

Agilent N4975A

PRBS Generator 56 Gb/s

User Guide

Notices

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For Assistance and Support

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NOTE

A **NOTE** provides important or special information.

Safety Summary

General Safety Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.

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

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

Initial Inspection

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically. The Performance Tests give procedures for checking the operation of the instrument. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Agilent Technologies Sales/Service Office.

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

General

This product is a Safety Class 1 product (provided with a protective earthing ground incorporated in the power cord). 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, will make the instrument dangerous. Intentional interruption is prohibited.

Environment Conditions

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment per IEC 61010 Second Edition and 664 respectively. It is designed to operate within a temperature range of 10 to 40 °C at a maximum relative humidity of 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C at an altitude of 2000 meters.

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

Before Applying Power

Verify that all safety precautions are taken. The power cable inlet of the instrument serves as a device to disconnect from the mains in case of hazard. The instrument must be positioned so that the operator can easily access the power cable inlet. When the instrument is rack mounted the rack must be provided with an easily accessible mains switch.

Ground the Instrument

Install the instrument so that the ON / OFF switch is readily identifiable and is easily reached by the operator. The ON / OFF switch is the instrument disconnecting device. It disconnects the mains circuits from the mains supply before other parts of the instrument. Or the detachable power cord can be removed from the electrical supply. Alternately, 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.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes.

Do Not Remove the Instrument Cover

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified 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.

Symbols on Instruments



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.



C-Tick Conformity Mark of the Australian ACA for EMC compliance.



Indicates that protective earthing ground is incorporated in the power cord.

ICES/NMB-001

This mark indicates compliance with the Canadian EMC regulations.

ISM 1-A

This text denotes the instrument is an Industrial Scientific and Medical Group 1 Class A product.



CE Marking to state compliance within the European Community: This product is in conformity with the relevant European Directives: EMC Directive 2004/108/EC and Low Voltage Directive 2006/95/EC.



This symbol indicates that internal circuits can be damaged by electrostatic discharge (ESD), therefore, avoid applying static discharges to the panel input connectors.



China RoHS regulations include requirements related to packaging, and require compliance to China standard GB18455-2001. This symbol indicates compliance with the China RoHS regulations for paper/fiberboard packaging.



Indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.



The Korean Certification (KC) mark is required for products that are subject to legally compulsory certification.

The KC mark includes the marking's identifier code that has up to 26 digits and follows this format: KCC-VWX-YYY-ZZZZZZZZZZZZ.



This symbol indicates that the instrument requires alternating current (AC) input.

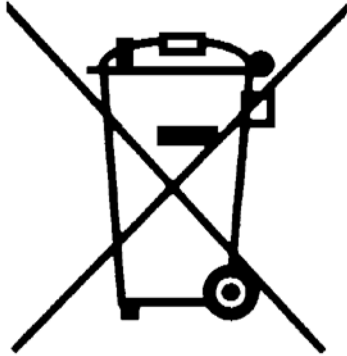


This symbol indicates that the power line switch is in the ON position.



This symbol indicates that the power line switch is in the OFF position.

Environmental Information



This product complies with the WEEE Directive (2002/96/EC) marketing 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 Annexure I, this product is classed as a "Monitoring and Control instrumentation" product.

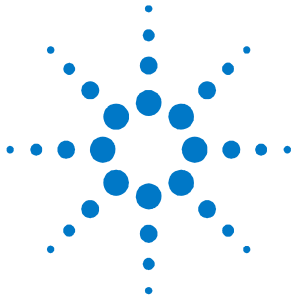
Do not dispose in domestic household waste.

To return unwanted products, contact your local Agilent office, or see

www.agilent.com/environment/product/ for more information.

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1 Getting Started

1.1 Unpacking and Installation

The N4975A PRBS generator 56 Gb/s is shipped with all the accessories required for the self-test mode and verification.

The shipment includes:

- N4975A PRBS generator 56 Gb/s
- AC power converter module
- AC power cord
- 3 dB 67 GHz attenuator
- 50 Ω 67 GHz load 1.85 mm
- 50 Ω 18 GHz load SMA
- Small screwdriver for data phase adjust
- Clock out to clock in RF cable
- CD containing the N4975A user guide and N4975A data sheet

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.

CAUTION

Before switching on this instrument, make sure the supply voltage is in the specified range.

CAUTION

To prevent damage to the DATA output stage, before switching on, ensure that the front panel DATA outputs are terminated to a 50 Ω load or equivalent circuit.

CAUTION

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

CAUTION

To prevent damage to the instrument, make all RF connections between the N4975A and the DUT or test equipment BEFORE applying AC power to the N4975A. Also, remove AC power from the N4975A instrument before disconnecting any RF connections.

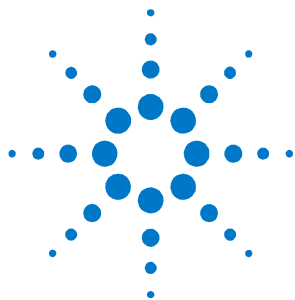
In an ESD-safe environment, carefully remove the N4975A from the packaging. Install on a flat surface with unobstructed air flow to the back panel. Plug the AC power cord into the power converter module and a wall socket, then plug the converter module into the N4975A.

