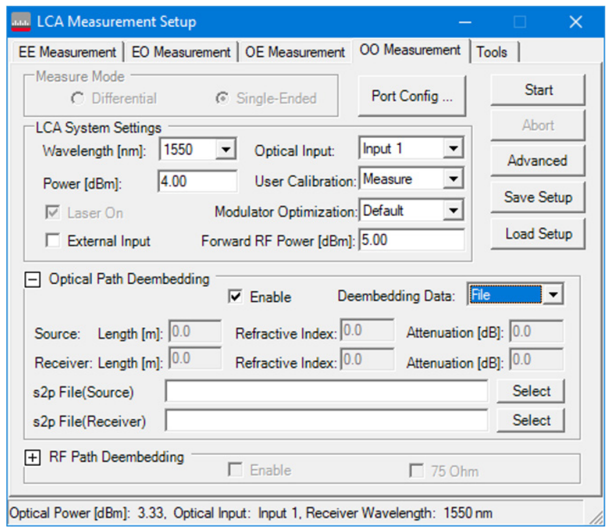


Figure 21 Graphical user interface of the LCA software with enabled optical path deembedding based on a file-selection

These results need to be in the form of a 2-port S-parameter data files (also known as Touchstone .s2p data files).

Only the s21 values of the file are used for correction of the transmission properties. All other parameters are ignored.

To assign a file,

1 Click 

at the right of the field to which you want to assign a file.

2 Locate and select the file in the explorer window.

RF Path Deembedding

Enable

Select if you want the LCA to compensate for the RF connections to the DUT.

Use the results of a measurement of the RF path to characterize the source or receiver RF path.

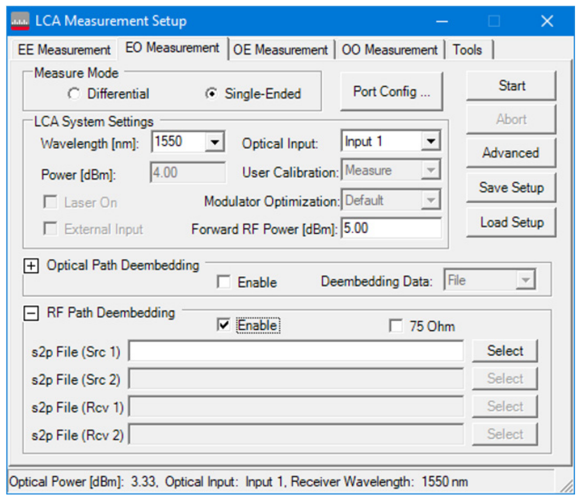


Figure 22 Graphical user interface of the LCA software with enabled RF path deembedding

- For Single-Ended measurements, Src 1 corresponds to the path to network analyzer Port 1, and Rcv 1 corresponds to the path to Port 2 on a two-port network analyzer or, respectively, to Port 4 on a four-port network analyzer.
- For Differential measurements, Src 1 corresponds to the path to Port 2 (on the network analyzer), Src 2 corresponds to the path to Port 3 (on the network analyzer), Rcv 1 corresponds to the path to Port 2 (on the network analyzer), Rcv 2 corresponds to the path to Port 3 (on the network analyzer).

The results need to be in the form of a 2-port S-parameter data file (also known as Touchstone .s2p data files). All the S-Parameters in the supplied file are used.

Please note that 4-port S-parameter files (e.g. for differential probes) are currently not supported.

According to the convention of the LCA (where any port can be an input or an output), these values are directional. This means port 1 of the connector is always connected to the network analyzer and port 2 is always connected to the DUT.

We recommend you use the AdapterChar macro supplied with the network analyzer. This includes this directionality in its characterization. Please refer to the online help on the Network Analyzer for further details.

To assign a file,

1 Click 

.

2 Locate and select the file in the explorer window.

75 Ohm

Select if you measure components with 75 Ohm impedance. Insert the s2p file name for the file that characterizes the minimum loss pad.

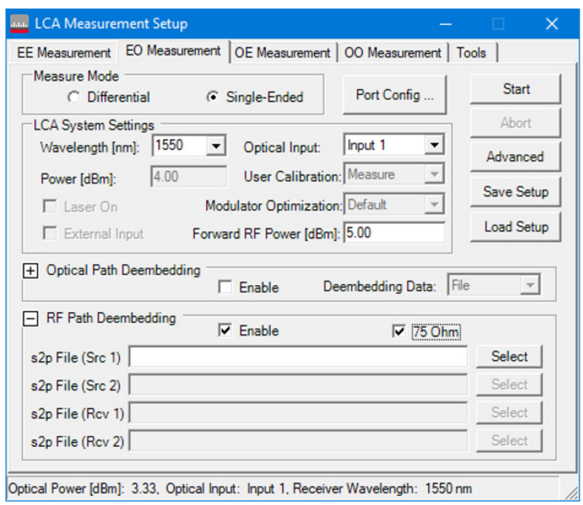


Figure 23 Graphical user interface of the LCA software with enabled RF path deembedding for 75Ohm

Tools

Some of the controls that can be selected on the Tools tab are also available on the measurement tabs. The controls on the measurement tabs are activated when you start the next measurement setup. The controls on the Tools tab are activated immediately.

The Tools tab always showing the current settings of the instrument. These may be different to what is selected on the other tabs.

Receiver

Receiver Wavelength (nm)

Set the wavelength to be used by the optical power meter.

RF Power

Forward RF Power [dBm]

Sets the RF power level for the source port(s).

For balanced measurements (on 4-port network analyzers), Ports 2 and 3 of the network analyzer are forward for EO measurements and reverse for OE measurements.

Increasing the forward RF power for OE measurements increases the optical modulation amplitude.

Reverse RF Power [dBm]

Sets the RF power level for the receiver port(s).

We recommend the factory calibrated default value for the best results.

To reset to the factory default, leave the text box empty or enter a value less than -200 dBm.

Reset UI

The **Reset UI** button resets all LCA settings to default settings.

