ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Keysight / Agilent N7004A* at our website: *Click HERE*

Keysight N7004A 33 GHz Optical-to-Electrical Converter

User Guide



KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Notices

© Keysight Technologies 2016

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies as governed by United States and international copyright laws.

Manual Part Number

N7004-92000

Edition

First Edition, November 2016

Available in electronic format only

Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

U.S. Government Rights

The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement ("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data. 52.227-14 (June 1987) or DFAR 252.227-7015 (b)(2) (November 1995), as applicable in any technical data.

Safety Notices

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.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Contents

1 N7004A - Overview

Introduction 6

Usage 7

Features 8

Specifications and Characteristics 9

Dimensions 10

2 Setting up the N7004A O/E Converter

Prerequisites 12

Oscilloscope Bandwidth Requirements 12

Step 1 - Clean the Fiber-Optic Connectors 13

To visually inspect the fiber-ends 13

To clean the fiber-end of the N7004A fiber-optic connector 14

To clean the fiber-end of the mating fiber-optic cable or patch cable 15

Step 2 - Connect the N7004A Output to a Compatible Keysight Oscilloscope 17

Step 3 - Connect a Fiber-optic Cable to the N7004A Optical Input Connector 18

Selection of the Fiber-optic Cable 18

Guidelines for Making the Connection 18

Aligning the Keying Features while Making the Connection 18

Step 4- Configure the N7004A Setup on the Infiniium Software 20

Selecting the Wavelength 20

Adjusting Conversion Gain for a User-defined Wavelength 21

Configuring the Bandwidth Limits for the Oscilloscope and its Channel 23

Adjusting the Vertical Settings for the Oscilloscope Channel 24

Adding and Configuring Optical Measurements 24

Step 5 - Perform Dark Calibration 27

What is Dark Calibration 27

When to perform Dark Calibration 27

To perform dark calibration 27

Reasons for the Failure of the Dark Calibration 29

3 Making Optical Measurements and Analyzing Results

N7004A Optical Measurements 32

Optical Measurement Results 32

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Performing Eye Mask Testing 35
Types of Masks Supported with N7004A 35
Mask Margins 35

4 Remotely Controlling the N7004A Measurement Setup

Sample Remote Control Setup of N7004A 38

SCPI Commands for Controlling the N7004A Setup 39
:MEASure:OPOWer 40
:MEASure:CGRade:OLEVel 41
:MEASure:CGRade:ZLEVel 42
:MEASure:OMAMplitude 43
:MEASure:ERATio 44

5 Performance Verification for N7004A

Test Strategy 46
Test Interval 46
Test Equipment 46
Test Procedure 47

6 Calibration Strategy

7 Troubleshooting

Troubleshooting Flowchart 54

8 Returning the N7004A for Repair or Service

Contacting Keysight Technologies 55

9 Safety and Regulatory Information

Instrument Markings 58

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

1 N7004A – Overview

Introduction / 6
Usage / 7
Features / 8
Specifications and Characteristics / 9
Dimensions / 10

This chapter introduces the N7004A O/E Converter and lists its features, usage, characteristics and specifications.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Introduction

The N7004A 33 GHz optical-to-electrical converter directly converts optical signals into electrical signals for convenient analysis on a compatible Infiniium real-time oscilloscope.

The N7004A is a high-sensitivity photodetector module that comes with an FC/PC input connector to receive optical telecom or datacom signals from an optical source/transmitter through a single-mode or a multimode fiber.

The electrical output of the N7004A is provided for analysis to an Infiniium real-time oscilloscope through the AutoProbe II connector that connects the N7004A to the oscilloscope's channel input.

NOTE

The N7004A O/E Converter is designed for use with oscilloscopes that have AutoProbe II interface channel inputs.

In addition to providing connectivity between the oscilloscope and N7004A, this interface also provides power to the N7004A as well as ensures the auto-configuration of probe type and attenuation settings when you connect the N7004A to the oscilloscope.



Figure 1 N7004A Optical-to-Electrical Converter - Components

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Usage

The following points highlight the broad usage scenarios of N7004A as an optical measurement solution:

- To measure optical telecom or datacom signals up to 28 Gbps data rates.
- To view the raw (unfiltered) response of the optical source/transmitter under test.
- To take industry-standard optical measurements on the optical source/transmitter under test. The N7004A supports 4th Order Bessel Thomson filter to help you accomplish this.
- To troubleshoot and perform characterization for the optical source(s) used in your optical system.
- To test system boards with an embedded optical transceiver in scenarios where there is no clock signal. The N7004A and real-time oscilloscope setup does not require an external clock source to trigger the oscilloscope for capturing data.
- To view and troubleshoot a one-time, transient single-shot event.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Features

- DC to 33 GHz of electrical bandwidth.
- You can either use front panel controls on the oscilloscope or remote programs to set up, configure, and make measurements using the N7004A.
- Critical optical signal measurements can be made in real time using the N7004A with an Infiniium Realtime oscilloscope.
- Supports built-in trigger source. You need not configure a trigger setup explicitly for making optical measurements using the N7004A.
- Supports two filter types:
  - Brick Wall filter
  - 4th Order Bessel Thomson filter
- Provides a built-in software reference receiver filter. The reference receiver measurement is made with a 4th Order Bessel Thomson filter set to 75% of the data rate. This reduces the effects of the transmitter's high frequency overshoot and noise.
- Provides a complete suite of optical measurements with data presented in watts in the Infiniium software GUI.
- Allows you to perform eye-mask tests and measure eye diagram parameters including extinction ratio.
- Allows you to improve the accuracy of the extinction ratio measurement by providing the option of Dark Calibration which is performed by covering the optical input of the N7004A. The optical power reading thus obtained from dark calibration is subtracted from the optical measurements to achieve accuracy in measurements.
- Allows you to load masks with margin or draw your own mask or create an automask.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Specifications and Characteristics

Table 1 N7004A Environmental Specifications

Item	Description
Use	For indoor use only
Temperature	Operating 10°C to +40°C (50°F to +104°F) Non-operating -40°C to +70°C (-40°F to +158°F)
Altitude	Up to 4,600 meters (15,000 ft)
Maximum relative humidity	80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C
Weight	350 g (0.77 lbs)
Dimensions	Refer to the topic "Dimensions" on page 10.

Table 2 Bandwidth Performance Specification for N7004A

Item	Description
Bandwidth, warranted (electrical, –3 dBe)	32 GHz (with Brickwall filter) 21.3 GHz (with 4th order Bessel Thomson filter)
Specifications are the performance standards against which the product is tested. It represents warranted performance of a calibrated instrument.	

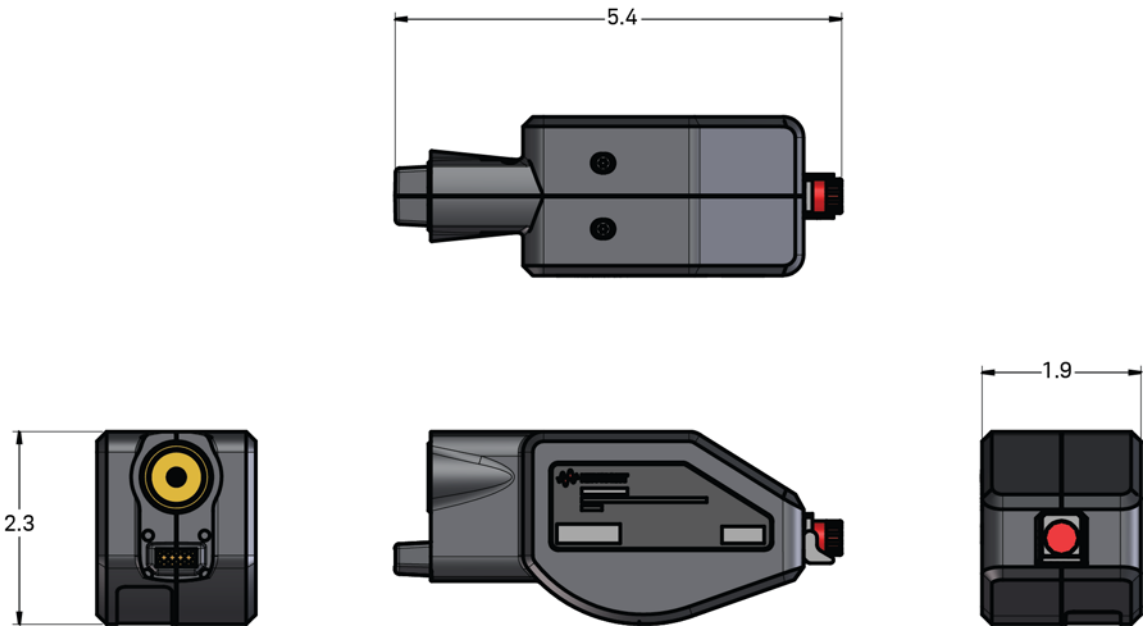
Table 3 N7004A Optical and Electrical Characteristics

Item	Description
Bandwidth, typical (electrical, –3 dBe)	33 GHz (with Brickwall filter) 22 GHz (with 4th order Bessel Thomson filter)
Rise time (10 to 90%), typical	13.3 psec (with Brickwall filter) 17.7 psec (with 4th order Bessel Thomson filter)
Rise time (20 to 80%), typical	9.4 psec (with Brickwall filter) 12.3 psec (with 4th order Bessel Thomson filter)
Optical output coupling	DC
Wavelength range	750 to 1650 nm
RMS noise (iW)	See the noise characteristics table in the data sheet
Conversion gain (V/W)	850 nm Multimode: –68 (min), –75 (typical) 1310 nm Multimode/Single Mode: –105 (min), –110 (typical) 1550 nm Single Mode: –105 (min), –110 (typical)
Maximum linear input power	4 mW
Maximum non-destructive input power	8 mW
Input return loss (dB)	850 nm Multimode: –17 (typical), –15 (max) (fully filled fiber) 1310 nm Single Mode: –18.5 (typical), –16 (max) 1550 nm Single Mode: –14 (typical)
Optical Input Connector type	50/125 µm fiber with an FC/PC connector Compatible with single-mode or multimode fibers

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Dimensions

The N7004A dimensions shown below are in Inches.



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

2 Setting up the N7004A O/E Converter

Prerequisites / 12
Step 1 - Clean the Fiber-Optic Connectors / 13
Step 2 - Connect the N7004A Output to a Compatible Keysight Oscilloscope / 17
Step 3 - Connect a Fiber-optic Cable to the N7004A Optical Input Connector / 18
Step 4- Configure the N7004A Setup on the Infiniium Software / 20
Step 5 - Perform Dark Calibration / 27

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Prerequisites

Before you start using the N7004A O/E Converter, ensure that the following prerequisites are met.

