Keysight N4974A
PRBS Generator 40 Gb/s

User's Guide

KEYSIGHT TECHNOLOGIES

Notices

Manual Part Number

N4974-91021

Edition

Edition 2, November 2014

Keysight Technologies, Deutschland GmbH

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For Assistance and Support

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

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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

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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.

Keysight Technologies 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 Keysight Technologies Sales/Service Office.

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

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.

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 or, for paper / fibreboard packaging an internationally recognized marking such as ISO standard symbol is acceptable. Keysight will comply with China RoHS packaging marking requirements by implementing the ISO standard recycling symbol marking on all primary (generally for customers) and secondary (generally for distributors) fibreboard packaging for goods covered by China RoHS. Tertiary packaging (generally for shippers, i.e. shrink wrapping and pallets) are not required to be marked. At this time Keysight will not be marking solid wood packaging.

Indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Twenty five 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.

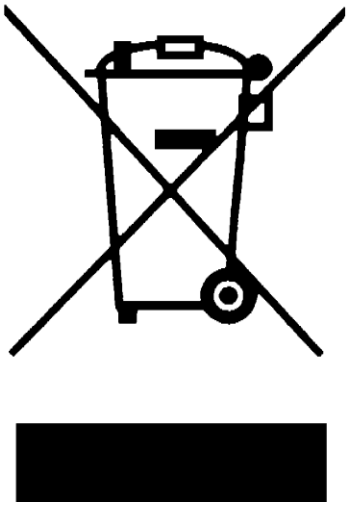
This symbol indicates that the instrument requires alternating current (AC) input.

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

O

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 Keysight office, or see **http://about.keysight.com/en/companyinfo/environment/takeback.shtml** for more information.

Contents

1 Getting Started

1.1 Unpacking and Installation

The N4974A PRBS generator 40 Gb/s is shipped in a protective carrying case with all the accessories required for the self-test mode and verification. The case includes:

- N4974A PRBS generator 40 Gb/s
- AC power converter module
- AC power cord
- CD containing the N4974A user guide and N4974A 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 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 N4974A from the case. 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 N4974A.

1.2 Important Notes

- Use ESD protection at all times when using the system
- Review min/max specifications before applying input signals
- Use only SMA-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 second end 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 N4974A Operation Overview

The Keysight Technologies N4974A PRBS generator 40 Gb/s is a fully self-contained pattern generator operating at 40G, 28G, or 25 Gb/s data rates. The product contains an internal 19.9 GHz oscillator to supply the half rate clock source for 40 Gb/s operation. Ordering options substitute the correct oscillator frequency for 28 or 25 Gb/s operation. Alternatively, a wideband option allows the user to supply a half rate clock externally to operate at any data rate between 22 and 44 Gb/s.

The 40G PRBS source is based on full custom ASICs, allowing a high degree of integration. The low parts count in the signal path minimizes the degradation of the low phase noise oscillator, providing an extremely clean eye pattern. Utilizing the internal oscillator, the generator achieves performance of less than 400 fs rms jitter, with a 500 mv output amplitude and <7 ps rise time.

2.1 N4974A System Overview

The N4974A PRBS generator 40 Gb/s is an instrument grade source required for accurate, high resolution measurements.

The N4974A is a versatile PRBS source with precision triggering needed for accurate jitter and timing measurements. Completely self-contained, the N4974A is an excellent companion to modern digital oscilloscopes such as the Keysight 86000 series digital communication analyzer.

For R&D applications the N4974A 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.

