

Agilent N4973A

PRBS Generator 22 Gb/s

User Guide

Notices

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For Assistance and Support

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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.

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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.



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



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



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



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.



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



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



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



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.

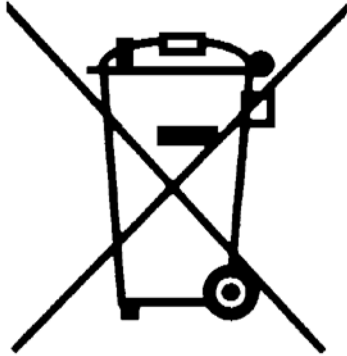
ICES/NMB-001

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.

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.

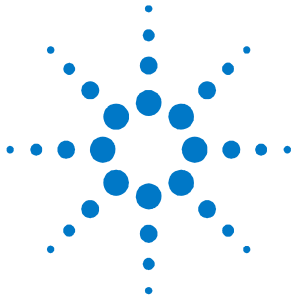
Do not dispose in domestic household waste.

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

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1 Getting Started

1.1 Unpacking and Installation

The N4973A PRBS generator 22 Gb/s is shipped with all the accessories required for the self-test mode and verification. The shipment includes:

- N4973A PRBS generator 22 Gb/s
- AC power converter module
- AC power cord
- 3 dB 67 GHz attenuator
- 50 Ω 67 GHz load
- Small screwdriver for data phase adjust
- CD containing the N4973A user guide and N4973A 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.

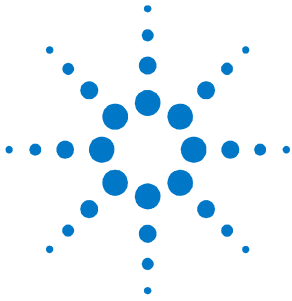
In an ESD-safe environment, carefully remove the N4973A from the packaging. Install on a flat surface with unobstructed air flow to the back panel. Make all RF connections between the N4973A and the DUT or test equipment BEFORE applying AC power by plugging the converter module into the N4973A. Also, remove AC power from the N4973A instrument before disconnecting any RF connections. Plug the AC power cord into the power converter module and a wall socket, then plug the converter module into the N4973A.

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 N4973A Introduction

The Agilent N4973A PRBS generator 22 Gb/s is a precision pseudo random bit stream generator designed for 11 to 22 Gb/s data systems. The source features exceptionally low jitter, fast rise time, and 3 selectable bit stream pattern lengths. The N4973A is an easy to use, compact laboratory bench instrument.

2.1 N4973A System Overview

For R&D applications the N4973A 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 and will provide simple, quick and accurate measurements. The wideband design provides very fast rise and fall time edges, low jitter and wide dynamic range. A pattern trigger output is provided for direct viewing of the data pattern on the oscilloscope as shown in Figure 1.