Prerequisites
Compatible Oscilloscopes
The following Keysight Real-time Infiniium oscilloscopes are compatible with the N7004A O/E Converter. - V-Series - Z-Series - 90000 Q-Series - 90000 X-Series
Oscilloscope Software
Infiniium baseline software version 5.70 or higher

Is Your Oscilloscope Software Up-to-Date?

Keysight periodically releases software updates to support your probe, fix known defects, and incorporate product enhancements. To download the latest firmware, go to www.keysight.com and search for your oscilloscope's series. Then click on the "Drivers, Firmware & Software" tab.

Oscilloscope Bandwidth Requirements

The real-time oscilloscope bandwidth that you need when using the N7004A is calculated as:

Oscilloscope bandwidth >= Optical data rate (Gbps) * 0.75 * 3/2

For example, if the optical data rate is 10 Gbps, then the oscilloscope bandwidth requirement is:

*10 Gbps * 0.75 * 3/2* which is equal to *11.25 GHz*.

Based on the above-mentioned calculations, the following table provides a list of the recommended bandwidth of V-series Infiniium oscilloscopes needed for various optical data rates operations.

Optical Data Rates	Reference Receiver Bessel Thomson Bandwidth *(0.75 * optical data rate)*	Oscilloscope Bandwidth Requirement *(3/2 * Reference Receiver Bandwidth)*	Recommended Bandwidth *(Values are given for V-series Oscilloscopes)*
4.25 Gbps	3.1875 GHz	>4.78 GHz	8 GHz
10 Gbps	7.5 GHz	>11.25 GHz	13 GHz
25 Gbps	18.75 GHz	>28.125 GHz	33 GHz
28 Gbps	21 GHz	>31.5 GHz	33 GHz

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Step 1 - Clean the Fiber-Optic Connectors

Fiber-optic connectors are very sensitive, easy to damage, and expensive to replace. These connectors can be easily damaged when connected to dirty or damaged cables and accessories. Therefore, you must clean the fiber ends of the N7004A fiber-optic connector and the mating fiber-optic cable or patch cable before each and every time a connection is made.

CAUTION

Damage to the fiber-optic connectors can:

- Degrade measurement accuracy and repeatability.
- Cause expensive damage to instruments.

Repair of the N7004A connector damaged due to lack of cleaning, improper use, or improper cleaning procedures is NOT covered under warranty.

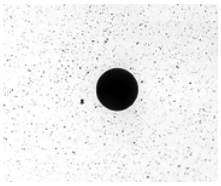
NOTE

Keep fiber-optic connectors covered when not in use. The N7004A shipment includes protective plastic caps for covering its fiber-optic connector.

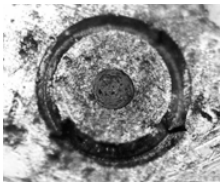
To visually inspect the fiber-ends

The visual inspection of the fiber-ends can help you identify any damage to the ferrule or end of the fiber, any stray particles, or finger oil that can have a significant effect on connector performance.

The following picture shows the end of a clean, problem-free fiber-optic connector. The dark center circle is the fiber's 125 mm core and cladding which carries the light. The surrounding area is the ferrule.

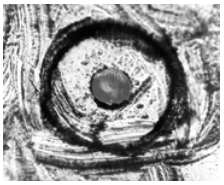


The following picture shows a fiber end that is dirty from neglect or improper cleaning. Loose particles or oils are smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can also grind off the glass face and destroy the connector.



The following picture shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles from the fiber end or by using improper cleaning tools. This damage can be severe enough to transfer the damage from the connector end to a good connector that comes in contact with it.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

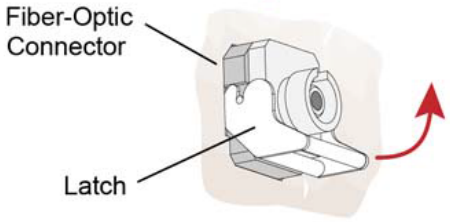


Use a microscope (100X to 200X magnification) to inspect the entire end face for contamination, raised metal, dents in the metal, and any other imperfections. Visible imperfections not touching the fiber core may not affect performance, unless the imperfections keep the fibers from contacting.

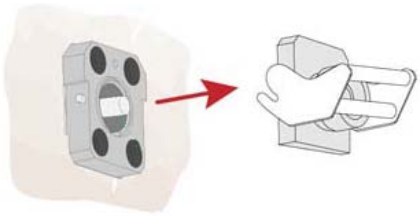
WARNING **Always remove both ends of fiber-optic cables from any instrument, system, or device before visually inspecting the fiber-ends. Disable all optical sources before disconnecting fiber-optic cables. Failure to do so may result in permanent injury to your eyes.**

To clean the fiber-end of the N7004A fiber-optic connector

1 Lift the latch of the fiber-optic connector.

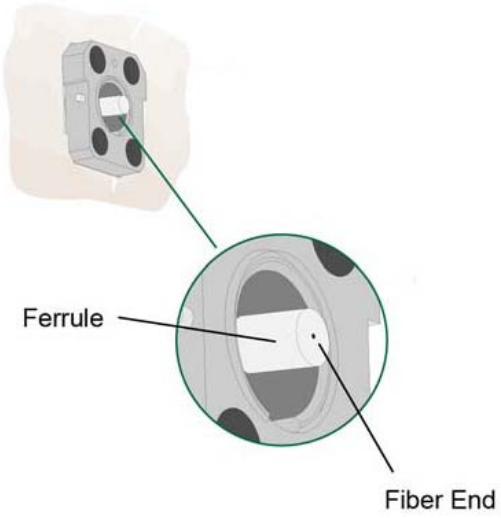


2 Carefully pull off the receptacle without touching the ferrule or fiber end. This will expose the fiber-end for cleaning.



3 Clean the fiber-optic end using a professional fiber-optic cleaning product. A variety of products are available and are easily located via an Internet search on "fiber optic cleaning products". You can purchase tools designed specifically for the type of fiber-optic cable that you are using. You can also use a cloth or a swab with alcohol to clean.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



CAUTION Never use metal or sharp objects to clean a connector and never scrape the connector.

To clean the fiber-end of the mating fiber-optic cable or patch cable

a Use a clean wipe each time you need to clean the mating cable. Wipes that are available in a dispenser are recommended for cleaning.

WARNING If flammable cleaning materials are used, the material shall not be stored, or left open in the area of the equipment. Adequate ventilation shall be assured to prevent the combustion of fumes, or vapors.

WARNING Cleaning connectors with alcohol shall only be done with the instruments power cord removed, and in a well-ventilated area. Allow all residual alcohol moisture to evaporate and the fumes to dissipate prior to energizing the instrument.

CAUTION Do not use any type of foam swab to clean optical fiber ends. Foam swabs can leave filmy deposits on fiber ends that can degrade performance.

CAUTION Do not scrub during this initial cleaning because grit can be caught in the swab and become a gouging element.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

CAUTION Do not shake, tip, or invert compressed air canisters, because this releases particles in the can into the air. Refer to instructions provided on the compressed air canister.

CAUTION Keysight Technologies strongly recommends that index matching compounds not be applied to their instruments and accessories. Some compounds, such as gels, may be difficult to remove and can contain damaging particulates. If you think the use of such compounds is necessary, refer to the compound manufacturer for information on application and cleaning procedures.

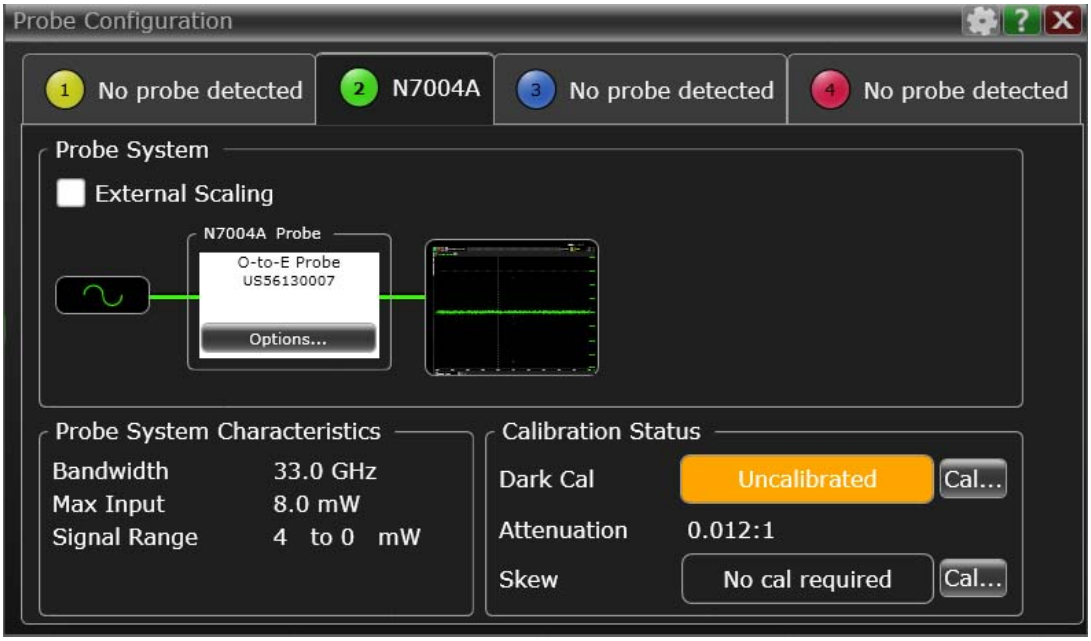
Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Step 2 - Connect the N7004A Output to a Compatible Keysight Oscilloscope



On connecting,

- the oscilloscope automatically recognizes the N7004A.
- The S-parameters are automatically read to adjust the system response and the N7004A is displayed in the Infiniium software GUI for setup and configuration.
- The vertical unit is changed to **Watts** in the Infiniium software GUI.



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Step 3 - Connect a Fiber-optic Cable to the N7004A Optical Input Connector

Selection of the Fiber-optic Cable

- You can use a 9/125 µm single mode or a 50/125 µm multimode fiber-optic cable that has an FC/PC connector.
- If your fiber has a connector other than FC/PC, then you can use a LC-to-FC or SC-to-FC patch cord to establish connectivity with the N7004A.
- Ensure that you use a fiber patch cord with ceramic fiber-optic ferrule.

Guidelines for Making the Connection

When inserting a fiber-optic cable into a connector:

- Gently insert it in as straight a line as possible. Tipping and inserting at an angle can scrape material off the inside of the connector or even break the inside sleeve of connectors made with ceramic material.
- Ensure that the fiber end does not touch the outside of the mating connector or adapter.
- Avoid over tightening connections. Unlike common electrical connections, tighter is not better. The purpose of the connector is to bring two fiber ends together. Once they touch, tightening only causes a greater force to be applied to the delicate fibers.