1.2 Important Notes

- Use ESD protection at all times when using the system.
 - Review min/max specifications before applying input signals.
 - Use only high quality RF connectors on the RF ports.
 - Use dust jackets on unused back panel connectors.
 - Situate the instrument away from heat sources.
-

1.3 Performance Recommendations

1. When using differential-mode connections, ensure the cables are phase balanced.
 2. Differential connectors may be used single-ended if unused connector is terminated in 50 Ω .
 3. Use high quality cables and connector savers (or adaptors).
 4. Keep cable lengths short and minimize number of cable bends.
 5. Use a 7 to 10 in-lbs torque wrench when attaching connectors.
-



2 Introduction

The Agilent Technologies N4975A PRBS generator 56 Gb/s is a self-contained pattern generator capable of operating at either 56 Gb/s data rate using the internal oscillator or operating over a wider data rate range of 39.8 to 56 Gb/s when used with an external quarter-rate clock source. This is made possible through comprehensive integration of the key building blocks into monolithic integrated circuits founded on SiGe technology. The performance generated from the N4975A PRBS generator 56 Gb/s is world class with the typical data signal having 500 fs rms jitter, 500 mV of output swing and 9 ps rise time.

The N4975A PRBS generator 56 Gb/s, in conjunction with a high speed digital communications analyzer can be used to make eye and jitter measurements of 56 Gb/s components such as modulator drivers, optical modulators, MUX, and DEMUX components. The superior rise time, fall time, and excellent jitter of the N4975A PRBS generator 56 Gb/s make it desirable for production component test where the source performance needs to be as good as possible to meet production specification margins. The low price of the N4975A PRBS generator 56 Gb/s make it desirable for manufacturing environments which are cost sensitive.

2.1 N4975A System Overview

For R&D applications the N4975A provides the engineer with a precise, flexible PRBS source with the triggering needed for broadband precision time-base receivers. The compact source can be placed close to the DUT for minimal waveform distortion from cable losses. The custom design SiGe components in the N4975A design provide very fast rise and fall time edges, low intrinsic jitter, and high signal to noise ratio. A pattern trigger output is provided for “scope mode” presentation of the data pattern on the digital communications analyzer as shown in Figure 1.

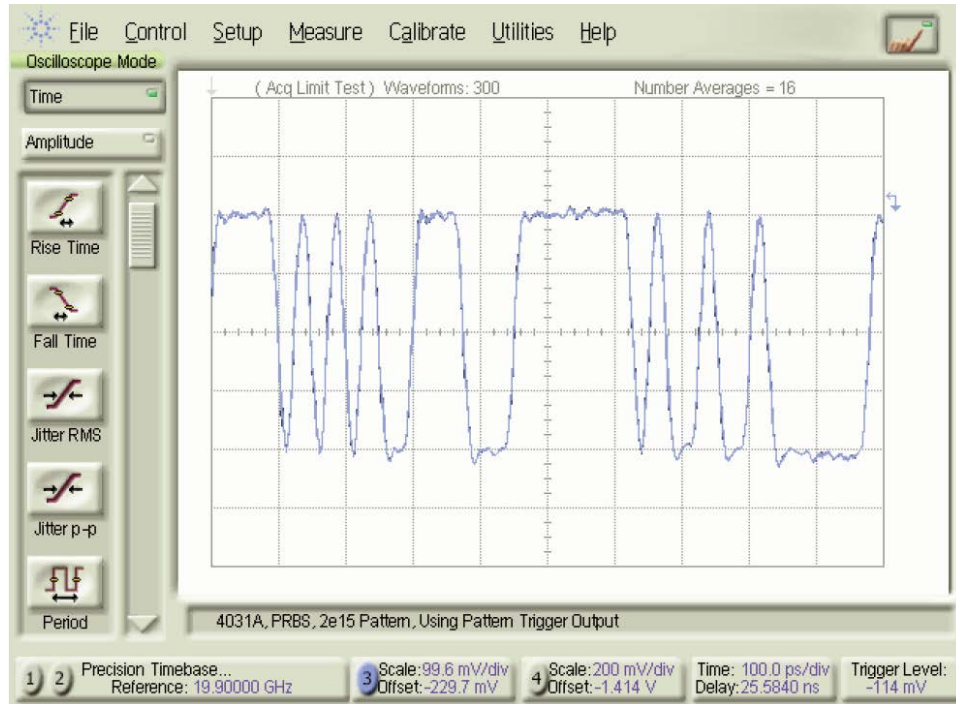


Figure 1. Pattern using pattern trigger

For manufacturing applications, the N4975A provides a low cost, high quality waveform needed for performance verification of high speed components.

Typical manufacturing applications include the characterization of residual (additive) jitter, eye distortion, and rise/fall time of high speed components such as driver amplifiers, optical modulators, TIA, and limiting amplifiers. The N4975A can also be used for the characterization of 56 Gb/s transmission systems driven with PRBS signals.

2.2 Front Panel Quick Reference



Figure 2. N4975A front panel

Pattern Select	There is a pattern select switch which can select from a “1010” pattern, a “1100” pattern, or the PRBS 15 pattern. One of the three front panel LED pattern indicator lights indicates which pattern is selected when N4975A is powered on.
Data Out	The N4975A output is a differential signal on the two 1.85 mm female output connectors.

NOTE

If a differential signal is not required, the unused output must be terminated with a 1.85 mm 67 GHz 50 Ω termination.

Outputs are CML and must be externally DC terminated with 50 Ω to GND. Refer to section 4.4 Terminating the N4975A Outputs for guidance on termination options for the N4975A.

NOTE

The N4975A data output stage can be damaged if the outputs are not properly terminated.

Clk2 Phase Adj: Use of an external clock may require a timing calibration adjustment, accessed through the top cover of the PRBS using a size C (0.07" blade) jeweler's screwdriver for tuning. This tuning aligns the clock to data on the output retimer for optimal performance. This must be re-adjusted if the clock frequency is modified. To adjust the phase a DCA is needed. View the data output eye on the DCA, and adjust the phase with a screwdriver to obtain the cleanest eye. Refer to section 4.5 N4975A Clk/2 Phase Adjustment for further information.

CAUTION

Excessive force on the tuning mechanism will cause damage to the internal "mechanical stops".

Data Amplitude Knob: The N4975A has a linear amplitude adjustment knob located on the front panel of the instrument. This allows a 0 to -6 dB adjustment of the data output amplitude, from nominally 250 to 500 mV single-ended, or 500 to 1000 mV differential. This is useful for testing the effect of input amplitude on the device under test.

Clk2 Out: The clock divided by 2 output can be used as a scope trigger or as the clock output for a half rate demultiplexer.

2.3 Rear Panel Quick Reference



Figure 3. N4975A rear panel

2.3.1 Connectors

- +9V:** The N4975A is powered from an external AC to DC power module which is supplied by Agilent. The N4975A draws about 2 A at +9 VDC. Use only the provided AC/DC adapter.
- Power:** The rear panel power switch applies power to the N4975A. When power is applied the N4975A is initialized and reset.
- Clk/4 Output:** The PRBS Source N4975A provides a 14 GHz quarter rate internal reference clock. The clock is set to provide a 56 Gb/s data stream. The internal clock is an exceptionally low phase noise, frequency stable oscillator. A factory provided external cable connects the “Clk/4 Out” to the PRBS “Clk/4 In” connector for operation at 56 Gb/s without the need for an external clock source.
- Clk/4 Input:** External clocks are connected to this port. Remove the factory installed jumper cable between “Clk/4 Out” and “Clk/4 In”. Terminate the “Clk/4 Out” with 50 Ω SMA termination. An external quarter-rate clock from 9.95 to 14 GHz can be used to drive the PRBS. The resultant output data ranges from 39.8 to 56 Gb/s.
- Clk/4 Buf Output:** The Clk/4 Buf output is a buffered version of the input clock. This may be used as a scope trigger or as a clock for a sub-rate de-multiplexer.
- Pattern Trigger:** In many situations, including the use of standard timebases, the pattern trigger can provide a trigger event synchronized to the start of the PRBS pattern. The pattern trigger output provides a trigger edge at 1/128th of the PRBS pattern repetition rate.
- NOTE** The pattern trigger is not applicable for the static “1010” pattern and the “1100” data pattern.
- Mux4 Clk Phase:** The Mux4 clock phase provides the ability to invert the clock phase delivered to the final 56 Gb/s Mux. This switch position may be changed to optimize the clock phase to the 56 Gb/s Mux. Whenever the clock frequency is modified this adjustment may be necessary to ensure the data signal is free of bit errors. Mux4 Clk Phase should only be adjusted after Clk2 Phase adjust and DCD Bias adjust have been optimized for best looking eye diagram on a scope. Mux4 Clk Phase should then be adjusted if necessary for error free BER measurement.

DCD Bias Adjust: The DCD Bias adjust is provided to optimize the duty cycle distortion of the Data output signals (adjacent bit to bit width of the eye diagram). Each time the clock frequency is modified, a duty cycle distortion adjustment may be necessary. The duty cycle distortion adjustment is accessed through the rear panel using a size C (0.07" blade) jeweler's screwdriver for tuning. This can be adjusted by looking at the front panel Data output on a DCA and adjusting for equal width of adjacent bits on an eye diagram display.

Label: N4975A serial number.

2.4 Safety and Regulatory

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.

WARNING

Do not remove instrument covers. There are no user serviceable parts within. Operation of the instrument in a manner not specified by Agilent Technologies may result in personal injury or loss of life.

WARNING

To prevent electrical shock, disconnect 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

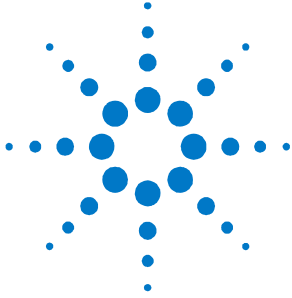
For continued protection against fire hazard, replace fuses, and or circuit breakers only with same type and ratings. The use of other fuses, circuit breakers or materials is prohibited.

CAUTION

The Mains wiring and connectors shall be compatible with the connector used in the premise electrical system. Failure, to ensure adequate earth grounding by not using the correct components may cause product damage, and serious injury.

2.4.1 Declaration of Conformity

A EU declaration of conformity is available at
<http://regulations.corporate.agilent.com/doc/search.htm>



3 Performance Specifications

Specifications describe the instrument's warranted performance. Non-warranted values are stated as typical. All specifications are valid in a range from 10 °C to 40 °C ambient temperature after a 30 minute warm-up phase.

3.1 General

Table 1. General and mechanical parameters of N4975A

Operating Temperature	+10 to +40 °C
Storage Temperature	−40 to +70°C
Power Requirements	25 W External AC Adaptor (included) <ul style="list-style-type: none"> • 100 to 240 VAC, 50 to 60 Hz
Physical Dimensions (W x H x D)	178 mm (7 in) x 63.5 mm (2.5 in) x 229 mm (9 in)
Weight	2.5 kg (5.5 lbs)
EMC	<p>Complies with European EMC Directive 2004/108/EC</p> <ul style="list-style-type: none"> • IEC/EN 61326-1 • CISPR Pub 11 Group 1, class A • AS/NZS CISPR 11 • ICES/NMB-001 <p>This ISM device complies with Canadian ICES-001.</p> <p>Cet appareil ISM est conforme a la norme NMB-001 du Canada.</p>

3.2 N4975A PRBS Generator Specifications

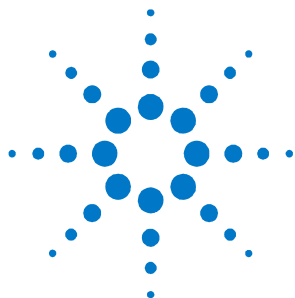
Table 2. N4975A PRBS generator specifications

Parameter	Specification
Data Output	
Data rate	39.8 to 56 Gb/s ¹
Patterns	$2^{15}-1 : 1 + X^{14} + X^{15}$ Divided Clock 1010, 1100
Output amplitude (single-ended)	500 mV p-p typical (at maximum setting on amplitude adjust control)
Output amplitude adjustment range	0 to -6 dB typical
Output level	High: 0 V nominal Low: -500 mV nominal
Jitter	500 fs rms typical
Rise/fall time (20% to 80%)	9 ps typical
External interface	Differential. DC coupled, 50 Ω nominal, 1.85 mm female connectors.
	<div style="background-color: #cccccc; padding: 2px; display: inline-block;">NOTE</div> Outputs are CML and must be externally DC terminated with 50 Ω to GND.
Clock/4 Input	
External quarter-rate clock input range	9.95 to 14 GHz
External half-rate clock input power required	+4 to +15 dBm (1 to 3.5 V p-p)
External interface (Clk/4 In)	Single-ended. AC coupled, 50 Ω nominal, SMA female connector.

Parameter	Specification
Internal Clock/4 Internal quarter-rate clock frequency Frequency accuracy Output power External interface (Clk/4 Out)	14.0 GHz internal oscillator (for 56 Gb/s data rate) < ±20 ppm typical +7.5 dBm typical (1.5 V p-p) Single-ended. AC coupled, 50 Ω nominal, SMA female connector.
Buffered Clock/4 Output Frequency accuracy Output power External interface (Clk/4 Buf)	9.95 to 14 GHz +2 dBm typical (800 mV p-p) Single-ended. AC coupled, 50 Ω nominal, SMA female connector.
Clock/2 Output Frequency accuracy Output power External interface (Clk/4 Buf)	19.9 to 28 GHz 0 dBm typical (630 mV p-p) Single-ended. AC coupled, 50 Ω nominal, 2.92 mm female connector.
Pattern trigger output² Frequency Output amplitude External interface	$(\text{Bit_rate}) / (128 * (2^{15} - 1))$ e.g. at 56 Gb/s frequency = 13.35 kHz 600 mV p-p nominal Single-ended. DC coupled, SMA female connector

¹ With an external clock. Internal clock (14 GHz) provides fixed 56 Gb/s data rate operation.

² Available only with PRBS-15 pattern. Pattern trigger is a square wave output.



4 Operation

The following section provides more detailed information regarding the use of the N4975A.

4.1 General Information

The N4975A should be used in accordance with the following:

- Read and follow operating instructions; do not exceed min/max specifications.
 - Use ESD protection at all times, but especially when handling RF input/outputs; ground coaxial cable conductor pins before use to remove static buildup.
 - Situate the instrument away from heat sources.
 - Do not allow foreign material into enclosure.
 - Always use provided AC adaptor. Do not power the unit with a different adaptor. Do not modify the power plug or wall outlet to remove the third (ground) pin.
 - Do not drop or shake the instrument; minimize vibration; handle with care.
 - There are no user-serviceable parts within. Return damaged instruments for factory-authorized repair. Refer to instrument warranty for more information.
 - To prevent damage to the instrument, make all RF connections between the N4975A and the DUT or test equipment BEFORE applying AC power to the N4975A. Also, remove AC power from the N4975A instrument before disconnecting any RF connections.
 - Outputs are CML and must be externally DC terminated with 50 Ω to GND.
-

4.1.1 Performance Recommendations

Follow the following recommendations for best performance:

1. When using differential mode connection for Data output connections, ensure the cables are phase balanced. If the electrical length of one cable is a significant fraction of a unit interval longer than the other, the quality of the differential signal will be degraded.
 2. Keep cable lengths short and minimize number of cable bends.
 3. When using a single port of differential output channel for single-ended measurements, the complementary port must be terminated with a 50 Ω termination.
-

4.1.2 Connector Care

The N4975A features high-quality SMA, 2.92 mm, and 1.85 mm connectors for the front and rear panel Input and Output, RF connections. Connector damage will degrade signal fidelity.

Refer to the N4960-90030 N495xA through N498xA Connector Care Reference Guide at www.agilent.com/find/N4975A.

Agilent Technologies also recommends the following:

- Use a 7 to 10 in-lbs torque wrench when attaching connectors.
- Consider using connector savers to prolong performance and minimize damage.
- Differential connectors may be used single-ended if second end terminated in 50 Ω .

Inspect the connectors for the following:

- Worn or damaged threads
- Scratches to mating surface
- Burrs and loose metal particles
- Dust or foreign material in the space surrounding the center pin
- Ensure that female contacts are straight and aligned

Clean the connectors as described in the following procedure. 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.

1. Remove any dust or loose particles using a low-pressure air source.
 2. Moisten a lint-free swab with isopropyl alcohol. Do not saturate the swab.
 3. Minimize the wicking of the alcohol into the connector structure.
 4. Clean the mating plane surfaces and threads.
 5. Allow alcohol to evaporate, and then use a low-pressure air source to blow surfaces clean.
 6. Make sure no particles or residue remains.
 7. Inspect connector for damage.
-

4.2 System Verification

The figure below shows the setup required to verify performance of the source. The performance verification is a single ended output measurement. A digital communications analyzer is used to verify the quality of the pattern generator waveform. Care must be taken to terminate the unused output with a 1.85 mm 67 GHz 50Ω termination (provided). Use a 3 dB 1.85 mm pad between the N4975A output and the Agilent 86118A 70 GHz electrical sampling head. The oscilloscope is triggered using the front panel CLK/2 output connected to the Agilent 86107A precision timebase. For best results use a short high quality 1.85 mm cable to connect the output of the N4975A to the sampling heads.

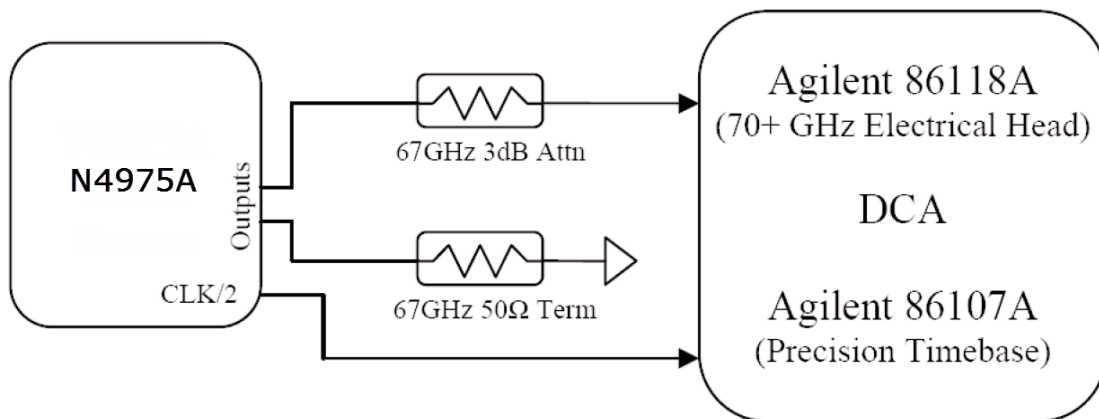


Figure 4. Verification setup

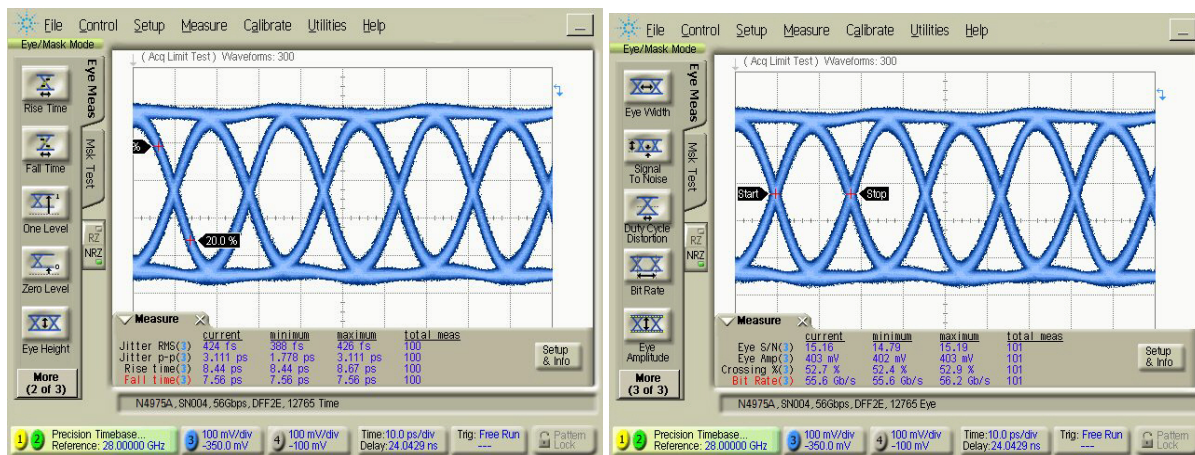


Figure 5. 56 Gb/s eye output from N4975A

4.3 Application Example

A typical residual or additive jitter test system is shown in Figure 6. Additive jitter measurements require a precise, low jitter clock. The N4975A features an exceptionally low jitter internally-referenced, frequency-stable, microwave oscillator which can be used as the reference clock.

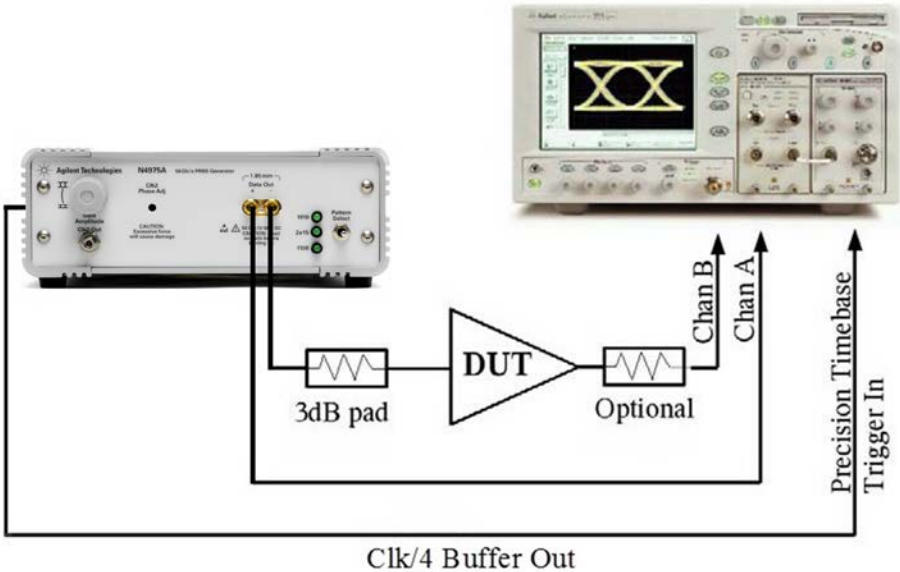


Figure 6. N4975A generic test example experimental setup

NOTE To maintain the integrity of the system the user must select the appropriate connectors and minimize the length of microwave cabling.

4.4 Terminating the N4975A Outputs

Figure 7, Figure 8, and Figure 9 are examples of 50 Ω DC terminating the N4975A outputs.

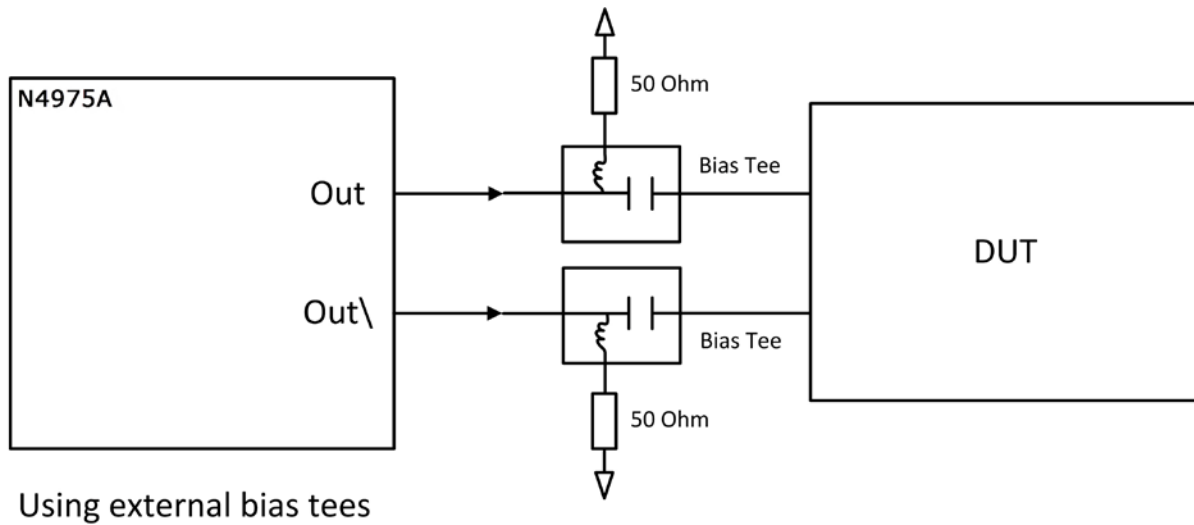


Figure 7. Termination using external bias tees

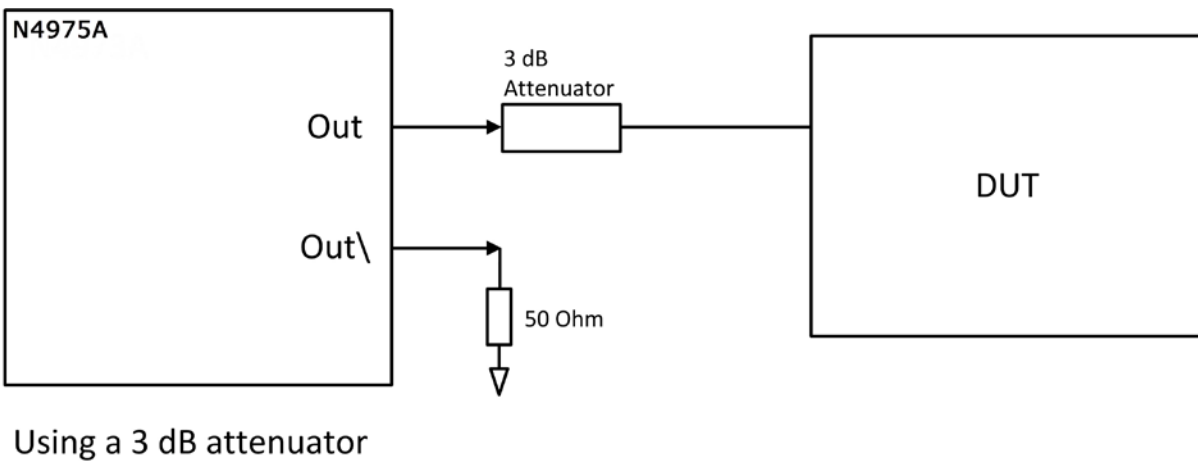


Figure 8. Termination using 3 dB attenuator

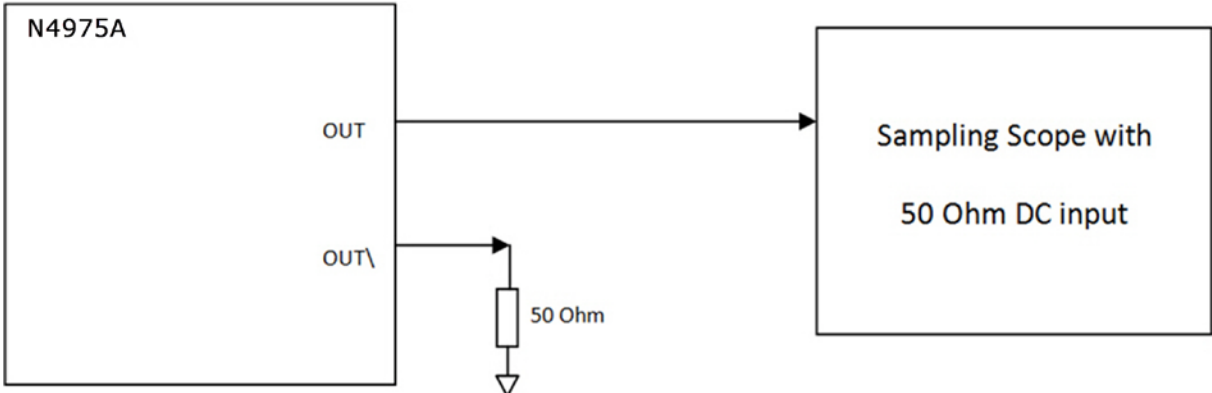


Figure 9. Termination using direct connection to a DC-coupled 50 ohm scope input

4.5 N4975A Clk/2 Phase Adjustment

Connect the output of the N4975A to the DCA as shown in Figure 10. Make sure to terminate the unused output with a 50 Ω termination. A divider may be required to trigger the scope depending on the bandwidth of the scope trigger.

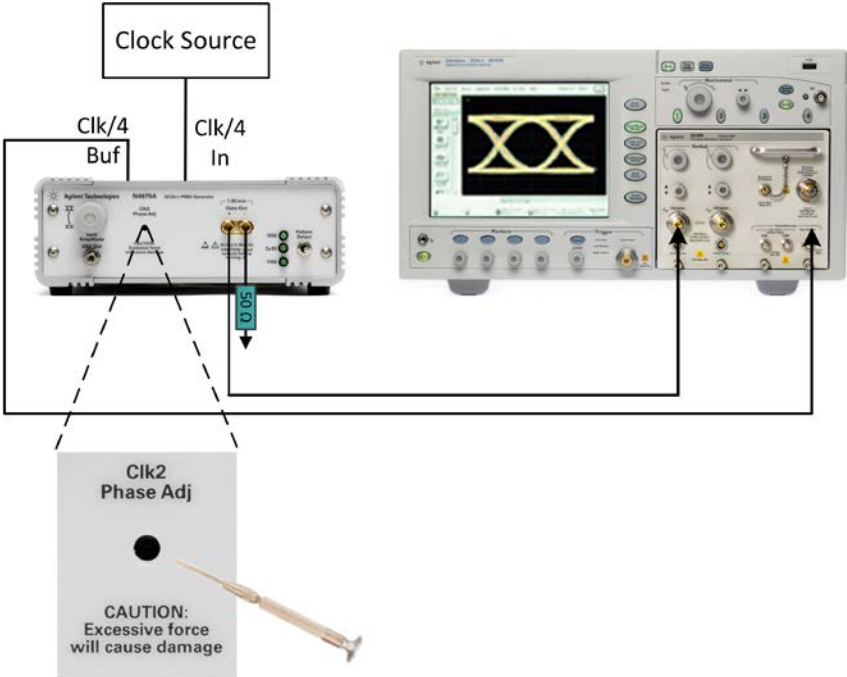


Figure 10. Clk/2 phase adjustment setup

Set the scope to a fast update rate or low persistence mode to quickly

see the affects of the phase adjustments. View the output eye diagram on the scope.

Place the screwdriver in the hole and make sure that it engages with the screw slot. Turn the screwdriver clockwise until there is increased jitter and additional noise inside the eye as shown in Figure 11. Now turn the screwdriver in the opposite (counterclockwise) direction until the additional noise reduces, as shown in Figure 12, and keep turning until a clean eye is achieved and the jitter is minimized at the crossover points as shown in Figure 13.

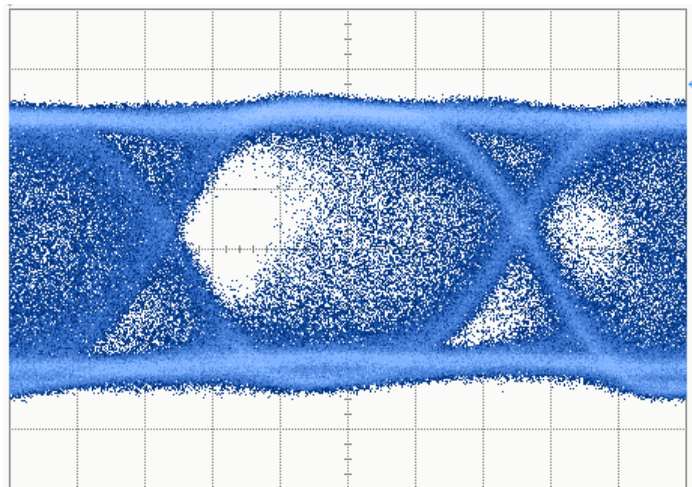


Figure 11. Eye with re-timer out of phase alignment

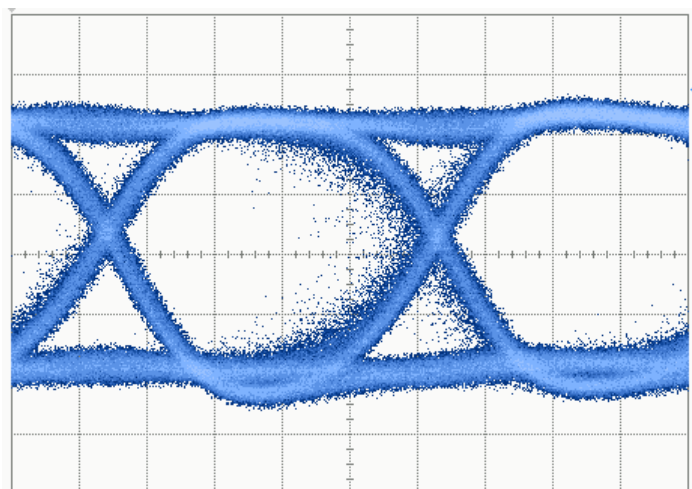


Figure 12. Eye with re-timer phase alignment almost correct

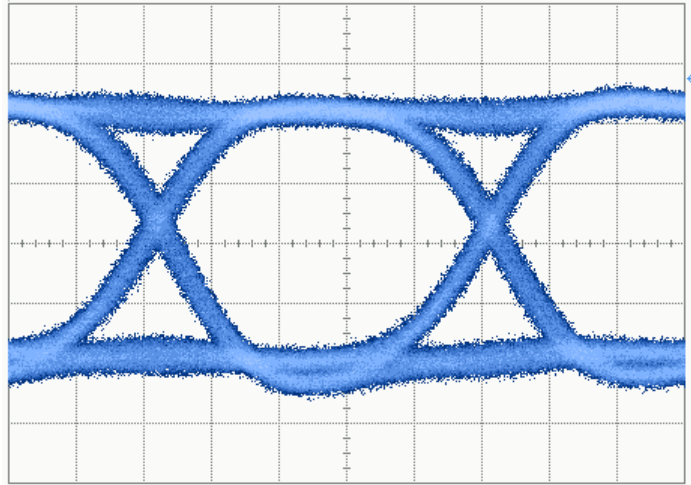
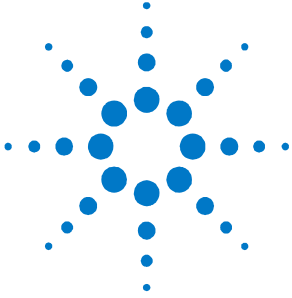


Figure 13. Eye with re-timer phase at optimum alignment



5 Returning the N4975A to Agilent Technologies

If the N4975A fails system verification and you cannot correct the problem, return it to Agilent Technologies for repair following the steps shown below.

1. Record all symptoms.
 2. Contact Agilent Technologies at <http://www.agilent.com/find/assist>.
 3. Use the original packing material or comparable packing material to ship the instrument to Agilent Technologies.
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