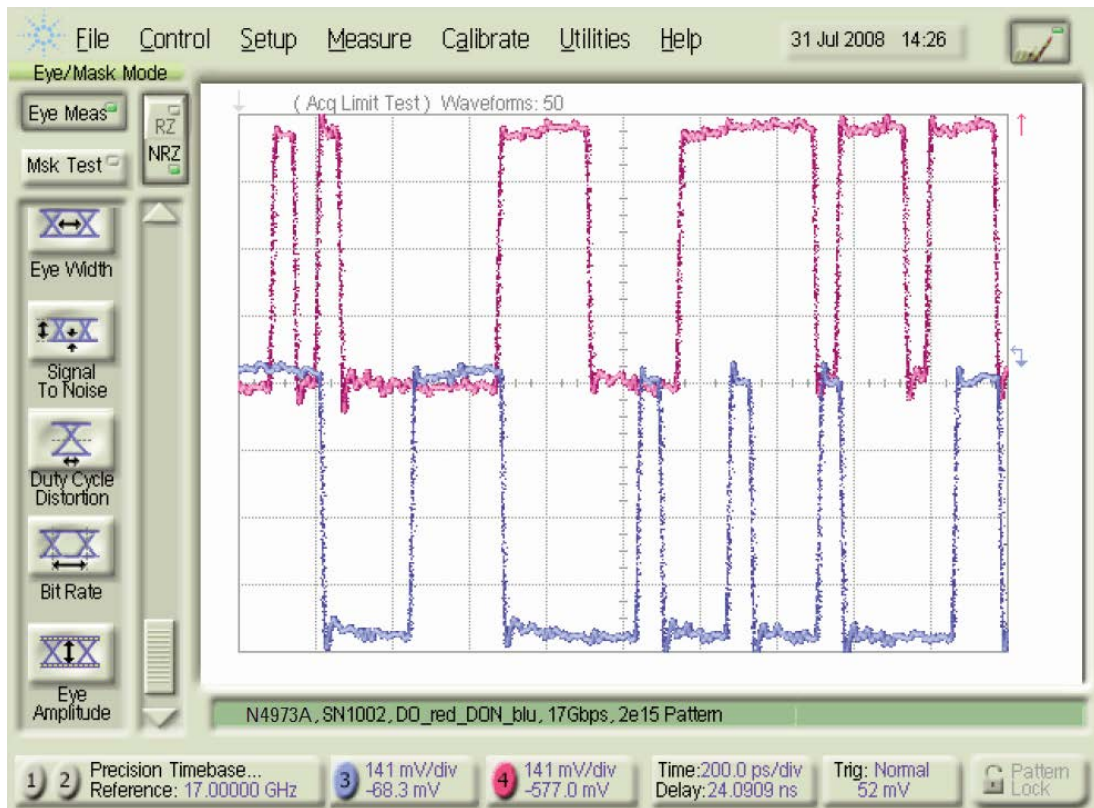


Figure 1. Pattern using pattern trigger

For manufacturing applications, the N4973A Source provides a low cost, high quality waveform needed for performance verification of Fibre Channel components.

Residual (additive) jitter and eye distortion of driver amplifiers, optical modulators, TIA, limiting amplifiers and 14 Gb/s Fibre Channel systems can also be characterized using the N4973A.

2.2 Front Panel Quick Reference



Figure 2. N4973A front panel

2.2.1 Front Panel Connectors

Power	The front panel LED indicator light glows when power is on.
OUTPUT	The PRBS signal is available as a differential signal on the 1.85 mm female output terminals. 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 N4973A Outputs for guidance on termination options for the N4973A.

NOTE

The N4973A data output stage can be damaged if the outputs are not properly terminated.

NOTE

When PRBS pattern lengths 2^7-1 or $2^{15}-1$ are selected and power is applied, a manual reset may be required to initiate the PRBS output. To reset the instrument, briefly depress the reset switch on the rear panel.

2.3 Rear Panel Quick Reference



Figure 3. N4973A rear panel

2.3.1 Rear Panel Connectors

- Power:** The rear panel power switch applies power to the N4973A. When power is applied the N4973A is initialized and reset.
- Clk Input:** External clocks are connected to this port. An external full-rate clock from 11 to 22 GHz can be used to drive the PRBS with the required drive power (+10 dBm to +16 dBm). The corresponding output data rate ranges from 11 to 22 Gb/s.

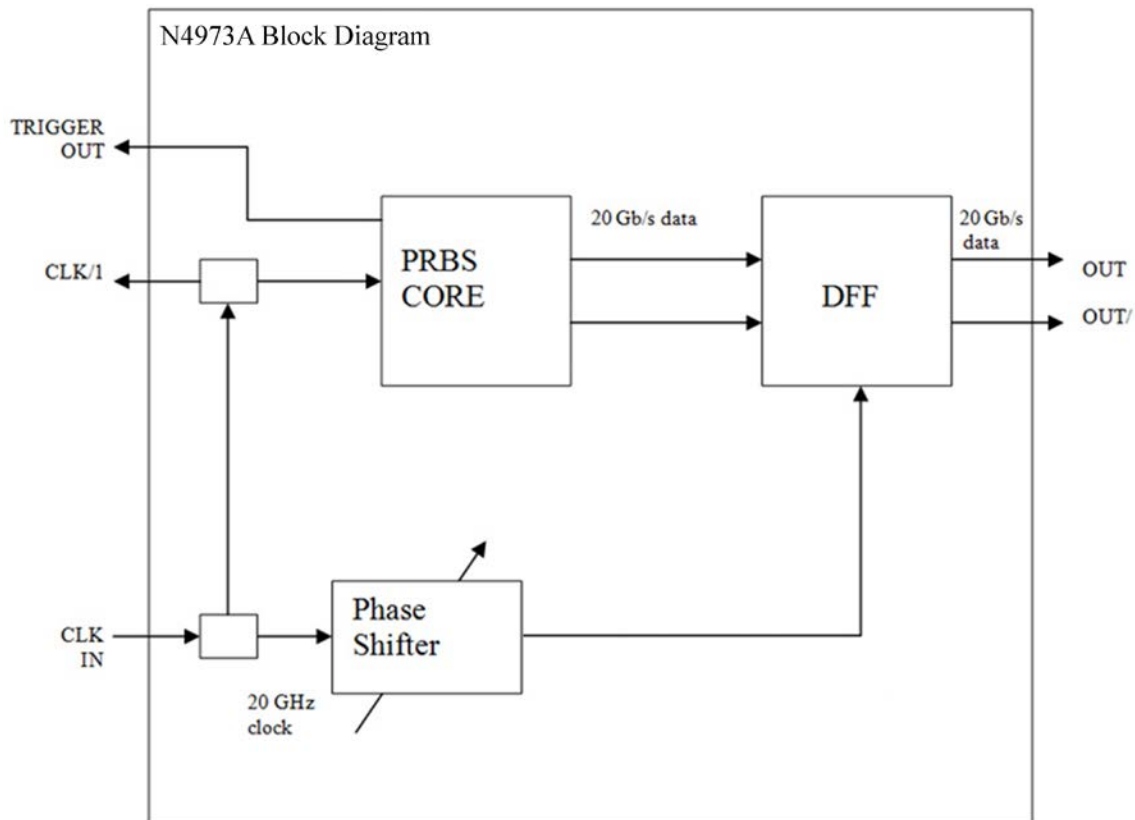
Retimer phase adjustment: a timing calibration adjustment is required after a new frequency of the external clock is set. The adjustment is accessed through the top cover of the PRBS using a size C (0.07" blade) jewelers screwdriver for tuning. This tuning aligns the clock and data on the output retimer for optimal performance. View the data output eye on a scope, and optimize the phase to obtain the cleanest eye. Refer to section 4.5 N4973A Re-timer Phase Adjustment for further information.