  With connectors that have a convex fiber end, the end can be pushed off-axis resulting in misalignment and excessive return loss. Many measurements are actually improved by backing off the connector pressure. Also, if a piece of grit does happen to get by the cleaning procedure, the tighter connection is more likely to damage the glass. Tighten the connectors just until the two fibers touch.
- Use fusion splices on the more permanent critical nodes. Choose the best connector possible. Replace connecting cables regularly. Frequently measure the return loss of the connector to check for degradation, and clean every connector, every time.

CAUTION

To avoid damage to the N7004A's fiber-optic connector, use proper cleaning techniques. Refer to "Step 1 - Clean the Fiber-Optic Connectors" on page 13.

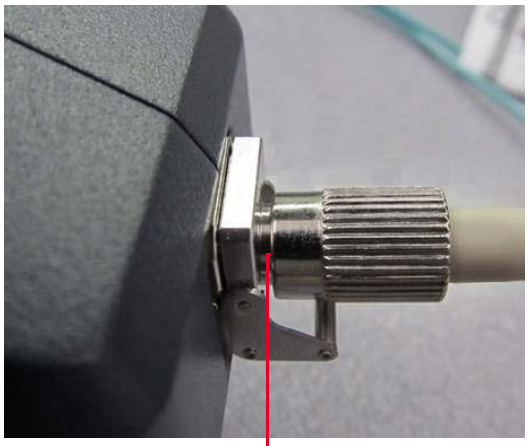
Aligning the Keying Features while Making the Connection

While securing the connection between the N7004A and fiber-optic cable, ensure that the keying features of both the N7004A FC/PC Input connector and fiber-optic cable's connector are aligned properly before you start finger-tightening the connection. Misaligned keys can adversely affect the optical signal transmission.

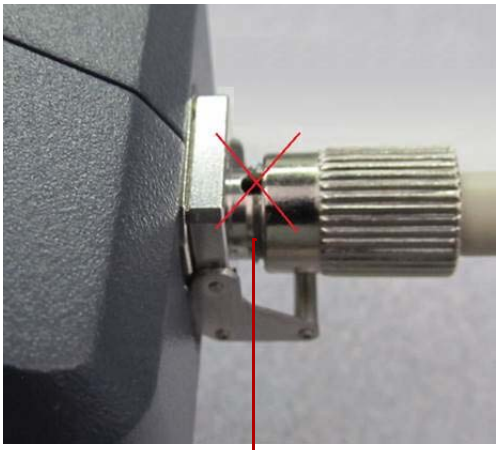
Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



The following are the examples of finger-tightened connections, one with the keying features properly aligned and the other with the keying features misaligned.



Keying features are aligned and connection is finger-tight



Keying features are misaligned but connection is finger-tight



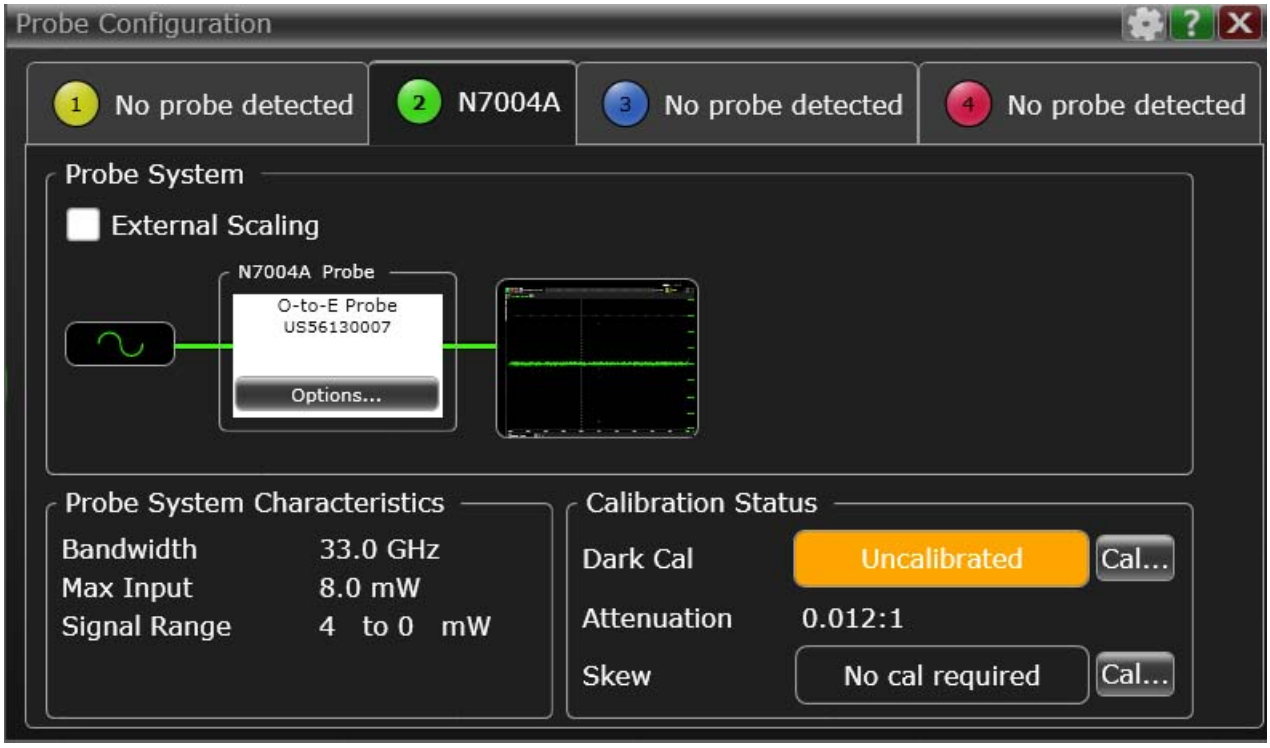
CAUTION The input circuitry of the N7004A can be damaged when total input power levels exceed 8mW. To prevent damage, this specified level must not be exceeded.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

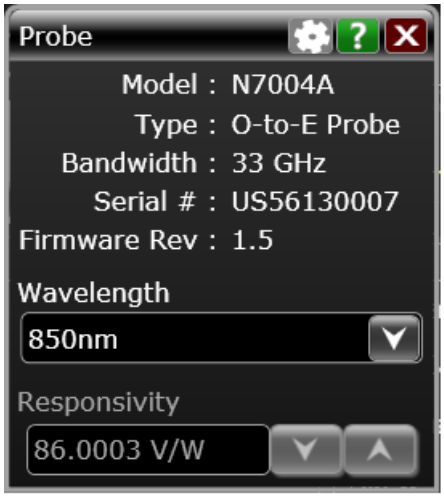
Step 4- Configure the N7004A Setup on the Infiniium Software

Selecting the Wavelength

1 In the Infiniium software GUI, choose **Setup** > **Probe Configuration...** to open the **Probe Configuration** dialog box. Notice that the N7004A is recognized and displayed as connected to the scope's channel.



2 Click **Options...** displayed under N7004A to set the wavelength for N7004A.



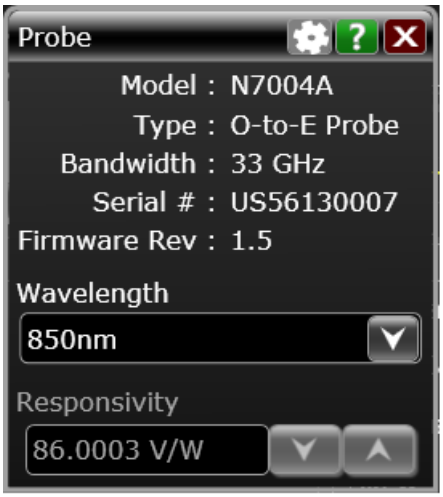
3 Select the required wavelength. N7004A supports the following wavelengths:

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Predefined (Factory-calibrated) Wavelengths	User-defined Wavelengths
850 nm	Wavelength should be in the range of 750 to 1650 nm.
1310 nm	
1550 nm	

Adjusting Conversion Gain for a User-defined Wavelength

If you select a predefined wavelength, the N7004A's predefined responsivity value for this wavelength is displayed in the **Responsivity** field. Based on the selected predefined wavelength, the N7004A's conversion gain is therefore automatically adjusted to provide an accurate measurement of the signal's average optical power.

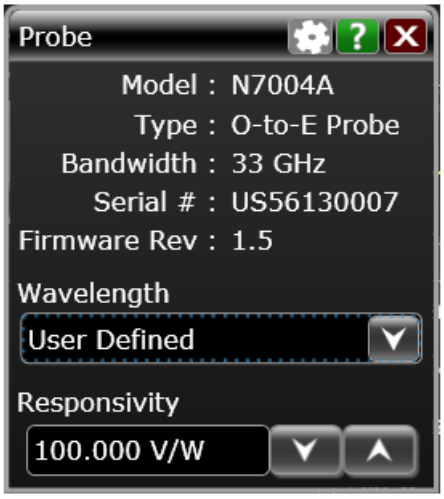


Responsivity Vs. Wavelength

Wavelength	Responsivity (Conversion Gain)	
	Minimum	Typical
850nm	Multimode: –68 V/W	Multimode: –75 V/W
1310 nm	Multimode/Single Mode: –105 V/W	Multimode/Single Mode: –110 V/W
1550nm	Single Mode: –105 V/W	Single Mode: –110 V/W
User-defined	To be manually adjusted	

If you select the **User Defined** wavelength option, then you need to manually specify and adjust the Responsivity value in the **Responsivity** field to adjust the N7004A's conversion gain for this user-defined wavelength.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

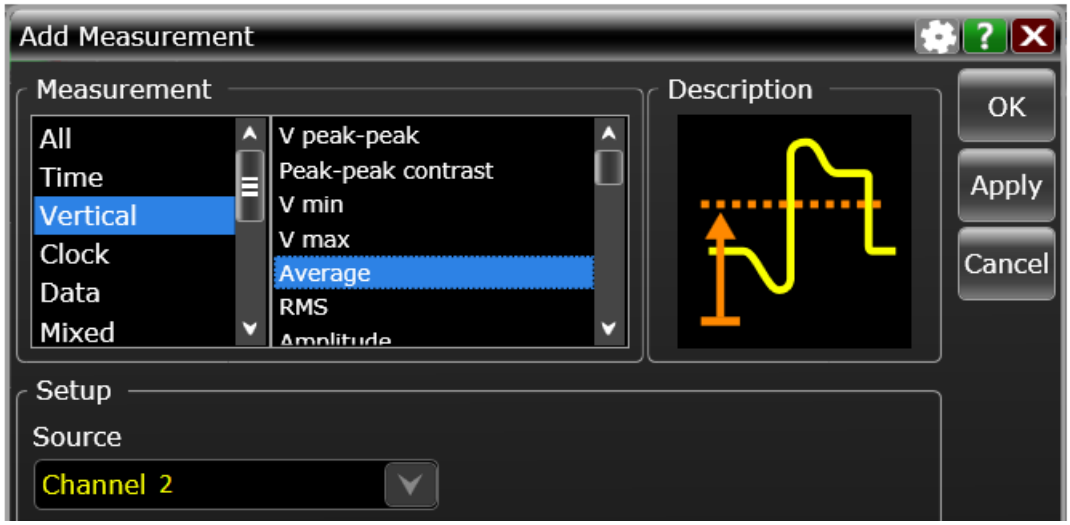


To determine the responsivity value for a user-defined wavelength

1 Measure the optical signal using an optical power meter.

2 Transmit this signal to the N7004A. This may be an active signal or just a DC optical level.

3 Set up the **Vaverage** measurement for the waveform on the Infiniium software GUI. This measurement is available under the **Vertical Measurements** group.