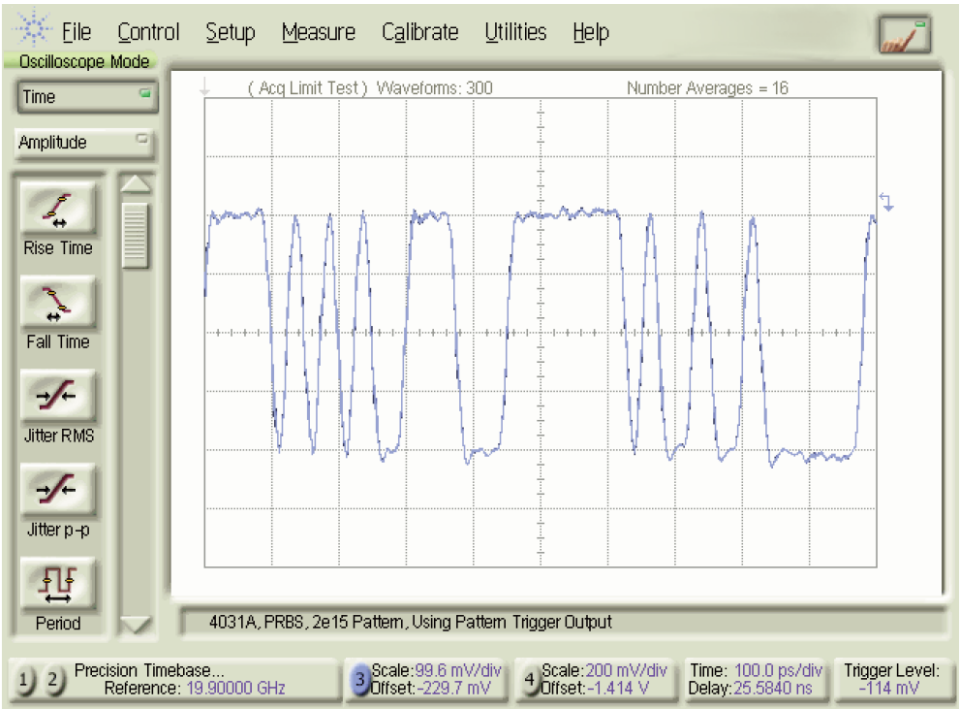


Figure 1. Pattern using pattern trigger

For manufacturing applications, the N4974A provides a low cost, high quality waveform needed for performance verification of SONET/SDH components.

Residual (additive) jitter and eye distortion of driver amplifiers, optical modulators, TIA, Limiting Amplifiers and integrated 40 Gb/s transmission systems can also be characterized using the N4974A.

2.1.1 Options

The N4974A is available with the following build options:

- standard: 40 Gb/s data rate operation
- N4974A-101: 25 Gb/s data rate operation
- N4974A-102: 28 Gb/s data rate operation
- N4974A-001: 22 to 44 Gb/s data rate operation (with external clock)

2.2 Front Panel Quick Reference

Figure 2. N4974A front panel

The front panel LED indicator light glows when power is on.

The PRBS signal is available as a differential signal on the 1.85 mm (V) female output terminals.

If a differential signal is not required, the unused output must be terminated with a 1.85 mm (V) 65 GHz 50 Ω termination.

Outputs are CML and must be externally DC terminated with 50 Ω to GND. One way to achieve DC termination while AC coupling is to use a bias-tee with its DC pin grounded through 50 Ω.

NOTE When pattern lengths less than the maximum [2^{31}-1] are selected and power is applied, a manual reset may be required to initiate the PRBS output. Manual reset occurs when both rear panel pattern-length switches are cycled to the up (1) position, then returned to the desired pattern-length position.

Manual reset can also be affected by briefly depressing the reset switch.

2.3 Rear Panel Quick Reference

Figure 3. N4974A rear panel

2.3.1 Connectors

Power: The rear panel power switch applies power to the N4974A. When power is applied the N4974A is initialized and reset.

Clk Output: The N4974A provides a fixed period internal reference clock. The clock is factory calibrated and set to provide a 39.8 Gb/s bit stream per OC768 standards. The internal clock is an exceptionally low phase noise, frequency stable 19.9 GHz oscillator. A factory provided external cable, located on the rear panel, connects the "*Clk Output*" to the N4974A "*Clk Input*" connector.

Clk Input: External clocks are connected to this port. Remove the factory installed cable between "*Clk Input*" and "*Clk Output*". Terminate the "*Clk Output*" with 50 Ω SMA termination. An external half-rate clock from 11 to 22 GHz can be used to drive the N4974A with the required drive power 15 dBm. The output bit stream ranges from 22 to 44 gb/s.

Retimer Phase Adjustment: 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) jewellers screwdriver for tuning. This tuning aligns the clock and data on the output retimer for optimal performance. This is done after a new frequency of the clock is set. View the data output eye on a scope, and optimize the phase to obtain the cleanest eye.

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

Label: N4974A serial number.

Trigger Outputs: The trigger output is provided on the rear panel. **Clk/1:** used with precision timebase oscilloscopes for accurate jitter characterization. Output is DC coupled, centered around 0 V.