CAUTION

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

Label:	N4973A serial number.
Trigger Outputs (Clk/1):	<p>The trigger outputs are provided on the rear panel. Clk/1: is a lower power sample of the input clock, designed for use with precision timebase oscilloscopes for accurate jitter characterization. Output is DC coupled, centered around 0 V. Leave this output open when using the Pattern Trigger output. Otherwise, terminate this output with a 50 Ω load when not in use.</p> <p>Lower frequency triggers may be provided by using an external divider from the Clk/1 output. The N4984A Clock Divider offers excellent divider rates for triggering scopes with 2.5 GHz as the highest trigger frequency available.</p>
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.
NOTE	[2 ³¹ -1] pattern length trigger at 22 Gb/s event occurs every ~3 seconds and will take a long time to produce a waveform on a sampling scope. It is recommended that [2 ⁷ -1] or [2 ¹⁵ -1] pattern lengths be selected when using pattern trigger. Nominal trigger level on the scope should be set to +0.1 V. It is recommended to use averaging for a clear view of waveform dynamics i.e. overshoot/undershoot, memory effects, rise/fall times, etc.
NOTE	The pattern trigger is only specified for operation up to 20 Gb/s. Also, it is recommended to leave the CLK/1 trigger output open when using the Pattern Trigger output.
Pattern Length:	Three PRBS pattern length selections are provided and selected from two toggle switches located on the rear panel. The selections are [2 ³¹ -1], [2 ¹⁵ -1] and [2 ⁷ -1]. The switch positions to select pattern lengths are indicated on the rear panel.
Reset:	Manual pattern reset can be done by briefly depressing the reset switch.
Aux Power:	The center conductor is -5 V DC. Use of this port is not supported.

2.4 Block Diagram



2.5 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

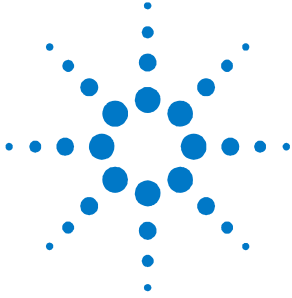
To prevent electrical shock, disconnect instrument from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

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.



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 N4973A

Operating Temperature	+10 to +40 °C
Storage Temperature	−40 to +70°C
Power Requirements	42 W External AC Adaptor (included) 100 to 240 VAC, 47 to 63 Hz
Physical Dimensions (W x H x D)	203 mm (8 in) x 63.5 mm (2.5 in) x 254 mm (10 in)
Weight	2.7 kg (6 lbs)
EMC	<ul style="list-style-type: none"> • 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 N4973A PRBS Generator Specifications

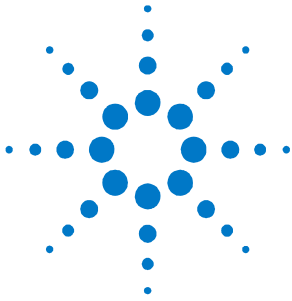
Table 2. N4973A PRBS generator specifications

Parameter	Specification
Data Output Data rate PRBS patterns Output amplitude (single-ended) Output level Jitter Rise/fall time (20% to 80%) Data crossover Data phase adjust range External interface	11 to 22 Gb/s ¹ $2^7-1 : 1 + X^4 + X^7$ $2^{15}-1 : 1 + X^{14} + X^{15}$ $2^{31}-1 : 1 + X^{28} + X^{31}$ > 500 mV p-p typical High: 0 V nominal Low: -500 mV nominal 510 fs rms typical 8 ps typical 55% typical 30 ps nominal Differential. DC coupled, 50 Ω nominal, 1.85 mm female connectors. <div style="display: flex; align-items: center;"> <div style="background-color: #cccccc; padding: 2px 5px; margin-right: 5px;">NOTE</div> <p>Outputs are CML and must be externally DC terminated with 50 Ω to GND.</p> </div>
Clock input External clock input range External clock input power required External interface	11 to 22 GHz +10 to +16 dBm Single-ended. AC coupled, 50 Ω nominal, 2.92 mm female connector.
Clock trigger output Clock trigger (CLK/1) output power External interface	Nominally -16 dB less than Clock Input power Single-ended. AC coupled, 50 Ω nominal, 2.92 mm female connector. Terminate if not used.