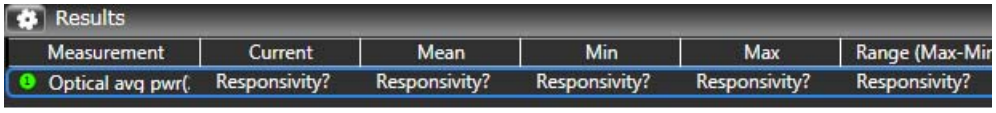


4 For the user-defined wavelength, the **Responsivity** field is enabled to allow you to adjust the responsivity value. Adjust the **Responsivity** value in this field until the **Vaverage** measurement agrees with the power level determined by the optical power meter in step1.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

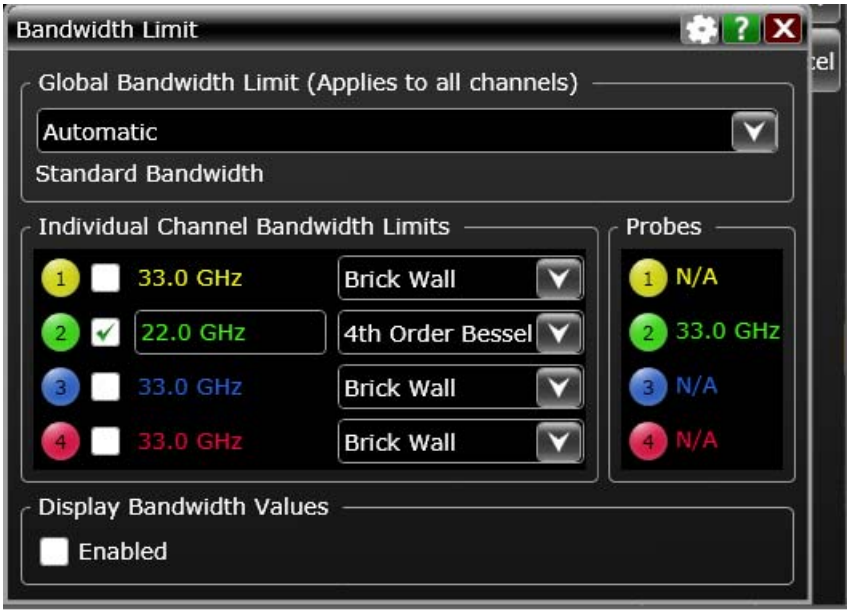
NOTE

On selecting the **User-defined** wavelength option, the **Optical Average Power** measurement displays the value "**Responsivity?**" instead of the average optical power value. This is because this measurement is calibrated based on the selected wavelength and in case of a user-defined wavelength, there is no calibration factor available for this measurement.



Configuring the Bandwidth Limits for the Oscilloscope and its Channel

You use the **Bandwidth Limit** dialog box to set the bandwidth limit for the oscilloscope and the individual channel to which you have connected the N7004A. You may want to reduce bandwidth settings for improved noise performance. For details on how to set bandwidth limits on the oscilloscope, click the ? icon in the Bandwidth Limit dialog box.



Individual Channel Bandwidth Limit Filters

When setting the bandwidth limits, you can select one of the following two bandwidth limit filters for the channel to which the N7004A is connected.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

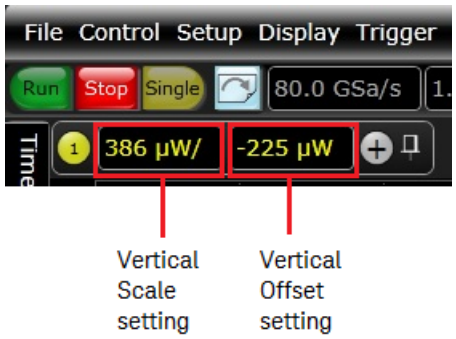
Brick Wall	4th Order Bessel Thomson
Suitable when you want to characterize the raw response of the optical transmitter under test.	Suitable when you want to do reference receiver testing of industry-standard optical measurements on the optical transmitter under test. This filter limits the bandwidth to optimize the signal-to-noise ratio but does not lower it down to the extent of causing inter-symbol interference. This allows the waveform to be displayed similar to what a receiver would see.
The maximum bandwidth limit that you can specify can be the same as the N7004A's bandwidth limit, that is, 33 GHz.	The maximum bandwidth limit that you can specify is about 2/3 of the maximum bandwidth you could specify with the Brick-Wall filter. For a 33 GHz oscilloscope with the Bessel Thomson filter on, this yields a 22 GHz Bessel Thomson filter, which covers 28 Gbps x 0.75 = 21 GHz.

While setting up the bandwidth limits, refer to the topic "Oscilloscope Bandwidth Requirements" on page 12 to know how much oscilloscope bandwidth is needed based on your optical data rates requirements.

Adjusting the Vertical Settings for the Oscilloscope Channel

Adjust the vertical scale (Watts per division) and offset settings for the oscilloscope channel to which you connected the N7004A O/E Converter. For the extinction ratio measurement, this step is critical as the vertical settings affect the magnitude of the dark level offset which can affect the accuracy of this measurement.

You can adjust the vertical settings using the options displayed in the Infiniium software GUI or using the vertical scale and offset knobs of the oscilloscope.



NOTE

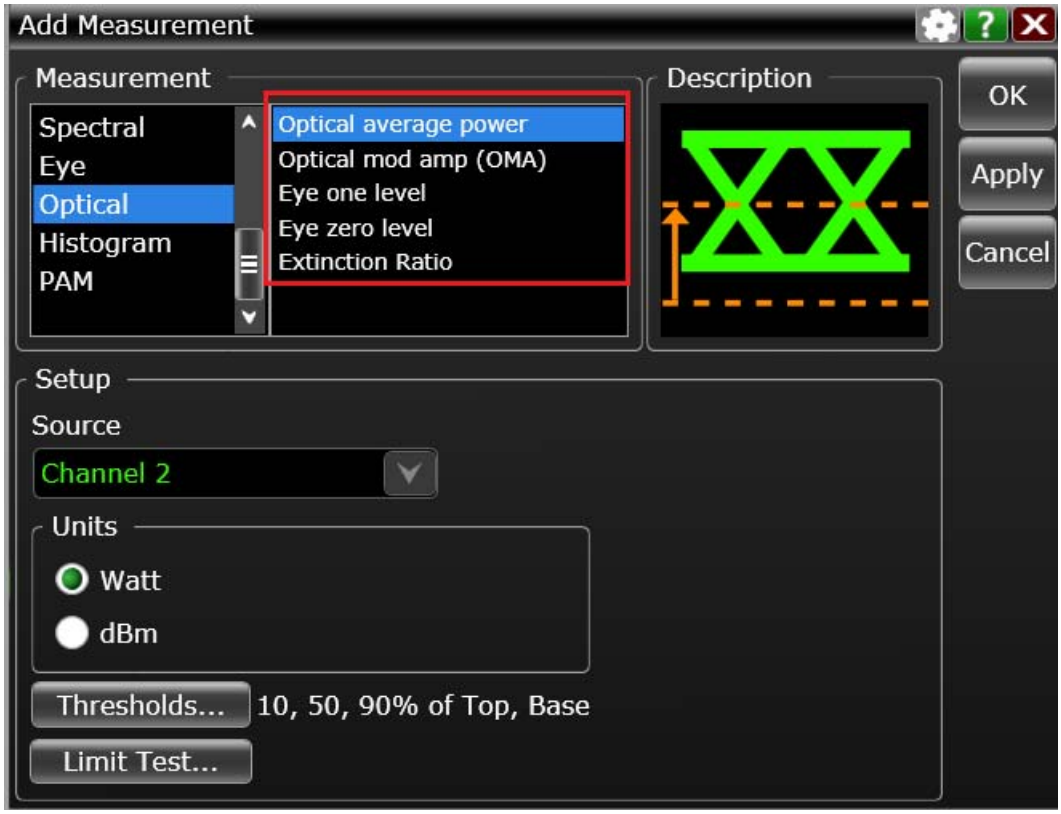
The Vertical scale of an oscilloscope channel is displayed in Watts when you connect the N7004A O/E Converter to the channel.

Adjust the vertical scale and offset levels in such a way that the output levels are completely on the screen and the eye diagram uses the full display.

Adding and Configuring Optical Measurements

1. Click **Measure** > **Add Measurement** to access the **Add Measurement** dialog box.
2. Select and add the required optical measurements from the set of measurements displayed under the **Optical** group in the Add Measurement dialog box.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

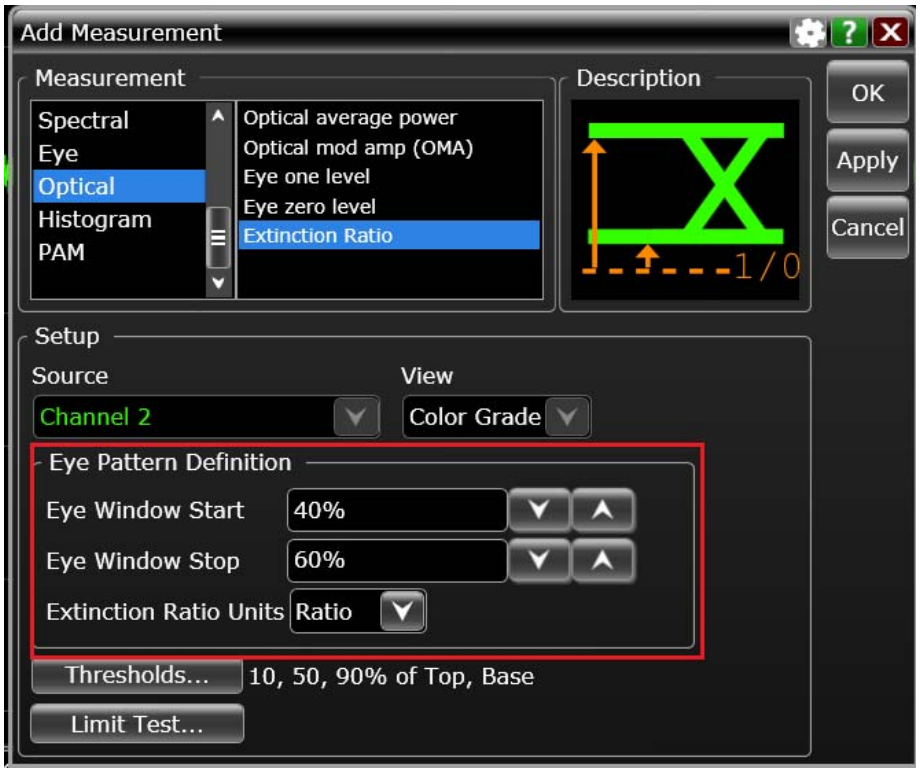


Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

NOTE

For measurements such as the Extinction ratio measurement, you may want to define settings such as eye pattern settings used to make eye waveform measurements. You can do this while adding the measurement using the Add Measurement dialog box.