Lower frequency triggers may be provided by using an external divider from the **Clk/1** output. The N4984A-040 offers excellent divider rates, for triggering scopes with 2.5 GHz as the highest trigger frequency available. The clock output is running at half the data rate, so a divide by 16 from the data rate, (40 G/16=2.5 G) is equal to the clock output (**Clk/1)** divided by 8 (20 GHz/8=2.5 GHz).

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 event occurs every ~3 seconds and will take a long time to produce a waveform. It is recommended that [2^{7}-1] or [2^{15}-1] pattern lengths be selected when using pattern trigger. Nominal trigger level 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.

Pattern Length: Three 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. Manual reset occurs when both rear panel pattern-length switches are cycled to the up (1) position, then returned to the desired pattern-length position.

Reset: Manual pattern reset can be affected by briefly depressing the reset switch.

Aux Power: A power supply output is provided to power options such as external amplifiers for higher output swings or power level control, external dividers needed for low frequency triggers, 10/40 Gb/s error detectors, etc. The center conductor is –5 V DC.

2.4 Safety and Regulatory

WARNING **Do not remove instrument covers. There are no user serviceable parts within. Operation of the instrument in a manner not specified by Keysight 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.

The clock output channels are grouped in differential pairs. When a single port of a differential pair is used in a single-ended method of measurement, the complementary port must be terminated with a 50 Ω-terminated connector.

3.1 General

Table 1. General and mechanical parameters of N4974A

Operating Temperature	+10 to +40 °C
Storage Temperature	–40 to +70°C
Power Requirements	42W External AC Adaptor (included) • 100 to 240 VAC, 47 to 63 Hz
Physical Dimensions (W x H x D)	7 x 2.5 x 10 inches
Weight	6 lbs
EMC	Complies with European EMC Directive 2004/108/EC • IEC/EN 61326-1 • CISPR Pub 11 Group 1, class A • AS/NZS CISPR 11 • ICES/NMB-001 This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada.

3.2 Performance Specification Table

Table 2. Performance specifications

	Description		Minimum	Typical	Maximum	Unit
Data output	Bit rate	N4974A	37	–	44	Gb/s
		N4974A-001	22	–	44	Gb/s
	RMS jitter	N4974A	–	400	600	fs
		N4974A-001	–	400	1000	fs
	Rise/fall times (20 to 80%)		–	6	8	ps
	Amplitude		500	550	600	mV pp
	SNR		–	18	–	
	Crossing		45	55	65	%
	Output level	High	–50	0	–	mV
		Low	450	–	–600	mV
Clock output	Offset		–	0	–	V
	RMS jitter		175	250	–	fs
	Amplitude		3.1	–	4	V
	Frequency		–	19.9	–	GHz
Clock input	Input level		13	–	16	dBm
	Offset		–	0	–	V
	Frequency		11	–	22	GHz
Pattern trigger output (22 to 43 Gb/s only)	Output level		–	800	–	V
	Jitter		–	20	–	ps
CLK/1 output	Output level		–6	–	+2	dBm

	Description		Minimum	Typical	Maximum	Unit
Phase adjustment	Phase adjustment range		–	30	–	ps
Pattern trigger	Pulse rate	64 * (1/Output_Bit_Rate) * (2^n-1)				
	Pulse width	64 * (1/Output_Bit_Rate)				

4 Operation

The following section provides more detailed information regarding the use of the N4974A.

4.1 General Information

The N4974A 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.

4.1.1 Performance Recommendations

Follow the following recommendations for best performance:

1. When using differential mode connection for OUT/$\overline{\text{OUT}}$, 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 N4974A features high-quality SMA connectors for the front and rear panel Input and Output, RF connections. Connector damage will degrade signal fidelity.

Keysight 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 (type K only)
- 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 N4974A. The performance verification is a single ended output measurement. Terminate the unused output with a 1.85 mm (V) 65 GHz 50 Ω termination (provided). Use a 3 dB 65 GHz pad between the N4974A output and the Keysight 86118A 70 GHz electrical sampling head. The oscilloscope is triggered using the N4974A "*Clk/1 Trigger Output*" connected to the Keysight 86107A precision timebase.

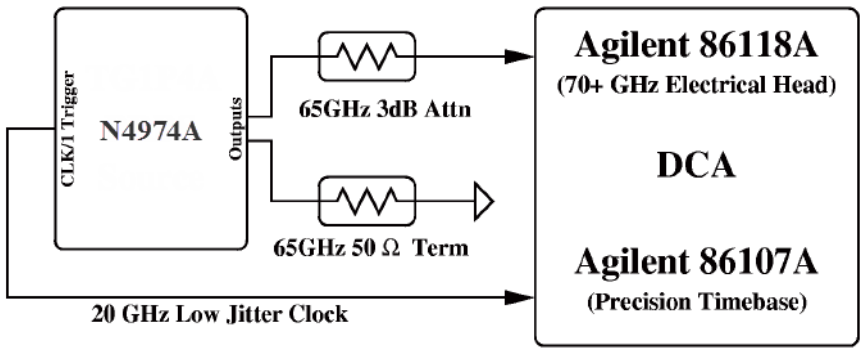


Figure 4. Verification setup

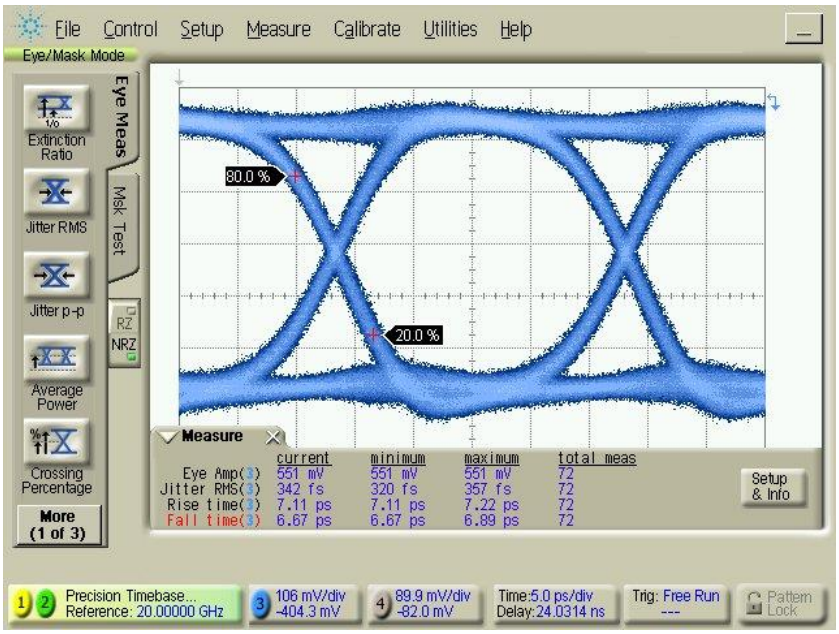


Figure 5. 40 Gb/s eye output from N4974A

4.3 Simple Functional Example of N4974A Use

A typical residual or additive jitter test system is shown in Figure 6. Additive jitter measurements require a precise, low jitter clock. The N4974A features an exceptionally low jitter internally-referenced, frequency-stable, microwave oscillator which can be used as the reference clock.

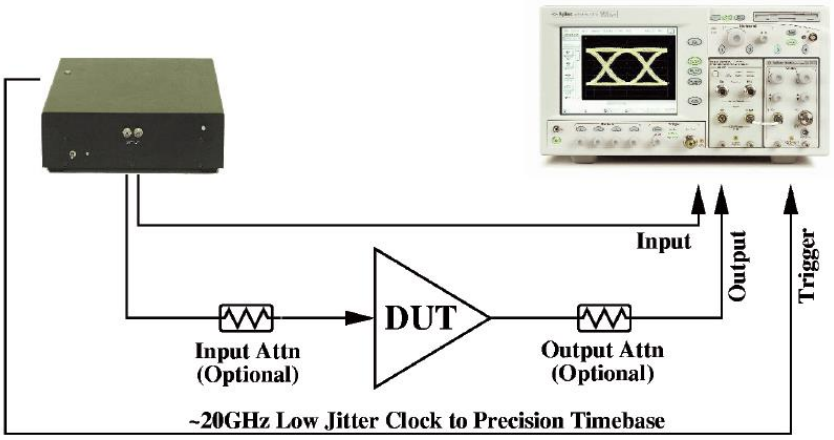


Figure 6. N4974A generic test example experimental setup

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

5 Returning the N4974A to Keysight Technologies

If the N4974A fails system verification and you cannot correct the problem, return it to Keysight Technologies for repair following the steps shown below.

1. Record all symptoms.
2. Contact Keysight Technologies using the "Request an RMA" form at http://www.keysight.com/find/assist
3. Use the original packing material or comparable packing material to ship the instrument to Keysight Technologies.

Edition 2, November 2014
N4974-91021
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