Parameter	Specification
Pattern trigger output ²	
Pulse width	$64 * (1/(2 * \text{Bit_rate}))$ e.g. at 20 Gb/s pulse width = 1.6 ns
Repetition period	$64 * (1/(2 * \text{Bit_rate})) * \text{Pattern_length}$ e.g. at 20 Gb/s, $2^{31}-1$ pattern, period = 3.4 s
Output amplitude	200 mV p-p typical
External interface	Single-ended. DC coupled, 50 Ω nominal, SMA female connector

¹ The N4973A requires an external clock signal.

² Pattern trigger specified at ≤ 20 Gb/s only. Remove termination from CLK/1 output when using the Pattern Trigger.



4 Operation

The following section provides more detailed information regarding the use of the N4973A.

4.1 General Information

The N4973A 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 N4973A and the DUT or test equipment BEFORE applying AC power to the N4973A. Also, remove AC power from the N4973A 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 N4973A features high-quality 1.85 mm and 2.92 mm connectors for the front and rear panel Input and Output, RF connections. Connector damage will degrade signal fidelity.

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 N4973A source. The performance verification is a single ended output measurement. Terminate the unused output with a 1.85 mm 67 GHz 50 Ω termination (provided). Use a 3 dB 67 GHz attenuator (provided) between the N4973A output and the Agilent 86118A 70 GHz electrical head. The oscilloscope is triggered using the N4973A "Clk/1 Trigger Output" connected to the Agilent 86107A precision timebase.

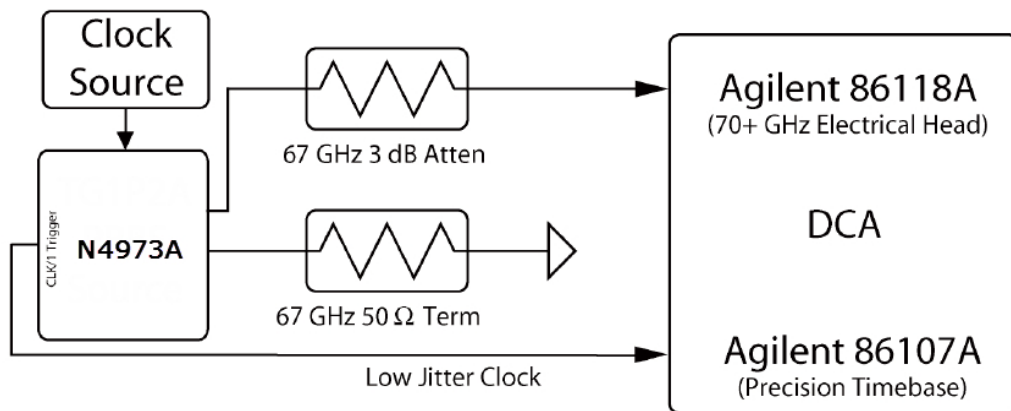


Figure 4. Verification setup

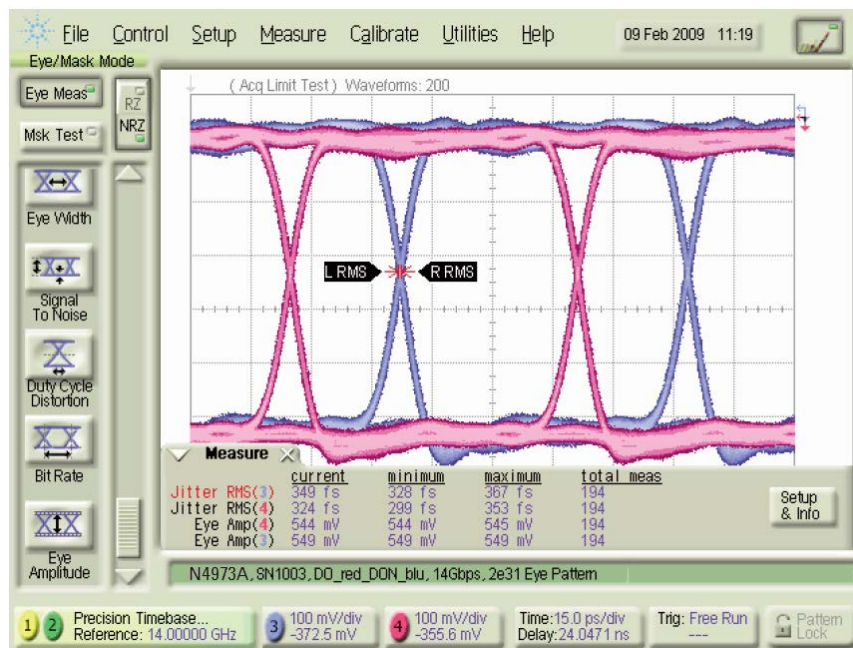


Figure 5. 14 Gb/s eye output from N4973A

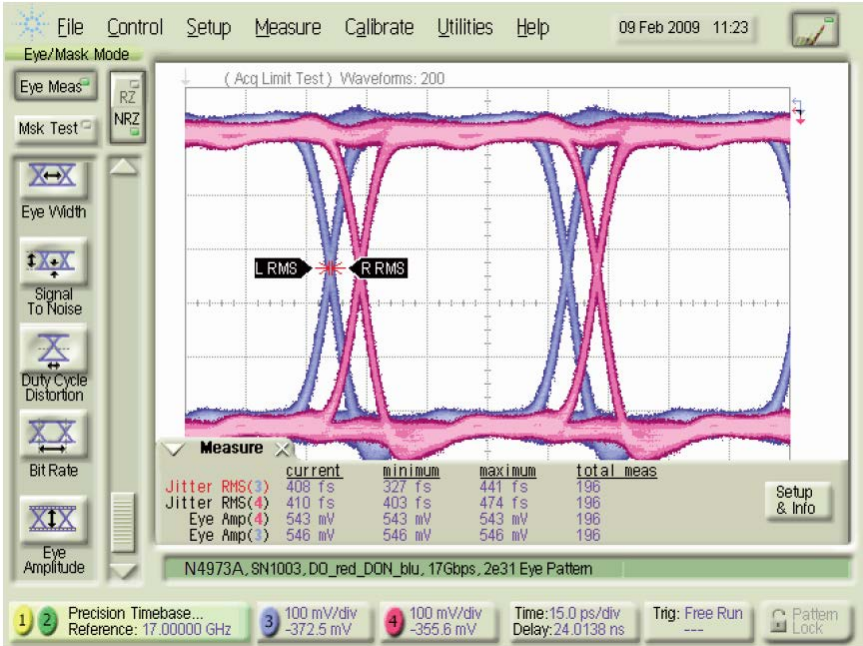


Figure 6. 17 Gb/s eye output from N4973A

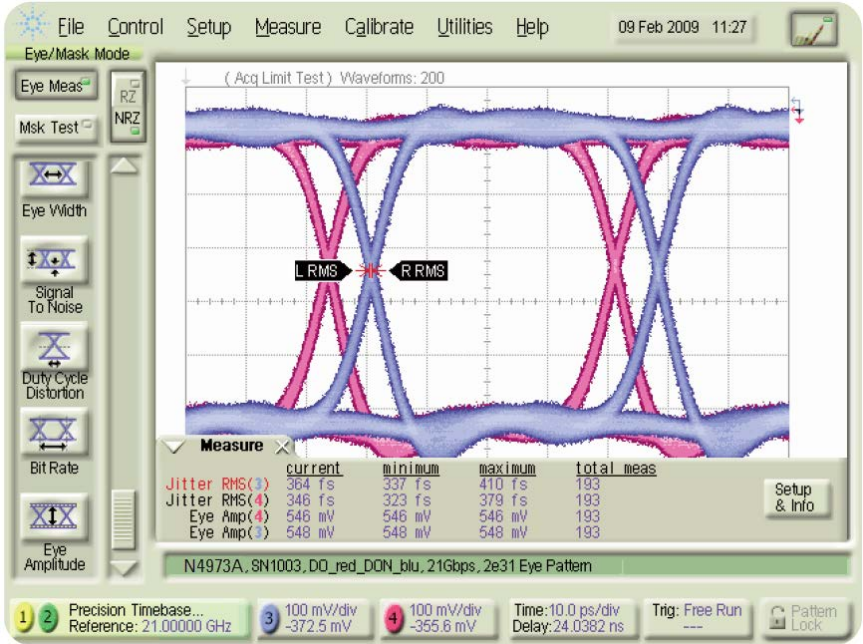


Figure 7. 21 Gb/s eye output from N4973A

4.3 Application Example

A typical residual or additive jitter test system is shown in Figure 8. Additive jitter measurements require a precise, low jitter clock.

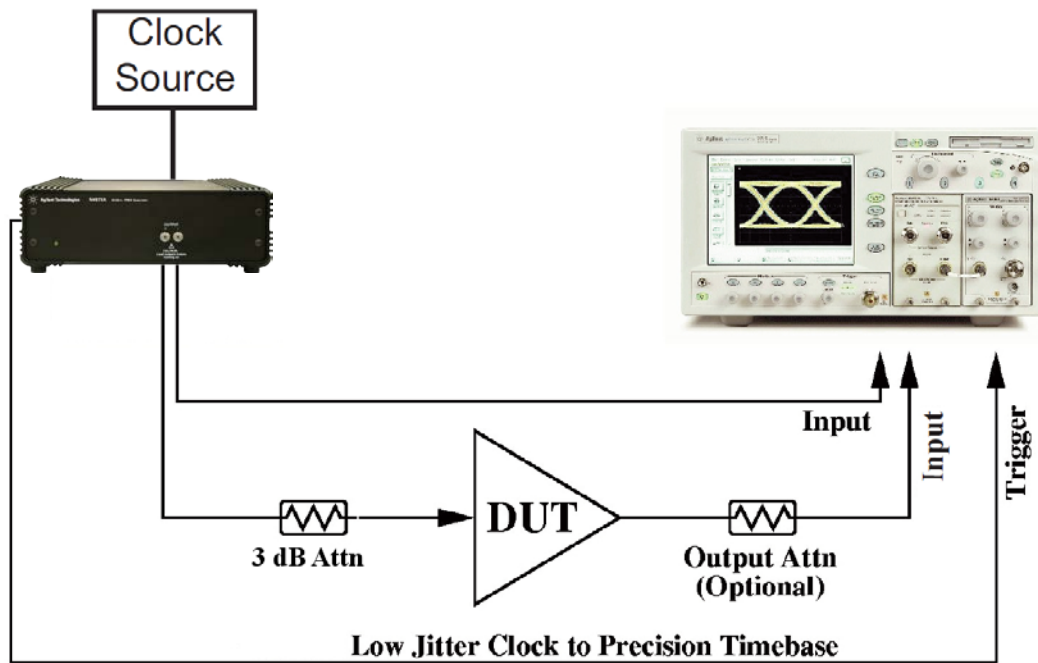


Figure 8. N4973A generic test example experimental setup

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 N4973A Outputs

Figure 9, Figure 10, and Figure 11 are examples of DC 50 Ω terminating the N4973A outputs.

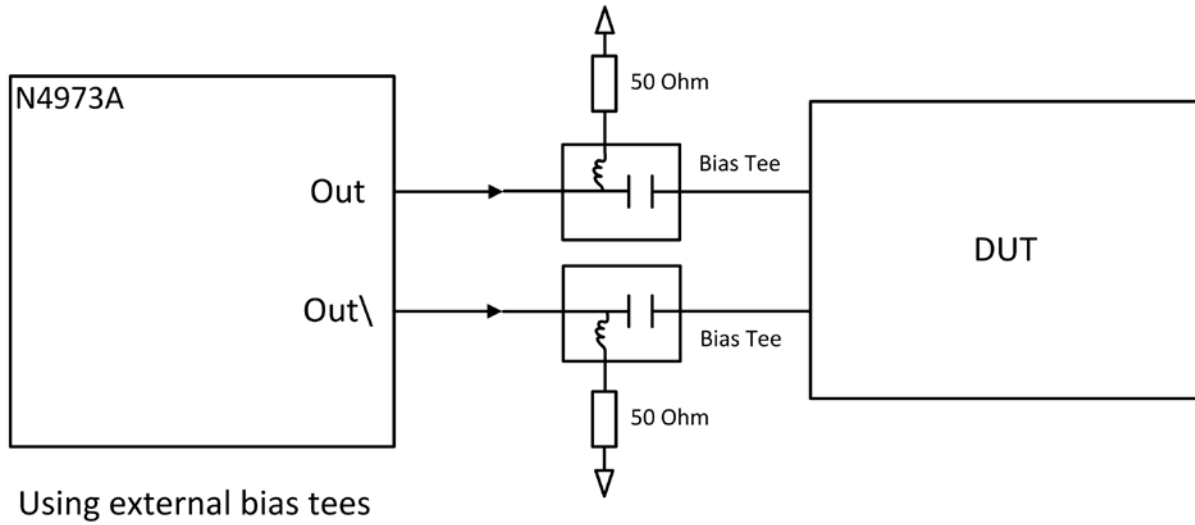


Figure 9. Termination using external bias tees

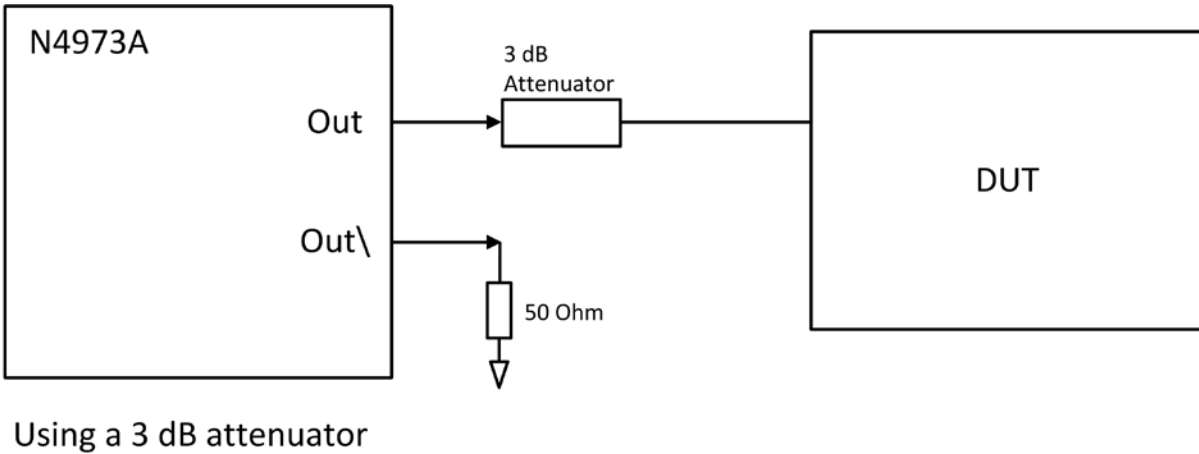


Figure 10. Termination using 3 dB attenuator

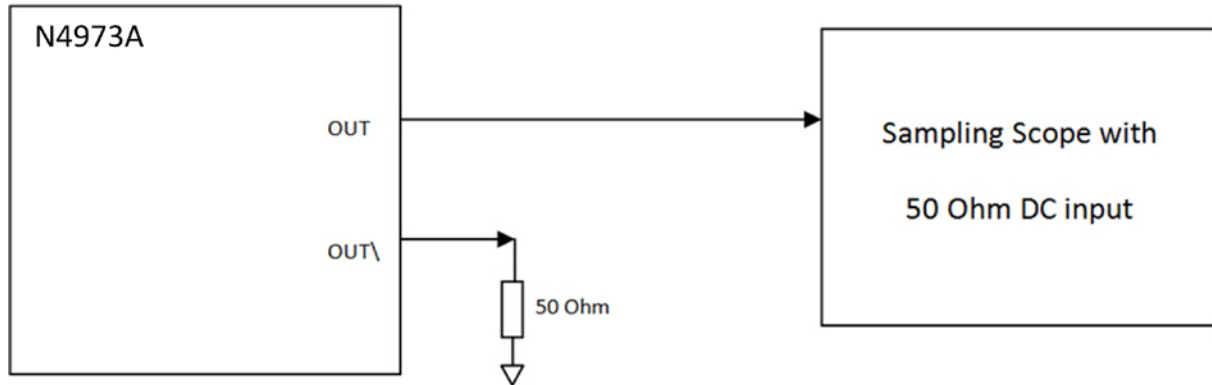


Figure 11. Termination using direct connection to a DC-coupled 50 ohm scope input

4.5 N4973A Re-timer Phase Adjustment

Connect the output of the N4973A to the DCA as shown in Figure 12. 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.

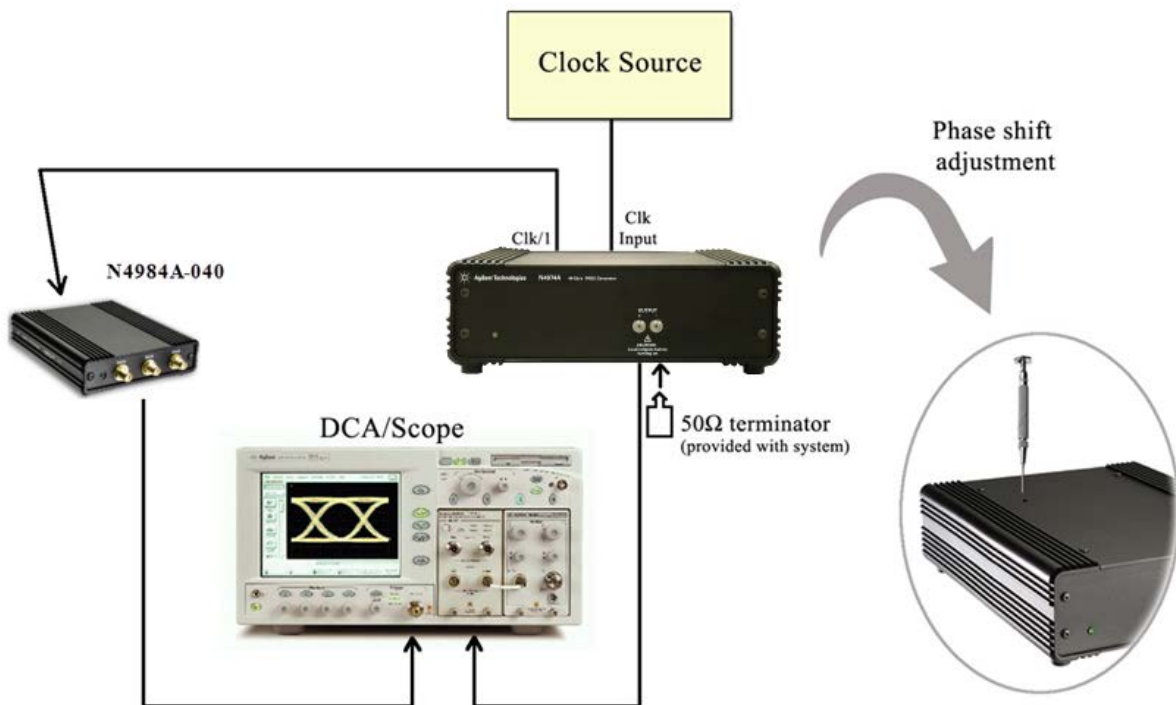


Figure 12. Re-timer phase adjustment setup

Set the scope to a fast update rate or low persistence mode to quickly see the effects 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 13. Now turn the screwdriver in the opposite (counterclockwise) direction until the additional noise reduces, as shown in Figure 14, and keep turning until a clean eye is achieved and the jitter is minimized at the crossover points as shown in Figure 15.

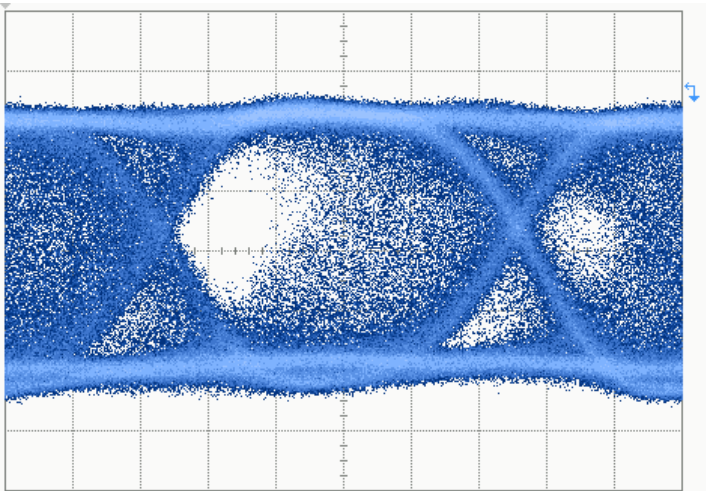


Figure 13. Eye with re-timer out of phase alignment

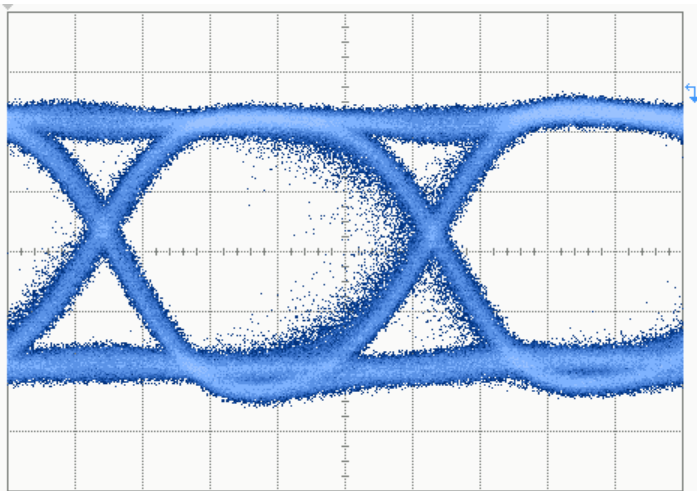


Figure 14. Eye with re-timer phase alignment almost correct

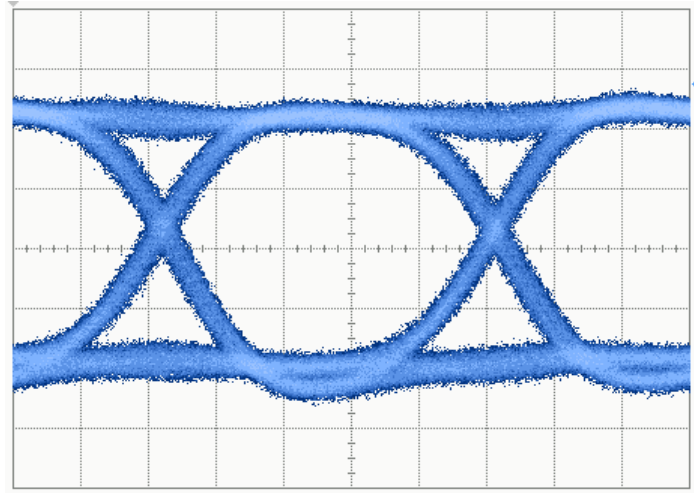
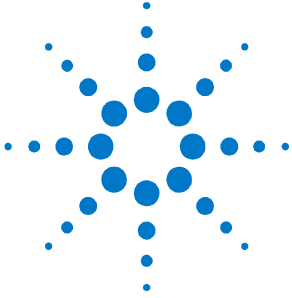


Figure 15. Eye with re-timer phase at optimum alignment



5 Returning the N4973A to Agilent Technologies

If the N4973A 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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