Refer to the *Optical Measurements* help topics in the online help of your Infiniium oscilloscope to get a detailed description of each of the optical measurements.



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Step 5 - Perform Dark Calibration

After you have configured the N7004A settings and the optical measurement setup on the Infiniium software, you can perform dark calibration for N7004A.

What is Dark Calibration

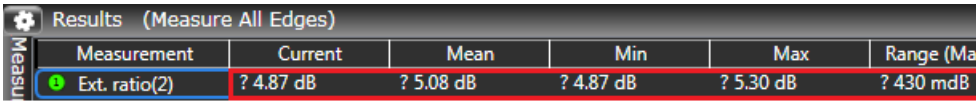
Dark calibration is the process of factoring out the power transmitted by the N7004A when there is no light being transmitted. For this calibration, the optical input of the N7004A is covered to block light completely.

In this calibration, the oscilloscope identifies the offset (dark level) signals internally generated by N7004A when no light is present at the input channel. These internal offset signals are then removed by the oscilloscope from the extinction ratio calculations to ensure accurate measurement results.

NOTE

When the Extinction Ratio measurement is performed, the oscilloscope mathematically removes the offset error measured by dark calibration from the extinction ratio calculation. Therefore, if you plan to make the Extinction Ratio measurement, it is highly recommended that you perform dark calibration to maximize the accuracy in this measurement's results.

A "?" is displayed with the Extinction Ratio measurement results if dark calibration is not valid.



When to perform Dark Calibration

Dark calibration is only valid for a given vertical scale, offset, and sample rate of the oscilloscope. A change in any of these invalidates the calibration and you have to perform dark calibration again. Therefore, you must perform dark calibration as the last step just before making optical measurements when you have set the vertical scale and offset at which you want to make your measurements.

NOTE

You need to perform dark calibration again when:

- vertical scale or offset is changed.
- sample rate is changed.
- ±2°C temperature change from the calibration temperature.
- wavelength or responsivity is changed.
- power is recycled.

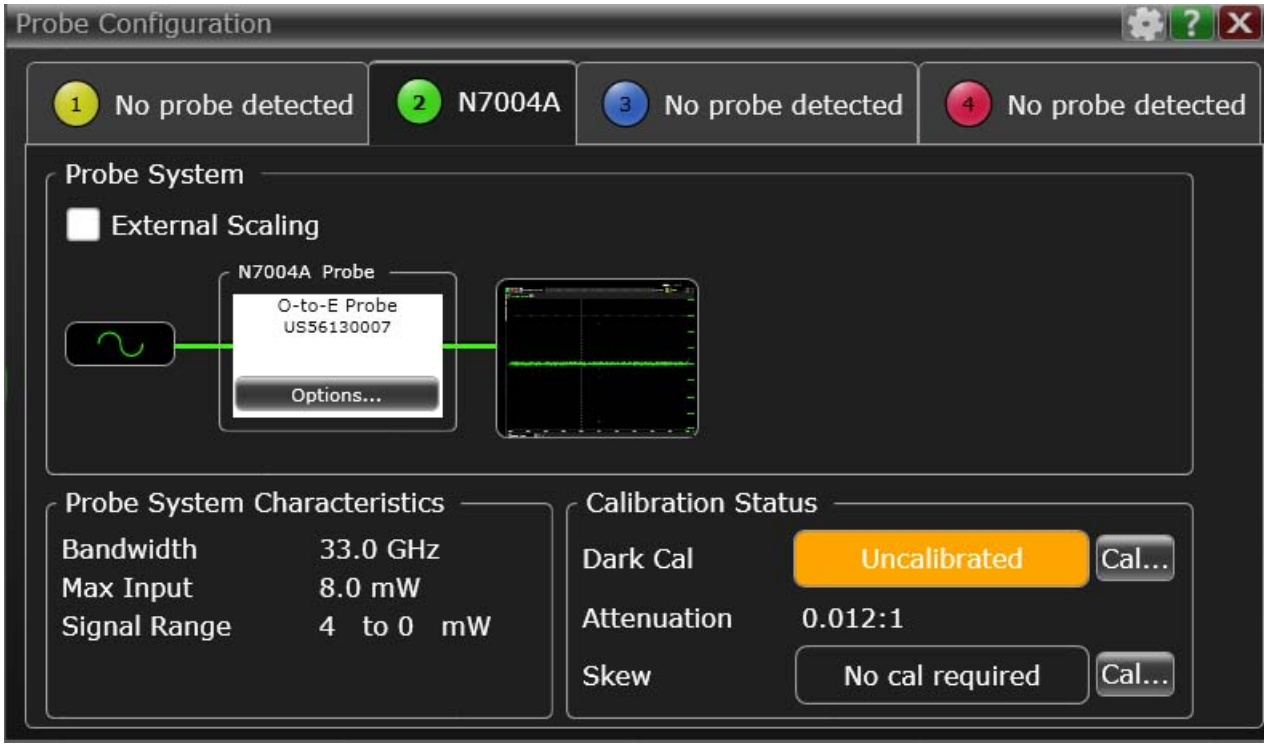
To perform dark calibration

1 Allow the N7004A to warm up for15 minutes before starting the calibration.

2 Choose **Setup** > **Probe Configuration...**.

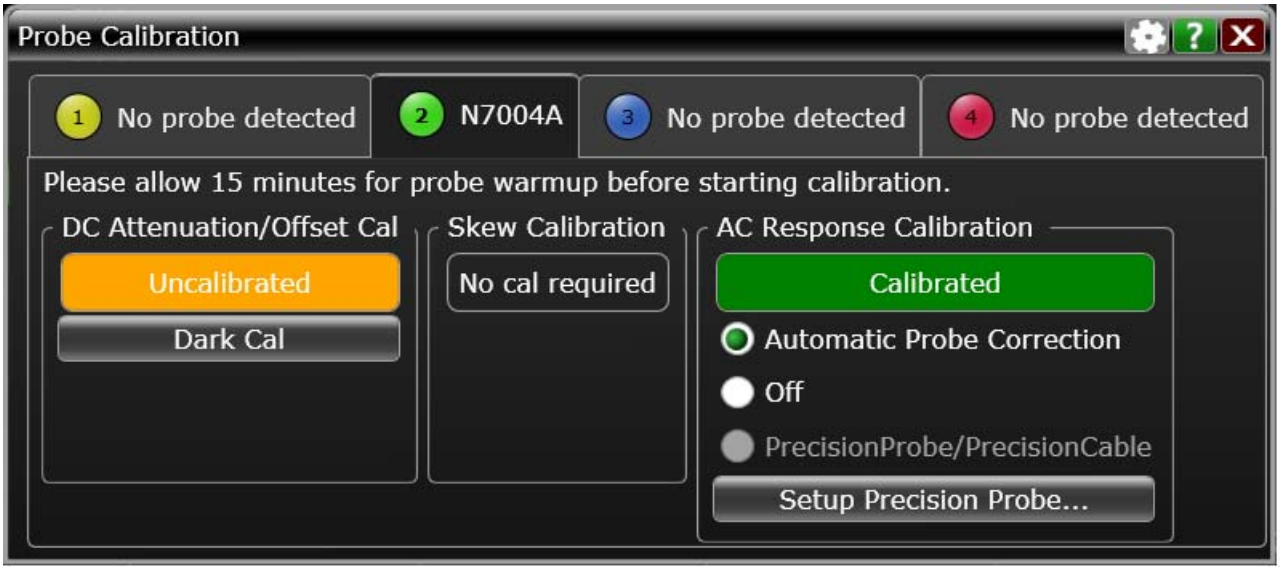
The **Probe Configuration...** dialog box is displayed.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



3 In the **Calibration Status** section, the **Dark Cal** status is currently displayed as **Uncalibrated**. Click the **Cal...** button.

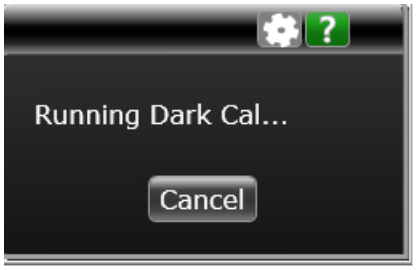
The **Probe Calibration** dialog box is displayed.



4 Cover the N7004A's FC/PC input connector with the cap that accompanies the N7004A.

5 Click the **Dark Cal** button to begin dark calibration.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



If the dark calibration competes successfully, the date and time of its completion is shown on screen. If it fails, the status is displayed as Uncalibrated.



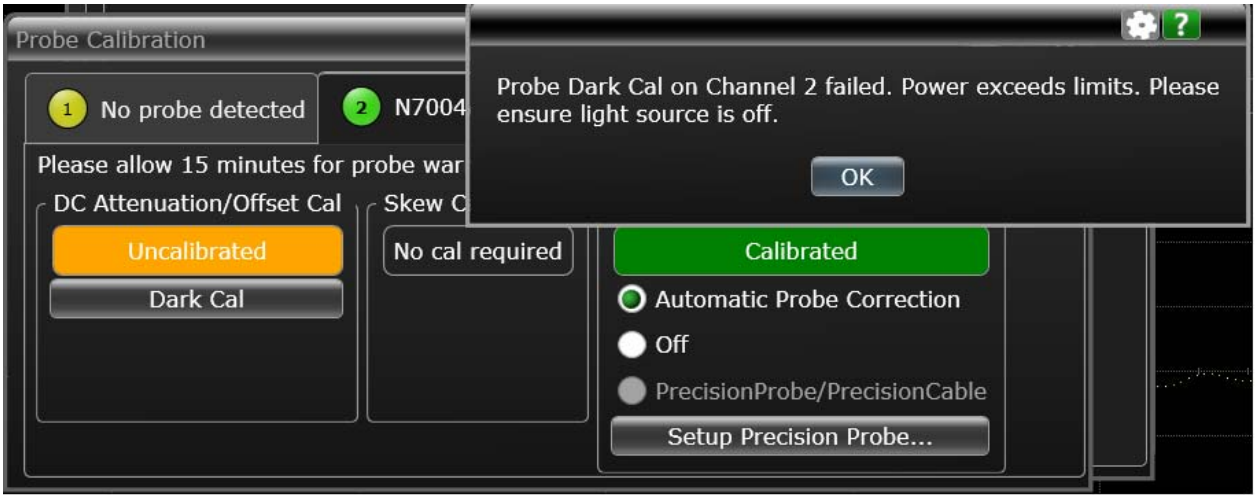
6 After the dark calibration is successfully complete, remove the cap from the N7004A and reconnect the fiber-optic cable to the N7004A.