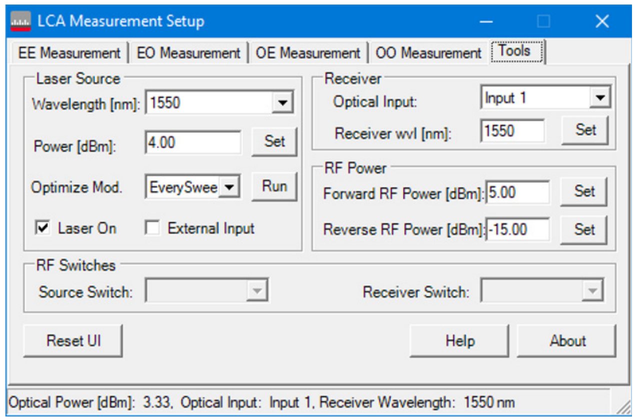


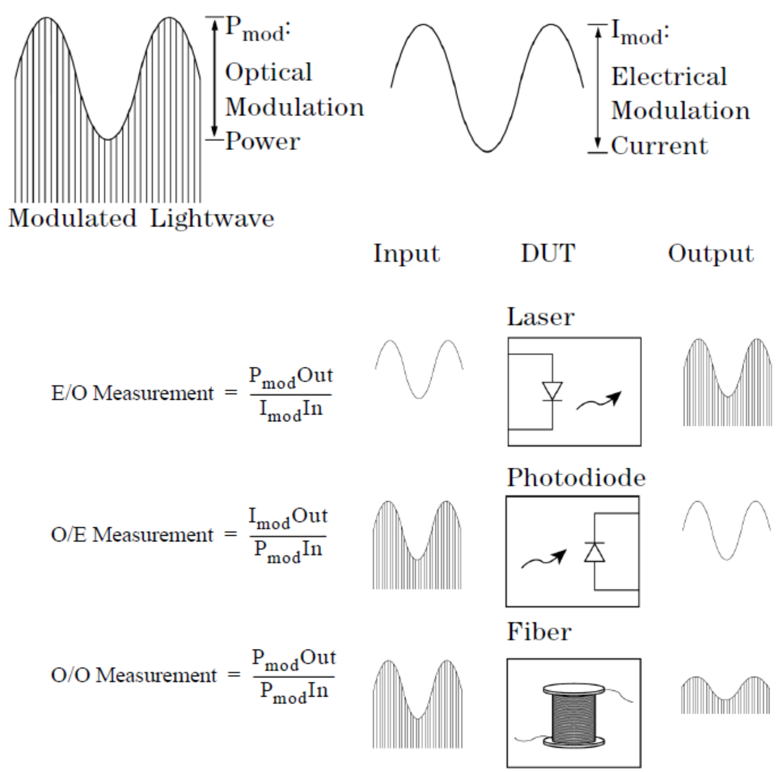
Figure 24 Tools-section of the LCA software

6 Measurement Concepts

General Measurement Techniques and Considerations

The concept of lightwave component analysis is straightforward. Measurements are made of the small-signal linear transmission characteristics of a variety of lightwave components. A precise electrical (signal generator) or optical (laser) source is used to stimulate the component under test and a very accurate optical or electrical receiver measures the transmitted signal. Since characterization over a range of modulation frequencies is required, the frequency of modulation is normally swept over the bandwidth of interest.

Measurements are typically comprised of the appropriate ratio of microwave modulation current (or power) and lightwave modulation power.



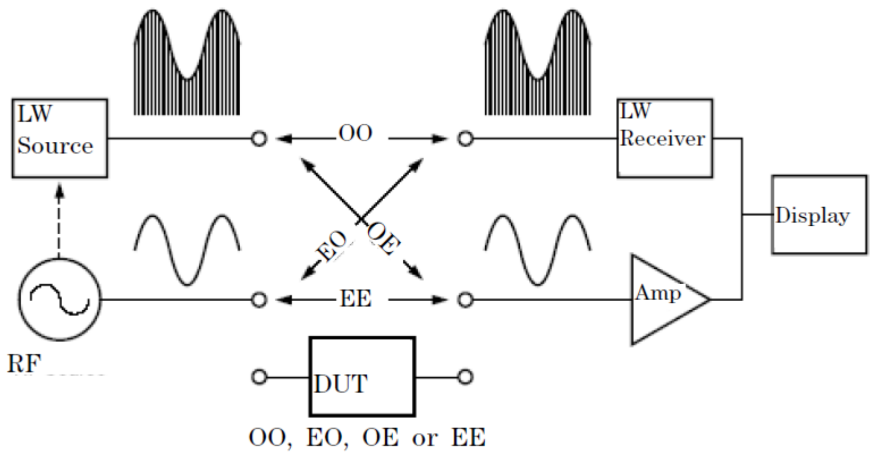
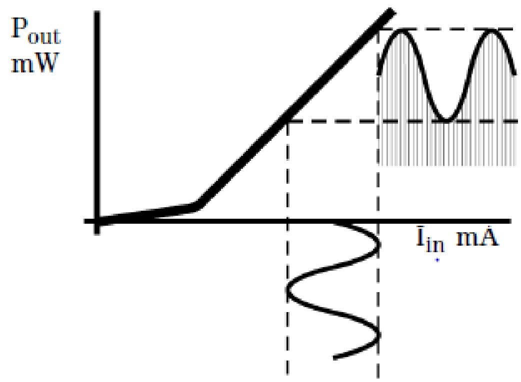


Figure 25 LCA Block Diagram

Figure 25 demonstrates the basic concepts of lightwave component analysis. An analysis of how various signals are used in the measurement process is found in Signal Relationships in Opto-Electric Devices on page 98.

EO measurements (lasers, modulators)

The measurement of an EO transducer is a combination of input modulating current and output optical modulation power. Slope responsivity is used to describe how a change in input current produces a change in optical power. Graphically this is shown in the following figure.



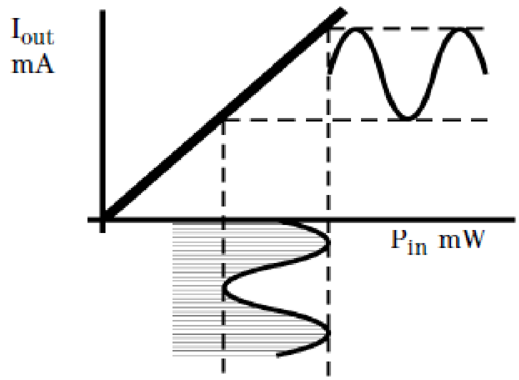
$$\text{Responsivity } R_s(W/A) = \frac{\Delta P_{out}}{\Delta I_{in}}$$

$$R_s(dB) = 20\log_{10}\frac{R_s(W/A)}{W/A}$$

An LCA measures input modulating current and output modulation power and displays the ratio of the two in Watts/Amp, either linearly or in decibels.

OE measurements (photodiodes)

The measurement process for OE devices is similar to EO devices. The measurement consists of the ratio of output electrical modulation current to input optical modulation power. Slope responsivity for OE devices describes how a change in optical power produces a change in electrical current. Graphically this is shown in the figure below.



$$\text{Responsivity } R_r(A/W) = \frac{\Delta I_{out}}{\Delta P_{in}}$$

$$R_r(dB) = 20\log_{10}\frac{R_r(A/W)}{A/W}$$

The LCA measures the input optical modulation power and output modulation current and displays the ratio of the two in Amps/Watt.

OO measurements

Characteristics of purely optical devices can also be measured. In this case, both the stimulus and response are modulated light. The ratio measurement is simply one of gain or loss versus modulation frequency.

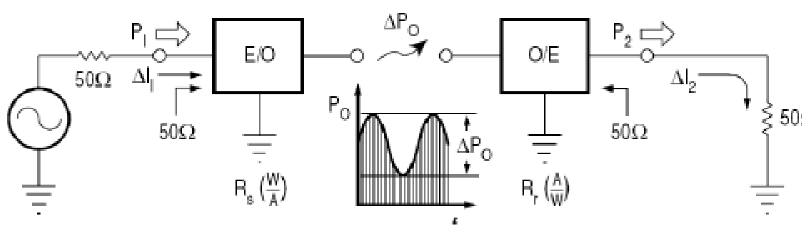
As the lightwave component analyzer is able to measure amplitude and phase, dispersion measurements can be made with very high frequency resolution. This can be used to characterize narrow band optical components with a very high frequency resolution within the modulation bandwidth.

Signal Relationships in Opto-Electric Devices

The LCA measurement technique is built upon concepts used in characterizing RF and microwave devices. “S-parameter” or scattering matrix techniques have proven to be convenient ways to characterize device performance.

The following section will discuss how similar techniques are used in characterizing devices in the lightwave domain. This is intended to show the basis on which EO and OE responsivity measurements are defined.

The figure below is a general representation of a lightwave system, showing input and output signals in terms of terminal voltages, input and output currents, and optical modulation power.



S-parameters are used to describe the transmitted and reflected signal flow within a device or network. For the model, the following S-parameters are defined:

$$S_{11} = \frac{b_1}{a_1}(a_2 = 0)$$

$$S_{22} = \frac{b_2}{a_2}(a_1 = 0)$$

where:

$$a_1 = \frac{\Delta V_1}{\sqrt{Z_0}}$$ incident on E/O device

$$= \Delta I_1 \bullet \sqrt{Z_0}$$

$$b_1 = \frac{\Delta V_{1refl}}{\sqrt{Z_0}}$$ reflected from E/O device

$$a_2 = \frac{\Delta V_2}{\sqrt{Z_0}}$$ incident on E/O device

$$b_2 = \frac{\Delta V_{2refl}}{\sqrt{Z_0}}$$ reflected from E/O device

$$= \Delta I_2 \bullet \sqrt{Z_0}$$

It is interesting to note that delta voltages and currents are used as opposed to RMS values. This is done because we deal with modulation signals in describing lightwave transducers, where a change in optical power is proportional to a change in electrical current or voltage.

The overall system forward gain is defined as:

$$S_{21} = \frac{b_2}{a_1}(a_2 = 0)$$

$$S_{12} = 0$$ (no reverse transmission is assumed)

Though the overall system gain is defined as an S-parameter, the individual transfer functions of the EO and OE devices are typically defined in terms of responsivities, because signals in both the optical and electrical domain are used and optical signals do not lend themselves conveniently to S-parameter definitions. Initially, the input impedance of the EO converter and the output impedance of the OE converter will be assumed to be Z_0 (thus S_{11} and S_{22} are zero).

$$R_s = \frac{\Delta P_0}{\Delta I_i} = \text{E/O source resp}$$

and

$$R_r = \frac{\Delta I_2}{\Delta P_0} = \text{O/E receiver res}$$

Using the above relationships, we can rewrite S_{21} in terms of the transducer responsivities R_s and R_r:

$$S_{21} = \frac{b_2}{a_1}$$

$$= \frac{\Delta I_2}{\Delta I_1}$$

$$= \frac{(R_r \bullet \Delta P)}{(\Delta P / R_s)}$$

$$= R_s \bullet R_r$$

It is convenient to express the transducer functions logarithmically in decibels. The system power gain from a Z_0 source to a Z_0 load can be defined using the above relationships:

$$|a_1|^2 = \text{Power incident on the E/O converter}$$

Power delivered to a

$$|S_{21}|^2 = \frac{|b_2|^2}{|a_1|^2}$$

$$= |R_s \bullet R_r|^2$$

$$= \text{System power gain}$$

$$20\log_{10}|S_{21}| = \text{System gain in dB}$$

$$= 20\log_{10}|R_s \bullet R_r|$$

The responsivities R_S and R_r need to be related to some value in order to have meaning as individual quantities expressed logarithmically, just as 0 dB represents an S_{21} of unity or gain of 1.

Consequently source responsivity will be expressed in Watts per Amp, which in decibels will be related to a conversion efficiency of 1 W/A. Similarly, receiver conversion efficiency will be relative to 1 A/W.

$$20\log_{10}|R_s \bullet R_r| = 20\log_{10}\frac{R_s(W/A)}{W/A} \bullet \frac{R_r(A/W)}{A/W}$$

The individual responsivities can now be expressed individually in decibels:

$$R_s(dB) = 20\log_{10}\frac{R_s(W/A)}{W/A}$$

$$R_r(dB) = 20\log_{10}\frac{R_r(A/W)}{A/W}$$

This now allows us to express the original equations for responsivity in logarithmic terms:

$$R_s(dB) = 20\log_{10}\frac{\Delta P}{\Delta I_1}$$

$$R_r(dB) = 20\log_{10}\frac{\Delta I_2}{\Delta P}$$

Responsivity measurements are now based on the LCA's ability to accurately measure optical modulation power (ΔP_0) and modulation current ($\Delta I_{1,2}$).

The measurement of modulation current is derived from the system characteristic impedance and a measurement of electrical power.

The measurement of optical modulation power is based on a “standard” lightwave receiver whose characteristics are predetermined and known by the LCA.

Single-Ended Measurements

Single port measurements are made on devices when the signal on the electrical port is referenced to ground. This port is described by S-parameters.

Figure 26 Single ended EO measurement

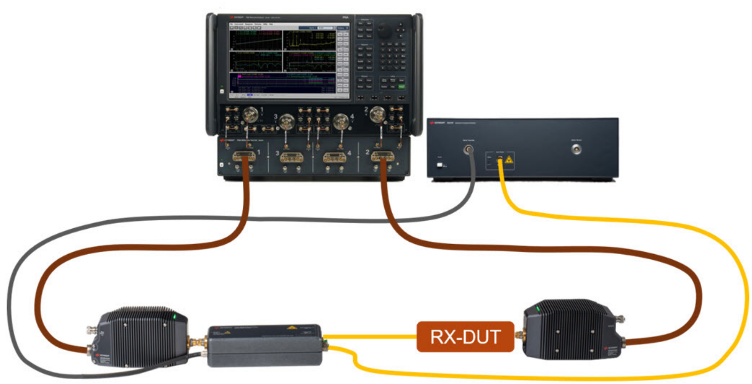


Figure 27 Single ended OE measurement

Differential Measurements (applies to 4-port PNA only)

Differential measurements are made on devices when the signal on the electrical port is the difference between two electrical signals, each of which is referenced to ground. A differential measurement needs two input or two output channels on the network analzyer. The optical port of the device is a third port. For valid differential measurements, make sure the electrical calibration of the network analyzer includes at least three ports.

For more details on differential measurements, please consult the network analyzers user's guide.

For differential device measurements the LCA assumes fixed port configuration. The physical ports 1 and 4 on the network analyzer connect to the LCA test set. The physical ports 2 and 3 on the network analyzer connect to the differential electrical ports of the DUT. Figure 28 shows the physical setup for EO measurement and OE measurement, respectively.

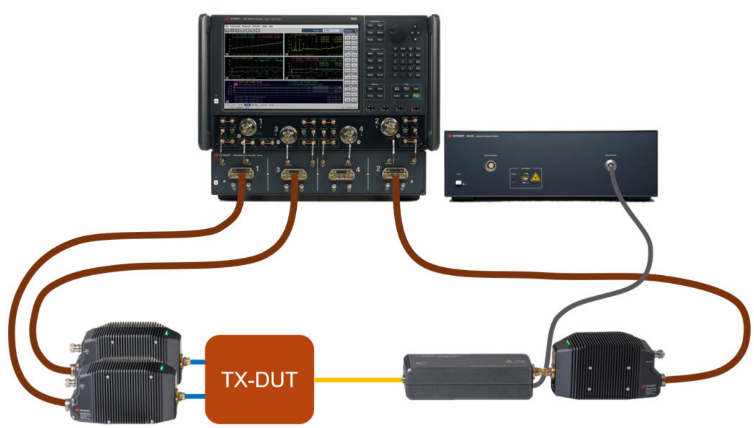


Figure 28 Differential EO measurement setup

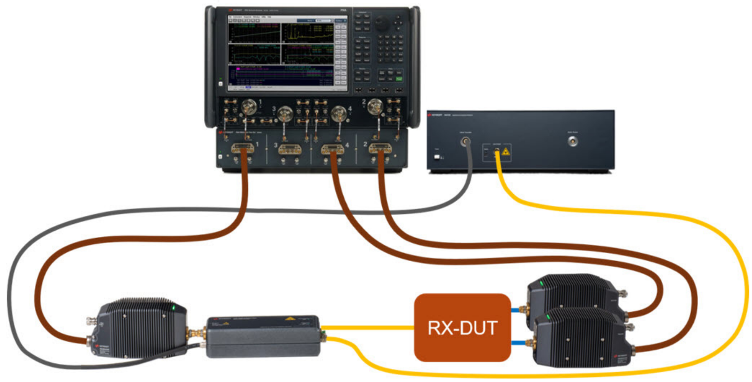


Figure 29 Differential OE measurement setup

For the differential measurement the logical port configuration of the network analyzer need to be set as follows:

- Logical port 1 is assigned to the single ended, unbalanced port and
- Logical port 2 is assigned to the balanced, differential port.

Differential OE measurements

For OE measurements the single- ended (SE), logical port 1 is assigned to physical port 1 and the balanced (BAL), logical port 2 is assigned to the physical ports 2 and 3 (see Figure 30).

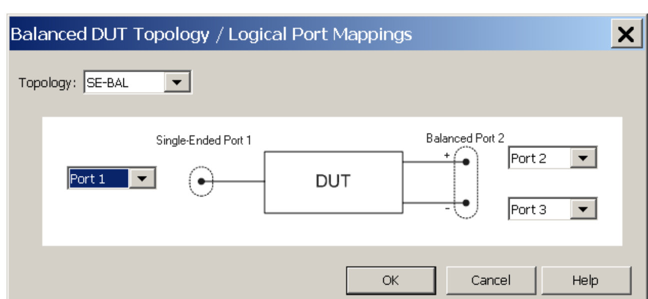


Figure 30 Logical Port Mapping for OE measurement

For OE measurements, the LCA sets up traces for S22, S21, S33, S31 by default.

Differential EO measurements

For EO measurement the single- ended (SE), logical port 1 is assigned to physical port 4 and the balanced (BAL), logical port 2 is assigned to physical ports 2 and 3 (see Figure 31).

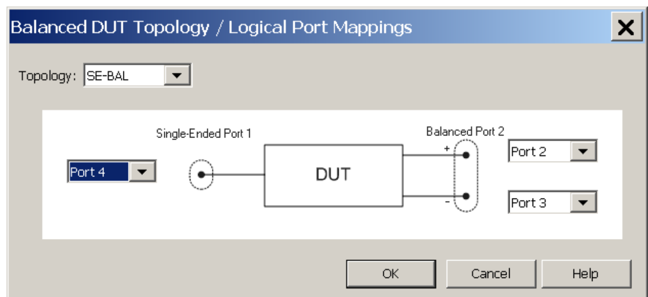


Figure 31 Logical Port Mapping for EO measurement

For EO measurements the LCA sets up traces for S22, S42, S33, S43 by default.

Differential results

When measuring differential devices, the network analyzer displays traces of interest for balanced devices. These include, differential responsivity S, common mode rejection or port imbalance.

Since opto- electronic components are unidirectional, non-reciprocal devices, only the measurement types circled in Figure 32 are relevant.

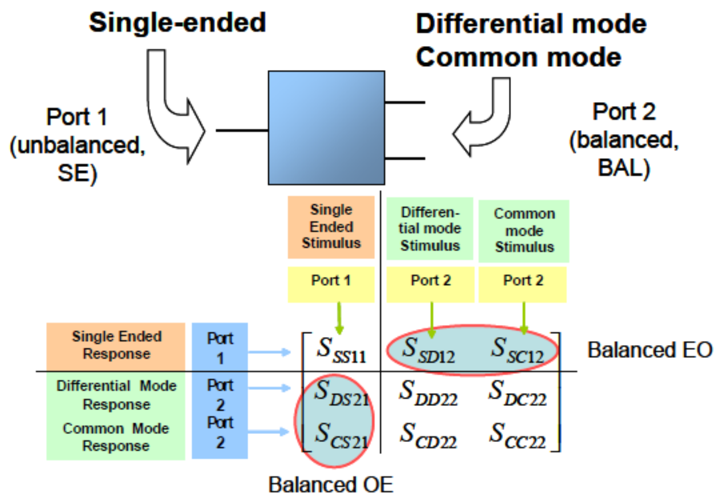


Figure 32 Balanced Measurement types for opto-electronic components

Calibration Concept

The key to making accurate EO, OE, or OO measurements is calibrated instrumentation.

There are a number of calibration stages involved.

The first stage is the electrical calibration of the network analyzer.

This calibration establishes the electrical calibration reference planes for the measurements to be at the RF output port of the frequency extender heads. Whenever there are additional electrical adapters or elements required for connecting the device under test these electrical paths can be accounted for by "RF path deeembedding" (see RF Path Deembedding on page 88).

The second stage is the calibration of the optical test set. This is handled as a “Fixture” by the network analyzer.

For more information on Fixtures, please refer to the documentation of the network analyzer.

The instrument lightwave source and receiver are individually characterized in the factory, from the ruggedized 1.0 mm female to female adapter on Port A to the optical output, and from the optical input to the ruggedized 1.0 mm female to female adapter Port B, respectively.

This electro-optical calibration is provided by Keysight, and includes the two Y1900D ruggedized 1.0 mm adapters supplied and connected to the optical test set. The calibration is with respect to the optical connectors on the front of the optical test set. Whenever there are additional optical adapters or elements connecting to the device under test, these optical paths can be accounted for by "optical path deeembedding" (see “Optical Path Deembedding on page 86).

The systematic responses of these two stages of calibration can then be deembedded, yielding the response of the device under test (DUT). (See Signal Relationships in Opto-Electric Devices on page 98 for more detail.)

Triggering Concepts

It is possible to trigger the DUT measurements either directly on the network analyzer or using the LCA software, by pressing the LCA "Single" or "Continuous" keys.

However there are some differences:

- when the modulator bias optimization mode is set to"Every Sweep" or "Continuous" (recommended), using the LCA software starts a modulator bias optimization before starting a DUT measurement. This is not done when triggering the measurements directly on the network analyzer.
- when doing EO or OO measurements, using the LCA software, it measures the DC level of the optical power on the receiver, and adjusts the deembedding data if necessary. This means more accurate results than a measurement started directly on the network analyzer. During "LCA Measurement Setup" it is assumed that the DUT has no optical loss and the receiver deembedding is setup for a DC power level equal to the selected optical output power of the LCA. When the internal light source is not used (EO measurement in "Default" mode), the receiver deembedding is setup for a DC power level of 0.0 dBm.

During measurements started using the LCA software, the network analyzer does not respond to any keystrokes on the keypad. The only way to stop a measurement during a sweep is to press the "Abort Measurement" button in the LCA Server window.

When doing an OE measurement with modulator bias optimization mode set to "Single", this time window is very short, since the LCA does nothing between the sweeps. In such cases, the running measurements can always be stopped by pressing the "Abort Measurement" button on the LCA Server window.

Measuring at Different Wavelengths and with the External Optical Source Input

You can also make EO, OE and OO measurements on devices at wavelengths that are different from the default wavelengths.

The LCA uses two wavelength correction files "LCA_TxCorr.csv" and "LCA_RxCorr.csv". These files contain typical correction data for the wavelength dependency of the LCA Optical Transmitter and LCA Optical Receiver. When starting up or resetting, the LCA server reads the data of these two files.

The files "LCA_RxCorr.csv" and "LCA_TxCorr.csv" are located in the following directory:

C:\ProgramData\Agilent\LCA\Table\SN...\

where SN... is the serial number of the optical test set.

For higher accuracy, you could measure the Rx correction data for your specific test head and wavelength and enter these values into the "LCA_RxCorr.csv" file. Since the LCA uses relative correction values between the closest internal wavelength and the wavelength you select, it is important that you measure the Rx responsivity for every internal wavelength and your additional wavelengths. Follow the following procedure:

1 In "Tools" Tab set the receiver wavelength to either 1550 nm or 1310 nm.
2 Apply an external laser source at wavelength set to the internal wavelengths (1310 nm and/or 1550 nm) and known power (e.g. 0 dBm) to the LCA Optical Receiver input.
3 Record the displayed power on the LCA using the optical power monitor. The optical power is displayed at the bottom of the LCA macro screen, or you can activate the optical power monitor display using the LCA function keys in the macro menu.
4 For every additional wavelength apply laser light with same known power (e.g. 0 dBm) and record the displayed power. Do not change the receiver wavelength setting in the "Tools" tab.
5 In the "LCA_RxCorr.csv" file, replace the default values with the recorded power values in 2nd column for the optical input for each wavelength measured (i.e. both the internal and the additional wavelengths).
   Delete all other wavelength values. (Note: LCA interpolates for missing wavelengths.)

We do not recommend to change the values in the "LCA_TxCorr.csv" file. Instead we recommend you measure with user calibration for measurements using an external input.

EO measurements

The wavelength box on the EO tab is an editable, drop down list. This means you can select one of the default wavelengths, or enter a different wavelength.

If you select a wavelength other than the default wavelengths, the LCA checks for the closest default wavelength. The calibration data for this wavelength is used for the LCA measurements.

Next the LCA checks if the "LCA_RxCorr.csv" file is available.

- If not, no wavelength correction is applied.
- If the file is found, the LCA performs a wavelength correction.
- If the wavelength you entered is not covered by the"LCA_RxCorr.csv" file, an error message will be shown.

If the selected wavelength is covered by the correction file, the correction factor is calculated from the values found in the file. This correction factor is applied to the values from the internal optical power meter and to the calibration data used for the LCA measurements.

OE measurements

On the OE tab of the LCA user interface, if you check the external (laser) input check box, you can edit the wavelength. The principles described for EO measurements are applied to the transmitter side, using the wavelength correction data in the file: "LCA_TxCorr.csv".

The LCA expects the power value in the "Power" box to be the optical power at the Optical Output of the LCA test head.

To set the right power value if you are using an external source:

1 Use a short patch cord to connect the Optical Output to the Optical Input.
2 Switch to the "Tools" tab of the user interface and set the receiver wavelength to the external laser wavelength and check the "External Input" check box.
3 Switch on your external source and run the modulator optimization in the "Default" mode.
4 When the optimization is finished, transfer the optical power value displayed in the status bar to the "Power" box.

OO measurements

The principles described above for EO and OE measurements also apply to OO measurements.

7 Maintenance

This system should be serviced only by authorized personnel.

WARNING **Using controls or adjustments or performing procedures other than those specified in the documentation supplied with your equipment can result in hazardous radiation exposure.**

Cleaning

Safety Precautions

The following Cleaning Instructions contain 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.

WARNING

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.

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/m2). 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.

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 protected 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.

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 try to drink this alcohol, as it may seriously damage 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.

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 produce scratches.

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

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.

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
- Lens cleaning papers
- 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.

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 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 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.

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.

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.

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.

WARNING **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.**

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 patch cord 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.

Keep the caps on the equipment always 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

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

Cleaning Instrument Housings

WARNING **Do not open the instruments as there is a danger of electric shock, or electrostatic discharge.**

CAUTION **Do not open instruments. Opening the instrument can cause damage to sensitive components, and in addition your warranty will be voided.**

CAUTION **Do not use isopropyl alcohol to clean instrument housings.**

Use a dry and very soft cotton tissue to clean the instrument housing and the keypad. In the case of heavy dirt, you can moisten the cotton tissue in water.

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 on page 114 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.

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

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 project 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 particularly when there is greasy dirt on the connector:

1 Moisten a new cotton-swab with isopropyl alcohol.
2 Clean the connector by rubbing the cotton-swab over the surface using a small circular movement.

3 Take a new, dry soft-tissue and remove the alcohol, dissolved sediment and dust, by rubbing gently over the surface using a small circular movement.

4 Blow away any remaining lint with compressed air.

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.

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 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.**

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 Blow away any remaining lint with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly 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 Using a new, dry pipe-cleaner, and a new, dry cotton-swab remove the alcohol, any dissolved sediment and dust.

5 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.

They can 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.

- Blow away any dust or dirt with compressed air.

Procedure for Stubborn Dirt

Use this procedure particularly 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 pushing and pulling a new, dry pipe cleaner into the opening. Rotate the pipe cleaner slowly as you do this.

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

4 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.

How to clean instruments with a fixed connector interface

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.

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 be misaligned.

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 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 mm. 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.

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

For instruments with a deeply recessed lens interface (for example the Keysight Technologies 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 the Keysight 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 do the following:

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

   b 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 procedure for light dirt is not sufficient.

Using isopropyl alcohol should be your last choice for recessed lens interfaces because of the difficulty of cleaning out any dirt that is washed to the edge of the interface.

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 Reference Reflectors, 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.

- 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.
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 to 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 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, do the following:

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.

8 Troubleshooting

This system should be serviced only by authorized personnel.

WARNING **Using controls or adjustments or performing procedures other than those specified in the documentation supplied with your equipment can result in hazardous radiation exposure.**

KEYSIGHT TECHNOLOGIES

Checking the Operation of the Lightwave Component Analyzer

1 Shut down the network analyzer, as described in the network analyzer user guide and online help.

2 Power down both the network analyzer and the LCA Test Set Controller.

3 Start the equipment and perform an electrical calibration of the network analyzer, as described in Starting the Lightwave Component Analyzer on page 50.

4 Perform the performance verification, as described in Performance Quick Check on page 39.

Event Log

Further troubleshooting information is available from the event log.

You can find this log in the \bin subdirectory of the directory where the LCA program is installed.

If you want to refer to the log, save a copy of it before you restart the LCA server. The log file is cleared each time the LCA server is restarted.

If you have a problem with the LCA, you can also send the event log file to your Keysight contact person to speed up diagnosis.

9 Reinstalling and Updating the Software

KEYSIGHT TECHNOLOGIES

Backing Up your LCA Data

The information for your particular configuration of the LCA and the factory calibration data are kept in the “Table” and “Information” subdirectories of the directory in which the software is installed.

These two directories are backed up under the "LCA" directory on the "D" drive of your network analyzer. These directories are not overwritten when performing the network analyzer's system recovery process.

Please refer to the user documentation of the network analyzer for information on backing up calibration data.

Reinstalling the LCA Software

There are two cases:

- Updating the LCA software.
- Reinstalling the LCA software completely, for example after recovering the network analyzer

Updating the LCA software

1 Before updating the software, you must remove the existing software.
   a In Windows’ Settings, go to the Control Panel and select Add or Remove Programs.
   b Select the LCA application from the list of programs.
   c Remove the program.
2 Start the LCA setup software LCAInstaller.msi.
3 Follow the instructions on the screen. We recommend you use the default settings.

Reinstalling the LCA software

Preparing the reinstallation.

1 Download the LCA software from the Keysight website to a location on the network analyzer's "D" drive.

2 Alternatively, copy the software installation file from the CD-ROM supplied with the LCA to the "D" drive, or run the software installation file directly from the CD-ROM using a USB-connected optical drive.

Reinstalling the software

1 On the "D" drive location, or on the CD-ROM, find the directory \Reinstallation\LCA Software\<version number>\ and start the LCA installation program.

2 Follow the instructions on the screen.

We recommend you use the default settings.

Note the directory to which the LCA application is installed.

3 The registry script in the next step installs LCA related functions in the first 6 positions of the network analyzers macro group "Macro 1".

In this LCA directory, right click on the file NWAShortcuts.reg.

4 From the context menu, select Merge.

Restoring the hardware calibration files

1 On the network analyzer’s “D” drive, open the directory “LCA”.

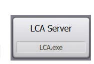
2 Copy all folders (with all their sub-folders) into the LCA program data directory: C:\ProgramData\Agilent\LCA”. (default directory).

Starting the LCA Server

NOTE **When starting the “LCA Measurement Setup” with no server running, the server is started automatically.**

1 Run the network analyzer.

2 Double-click on the “LCA Server” shortcut on the Desktop of the network analyzer.

3 Or start the LCA server by pressing 

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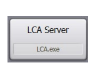
4 Press 

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10 Definition of Terms

KEYSIGHT TECHNOLOGIES

Definition of Terms

Absolute frequency response uncertainty

The maximum difference between measured Responsivity of a device under test and the actual (true) responsivity, expressed in dBe.

Conditions: as specified.

NOTE Any change in the cabling after calibration add to the specified absolute frequency response uncertainty.

Measurement: Based on a reference RF O/E receiver.

Average output power (optical)

The (actual or nominal) average output power from the LCA optical output.

Average output power range (optical)

The nominal (selectable) range for Average output power (optical).

Average output power stability (optical)

The variation of the optical Average output power (optical) P over time, calculated as

$$\pm\frac{\max_t\{P(t)\} - \min_t\{P(t)\}}{2}$$

where maxt{} and mint{} are the maximum and minimum value over time t.

Conditions: Time period as specified after modulator auto bias ("modulator optimization") is performed with the selected wavelength. Other conditions as specified.

Measurement: Using an average power meter with averaging time set to 1 s.

Average output power uncertainty (optical)

The maximum difference between actual (true) Average output power (optical) and the nominal (selected) average output power.

Conditions: After modulator auto bias ("modulator optimization") performed with the selected wavelength. Other conditions as specified.

Measurement: Using an average power meter with averaging time set to 1 s.

Average power measurement uncertainty (optical)

Maximum difference between measured average (over time) optical power and true average optical power at the LCA optical input.

Measurement: Comparison with an average power meter with averaging time set to 1 s.

Average power measurement range (optical)

The range for the average optical power where the specification for Average power measurement uncertainty (optical) applies.

Decibel (dBm, dBo, dBe)

A ratio in decibel (dB) is calculated as 10-log10{ratio}. Special cases:

- dBo: specifically the ratio of optical powers (‘o’ for ‘optical’).
- dBe: specifically the ratio of electrical powers (‘e’ for ‘electrical’).
- dBm: power level related to 1 mW (electrical or optical).

NOTE

Differences of powers in dBm are written as “dBo” for optical powers or “dBe” for electrical powers.

$dB_{W/A}$: The square of the Responsivity R divided by 1 A/W,

$$10\log_{10}\left\{\left(\frac{R}{1A/W}\right)^2\right\}$$

or

$$20\log_{10}\left\{\frac{R}{1A/W}\right\}$$

$dB_{W/A}$ is defined correspondingly to $dB_{W/A}$.

NOTE

Differences of responsivities in $dB_{A/W}$ or $dB_{W/A}$ are written as “dBe”.

NOTE For O/E and E/O converters with linear relation between optical power and electrical current, optical ratios in dBo have half the magnitude of the electrical ratios in dBe.

Electrical loss of optical test set

The electrical (RF) signal loss of the optical test set between Network Analyzer electrical port and LCA electrical port. LCA set to E/E mode.

Conditions: Frequency range as specified.

Frequency response repeatability

In repeated measurements of the (absolute) frequency response under constant conditions, the repeatability ±Rep at each modulation frequency is defined as twice the standard deviation, StDevi, of the measured responsivities Ri over the repetitions i:

$$\text{Rep} = 2 \times \text{StDev}_i\{R_i\}$$

Conditions: fixed cables and unchanged connections. Other conditions as specified.

Measurement: using a stable DUT.

Group delay (GD)

The signal delay time caused by a transmission path (component). The group delay is derived from the phase change dφ of a harmonic signal detected after the path (component) resulting from a small frequency change dfmod of the signal,

$$\text{GD} = \frac{d\varphi}{df_{mod}} / 360°$$

with phase change dφ expressed in degrees.

Group delay uncertainty

Specifies the maximum difference between measured and actual Group delay (GD).

NOTE For E/O and O/E, group delay uncertainty excludes a constant group delay offset (see Phase uncertainty). Other conditions as specified.

Measurement: Derived from Phase uncertainty.

Maximum linear average input power (optical)

The maximum average optical input power at the LCA optical input for which the system specifications apply.

Conditions: as specified.

Maximum safe average input power (optical)

Maximum optical power that can be applied to the LCA optical input without permanent change of the LCA's characteristics.

CAUTION Applying more than the specified maximum safe input power may damage the LCA.

Minimum measurable frequency response (noise floor)

The average of the Responsivity measured by the LCA on a DUT with zero output, expressed in Decibel (dBm, dBo, dBe). The value is calculated by averaging the measured responsivity in linear space (rather than decibel space) over the modulation frequency within a specified modulation frequency range.

Conditions: As specified.

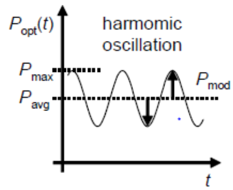
NOTE Responsivity values are converted from Decibel (dBm, dBo, dBe) values to linear values by: linear = $10^{decibel/20}$. The average is converted back to decibels by: decibel = $20*\log_{10(linear)}$.

Modulated optical power

The amplitude of a harmonic optical power modulation. The modulated optical power is calculated from the peak optical power P_{max} and the average optical power P_{avg},

in Watts: $P_{mod} = P_{max} - P_{avg}$

in dBm: $P_{mod,dB} = 10\text{-}\log(P_{mod} / 1mW)$.



NOTE Modulated optical power divided by average optical power is a value between 0 (no modulation) and 1 (full modulation). See OMI (optical modulation index).

NOTE For full modulation, modulated optical power equals average optical power.

Operating frequency range (optical test set)

The modulation frequency range for which the LCA optical test set (including optical transmitter and receiver) is designed to supply give measurement results.

OMI (optical modulation index)

Specifies the Modulated optical power divided by Average output power (optical).

Condition: modulation frequency as specified.

NOTE OMI is a value between 0% (no modulation) and 100% (full modulation).

Operating input wavelength range

The wavelength range on the LCA optical input for which the LCA system is designed.

Optical return loss (LCA optical input)

Ratio between incident optical power at LCA optical input and reflected optical power, expressed in dBo.

Output wavelength

Center of gravity wavelength of the signal at LCA optical output. Wavelength is defined as wavelength in vacuum.

Phase uncertainty

When measuring the phase difference of the harmonic signals between DUT input and DUT output at a given modulation frequency, phase uncertainty specifies the maximum deviation between measured and actual phase difference.

NOTE

For E/O and O/E, phase uncertainty excludes the effect of a (constant but unknown) Group delay (GD) offset (resulting from a path length uncertainty in the LCA system). A group delay offset ⊗GD at modulation frequency f_{mod} causes a phase change of $\otimes\phi = 360° - \otimes GD - f_{mod}$ expressed in degrees.

Measurement: Based on a reference RF O/E receiver.

Relative frequency response uncertainty

When taking the difference between measured Responsivity of a device under test and actual (true) responsivity in dBe over modulation frequency, the system relative frequency response uncertainty is ± half the peak- to-peak difference.

Conditions: Modulation frequency range as specified. Other conditions as specified.

NOTE

Changes in the cabling after user e-cal add to the specified relative frequency response uncertainty.

Measurement: Based on a reference RF O/E receiver.

Responsivity

The amplitude response R of a device under test (DUT) to a harmonic stimulus:

- E/O measurement: R is the ratio of Modulated optical power in Watt to the electrical stimulus amplitude in Ampere, expressed in W/A.
- O/E measurement: R is the ratio of electrical response amplitude in Ampere to the Modulated optical power in Watt, expressed in A/W.

In both cases, responsivity in Decibel (dBm, dBo, dBe) (“$dB_{W/A}$“ or “$dB_{A/W}$“) is calculated as 20-log(R).

- O/O measurement: R is the difference between the Modulated optical power in dBm at the DUT output and at the DUT input, expressed in dBo. If expressed in dBe, it is twice this number.

NOTE **Responsivity of an O/E or E/O device may be called conversion efficiency. For an O/O device, R [dBo] = -(insertion loss [dB]).**

References

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

11 Characteristics and Specifications

Characteristics and Specifications

For the characteristics and specifications of the N4372E, refer to the datasheet at:
https://www.keysight.com/us/en/assets/3119-1065/data-sheets/5992-4215.pdf

Declaration of Conformity

Declarations of Conformity for this product and for the Keysight products may be downloaded from the Web. Go to http://www.keysight.com/go/conformity.

You can then search by product number to find the latest Declaration of Conformity.

12 Regulatory and Warranty Information

KEYSIGHT TECHNOLOGIES

Regulatory Information

Compliance with Canadian EMC Requirements This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme à la norme NMB-001 du Canada.

Acoustic Noise Emission
LpA < 50 dB Operator
position Normal
operation per
ISO 7779

Declaration of Conformity

For latest DoC, please visit the web link:
http://www.keysight.com/go/conformity

Warranty

All system warranties and support agreements are dependent upon the integrity of the Keysight N4372E Lightwave Component Analyzer. 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.

Remove all doubt

Keysight offers a wide range of additional expert test and measurement services for your equipment, including initial start- up assistance onsite education and training, as well as design, system integration, and project management.

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Keysight equipment throughout its lifetime. Your equipment will be serviced by Keysight- trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements. For more information on repair and calibration services, go to www.keysight.com/find/removealldoubt

Keysight E-mail Updates

Get the latest information on the products and applications you select. www.keysight.com/find/emailupdates

myKeysight

Quickly choose and use your test equipment solutions with confidence. www.keysight.com/find/mykeysight

Keysight Open

Keysight Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Keysight offers open connectivity for a broad range of system ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

www.keysight.com/find/open

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Keysight Online Information

Optical test instruments

www.keysight.com/find/oct

Lightwave Component Analyzers

www.keysight.com/find/lca

Polarization solutions

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Spectral analysis products

www.keysight.com/find/osa

Electro-optical converters

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Firmware and driver download

www.keysight.com/find/octfirmware

Keysight photonic discussion forum

http://www.keysight.com/find/photonic_forum

For Network analyzer related literature, please visit: Keysight Network Analyzers:

www.keysight.com/find/na

Mechanical and Electronic Calibration Kits: www.keysight.com/find/ecal

RF Test Accessories, Cabinets, Cables: ww.keysight.com/find/accessories

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