The setup is now complete to start making the measurements.

Reasons for the Failure of the Dark Calibration

- The N7004A optical input is not covered properly or the optical source is not turned off.
- The dark level (signal with the light source off) is not on the Infiniium screen. This signal must be completely on the screen to be correctly measured during dark calibration.
- The dark level (signal with the light source off) is less than 20mV converted to Watts by the responsivity. The dark calibration should be performed after the signal has been scaled correctly. It is recommended to set the vertical sensitivity of the oscilloscope so that the signal you try to capture takes about 5-6 divisions high.
- The dark calibration is canceled by the user.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

3 Making Optical Measurements and Analyzing Results

N7004A Optical Measurements / 32
Performing Eye Mask Testing / 35

This chapter provides information on the optical measurements that you can make using the N7004A on an Infiniium real-time oscilloscope. It also provides an overview of how you can use the N7004A to perform eye mask testing.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

N7004A Optical Measurements

You can make the following optical measurements using the N7004A:

Optical Measurement		Description
Optical Average Power		Optical power is a measure of the true average component of an optical signal. it differs from other measurements because it does not rely on the waveform display to determine the measurement result. The analog-to-digital converter in the N7004A allows the generation of this result independent of the waveform displayed on the screen.
Optical Modulation Amplitude (OMA)		Optical Modulation Amplitude (OMA) is the measure of the difference between the optical power of an NRZ (non-return-to-zero) one pulse and the optical power of an NRZ zero pulse.
Eye One Level		Eye one level is a measure of the mean value of the logical 1 of an eye diagram.
Eye Zero Level		Eye zero level is a measure of the mean value of the logical 0 of an eye diagram.
Extinction Ratio		Extinction Ratio is the ratio of the one level and the zero level of an eye diagram of an optical signal.
Refer to the **Optical Measurements** *help topics in the online help of your Infiniium real-time oscilloscope to get a detailed description of each of these measurements.*		

Optical Measurement Results

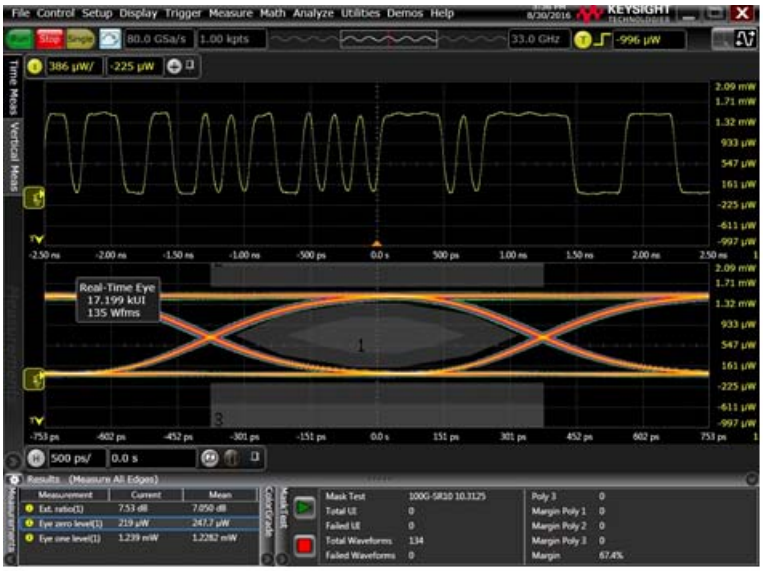
The following screens display sample optical data and optical measurements results as displayed on an Infiniium oscilloscope connected to N7004A.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



Examples of Optical Data Acquired with N7004A for Different Optical Data Rates

For 10 Gbps data rate



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

For 25 Gbps data rate



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Performing Eye Mask Testing

When using the N7004A with an Infiniium oscilloscope, you can use the mask testing feature of the oscilloscope to verify whether or not a displayed eye diagram complies with industry-standard definitions for optical waveforms. A mask (template) defines the shaded mask regions in the display. A waveform must remain outside these mask regions to meet the requirements of a standard. A data point from a waveform that illuminates a pixel in the mask region causes a mask test failure.

Types of Masks Supported with N7004A

You can:

- either load standard masks (for Keysight DCA oscilloscopes). These are provided with the Infiniium software for optical waveforms. These masks have the **.mskx** extension and are available at the following location:

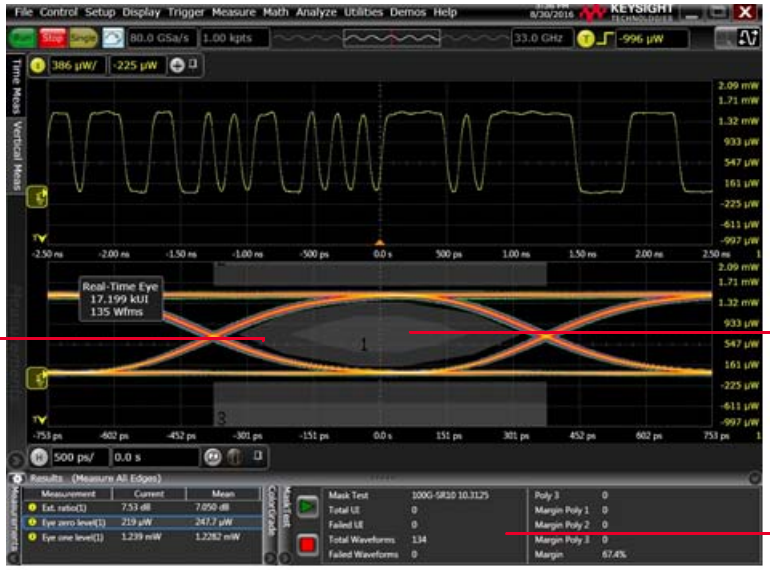
  C:\Users\Public\Documents\Infiniium\Masks

- or create your own masks and load these in the Infiniium software.
- or use the Automask or the Draw Mask feature of the oscilloscope.

Mask Margins

You can also enable mask test margins to ensure that mask testing is performed using the defined margins.

The following screen displays optical data with a standard mask applied. Mask regions are shown in lighter shade of gray and mask margins are shown in darker shade of gray.



You use the **Mask Test** dialog box to enable and load a mask and the **Mask Test Margins** dialog box to enable and specify margins for the mask.

To know in detail how you can implement mask testing and mask margins on your Infiniium oscilloscope, refer to the ***Mask Testing*** help topics in the Infiniium online help. You can also click the  icon displayed in these dialog boxes.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

4 Remotely Controlling the N7004A Measurement Setup

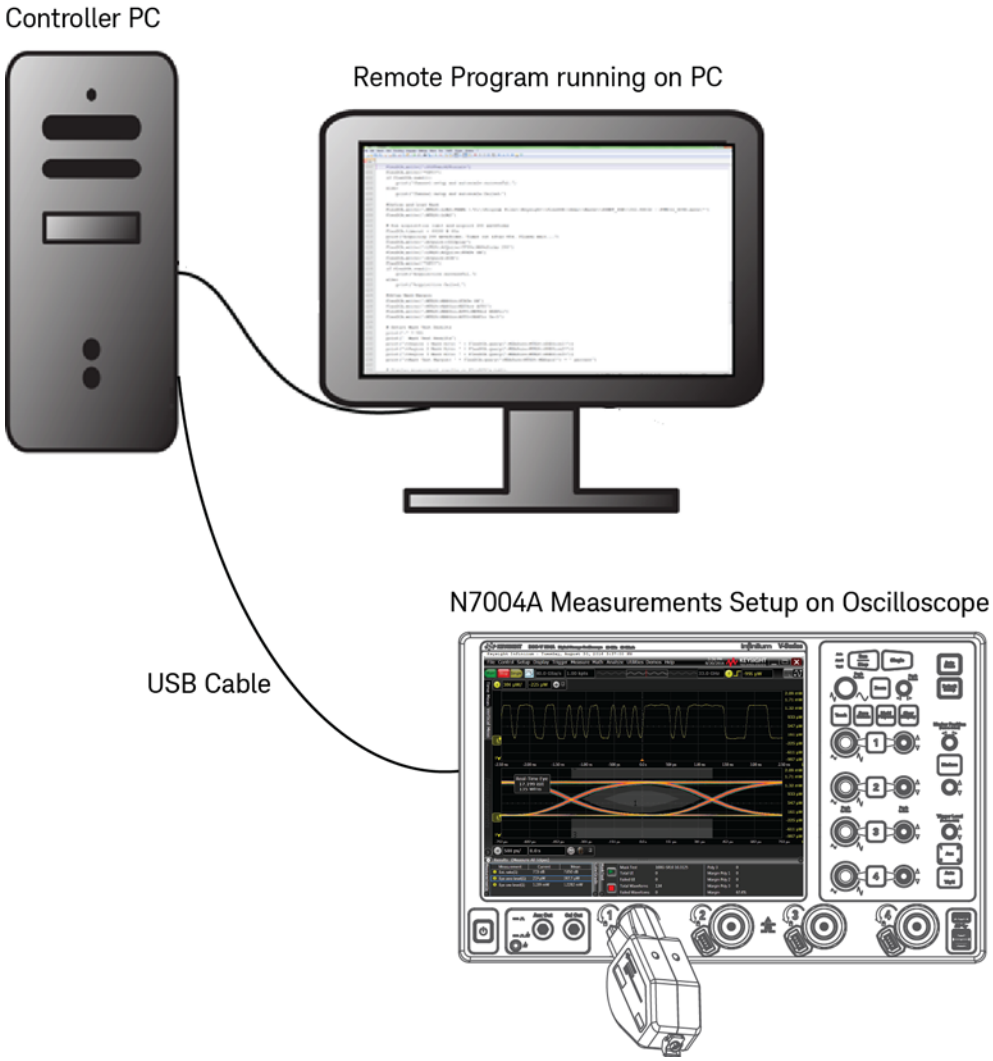
You can use the Remote Programming SCPI commands described in this chapter to remotely control the oscilloscope from a controller PC for:

- configuring the N7004A setup such as channel's bandwidth limit filter response.
- adding optical measurements and querying for these measurements' results.
- configuring eye mask testing.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Sample Remote Control Setup of N7004A



NOTE

Before you can start remotely controlling the N7004A setup using SCPI commands, ensure that you have:

- installed the Keysight IO Libraries Suite software on the controller PC.
- connected the oscilloscope to the controller PC using USB, LAN, or GPIB.
- verified the oscilloscope connection.

To get detailed information on the above-mentioned points or on basic program communications, interface, syntax, data types, and status reporting, refer to your oscilloscope's Programmer's Guide.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

SCPI Commands for Controlling the N7004A Setup

This topic includes only those SCPI commands that are unique to the N7004A scenario. You can find the complete list of SCPI commands for remotely controlling you oscilloscope in your oscilloscope's *Programmer's Guide*.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

:MEASure:OPOWer

Command Syntax

```
:MEASure:OPOWer [<source>][,{WATT | DBM}]
```

where:

- **<source>** can be {CHANnel<N> | DIFF<D> | COMMonmode<C> | FUNCtion<F> | WMEMory<R> |CLOCk | MTRend | MSPectrum | EQUalized}
- **{WATT | DBM}** - Specifies the measurement units in Watts or dBm.

Description

The **`:MEASure:OPOWer`** command installs an Optical Average Power measurement into the user interface's measurement Results pane.

Optical average power is a measure of the true average component of an optical signal. If markers are tracking this measurement, the marker is placed on the optical power Watts. This measurement is commonly used when identifying the fundamental parameters of a lightwave transmitter. However, it differs from other measurements because it does not rely on the waveform display to determine the measurement. The analog-to-digital converter is in the probe itself, independent of the waveform displayed on the screen. You can measure the optical power of an eye diagram.

Query Syntax

```
:MEASure:OPOWer? [<source>][,{WATT | DBM}]
```

The query returns the measured Optical Average Power.

Query Response Format

```
[:MEASure:OPOWer] <value>[,<result_state>]<NL>
```

where:

- <value> is the measured Optical Average Power value.
- <result_state> - If SENDvalid is ON, the result state is returned with the measurement result. See the :MEASure:RESults table in your oscilloscope's programmer's guide for a list of the result states.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

:MEASure:CGRade:OLEVel

Command Syntax

`:MEASure:CGRade:OLEVel [<source>]`

where:

- <source> can be {CHANnel<N> | DIFF<D> | COMMonmode<C> | FUNCtion<F> | WMEMory<R> |CLOCk | MTRend | MSPectrum | EQUalized}
- If <source> is omitted, the Q-factor will be performed on the first waveform that has color grade enabled.

Description

The **`:MEASure:CGRade:OLEVel`** command installs an Eye One Level measurement into the user interface's measurement Results pane. Eye one level is a measure of the mean value of the logical 1 of an eye diagram.

Before using this command or query, you must use the **`:DISPlay:CGRade`** command to enable the color grade persistence feature. Also, there must be a full eye diagram on screen before a valid measurement can be made.

Query Syntax

`:MEASure:CGRade:OLEVel? [<source>]`

The query returns the measured Eye One Level.

Query Response Format

`[:MEASure:CGRade:OLEVel] <value>[,<result_state>]<NL>`

where:

- <value> is the measured Eye One Level value.
- <result_state> - If SENDvalid is ON, the result state is returned with the measurement result. See the :MEASure:RESults table in your oscilloscope's programmer's guide for a list of the result states.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

:MEASure:CGRade:ZLEVel

Command Syntax

`:MEASure:CGRade:ZLEVel [<source>]`

where:

- <source> can be {CHANnel<N> | DIFF<D> | COMMonmode<C> | FUNCtion<F> | WMEMory<R> |CLOCk | MTRend | MSPectrum | EQUalized}
- If <source> is omitted, the Q-factor will be performed on the first waveform that has color grade enabled.

Description

The **`:MEASure:CGRade:ZLEVel`** command installs an Eye Zero Level measurement into the user interface's measurement Results pane. Eye zero level is a measure of the mean value of the logical 0 of an eye diagram. Before using this command or query, you must use the **`:DISPlay:CGRade`** command to enable the color grade persistence feature. Also, there must be a full eye diagram on screen before a valid measurement can be made.

Query Syntax

`:MEASure:CGRade:ZLEVel? [<source>]`

The query returns the measured Eye Zero Level.

Query Response Format

`[:MEASure:CGRade:ZLEVel] <value>[,<result_state>]<NL>`

where:

- <value> is the measured Eye Zero Level value.
- <result_state> - If SENDvalid is ON, the result state is returned with the measurement result. See the :MEASure:RESults table in your oscilloscope's programmer's guide for a list of the result states.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

:MEASure:OMAMplitude

Command Syntax

`:MEASure:OMAMplitude [<source>][,{WATT | DBM}]`

where:

- <source> can be {CHANnel<N> | DIFF<D> | COMMonmode<C> | FUNCtion<F> | WMEMory<R> |CLOCk | MTRend | MSPectrum | EQUalized}
- {WATT | DBM} Specifies the measurement units in Watts or dBm.

Description

The **`:MEASure:OMAMplitude`** command installs an Optical Modulation Amplitude (OMA) measurement into the user interface's measurement Results pane. Optical Modulation Amplitude (OMA) is the measure of the difference between the optical power of an NRZ (non-return-to-zero) one pulse and the optical power of an NRZ zero pulse. It requires an NRZ pattern and is designed to be used with a square wave made of consecutive zeros followed by consecutive ones. Be sure to check any relevant standard for one and zero run requirements. All instances are measured if Measure All Edges is selected. Otherwise, the edges closest to the timebase reference are measured.

Query Syntax

`:MEASure:OMAMplitude? [<source>][,{WATT | DBM}]`

The query returns the measured Optical Modulation Amplitude (OMA).

Query Response Format

`[:MEASure:OMAMplitude] <value>[,<result_state>]<NL>`

where:

- <value> is the measured Optical Modulation Amplitude (OMA) value.
- <result_state> - If SENDvalid is ON, the result state is returned with the measurement result. See the :MEASure:RESults table in your oscilloscope's programmer's guide for a list of the result states.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

:MEASure:ERATio

Command Syntax

`:MEASure:ERATio [<source>[,{RATio | DB | PERCent}]]`

where:

- <source> can be {CHANnel<N> | DIFF<D> | COMMonmode<C> | FUNCtion<F> | WMEMory<R> |CLOCk | MTRend | MSPectrum | EQUalized}
- {RATio | DB | PERCent} Specifies the measurement units in Ratio, Decibel, or Percentage.

Description

The **`:MEASure:ERATio`** command installs an Extinction Ratio measurement into the user interface's measurement Results pane. Extinction Ratio is the ratio of the one level and the zero level of an eye diagram of an optical signal.

Query Syntax

`:MEASure:ERATio? [<source>[,{RATio | DB | PERCent}]]`

The query returns the measured extinction ratio.

Query Response Format

`[:MEASure:ERATio] <value>[,<result_state>]<NL>`

where:

- <value> is the measured extinction ratio value.
- <result_state> - If SENDvalid is ON, the result state is returned with the measurement result. See the :MEASure:RESults table in your oscilloscope's programmer's guide for a list of the result states.

NOTE

The `:MEASure:ERATio` query returns a '?' on the extinction ratio measurement if:

- The dark calibration has not been performed at all.

- The vertical sensitivity, offset, or sample rate of the oscilloscope has changed since the dark calibration was run.

- The N7004A's temperature has changed by > 2 ^{0} C.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

5 Performance Verification for N7004A

Test Strategy / 46
Test Interval / 46
Test Equipment / 46
Test Procedure / 47

This chapter describes how to verify the bandwidth performance of the N7004A against its bandwidth specification (as listed on page 9).

The bandwidth performance of N7004A is specified when used with an Infiniium 33 GHz oscilloscope. The oscilloscope automatically downloads S parameters and calibration data from the N7004A when you connect the N7004A to one of the oscilloscope's channels. This adjusts the system response and allows highly accurate measurements.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Test Strategy

The basic method for verifying the bandwidth of the N7004A is to use a femtosecond pulse laser. These types of laser sources output a very fast impulse that is much faster than the impulse response of the N7004A thus allowing measurement of the N7004A bandwidth without de-embedding the laser impulse response. Verification of the laser source is not considered in this testing but can be typically verified with an optical sampling scope or other optical methods.

NOTE

The performance verification testing is also performed at the Keysight Technologies as part of the return-to-factory recertification to warrant performance.

You can either test the N7004A bandwidth performance using the recommended test equipment and by following the procedure documented in this chapter. Or you may want to send your N7004A to the Keysight Technologies to get the bandwidth performance verification done by specialized Keysight staff.

Test Interval

The Keysight return-to-factory recertification interval to warrant performance of N7004A is 1 year. However, you can also test the N7004A bandwidth performance as and when required using the recommended test equipment and by following the procedure documented in this chapter.

Test Equipment

A list of the recommended test equipment is provided. The instructions in this chapter are written with the presumption that you are using these recommended test equipment. You can substitute these equipment with equivalent equipment that satisfy the specifications given. However, results with substituted equipment may or may not yield identical results.

Test Equipment	Model #
Calmar femtosecond pulse laser (Qty 1) This laser source has two outputs; ▪ a 1560nm port for testing longer wavelengths (i.e. 1310 and 1550nm) ▪ a 780nm port for testing shorter wavelengths (i.e. 760 and 850nm)	FPL-02RFFAGT12
Keysight Lightwave Multimeter 2 slot mainframe (or other Keysight mainframe with more slots) (Qty 1)	8163B
Keysight Single Mode optical attenuator module for use in mainframe (Qty 1)	81570A
Keysight Multi Mode optical attenuator module for use in mainframe (Qty 1)	81578A
L-Com 1m single mode FC/FC patch cables (or equivalent) (Qty 2)	SFOFC-01
L-Com dual multi-mode FC/FC patch cable (or equivalent) which can be separated into two single cables for use in this procedure (Qty 1)	FODFC50-01

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Test Procedure

CAUTION The Calmar pulse laser used in this procedure outputs a large impulse that could damage the input of the N7004A. As described in the procedure below, set the optical attenuators to maximum attenuation before enabling the optical attenuators and then lower the attenuation until a 1.5 to 2mW signal is seen on the oscilloscope's screen.

CAUTION Before making the connections between the fiber-optic connectors using a single-mode or a multi-mode patch cable as described in the procedure below, you must clean the fiber ends of these connectors and the mating fiber-optic cable or patch cable. To get details on the cleaning procedure, refer to the topic, "Step 1 - Clean the Fiber-Optic Connectors" on page 13

1 Install 81570A SM attenuator and 81578A MM attenuator in 8163B frame.
2 Turn on Calmar laser (but not the keyed "Pump Laser"), 33GHz Infiniium oscilloscope, and 8163B frame.
3 Connect N7004A to be tested to channel 1 of the oscilloscope.
4 Let all equipment warm up for 45 minutes.
5 Set both attenuators for the maximum attenuation of 60db.
6 While observing cleaning procedures, connect optical output A (760nm) to the input of the MM 81578A using the multi-mode patch cable.
7 While observing cleaning procedures, connect optical output B (1560nm) to the input of the MM 81570A using the single mode patch cable
8 Perform a default setup on the oscilloscope.
9 While observing cleaning procedures, connect the output of the 81578A to the N7004A using a multi-mode patch cable.
10 Under **Setup Probe Configuration**, select **Options** for the N7004A on channel 1 and select **850nm**.
11 Enable the 81578A attenuator by pressing the button on the front of the module. This allows the laser light through the attenuator.
12 Turn on the keyed Pump Laser on the Calmar laser and adjust the Pump Current to maximum.
13 Set up the oscilloscope as follows:
   - Trigger on channel 1, level **500uW**
   - Timebase to **200pS/div**
   - Channel 1 to **500uW/div**
   - In Setup Acquisition, set for average mode with **1024** averages
14 Begin lowering the attenuation on the 81578A until an impulse is seen. Lower it until the amplitude of the impulse is **1.5 to 2mW**.

NOTE The Calmar laser may produce a "double" (multiple) pulse when the pump laser is set to maximum. If it does, then lower the pump laser setting until the "double" pulse stops.

Single pulse outputs are stable with pulses evenly spaced in time. Multiple pulse outputs have arbitrary time delays between adjacent pulses. For details on single and multiple pulse, refer to the Calmar user manual.

15 Change the timebase to **2nS/div**.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

16 Invoke a frequency response (FFT) on channel 1 using **Math/New FFT/Channel1** from the pull down menu.

17 Set the FFT scale to **3db/div** and adjust the FFT offset to get the left hand side of the FFT waveform (0 to 4GHz) at center screen. To do this, grab the FFT waveform with the left mouse button and move it to center screen. See Figure 2.



Figure 2 Upper trace: N7004A impulse response. Lower trace: FFT of impulse showing bandwidth

Verify that the FFT is not down more than 3db at 32 GHz. For instance, in the sample screen above, the response is still at 0db at 32 GHz.

18 Disable the 81578A attenuator.

19 While observing cleaning procedures, connect the output of the 81570A to the N7004A using a single mode patch cable.

20 Under **Setup Probe Configuration**, select **Options** for the N7004A on channel 1 and select **1550nm**.

21 Enable the 81570A attenuator by pressing the button on the front of the module. This allows the laser light through the attenuator.

22 Begin lowering the attenuation on the 81570A until an impulse is seen. Lower it until the amplitude of the impulse is 1.5 to 2mW,

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

NOTE

The Calmar laser may produce a "double" (multiple) pulse when the pump laser is set to maximum. If it does, then lower the pump laser setting until the "double" pulse stops.

Single pulse outputs are stable with pulses evenly spaced in time. Multiple pulse outputs have arbitrary time delays between adjacent pulses. For details on single and multiple pulse, refer to the Calmar user manual.

23 If needed, center the FFT waveform as done earlier in this procedure.
Verify that the frequency response (FFT) is not down more than 3db at 32 GHz.

24 Disable the 81570A attenuator.
This completes the bandwidth performance verification testing for N7004A.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

6 Calibration Strategy

You need to perform dark calibration (see page 27) on N7004A whenever you change the vertical scale or offset of the oscilloscope.

In addition to performing dark calibration, Keysight recommends that you also get the factory calibration done once in a year by sending the N7004A to the Keysight Technologies. Factory calibration also includes bandwidth performance verification testing (see page 45) for N7004A.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

7 Troubleshooting

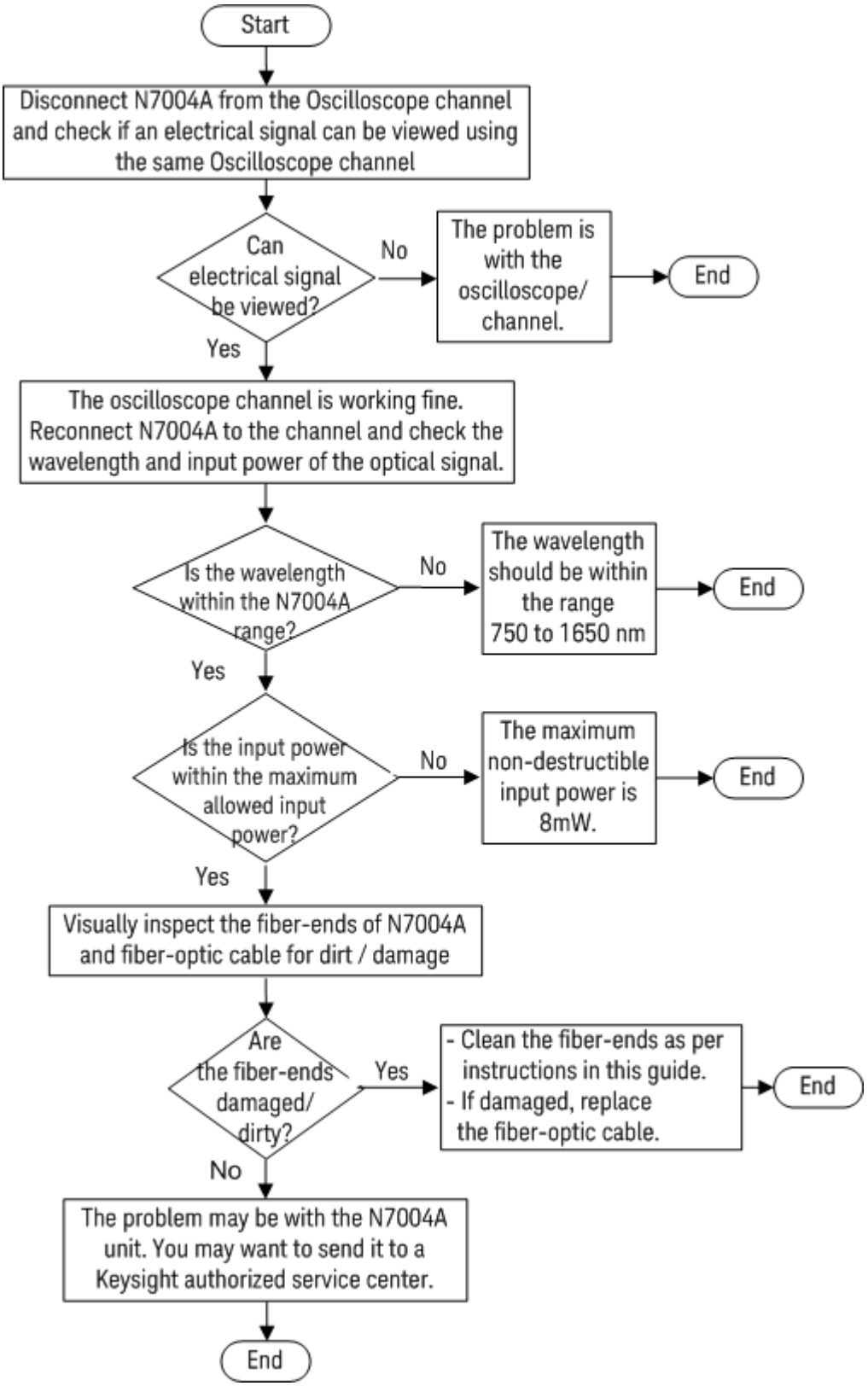
This chapter covers some common troubleshooting scenarios that may be relevant for you while using N7004A.
If the problem persists, contact Keysight Technologies. To locate a sales or a service office near you, go to www.keysight.com/find/contactus.
The service strategy for the N7004A is to send it to Keysight Technologies for all service work. Keysight requires that the N7004A unit be repaired only at qualified repair facilities such as the Keysight Repair Centers.

Problem	Possible Cause(s)	Solution
Unable to make optical measurements using N7004A.	Multiple (as indicated in the flowchart provided in "Troubleshooting Flowchart section.)	Start at the top of the flowchart provided in "Troubleshooting Flowchart section. The flowchart directs you to the relevant steps.
The dark calibration failed.	Refer to the topic "Reasons for the Failure of the Dark Calibration" on page 29.	
Problem in optical signal transmission	Low transmitted power	Check alignment of the optical cable into N7004A. Ensure that the keying features of both the N7004A FC/PC Input connector and fiber-optic cable's connector are aligned properly before you start finger-tightening the connection. Refer to the topic "Aligning the Keying Features while Making the Connection" on page 18.
Extinction ratio is out of range (that is, lower than expectations)	The optic connector of N7004A or optic cable is dirty and requires cleaning.	Clean the fiber-ends of both N7004A as well as optic cable's connectors as per instructions given in "Step 1 - Clean the Fiber-Optic Connectors" on page 13.
The Optical Average Power measurement displays the value "Responsivity?"	You have selected the User Defined wavelength option for N7004A.	Manually specify and adjust the Responsivity value for N7004A. Refer to the topic "Adjusting Conversion Gain for a User-defined Wavelength" on page 21.
Erratic optical measurements are displayed.	The optic connector of N7004A or optic cable is dirty and requires cleaning.	Clean the fiber-ends of both N7004A as well as optic cable's connectors as per instructions given in "Step 1 - Clean the Fiber-Optic Connectors" on page 13.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Troubleshooting Flowchart



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

8 Returning the N7004A for Repair or Service

If the N7004A is found to be defective, we recommend sending it to a Keysight authorized service center for all repair and calibration needs.

Perform the following steps before shipping the N7004A back to Keysight Technologies for repair / service.

1 Contact your nearest Keysight sales office for any additional details.
2 Write the following information on a tag and attach it to the malfunctioning equipment.
   - Name and address of owner
   - Product model number (N7004A)
   - Product Serial Number (for example, MYXXXXXXXX)
   - Description of failure or service required
3 Protect the N7004A by wrapping in plastic or heavy paper. Use original packaging or comparable.
4 Pack the N7004A in the original carrying case or if not available, use bubble wrap or packing peanuts.
5 Place securely in sealed shipping container and mark container as "FRAGILE".

If any correspondence is required, refer to the product by serial number and model number.

Contacting Keysight Technologies

For technical assistance, contact your local Keysight Call Center.

- In the Americas, call 1 (800) 829-4444
- In other regions, visit http://www.keysight.com/find/assist

Before returning an instrument for service, you must first call the Call Center.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

9 Safety and Regulatory Information

This product has been designed and tested in accordance with accepted industry standards, 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.

Only Keysight approved accessories shall be used.

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 personnel. To prevent electrical shock do not remove outer covers.

WARNING Indoor Use Only. Do not operate in wet / damp environments. Keep product surfaces dry and clean.

Do not operate in an explosive environment.

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Instrument Markings

Marking	Description
	The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to the instruction in the documentation.
	This symbol indicates the Environmental Protection Use Period (EPUP) for the product's toxic substances for the China RoHS requirements.
	This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive, 2002/96/EC).

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

This information is subject to change without notice.
© Keysight Technologies 2016
Edition 1, November 2016
N7004-92000
www.keysight.com

KEYSIGHT TECHNOLOGIES

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP