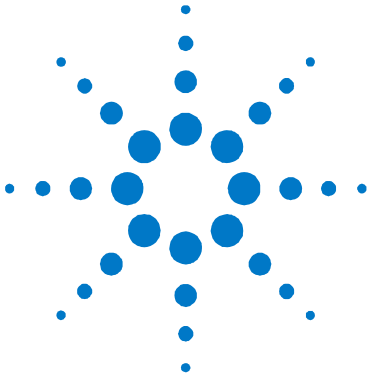

Agilent N4965A

Multi-Channel BERT 12.5 Gb/s

User Guide

Agilent Technologies

Notices

Manual Part Number

N4965-91021

Edition

Fifth edition, April 2014

Agilent Technologies, Deutschland GmbH

Herrenberger Str. 130

71034 Böblingen, Germany

For Assistance and Support

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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

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.

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

Indicates warning or caution. If you see this symbol on a product, you must refer to the manuals for specific Warning or Caution information to avoid personal injury or damage to the product.

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

The CSA mark is a registered trademark of the CSA International. This instrument complies with Canada: CSA 22.2 No. 61010-1 -04.

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

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

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.

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.

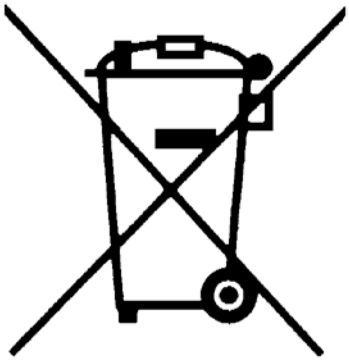
Indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.

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



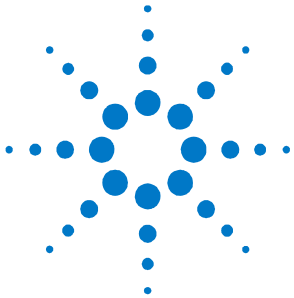
This product complies with the WEEE Directive (2002/96/EC) marketing requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste.

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.

Contents



1 Setting Up the System

1.1 Unpacking the N4965A

The N4965A is shipped in a protective box with all the accessories required for operation. The box includes:

- N4965A
- AC power cord
- CD, which includes:
  - Data sheet
  - User guide
  - Getting started guide

Carefully remove the N4965A from the box in an ESD-safe environment.

1.2 Unpacking the N4955A-P12

The N4955A-P12 is shipped in a protective box with all the accessories required for operation. The box includes:

- N4955A-P12 12.5 Gb/s Pattern Generator Remote Head
- Accessory kit, which includes the following for each N4955A-P12:
  - (Qty 2) 2.92 mm male-male cables
  - (Qty 2) 2.92 mm male-female cables
  - (Qty 1) 50 Ω 18 GHz 1 W SMA Male Terminations

Refer to the N4960-90030 N495xA through N498xA Connector Care Reference Guide at www.agilent.com/find/N4955A.

Carefully remove the N4955A-P12 from the box in an ESD-safe environment.

1.3 Unpacking the N4955A-D12

The N4955A-D12 is shipped in a protective box with all the accessories required for operation. The box includes:

- N4955A-D12 12.5 Gb/s Pattern Generator Remote Head with 4-tap De-emphasis
- Accessory kit, which includes the following for each N4955A-D12:
  - (Qty 2) 2.92 mm male-male cables
  - (Qty 2) 2.92 mm male-female cables
  - (Qty 1) 50 Ω 18 GHz 1 W SMA Male Terminations

Refer to the N4960-90030 N495xA through N498xA Connector Care Reference Guide at www.agilent.com/find/N4955A.

Carefully remove the N4955A-D12 from the box in an ESD-safe environment.

1.4 Unpacking the N4956A-E12

The N4956A-E12 is shipped in a protective box with all the accessories required for operation. The box includes:

- N4956A-E12 12.5 Gb/s Error Detector Remote Head
- Accessory kit, which includes the following for each N4956A-E12:
  - (Qty 2) 2.92 mm male-male cables
  - (Qty 2) 2.92 mm male-female cables
  - (Qty 1) 50 Ω 18 GHz 1 W SMA Male Terminations

Refer to the N4960-90030 N495xA through N498xA Connector Care Reference Guide at www.agilent.com/find/N4956A.

Carefully remove the N4956A-E12 from the box in an ESD-safe environment.

1.5 Important Notes

- Use ESD protection at all times when using the instrument.
- Review min/max specifications before applying input signals.
- Use high quality SMA-connectors on the SMA ports.

CAUTION Excessive mating of low quality SMA components to 2.92 mm female receptacles may degrade the 2.92 mm female receptacle.

- Leave dust covers on unused connectors.
- Situate the instrument away from heat sources, do not block the fan, and do not block the exhaust vent (minimum of 8 cm/3 inches clearance).
- When using multiple remote heads, allow adequate space around heads for cooling. If heads are stacked then additional cooling, e.g. using a fan, may be required.
- Use 50 Ω terminations on all unused differential ports.

1.6 Measurement Best Practices

- When using differential-mode connections, ensure the cables are phase balanced for best performance.
- Differential connectors may be used single-ended if unused outputs are terminated in 50 Ω.
- Use high quality cables and connector savers (or adaptors).
- Keep cable lengths short and minimize the number of cable bends.
- Use a 8 lb-in (90 N-cm) torque wrench when attaching connectors.

1.7 General Specifications

Before installing the system, review the specifications in Table 1.

Table 1. Specification considerations before installation

Parameter	Specification
Operating temperature	+10 °C to +40 °C
Storage temperature	–40 °C to +70 °C
Remote control interface	USB2.0 and IEEE-488 (GPIB)
Voltage	100 to 240 VAC auto ranging
Frequency	50/60 Hz nominal
Power consumption	170 Watts maximum
Current	1.8 A RMS maximum
Fuse	250 V 2 A (p/n 12260-002) Always replace instrument fuse with one of the same type and rating.
EMC	• 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.
Safety	• Complies with European Low Voltage Directive 2006/95/EC • IEC/EN 61010-1, 2nd Edition • Canada: CSA C22.2 No. 61010-1 • USA: UL std no. 61010-1, 2nd Edition Acoustic noise emission — Geraeuschemission LpA <70 dB — LpA <70 dB Operator position — Am Arbeitsplatz Normal position — Normaler Betrieb Per ISO 7779 — Nach DIN 45635 t.19
Dimensions (Height, Width, and Depth) N4965A N4955A-P12 N4955A-D12 N4956A-E12	 100 mm (3.9 in) x 214 mm (8.4 in) x 425 mm (16.7 in) 33 mm (1.3 in) x 72 mm (2.8 in) x 130 mm (5.1 in) 33 mm (1.3 in) x 72 mm (2.8 in) x 130 mm (5.1 in) 33 mm (1.3 in) x 72 mm (2.8 in) x 130 mm (5.1 in)
Weight	

Parameter	Specification
N4965A	3.3 kg (7.1 lbs)
N4955A-P12	0.38 kg (13.4 oz)
N4955A-D12	0.38 kg (13.4 oz)
N4956A-E12	0.38 kg (13.4 oz)

1.8 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 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.

1.8.1 Maintenance

To remove dirt or dust from the external case of the instrument, clean the case with a dry or slightly dampened cloth only.

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

1.9 Installing the N4965A

1. Install on a flat surface with unobstructed airflow to the back panel and right-hand side of the N4965A.
2. Plug the AC power cord into the N4965A controller.
3. Plug the AC power cord into a suitable wall socket (100 to 240 V AC, 50/60 Hz).

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.

4. Turn the N4965A on. After a few minutes the Push Any Key to continue... message will be displayed.
5. Press any softkey. The POD INACTIVE message will be displayed.
6. Press the softkey corresponding to the Menu label. The Main Menu will be displayed.
7. Turn the N4965A off before proceeding with the installation of the remote heads.

1.10 Installing the N4965A and N4955A-P12/N4955A-D12

1. Install on a flat surface with unobstructed airflow to the back panel and right-hand side of the N4965A.
2. Plug the AC power cord into the N4965A controller.
3. Plug the AC power cord into a suitable wall socket (100 to 240 V AC, 50/60 Hz).
4. Connect the N4955A-P12/N4955A-D12 PRBS Generator(s) to the N4965A controller Channel 0.
5. Connect the N4965A to a clock source and the N4955A-P12/N4955A-D12 (s) to a high speed sampling scope as shown in Figure 1. Tighten coax connectors to 8 lb-in (90 N-cm) and use 50 Ω terminations on all unused ports.
6. Turn on the N4965A.

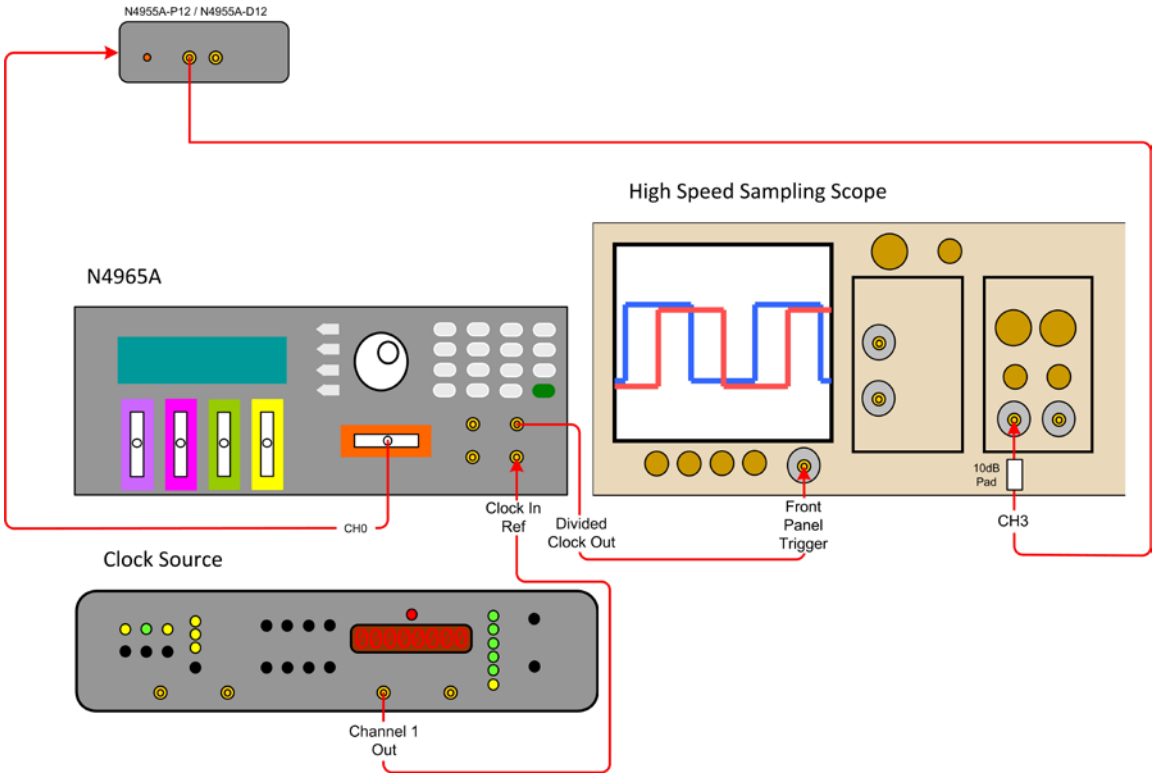


Figure 1. PRBS generator setup

7. Set up the clock source as follows:

Frequency: 10.3 GHz

Level: +3 dBm

Output: On

8. Set up the high speed sampling scope as follows:

NOTE For purposes of this example setup, an Agilent 86100A Infinium DCA was used. High-speed sampling scope setup option names may differ between models.

Set the high speed sampling scope to Eye/Mask model.

Trigger Setup

Trigger Level: 0 V

Slope: Rising Edge

Trigger Bandwidth: Standard (DC-2.5 GHz)

Timebase Setup

Scale:	16.3 ps/div
Reference:	center

Channel 3 Setup (data)

Attenuation:	10 dB (10 dB attenuator placed at the input)
Bandwidth:	maximum
Display:	On
Scale:	243 mV/Div
Offset:	0 V

9. If the STAT menu does not appear, press the softkey corresponding to the STAT label until the STAT (Status) menu appears. Refer to Figure 16.
10. On the keypad, press the number 0 to view the STAT (Status) menu settings for channel 0.
11. Position the arrow next to the Pat Out label on the N4965A then press the softkey corresponding to the EDIT label.
12. Rotate the knob until the highlighted text shows ON then press the softkey corresponding to the EXIT label to accept the change. This will turn on the data output. The channel ID LED of the N4955A-P12/N4955A-D12 should come on.
13. Position the arrow next to the Clk Output label on the N4965A then press the softkey corresponding to the EDIT label.
14. Rotate the knob until the highlighted text shows ON then press the softkey corresponding to the EXIT label to accept the change. This will turn on the clock output.
15. Verify that the waveform is similar to the one shown in Figure 2.

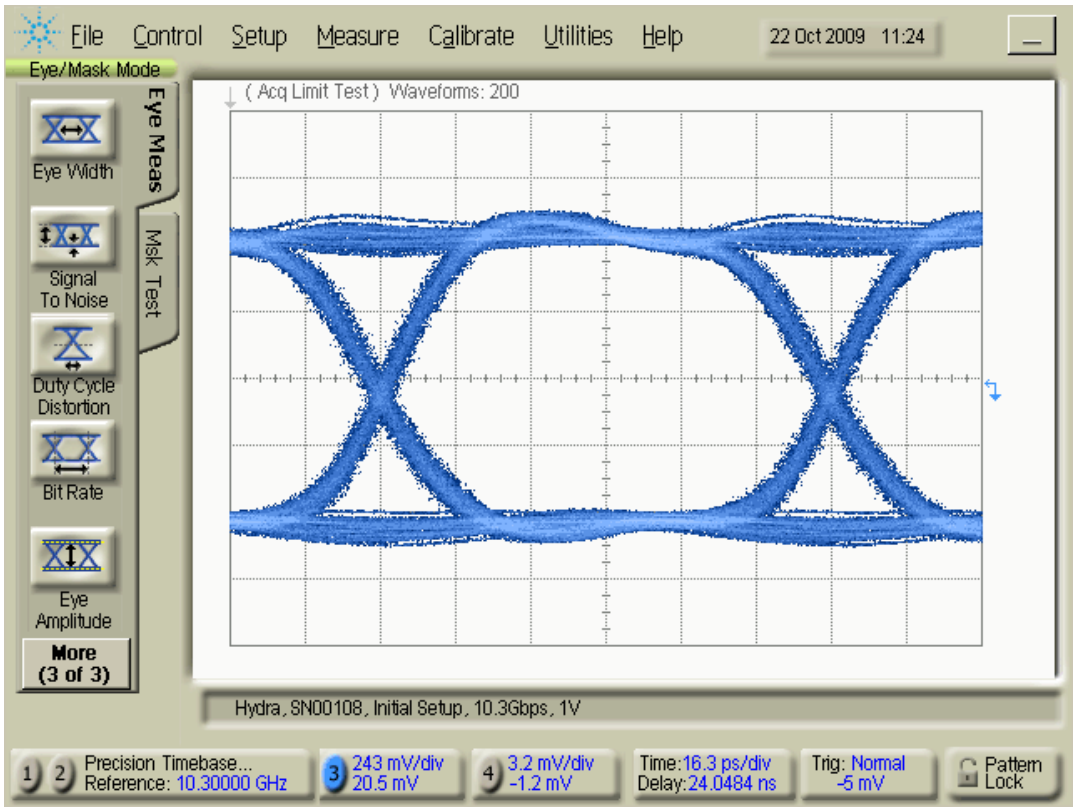


Figure 2. Installation setup waveform

1.11 Installing the N4965A and N4956A-E12

1. Install on a flat surface with unobstructed airflow to the back panel and right-hand side of the N4965A.
2. Plug the AC power cord into the N4965A controller.
3. Plug the AC power cord into a suitable wall socket (100 to 240 V AC, 50/60 Hz).
4. You will need a N4955A-P12 or N4955A-D12 PRBS generator head for this installation test. Connect the PRBS generator to the reference channel (Channel 0).
5. Connect the N4956A-E12 to channel 1.
6. Connect the remote heads and clock source to the N4965A controller as shown in Figure 3.
7. Using the supplied cables, connect $Data$ from the N4955A-P12/N4955A-D12 to $Data$ on the N4956A-E12 and $\overline{Data}$ from the N4955A-P12/N4955A-D12 to $\overline{Data}$ on the N4956A-E12. Tighten coax connectors to 8 lb-in (90 N-cm).

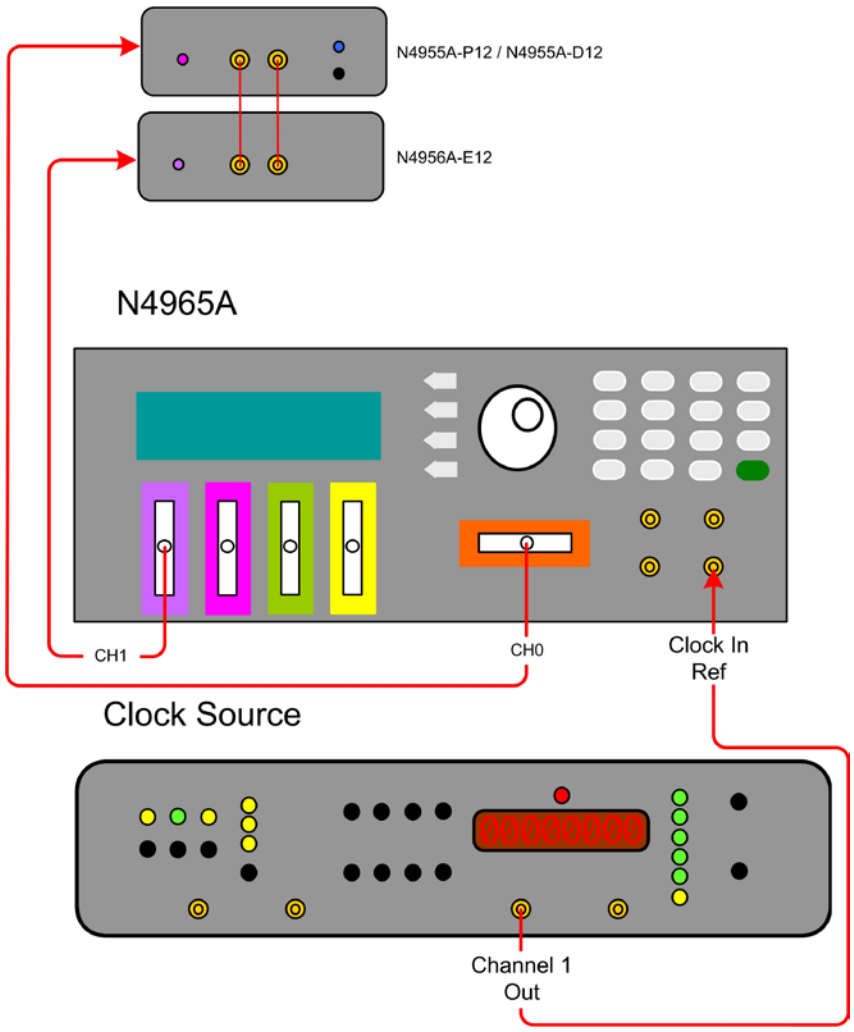


Figure 3. N4956A-E12 installation setup

8. On the keypad, press the number 0 to view the STAT (Status) menu settings for the PRBS generator connected to channel 0.
9. Position the arrow next to the Pat Out label on the N4965A then press the softkey corresponding to the EDIT label.
10. Rotate the knob until the highlighted text shows ON then press the softkey corresponding to the EXIT label to accept the change. This will turn on the data output. The channel ID LED of the N4955A-P12/N4955A-D12 should come on.
11. Set up the clock source as follows: Frequency 10 GHz, Output Level 0 dBm.
12. On the keypad, press the number 1 to view the STAT (Status) menu settings for the N4956A-E12 connected to channel 1.
13. Position the arrow next to the Sync label on the N4965A then press the softkey corresponding to the Align label. This will turn on the auto alignment.
14. Position the arrow next to the BER label on the N4965A then press the softkey corresponding to the RUN label. MEAS 000 000 should appear above BER and start counting. The BER and Errs should read 0.000e0.

2 System Operation Overview

The N4965A Multi-Channel BERT 12.5 Gb/s system is comprised of an N4965A-CTR controller plus up to 5 remote heads for testing up to 5 channels simultaneously. Channel 0 is the reference channel. Channels 1 through 4 can have a secondary clock signal applied using the Clock In Aux connector on the front panel of the N4965A.

Each channel has a delay adjust for adjusting the position of the edge. Each channel can be set up independent of the others by pressing the channel number on the keypad then changing parameters for the specific channel as needed. Or, you can apply the same settings to some or all channels (if applicable).

The remote heads have a channel ID LED indicating that the remote head is enabled. The LED color corresponds to the channel color on the front panel of the N4965A.

The system is used in bit error rate (BER) or eye-mask or crosstalk testing of multi-lane high-speed data channels, testing backplane performance in the presence of multiple aggressors, parallel stimulus/response testing for higher manufacturing throughput, and multi-aggressor crosstalk analysis and verification.

2.1 N4965A Features

All features can be controlled through the N4965A control panel, or remotely through the GPIB or USB interface using SCPI commands.

- Multi-channel remote-head system
- Pattern generators with 4-tap or 2-tap de-emphasis
- Operation from 1.0 Gb/s to 12.5 Gb/s
- Each channel features ±1000.00 UI of delay adjust
- Differential, divided clock output with amplitude and DC offset adjust
- Transparent jitter pass-through
- Swept aggressor channel delay for crosstalk characterization
- GPIB or USB control

2.2 N4955A-P12 PRBS Generator with 2-tap De-emphasis

The N4955A-P12 is a pattern generator used to generate various lengths of PRBS (Pseudo Random Bit Sequence), 1010, 1100, and DC logic 0 and 1 hardware patterns.

2.2.1 N4955A-P12 Features

- PRBS and alternating 1010, 1100 patterns
- Fully programmable output parameters
- Each N4955A-P12 generates differential outputs with the following adjustments:
    - Amplitude
    - DC offset
    - Crossover
    - 2-Tap De-emphasis

For more information, refer to the N4965A Datasheet.

2.2.2 Patterns Versus Features of N4955A-P12

Table 2. Patterns vs features of the N4955A-P12

	Pat-Invert	De-Emp	Xover	Delay/Skew	Swept Delay
PRBS	yes	yes	yes	yes	yes
1010	no	no	yes	yes	yes
1100	no	yes	yes	yes	yes
Logic low	yes	no	no	no	no
Logic high	yes	no	no	no	no
Disable	no	no	no	no	no

2.2.3 N4955A-P12 Offset and Termination Voltage

The minimum and maximum limits for offset voltage are functions of the termination voltage, determined by the following formulas:

Maximum V_{Offset} (V) = MIN(0.5*V_{Term} + 1.8, +2.0)

Minimum V_{Offset} (V) = MAX(0.5*V_{Term} −1.8, −2.0)

The ranges are shown graphically in Figure 4.

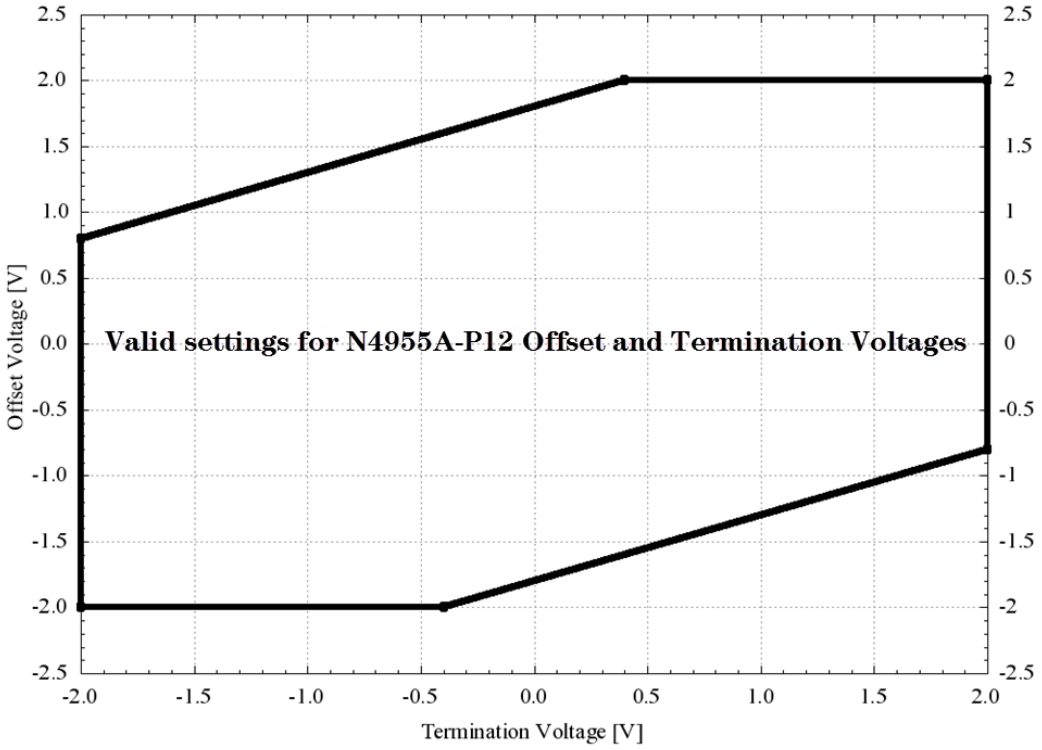


Figure 4. N4955A-P12 offset voltage vs termination voltages

However, because the resolution for V_{Offset} is 5 mV, any invalid updated values will be rounded to the nearest valid setting within the new limit. For example, consider the case when V_{Offset} = +1.3000 V, while V_{Term} is changed from –1.000 V to –1.005 V. According to the formula above, the new upper limit for V_{Offset} will be:

MIN(0.5*–1.005+1.8, 2.0)V = 1.2975 V,

which is not valid due to the 5 mV resolution. Therefore, the V_{Offset} will be set to the closest valid setting of +1.295 V instead.

2.3 N4955A-D12 PRBS Generator with 4-tap De-emphasis

The N4955A-D12 is a pattern generator used to generate various lengths of PRBS, divide by 2/4/8/16/32/64, and DC logic 0 and 1 hardware patterns. In addition, the integrated 4-tap de-emphasis feature utilizes one pre-cursor and two post-cursor de-emphasis adjustments to counteract high frequency loss in the channel.

2.3.1 N4955A-D12 Features

- Integrated 4-tap de-emphasis with pre- and post-cursor adjustment
- Fully programmable output parameters
- Low RMS jitter and very fast rise time

For more information, refer to the N4965A datasheet.

2.3.2 Patterns Versus Features of N4955A-D12

Table 3. Patterns vs features of the N4955A-D12

	Pat-Invert	Prec	Post1	Post2	Xover	Delay/skew	Swept delay
PRBS	yes	yes	yes	yes	yes	yes	yes
Div-2	no	no	no	no	yes	yes	yes
Div-4	no	yes	yes	yes	yes	yes	yes
Div-8	no	yes	yes	yes	yes	yes	yes
Div-16	no	yes	yes	yes	yes	yes	yes
Div-32	no	yes	yes	yes	yes	yes	yes
Div-64	no	yes	yes	yes	yes	yes	yes
Logic low	yes	N/A	N/A	no	no	no	no
Logic high	yes	N/A	N/A	no	no	no	no
Disable	no	N/A	N/A	no	no	no	no

2.3.3 N4955A-D12 Offset and Termination Voltage

The minimum and maximum limits for offset voltage are functions of the termination voltage, determined by the following formulas:

Maximum V_{Offset} (V) = MIN(0.5*V_{Term} + 1.8, +2.0)

Minimum V_{Offset} (V) = MAX(0.5*V_{Term} –1.8, –2.0)

The ranges are shown graphically in Figure 5.

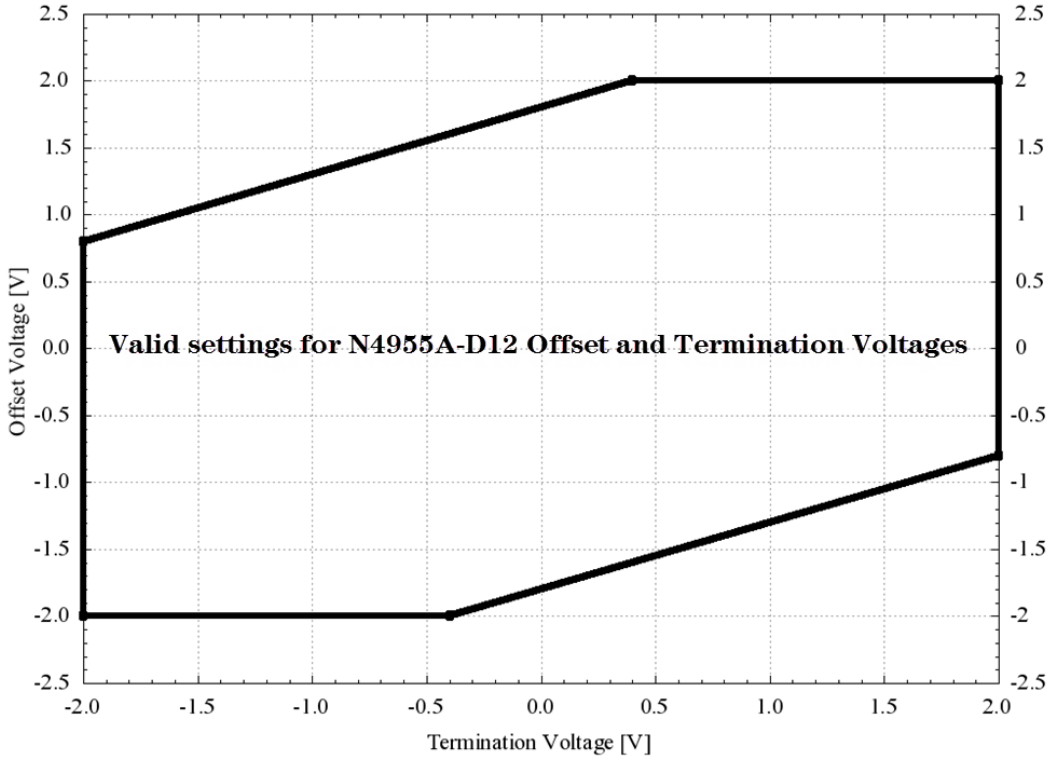


Figure 5. N4955A-D12 offset voltage vs termination voltages

However, because the resolution for V_{Offset} is 5 mV, any invalid updated values will be rounded to the nearest valid setting within the new limit. For example, consider the case when V_{Offset} = +1.3000 V, while V_{Term} is changed from –1.000 V to –1.005 V. According to the formula above, the new upper limit for V_{Offset} will be:

MIN(0.5*–1.005+1.8, 2.0)V = 1.2975 V,

which is not valid due to the 5 mV resolution. Therefore, the V_{Offset} will be set to the closest valid setting of +1.295 V instead.

2.4 N4956A-E12 12.5 Gb/s Error Detector Remote Head

The N4956A-E12 is an error detector designed to work in conjunction with an N4955A pattern generator and the N4965A controller as a bit error rate tester (BERT).

2.4.1 N4956A-E12 Features

- PRBS patterns
- Fully programmable input parameters
- Adjustable delay and voltage sampling point
- GPIB or USB control

For more information, refer to the N4965A datasheet.

2.5 Control

System configuration settings are all available from the local control panel interface, the remote GPIB (IEEE 488.2) interface, or the USB interface. Instrument status is conveyed on the front panel by the display.

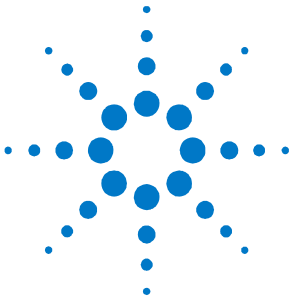
2.6 Compatible Products

2.6.1 Remote Head

N4955A-P12	Remote head: PRBS generator with 2-tap de-emphasis
N4955A-D12	Remote head: PRBS generator with 4-tap de-emphasis
N4956A-E12	Remote head: PRBS error detector

2.6.2 External Clock Generator

N4960A-CJ0	Clock synthesizer 16 GHz/serial BERT controller with single tone jitter injection
N4960A-CJ1	Clock synthesizer 16 GHz/serial BERT controller with multi-tone jitter injection
N4963A	Clock synthesizer to 13.5 GHz
N4963A-101	Clock synthesizer to 13.5 GHz with single tone jitter injection



3 Operation

The following section provides detailed information regarding the use of the system.

3.1 General Information

The system should be used in accordance with the following:

- Read and follow operating instructions of all system equipment and do not exceed min/max specifications.
- Use ESD protection at all times, but especially when handling RF inputs/outputs.
- Situate the instrument away from heat sources.
- Do not block airflow to the fan and do not allow foreign material into enclosure.
- Do not modify the power plug or wall outlet to remove the third (ground) pin.
- Do not drop or shake the instrument, minimize vibration, and handle with care.
- Turn off power before adding, removing, or swapping any remote head(s) to or from the N4965A.
- Wait 30 seconds after turning on power before connecting DUT to N4965A or any remote head(s).

NOTE There are no user-serviceable parts within. Return damaged instruments for factory-authorized repair. Refer to instrument warranty for more information.

3.1.1 Performance Recommendations

The following recommendations ensure best performance:

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

3.1.2 Connector Care

The system features high-quality SMA and 2.92 mm connectors for the front panel input and output connections. Connector damage will degrade signal fidelity.

Refer to the N4960-90030 N495xA through N498xA Connector Care Reference Guide at www.agilent.com/find/N4955A.

CAUTION Excessive mating of low quality SMA connectors to 2.92 mm female connectors may degrade the 2.92 mm female receptacle.

Inspect the connectors for the following:

- Worn or damaged threads
- Scratches to mating surface
- Burrs and loose metal particles
- 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 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.

3.2 N4965A Front and Rear Panel

3.2.1 N4965A Front Panel

The N4965A front panel indicates the system status and contains a control panel for local operation of the instrument.

Figure 6 shows the front panel of the N4965A.

Figure 6. N4965A front panel

Table 4. N4965A front panel

Label	Description
Display	The display is part of the Control Panel and is used to view the softkey menu structure.
Softkey buttons	The four softkey buttons to the right of the display are part of the Control Panel and are used to switch between the STAT (Status) and MENU (Main Menu) items, move the highlight up or down, and edit or select parameters.
Rotary knob	The Rotary Knob is part of the Control Panel and is used to increase or decrease a numeric value and move the highlight to the next digit, character, or item in a list.
Keypad	The Keypad is part of the Control Panel and is used to enter numeric values for parameters. The green PRST hardkey button is used to perform an instrument preset.

Label	Description
Clock input connectors	
Ref	The Ref clock input connector accepts a clock input from an external source to drive the N4965A.
Aux	The Aux input connector is an optional input that allows a separate, independent secondary clock input to be routed to channel 1 to 4.
Divided clock connectors	The divided differential clock output connectors produce a signal that is related to the REF clock rate by a divider factor. The clock signal is divided internally by two cascaded dividers. The divide ratios for Clk 1st divider are 1, 2, 4, or 8. The divide ratios for Clk 2nd divider are 8 to 511 in resolution of 1. Total range of divided factors is 1 to 4088.
D-type connectors	Connect pattern generators and/or error detectors to the Channel 0 through Channel 4 front panel connectors.

3.2.2 N4965A Rear Panel

Figure 7 shows the rear panel of the N4965A.

Figure 7. N4965A rear panel

Table 5 describes the N4965A rear panel.

Table 5. N4965A rear panel

Label	Description
USB	The USB connector is a Type B USB port that connects to an external PC controller to control the N4965A.
GPIB	The GPIB connector is a general purpose interface bus (GPIB, IEEE 488.1) connection that can be used for remote operation.
Label	N4965A serial number.
Power switch	N4965A main power switch (1=On; 0=Off).
Fuse drawer	Remove/replace the fuse by depressing the snap-in tab and withdrawing the fuse drawer.

3.3 N4955A-P12 Front and Rear Panel

The N4955A-P12 front panel indicates the status of the data output and contains the data output ports as shown in Figure 8.

3.3.1 N4955A-P12 Front Panel

Figure 8. N4955A-P12 front panel.

Table 6. N4955A-P12 frontpanel

Label	Description
Data output connectors	The differential data outputs are 2.92 mm connectors.
Channel ID LED Output off Output on	 The channel ID LED indicator is off when data output is turned off. The channel ID LED indicator is lit when the data output is turned on. Each channel has a different color to indicate the data output is on: Channel 0: orange Channel 1: purple Channel 2: pink Channel 3: green Channel 4: yellow

3.3.2 N4955A-P12 Rear Panel

Figure 9. N4955A-P12 rear panel

Table 7. N4955A-P12 rear panel

Label	Description
Cable	1 meter cable that connects to a channel on the N4965A.
Label	N4955A-P12 serial number.

3.4 N4955A-D12 Front and Rear Panel

3.4.1 N4955A-D12 Front Panel

The N4955A-D12 front panel indicates the status of the data output and contains the data output ports as shown in Figure 10.

Figure 10. N4955A-D12 front panel

Table 8. N4955A-D12 front panel

Label	Description
Data output connectors	The differential data outputs are 2.92 mm connectors.
Channel ID LED Output off Output on	 The channel ID LED indicator is off when data output is turned off. The cannel ID LED indicator is lit when the data output is turned on. Each channel has a different color to indicate the data output is on: Channel 0: orange Channel 1: purple Channel 2: pink Channel 3: green Channel 4: yellow

3.4.2 N4955A-D12 Rear Panel

Figure 11. N4955A-D12 rear panel

Table 9. N4955A-D12 rear panel

Label	Description
Cable	1 meter cable that connects to a channel on the N4965A.
Label	N4955A-D12 serial number.

3.5 N4956A-E12 Front and Rear Panel

3.5.1 N4956A-E12 Front Panel

The N4956A-E12 front panel indicates the channel identification and contains the data input ports as shown in Figure 12.

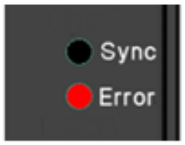
Figure 12. N4956A-E12 front panel

Table 10. N4956A-E12 front panel

Label	Description
Data input connectors	The differential inputs are 2.92 mm connectors.
Channel ID LED On	The channel ID LED indicator is always lit. Each channel has a different color to indicate that the error detector is enabled: Channel 0: orange Channel 1: purple Channel 2: pink Channel 3: green Channel 4: yellow
Sync LED	UNLIT when no data is detected, RED when data is detected but cannot be synchronized, BLUE when data is detected and is synchronized, GREEN while a measurement is running. **NOTE** Setting of DATA Threshold and observance of the Sync status is important for correct BER measurements. For example, if there is no data signal connected to the N4956A-E12 input, and the data threshold is set to 0V, it is possible to get a false indication of data present. Also when a valid data signal is present at the N4956A-E12 input, but the data threshold is set to a value that is either above or below the input eye amplitude, it is possible to get a false BER measurement; however, the Sync status will show no data is detected.
Errors LED	UNLIT when no errors are detected, RED when errors are detected.

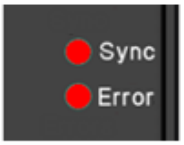
3.5.2 N4956A-E12 Indicators Quick Reference

Three LED indicators are integrated into the N4956A-E12 front panel. These indicators are used to communicate the current status of the N4956A-E12 error detector. The combinations are shown below.



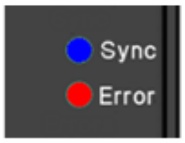
Sync- Unlit
Errors- Red
Status- NODATA

All-zeros or all-ones condition; no PRBS data is detected. BER measurements cannot be performed.



Sync- Red
Errors- Red
Status- NOSYNC

Data detected, but of unknown type; cannot synchronize. BER measurements cannot be performed.

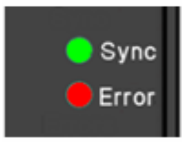


Sync- Blue
Errors- Red
Status- SYNC

Data detected and pattern synchronized; errors detected. BER measurement is possible.

Sync- Blue
Errors- Unlit
Status- SYNC

Data detected and pattern synchronized; no errors detected. BER measurement is possible.



Sync- Green
Errors- Red
Status- MEASURING

BER measurement is running. Errors detected.

Sync- Green
Errors- Unlit
Status- MEASURING

BER measurement is running. No errors detected.

3.5.3 N4956A-E12 Rear Panel

Figure 13. N4956A-E12 rear panel

Table 11. N4956A-E12 rear panel

Label	Description
Cable	1 meter cable that connects to a channel on the N4965A.
Label	N4956A-E12 serial number.

3.6 Block Diagram

Figure 14 is a simplified block diagram of the system that emphasizes all inputs and outputs.

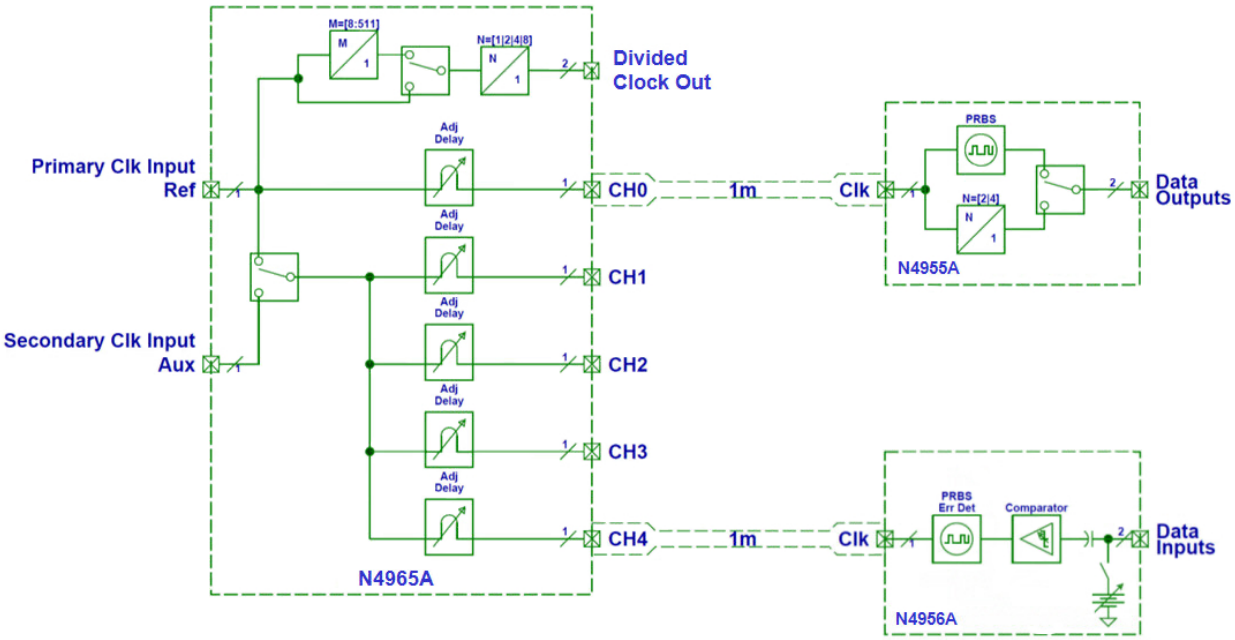


Figure 14. Simplified block diagram

3.7 Control Panel Operation

This section describes how to use the Control Panel to operate the system. The Control Panel is located on the front panel of the N4965A and consists of the display, four softkeys used to access functions shown in the display, rotary knob, and keypad. Refer to Figure 15.

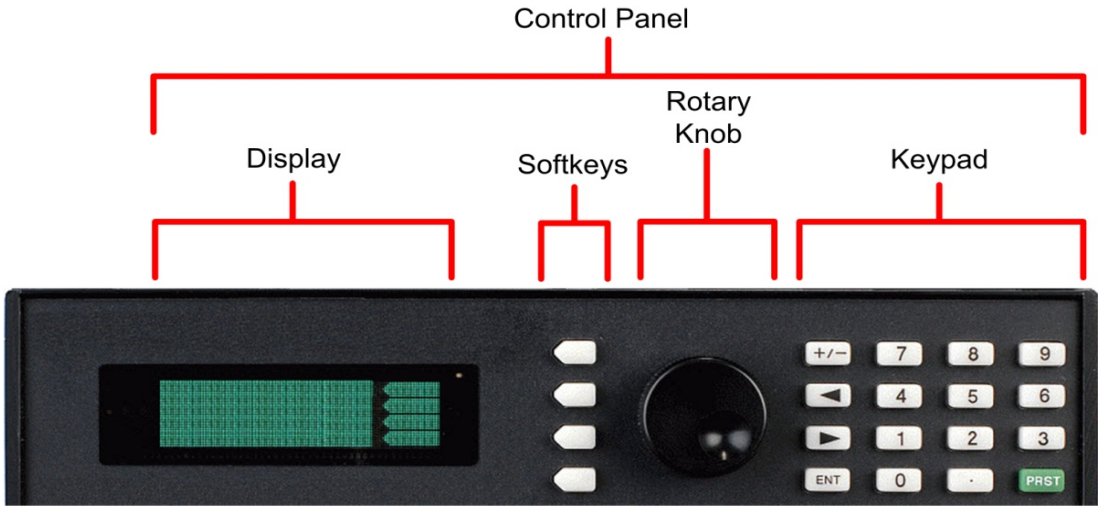


Figure 15. Control Panel

3.7.1 Power on Status Menu

When the system is powered on, the STAT (Status) menu appears in the display window of the Control Panel. Figure 16 shows the STAT menu for a channel with a pattern generator connected. The STAT menu is a list of the most common commands. Each unique model of remote head has a specific STAT menu.

STAT (Status) Menu

Figure 16. Status Panel

3.7.2 Main Menu

Pressing the softkey corresponding to the **MENU** label accesses the MAIN menu. Refer to Figure 17. Similarly, pressing the softkey corresponding to the STAT label will once again access the Status menu.

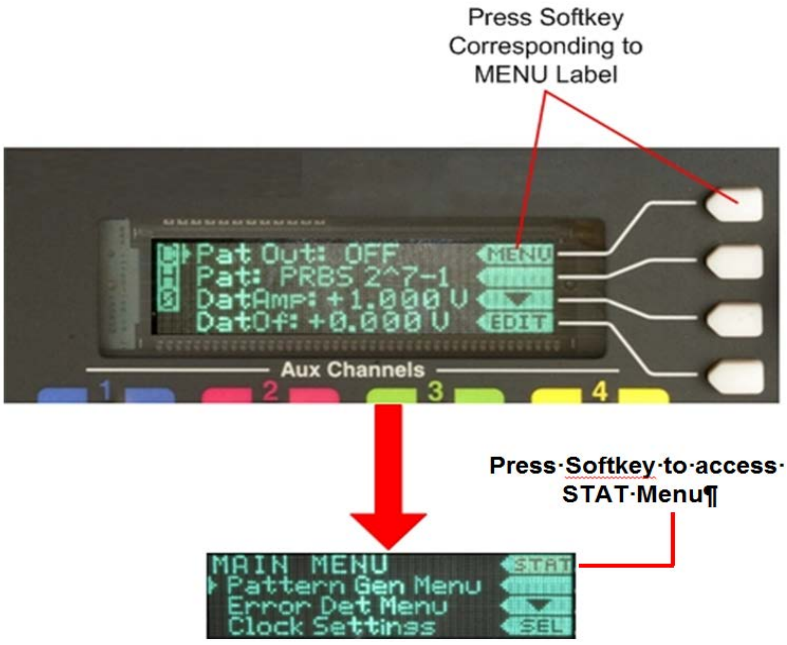


Figure 17. Accessing main menu

3.7.3 Selecting a Channel

To quickly view the settings for a specific channel in the Status menu, press the numeric key (0-4) on the keypad corresponding to the channel. Refer to Figure 18.

NOTE The Status menu must be displayed to change channels as shown in Figure 18.

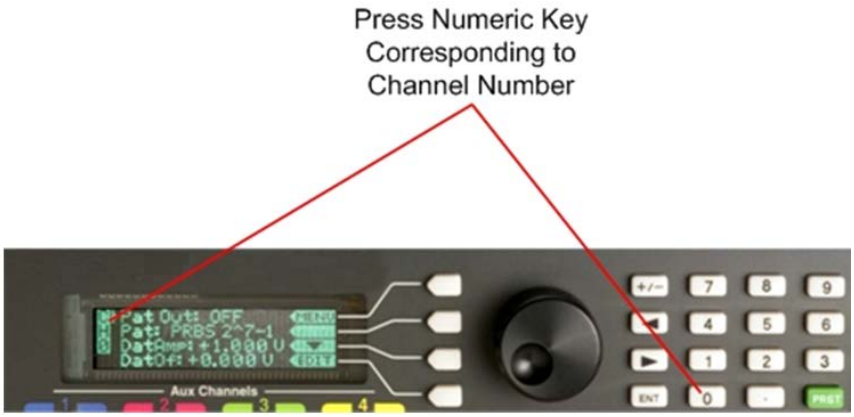


Figure 18. Viewing settings for a specific channel

3.7.4 Menu Structure

Figure 19 through Figure 27 show the hierarchical structure of the menus.

Pat Out: OFF
Pat: PRBS 2^7-1
DatAmp: 1.000 V
DatOfs: +0.000 V
DatTrm: +0.000 V
De-Em: 00.0 dB
DatXover: 50 %
PatInv: OFF
Dly Sweep: OFF
Dly: +0000.000
Clk Output: OFF
ClkAmp: 700 mV
ClkOfs: +0.000 V
ClkTrm: +0.000 V

Figure 19. N4955A-P12 STATus menu structure

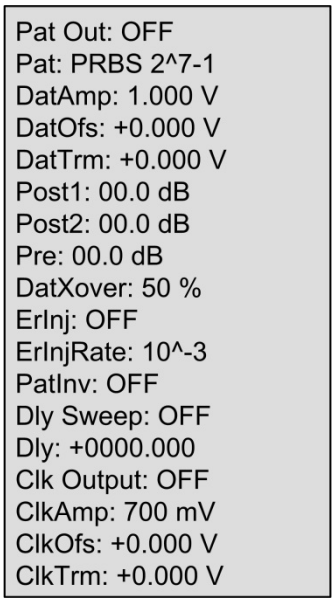


Figure 20. N4955A-D12 STATus menu structure

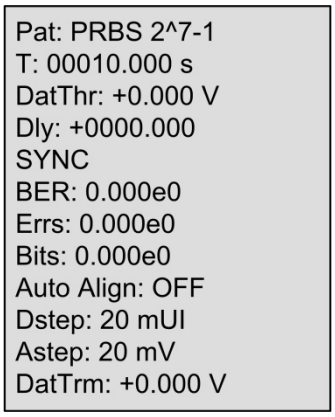


Figure 21. N4956A-E12 STATus menu structure

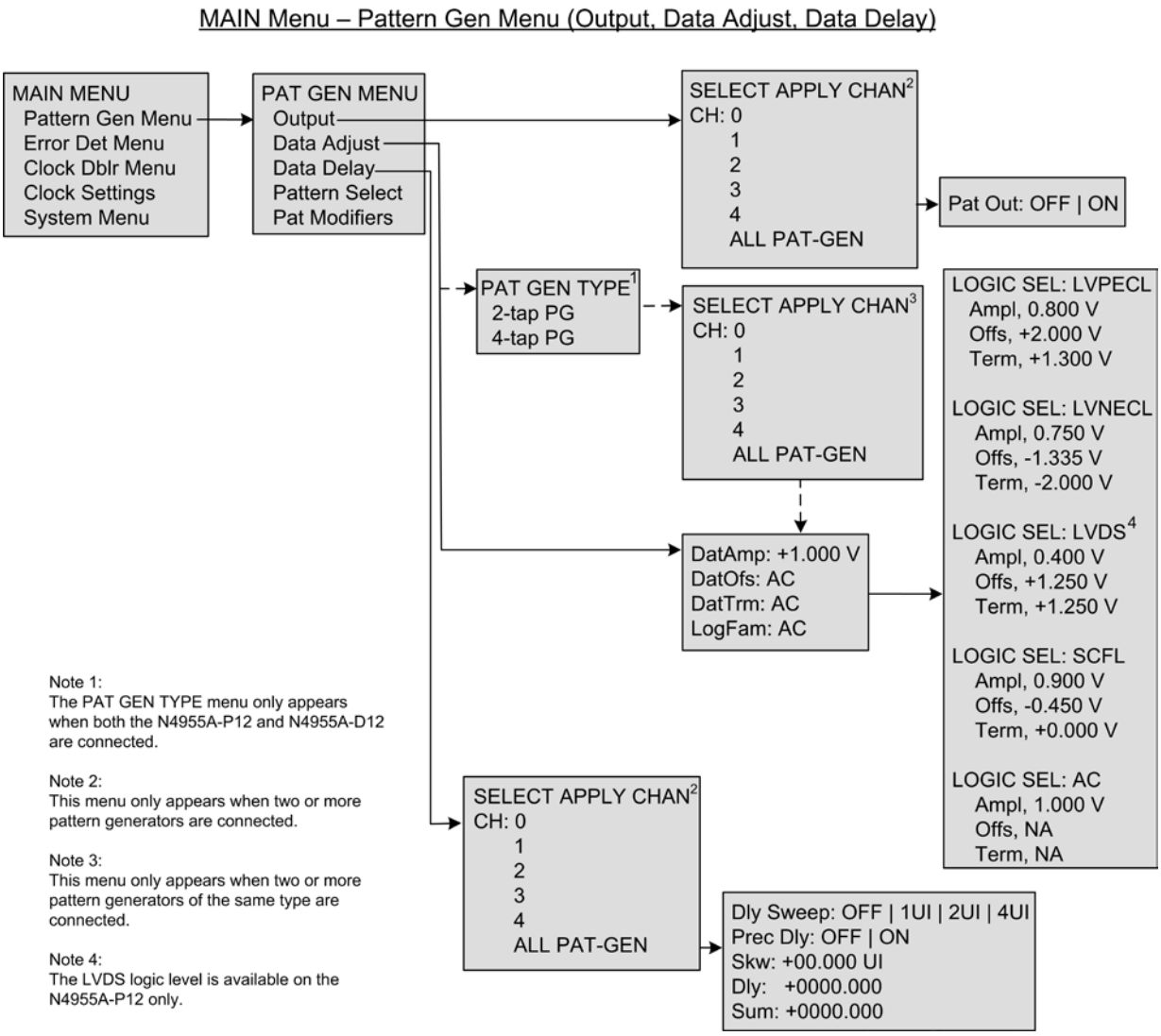


Figure 22. Pattern generator menu structure (output, data adjust, and data delay)

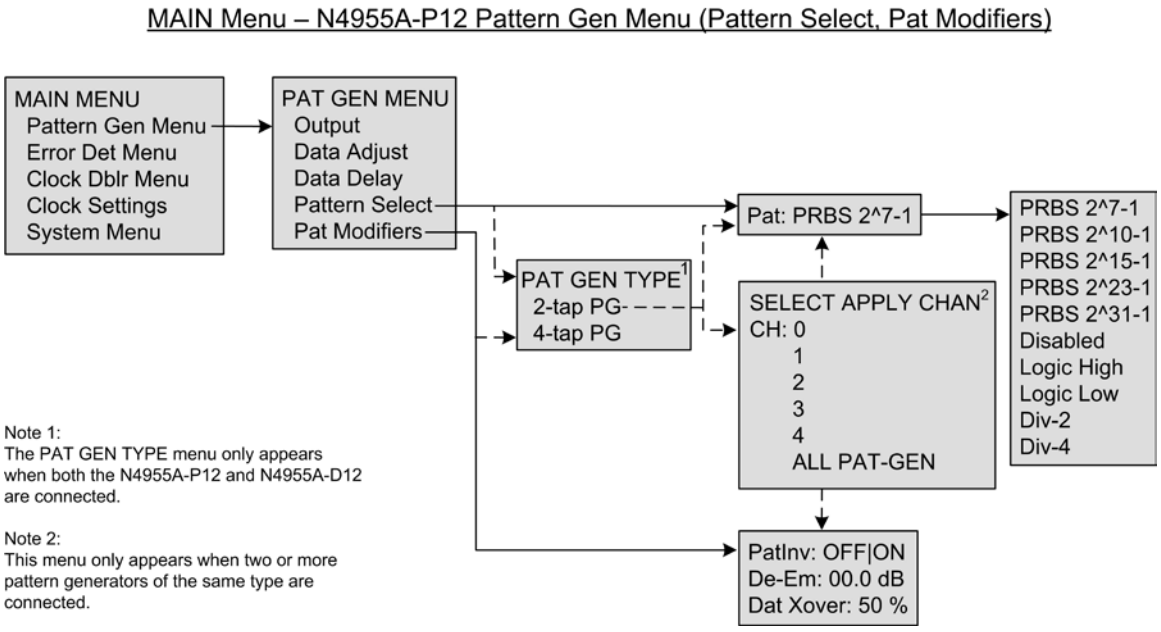


Figure 23. N4955A-P12 pattern generator menu structure (pattern select and pat modifiers)

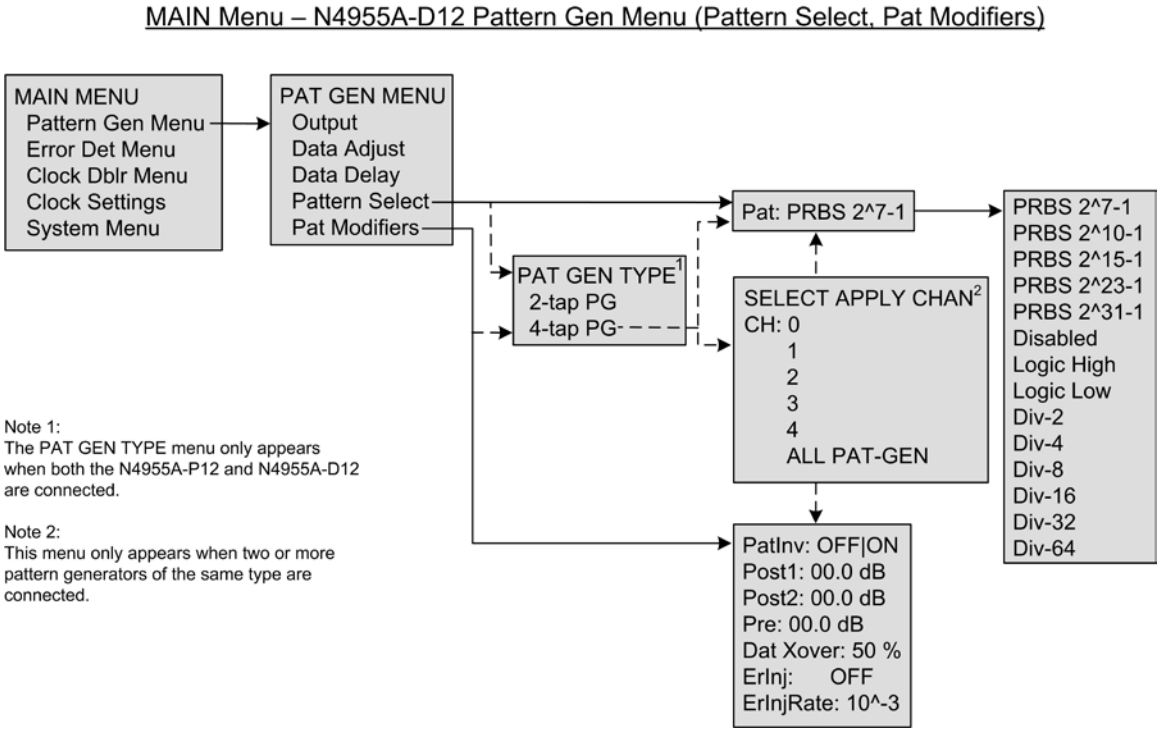


Figure 24. N4955A-D12 pattern generator menu structure (pattern select and pat modifiers)

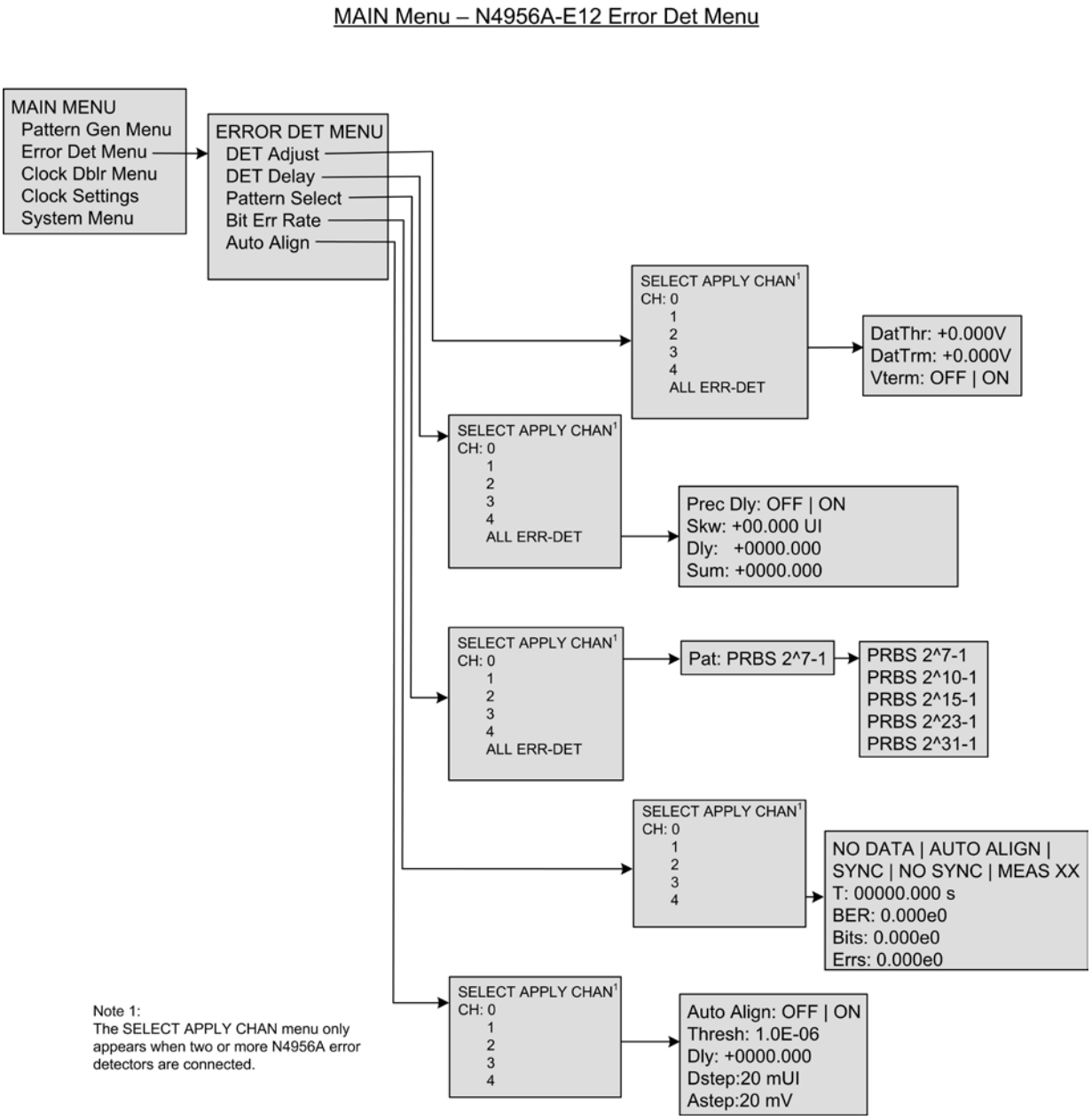


Figure 25. N4956A-E12 error detector menu structure

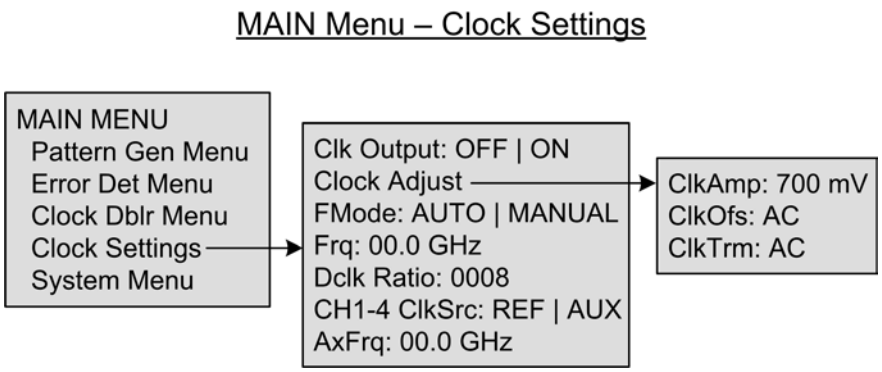


Figure 26. Clock settings structure

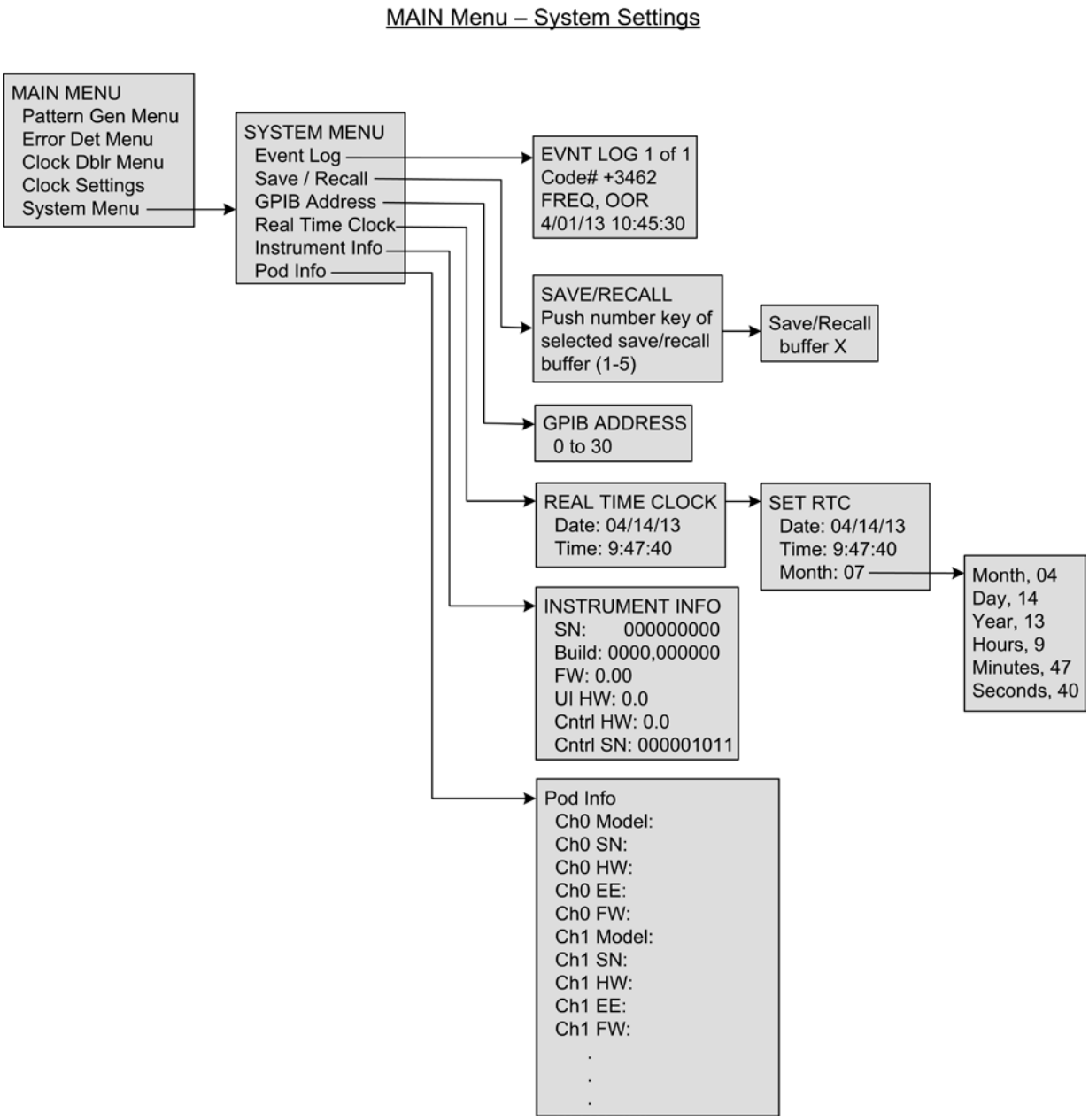


Figure 27. System settings structure

3.7.5 N4955A-P12 Menu Label Descriptions

Refer to Table 12 for the N4955A-P12 Pattern Gen Menu descriptions.

Table 12. N4955A-P12 pattern gen menu descriptions

Softkey Name	Description
SELECT APPLY CHAN	Select channel(s) to apply settings: 0, 1, 2, 3, or 4: apply settings to channel 0, 1, 2, 3, or 4 individually. ALL PAT-GEN: apply settings to pattern generators only.
Output	The Output options include: Pat Out: turns the data output for selected channel(s) on or off. Also, for ALL PAT-GEN selections, the current settings appear if they are identical. If the settings are not identical, the label **mixed** appears.
Data adjust	The data adjust options include: DatAmp: adjusts the data amplitude. DatOfs: adjusts the data offset. DatTrm: adjusts the data termination voltage. LogFam: selects the data logic. CUST: appears when the amplitude, offset, and termination combination do not match a particular logic family ('s default values). If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.
Data delay	The Data Delay options include: Dly Sweep: sets the pattern generator delay sweep. Prec Dly: Turns the precision delay feature on or off. Skw: adds a fixed offset to compensate for cable offsets when using different cable lengths. Dly: adjusts the relationship between the clock signal and the data stream. Sum: sum of the Skw and Dly. This is the total delay applied to a channel.

Softkey Name	Description
Pattern select	The Pattern Select options include: Pat: selects pattern. PRBS 2n-1 [n=7, 10, 15, 23, 31] Disabled: disables test pattern. Logic High: set all bits of the test pattern to logic high. Logic Low: set all bits of the test pattern to logic low. 1010: selects a repeating test pattern of 1010. 1100: selects a repeating test pattern of 1100. If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.
Pat modifiers	The Pat Modifiers options include: PatInv: inverts the data pattern. De-Em: adjusts de-emphasis. Dat Xover: adjusts the data crossover %. If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.

3.7.6 N4955A-D12 Menu Label Descriptions

Refer to Table 13 for the N4955A-D12 Pattern Gen Menu descriptions.

Table 13. N4955A-D12 pattern gen menu descriptions

Softkey Name	Description
SELECT APPLY CHAN	Select channel(s) to apply settings: 0, 1, 2, 3, or 4: apply settings to channel 0, 1, 2, 3, or 4 individually. ALL PAT-GEN: apply settings to pattern generators only.
Output	The Output options include: Pat Out: turns the data output for selected channel(s) on or off. Also, for ALL PAT-GEN selections, the current settings appear if they are identical. If the settings are not identical, the label **mixed** appears.

Softkey Name	Description
Data adjust	The data adjust options include: DatAmp: adjusts the data amplitude. DatOfs: adjusts the data offset. DatTrm: adjusts the data termination voltage. LogFam: selects data logic. CUST: appears when the amplitude, offset, and termination combination do not match a particular logic family. If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.
Data delay	The data delay options include: Dly Sweep: sets the pattern generator delay sweep. Prec Dly: Turns the precision delay feature on or off. Skw: adds a fixed offset to compensate for cable offsets when using different cable lengths. Dly: adjusts the relationship between the clock signal and the data stream. Sum: sum of the Skw and Dly. This is the total delay applied to a channel.
Pattern select	The pattern select options include: Pat: selects pattern. PRBS 2^n-1, n=7, 10, 15, 23, 31 Disabled: disables test pattern. Logic High: set all bits of the test pattern to logic high. Logic Low: set all bits of the test pattern to logic low. Div-2: selects a repeating test pattern of 1010. Div-4: selects a repeating test pattern of 1100. Div-8: selects a repeating test pattern of 4x 1's followed by 4x 0's. Div-16: selects a repeating test pattern of 8x 1's followed by 8x 0's. Div-32: selects a repeating test pattern of 16x 1's followed by 16x 0's. Div-64: selects a repeating test pattern of 32x 1's followed by 32x 0's. If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.

Softkey Name	Description
Pat modifiers	The pat modifiers options include: PatInv: inverts the data pattern. Post1: adjusts first post-cursor. Post2: adjusts second post-cursor. Prec: adjusts de-emphasis pre-cursor. Dat Xover: adjusts the data crossover %. ErInj: enables/disables constant error injection, or injects single error ErInjRate: adjusts fixed error rates with BER = 10^-N. If the settings for ALL PAT-GEN are not identical, the label **mixed** appears.

3.7.7 N4956A-E12 Menu Label Descriptions

Refer to Table 14 for the Error Det Menu descriptions.

Table 14. Error det menu descriptions

Softkey Name	Description
SELECT APPLY CHAN	Select channel(s) to apply settings 0, 1, 2, 3, or 4: apply settings to channel 0, 1, 2, 3, or 4 individually. ALL ERR-DET: apply settings to error detectors only.
DET Adjust	The DET Adjust options include: DatThr: adjusts the data threshold. DatTrm: adjusts the data termination voltage. VTerm: Turns DatTrm ON or OFF. If the settings for ALL ERR-DET are not identical, the label **mixed** appears.
DET Delay	The DET Delay options include: Prec Dly: Turns the precision delay feature on or off. Skw: adds a fixed offset to compensate for cable offsets when using different cable lengths. Dly: adjusts the relationship between the clock signal and the data stream. Sum: sum of the Skw and Dly. This is the total delay applied to a channel. If the settings for ALL ERR-DET are not identical, the label **mixed** appears.

Softkey Name	Description
Pattern Select	The Pattern Select options include: Pat: selects pattern. PRBS 2n-1, n=7, 10, 15, 23, 31 If the settings for ALL ERR-DET are not identical, the label **mixed** appears.
Bit Err Rate	The Bit Err Rate options include: Status messages: NO DATA: displayed when there is no data signal detected. AUTO ALIGN: displayed when performing an auto alignment. SYNC: displayed when the input data is synchronized. NO SYNC: displayed when the input data is not synchronized. MEAS XX: counts elapsed time during a bit error rate test in seconds. T: set bit error rate test duration in seconds. BER: starts/stops bit error rate test. Bits: number of bits. Errs: number of errors.
Auto align	The auto align options include: Auto align: turns auto align on and off. Auto Align is disabled during BER measurement. Thresh: Determines the duration of the measurement at each point. Dly: displays the delay setting for the current measurement. DStep: sets the step size for the delay centering alignment. AStep: sets the step size for the amplitude centering alignment.

3.7.8 Clock settings Menu Label Descriptions

Refer to Table 15 for the Clock Settings descriptions.

Table 15. Clock settings descriptions

Softkey Name	Description
Clk output	Turns the clock output on and off.
Clock adjust	The clock adjust options include: ClkAmp: adjusts clock output amplitude, peak to peak. ClkOfs: adjusts the clock offset. ClkTrm: adjusts the clock termination voltage.
FMode	The frequency mode options include: auto: automatically update N4965A when the Clock In Ref Input frequency is changed. manual: manually update N4965A when the Clock In Ref Input frequency is changed in the Frq field. NOTE In manual mode, all internal frequency dependent settings of the instrument are set by the frequency entered in the Frq field.
Frq	Displays the clock in ref input frequency in GHz. When the FMode is in manual, the Clock In Ref Input frequency is entered in this field manually.
Dclk ratio	Sets the divide ratio for the divided clock output.
CH1-4 ClkSrc	The Clock Source options include: REF: clock in ref applied to all channels. AUX: clock in aux applied to channels 1-4 and clock in ref input applied to channel 0 only.
AxFrq	Displays the AUX (secondary clock input) clock input frequency for channels 1-4. Note that the clock In Aux Input Frequency must be updated manually in this editable field.

3.7.9 System menu Label Descriptions

Refer to Table 16 for the System Menu descriptions.

Table 16. System menu descriptions

Softkey Name	Description
Event log	Accesses the list of error messages.
Save / recall	Stores the current instrument state into a buffer (1-5), which can then be recalled.
GPIB address	Sets the GPIB Address.
Real time clock	Sets the instrument time and date.
Instrument info	Accesses the instrument serial number, build number, firmware version, user interface hardware version, controller hardware version, and controller serial number.
Pod info	Accesses the model number, serial number, hardware version, and pod firmware and CPLD version of each remote head connected to the N4965A.

3.7.10 Menu Navigation

Navigation through the softkey menus is accomplished with the four softkeys to the right of the display and the rotary knob. Refer to Figure 28.

Figure 28. Softkey buttons and rotary knob

Toggle between the **STAT** (Status) menu and the **MENU** (Main Menu) using the top navigation softkey. Refer to Figure 17. Scroll through menu items using either the softkeys corresponding to the up and down arrow labels, or using the rotary knob. Refer to Figure 29.

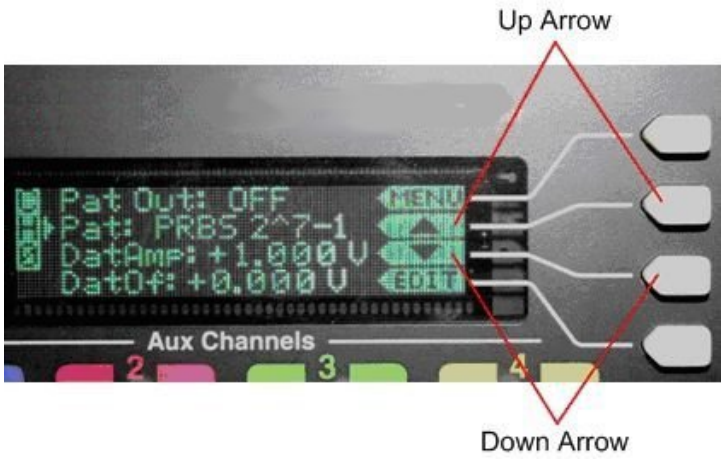


Figure 29. Scrolling through menu items

If a menu item has a lower-level menu that can be accessed, the **SEL** softkey appears. Press it to access the corresponding lower-level menu. Refer to Figure 30.

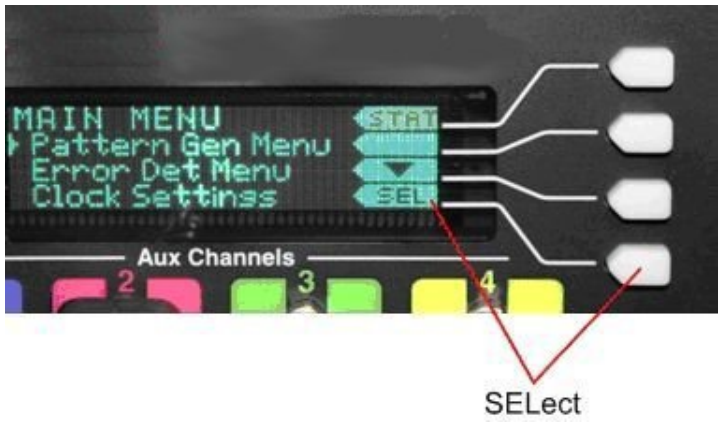


Figure 30. Accessing lower-level menus

3.7.11 Changing Parameters

If a menu item has a numeric value that can be changed or has multiple selections (for example, on and off), then the **EDIT** label appears. Refer to Figure 31.

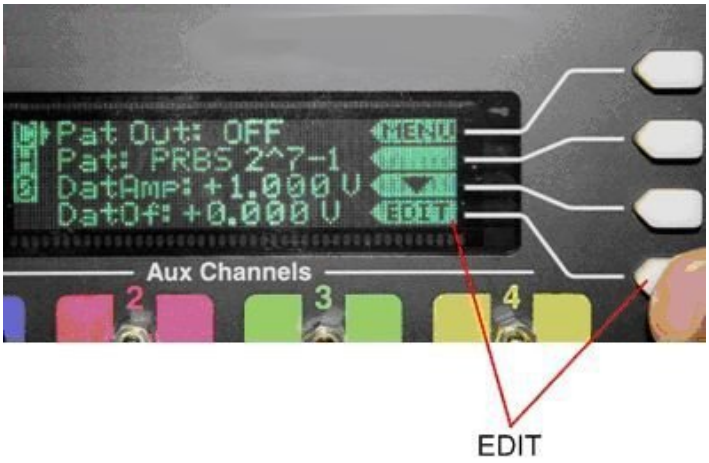


Figure 31. Edit label

When the softkey corresponding to the **EDIT** label is pressed, the function's parameter can be changed using the rotary knob or the keypad.

NOTE The keypad is used if a parameter is a numeric value only.

Figure 32 is an example of changing parameters using the rotary knob.

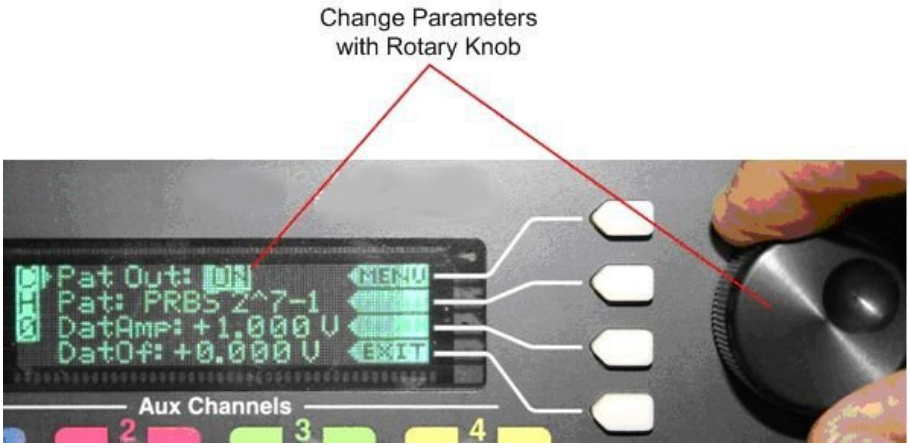


Figure 32. Changing parameters using the rotary knob

If you are using the rotary knob to change numeric values, use the right/left arrows on the keypad to highlight the digit you wish to change. The right arrow highlights the digit to the right. The left arrow highlights the digit to the left. When finished, press the softkey corresponding to the **EXIT** label to accept the changes. Refer to Figure 33.

Figure 33. Highlighting digits to change

In addition to the rotary knob, the numeric keypad can be used to change numeric values. Once the softkey corresponding to the **EDIT** label is pressed, simply enter the value using the numeric keypad. When finished, either press the **ENT** hardkey on the keypad, or press the softkey corresponding to the units (V or mV, etc.) to accept the entry. Refer to Figure 34.

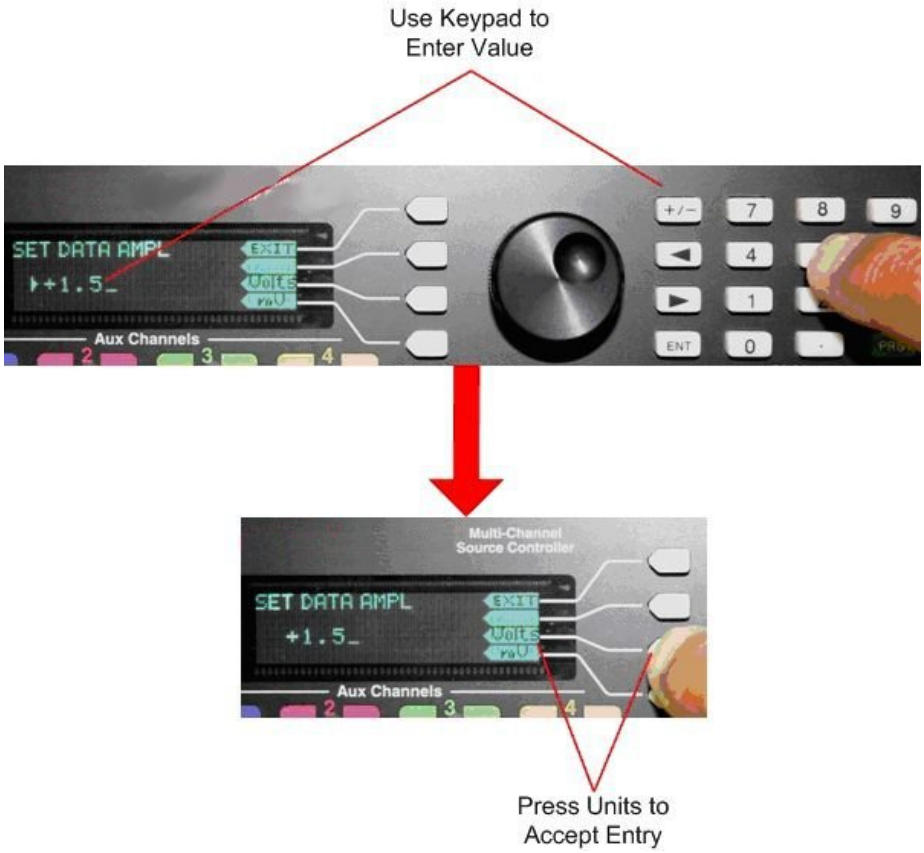


Figure 34. Using the numeric keypad

3.8 Clock Offset and Termination Voltage

The minimum and maximum limits for offset voltage are functions of the termination voltage, determined by the following formulas:

Maximum V_{Offset} (V) = MIN(0.5*V_{Term} + 2, +2.0)

Minimum V_{Offset} (V) = MAX(0.5*V_{Term} −2, −2.0)

The ranges are shown graphically in Figure 35:

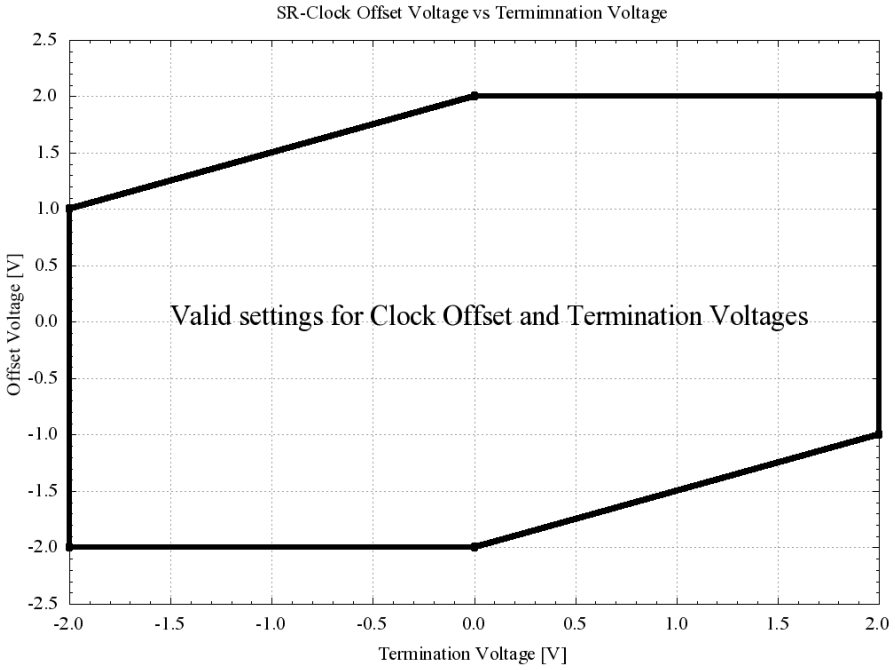


Figure 35. Clock offset and termination voltages

However, because the resolution for V_{Offset} is 5 mV, any invalid updated values will be rounded to the nearest valid setting within the new limit. For example, consider the case when V_{Offset} = +1.5000 V, while V_{Term} is changed from −1.000 V to −1.005 V. According to the formula above, the new upper limit for V_{Offset} will be:

MIN(0.5*−1.005+2.0, 2.0)V = 1.4975 V,

which is not valid due to the 5 mV resolution. Therefore, the V_{Offset} will be set to the closest valid setting of +1.495 V instead.

3.9 Delay, Precision Delay, Skew, and Swept Delay

The delay, skew, and swept delay features are all applicable for bit rates. The delay spans 2000 UI, while the skew spans 199.998 UI. The skew feature is essentially identical to the delay, and can be used for calibrating two or more channels to establish a reference relationship between edges.

Precision delay provides better delay accuracy, and is especially beneficial for certain types of BER measurements, such as bathtub jitter characterization. For this type of measurement where delay accuracy is critical, the precision delay feature should be enabled. The precision delay is calibrated internally when enabled, or when the input clock frequency changes, which can take up to 6 seconds for each channel that has precision delay enabled. For this reason, when measurement time is critical and delay accuracy is less important, the precision delay can be disabled on a per-channel basis. The default setting for precision delay is ON for the channel connected to the Error Detector head and OFF for the channel connected to the Generator head.

The swept delay feature uses triangular phase modulation with programmable total deviation of 1, 2, or 4 UI centered on transition edges to fully stress cross-talk in back-plane testing. Each of the five channels is swept at a unique rate as listed below:

Ref Ch – 7 Hz
Aux Ch 1 – 11 Hz
Aux Ch 2 – 13 Hz
Aux Ch 3 – 17 Hz
Aux Ch 4 – 19 Hz

When setting delay or skew, a finite amount of time is required for the operation to complete. Each delay change will take approximately 1 second per 100 UI per channel to complete. For example, increasing the delay by 200 UI for four channels will take up to 8 seconds total. The message “LOADING SETTINGS (Please wait)” will appear on the Front Panel Display when changing the delay or skew by 100 UI or more, while the operation is being completed.

When a frequency change is detected, any nonzero delay or skew values will be reset to zero.

When the reference clock is set to AUTO mode and a frequency change is detected by the N4965A, a Precision Delay calibration will be initiated and run in the background. The calibration time is approximately 6 seconds per each channel derived from the reference clock. When the reference clock is set to MANUAL mode, or if the auxiliary clock is used, and a new frequency is entered at the front panel, a Precision Delay calibration will be initiated and the display

will show "Load Settings" while the calibration is active.

3.10 Reference and Auxiliary Clock Inputs

3.10.1 Reference Clock Inputs

An external clock source is required to operate the N4965A. The reference clock input is considered the main input clock. The reference channel (channel 0) and the divided clock outputs are always derived from the reference clock. The auxiliary channels (channels 1-4) are derived from either the reference clock or the auxiliary clock, selected by the user.

The reference frequency can be measured automatically with resolution of 100 MHz, or it can be entered manually. The reference frequency value determines calibration settings for various parameters such as amplitude, de-emphasis, and cross-over.

When the input clock is removed or the amplitude is too low, the frequency value will be set to 00.0 GHz to indicate loss of clock. An event message will also be logged indicating loss of clock.

3.10.2 Auxiliary Clock Inputs

The auxiliary channels (channels 1-4) have the option to be derived from a separate clock source than the reference channel. Unlike the reference clock, the auxiliary frequency cannot be detected automatically, but instead the value must be entered by the user. When the clock source for channels 1-4 is “REF”, then the auxiliary frequency value will be displayed as 00.0 GHz. In addition, when the clock source is set to “AUX”, then the default auxiliary frequency value will be the same as the current reference frequency value. If the auxiliary clock frequency differs significantly from the reference clock, then the user must enter the correct auxiliary clock frequency, since the calibration settings depend on this information.

3.11 Divided Clock Outputs

The N4965A has the capability to divide the reference input frequency over a broad range of divide ratios and return the divided signal as fully differential outputs with adjustable amplitude and offset. This provides the user a convenient method for generating a trigger signal to use with a scope. Valid divide ratios are specified in section 5.1 N4965A Controller Specifications in 5 Performance Specifications, and are listed here again for convenience:

- 1, 2, 4
- 8 to 512 in resolution of 1
- 514 to 1024 in resolution of 2
- 1028 to 2048 in resolution of 4
- 2056 to 4088 in resolution of 8

Invalid divide ratios entered by the keypad on the front panel will result in setting the nearest valid divide ratio, and the display is updated accordingly. If the value is exactly centered between two valid numbers, then it will be rounded down to nearest valid number, except when the entered value is either 3 or 6, in which case the value will be rounded up to 4 or 8, respectively. Below are some examples of rounding invalid entries through the key pad on the front panel.

Table 17. Rounding invalid entries through the keypad on front panel

Entered Value	Nearest Lower Valid Setting	Nearest Upper Valid Setting	Actual Setting
3	2	4	4
6	4	8	8
513	512	514	512
1026	1024	1028	1024
2052	2048	2056	2048

The divide ratio setting behaves differently when interfacing remotely versus through the front panel. If an invalid divide ratio is entered remotely, then the divide ratio will not be set to the nearest valid number, but instead the current value is retained and an error message will be issued in the event log. Thus, when programming the divide ratio remotely, the entered value must be valid in order for any changes to occur to the divide ratio.

The duty cycle of the divided clock outputs varies with division ratio as shown in Figure 36 and Figure 37.

For division ratios of 1, 2, 4, 8, 16, 32, 64, 128, 256 and all values from 512 through 4088 the duty cycle is 50%. For other division ratios in the range of 9 to 511 the duty cycle varies from 25 to 75%.

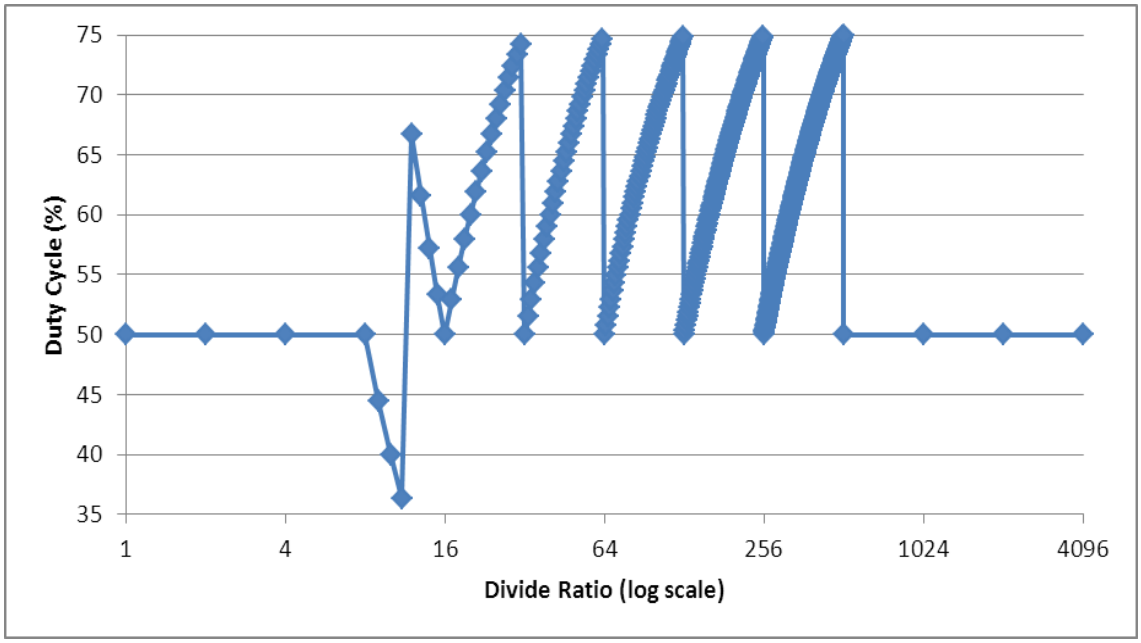


Figure 36. Divided Clock OUT+duty cycle vs divide ratio

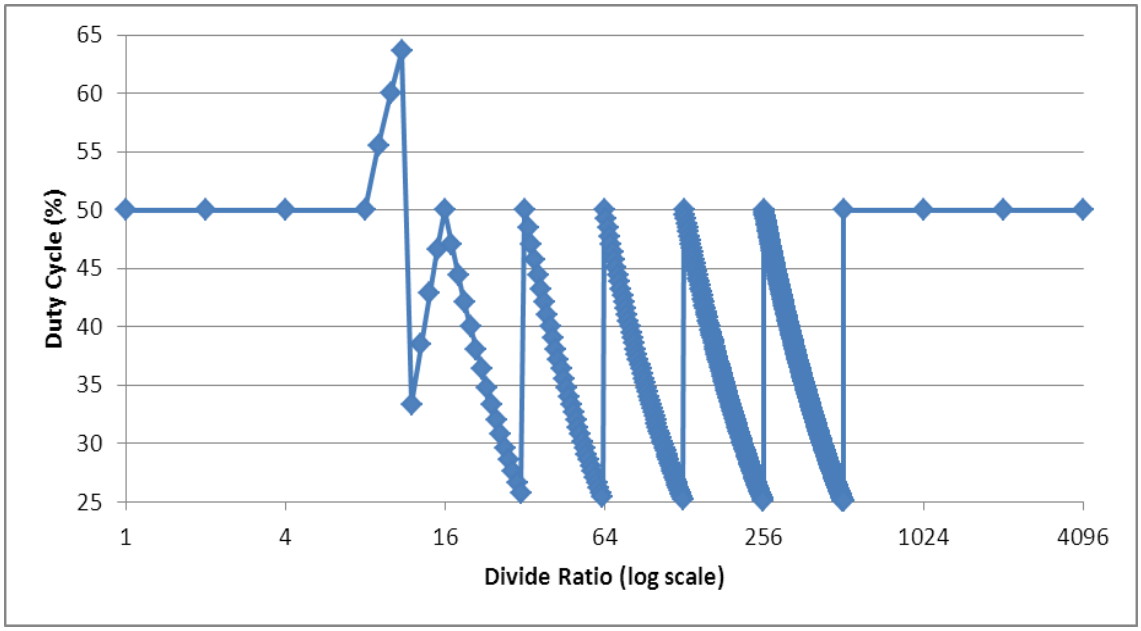


Figure 37. Divided Clock OUT- duty cycle vs divide ratio

The divided clock outputs are AC-coupled, with internal bias-T to support offsets and external termination voltage. The Offset Voltage setting represents the average DC voltage of the divided clock output. So for division ratios with 50% duty cycle, the Offset Voltage setting represents the voltage at the middle of the divided clock output waveform, whereas for division ratios with non-50% duty cycle, the Offset Voltage setting represents a position above or below the middle of the divided clock output waveform.

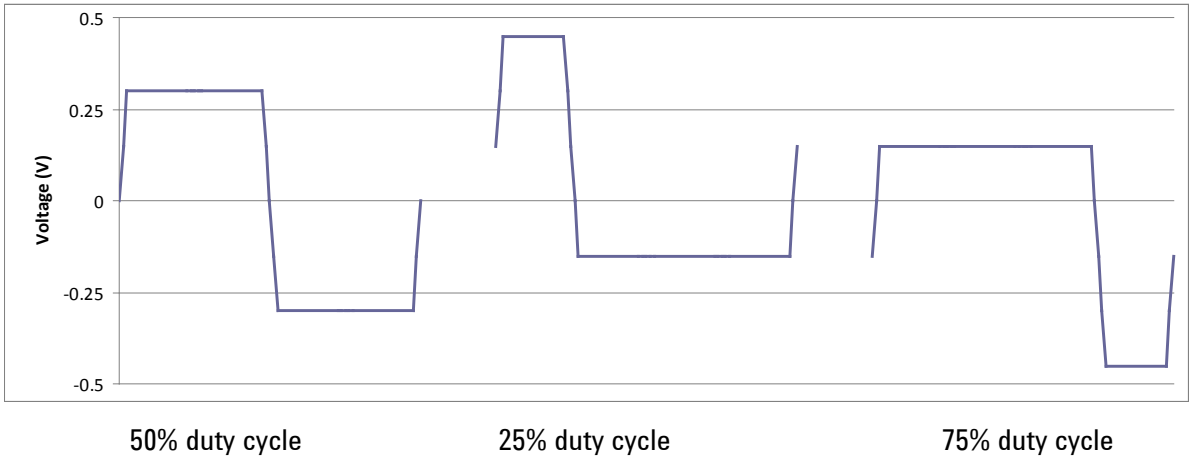


Figure 38. Divided Clock Output at 50, 25, 75% duty cycle with Offset Voltage = 0V

3.12 Selecting Patterns

The following procedure shows how to select from a list of patterns.

1. In the **MAIN MENU**, position the arrow next to the **Pattern Gen Menu** label (or Error Det Menu label if selecting a pattern for the N4956A-E12), then press the softkey corresponding to the **SEL** label.
2. Position the arrow next to the **Pattern Select** label then press the softkey corresponding to the **SEL** label.
3. In the **SELECT APPLY CHAN** menu, select the channel(s) you wish to apply the pattern, then press the softkey corresponding to the **SEL** label.
4. Press the softkey corresponding to the **EDIT** label and scroll through the list of test patterns until the desired pattern is highlighted.
5. Press the softkey corresponding to the **EXIT** label to select the pattern.

6. If necessary, press the softkey corresponding to the **BACK** label until the top menu is displayed.

3.13 Event/Error log

This subsystem collects commands and queries related to the reading and control of the event/error queue.

The event/error queue contains items that include a numerical and textual description of the event or error. The event/error number is a unique integer in the range of -32768 to +32767. All positive numbers are instrument-dependent. All negative numbers are reserved by the SCPI standard with certain standard event/error codes described in this document. The value zero is also reserved to indicate that no error or event has occurred (**0, "No error"**).

The second parameter of the full response is a quoted string containing an event/error description.

Refer to Table 18 through Table 20 for the list of error types and error codes found in the Event/Error Log.

3.13.1 SCPI Standard Negative Event/Error Codes

The following table represents the SCPI standard event/errors used by the N4965A.

Table 18. SCPI standard negative event/error codes

Error/Event Codes	Description
0, "No error"	Event/error queue is empty.
-100, "Command error"	Indicates that an undefined command was received via the SCPI interface.
-102, "Syntax error"	An unrecognized command or data type was encountered.
-103, "Invalid separator"	The parser was expecting a separator and encountered an illegal character.
-109, "Missing parameter"	Fewer parameters were received than required for the header.
-221, "Settings conflict"	A legal program data element was parsed but could not be executed due to current device.
-222, "Data out of range"	A legal program data element was parsed but could not be executed because the value was outside the legal range as defined by the device.
-224, "Illegal parameter	Used where exact value, from a list of possibles, was expected.

Error/Event Codes	Description
value"	
-400, "Query error"	Generic query error as defined in IEEE 488.2, 11.5.1.1.7.
-500, "Power on"	The instrument has detected an off to on transition in its power supply.
-600, "User request"	This event occurs when the instrument detects the activation of a user request local control.
-800, "Operation complete"	The instrument has completed all selected pending operations in accordance with the IEEE 488, 12.5.2 synchronization protocol.
-350, "Queue overflow"	If the queue overflows the last event/error in the queue is replaced with this error.

3.13.2 Device Specific Positive Event/Error Codes

The device specific event/error codes are positive with allowed values of 1 to 32767.

This code is made up of the instrument sub-system (values from 0-3), error type (values from 0-99) and error code (values from 0-79).

The sub-system relates to a specific instrument module and the corresponding port that communicates with that module. There can be up to 4 separate sub-systems.

The Type and Code values represent offsets into their respective tables shown below.

There can be up to 8000 values for a particular sub-system which is the combination of 100 types each having up to 80 corresponding codes.

Numbers from 0 to 7999 represent an event/error code for sub-system 0, 8000 to 15999 for sub-system 1, etc.

The SCPI event/error code is created by multiplying the sub-system by 8000 and adding the Type offset times 80, plus the Code offset.

An example SCPI event/error output would be:

+9772, “IPC, TIMEOUT”

Since this value lies between 8000 and 15999, the sub-system is 1.

Subtracting 8000 results in a value of 1772. Dividing this by 80 results in a Type of 22 and the remainder is a code of 12.

The 22nd entry in the event/error Type table - “IPC”. The code 12 in the event/error Code table - “TIMEOUT.

Table 19. Event types

Event Number	Event Type
1	PAYLOAD
2	INIT
3	UPGRADE
4	RESET
5	REV
6	AMPL_ADJ
7	AMPL_TERM
8	AMPL_OFFSET
9	AMPL_SR
10	AMPL_DCC
11	AMPL_DCD
12	PATTERN_SETUP
13	INVERT
14	DEEMPH
15	XOVER
16	MKDEN
17	ERRINJ
18	TRIG
19	PHASE
20	SI
21	CAL (Calibration type)
22	IPC (IPC protocol related type)
23	IAL
24	TLV
25	LED
26	REFCLK
27	FFS
28	AUX_IN
29	BTN
30	PH_DET
31	FREQ
32	FREQ_DET
33	FPGA

Event Number	Event Type
34	TEMP
35	FAN
36	GB
37	OS
38	UISPI
39	CPU
40	BOARD
41	DELAY
42	CHAN
43	POD

Table 20. Event/error codes

Event Number	Event Type	Description
1	OK	status good, no errors
2	ERR	misc. error
3	PROT	a protocol error
4	OOR	val out of range
5	INV_DATA	
6	OPER_FAIL	operation failed
7	OPER_DONE	operation complete
8	OPER_INPRG	operation in progress
9	RAILED	val railed high or low
10	SIZE	
11	OVERRUN	
12	TIMEOUT	
13	INV_UNIT	data is in an invalid unit or format
14	IDLE	
15	CHAR	
16	LOS	loss of signal/data etc.
17	NOT_FOUND	resource does not exist
18	BAD_SEQ	sequencing error

Event Number	Event Type	Description
19	CKSUM_FAIL	file md5 checksum failure
20	FILE_ERR	error on file operation
21	UNCAL	operation continuing, uncalibrated
22	I/O_ERR	I/O error
23	OVER_TEMP	Temperature
24	NOT_AVAIL	Results not available
25	INV_VERS	Invalid Version

4 Applications

This chapter contains measurement examples intended to demonstrate the major features of the system.

4.1 Setting Up 2-tap and 4-tap De-emphasis

4.1.1 What is the problem?

As data rates increase, frequency dependent losses in a channel increase which slow bit transition times, resulting in eye closure at the receiver. To counteract the effects of high frequency loss, a filter can be added to the channel as shown in Figure 39.

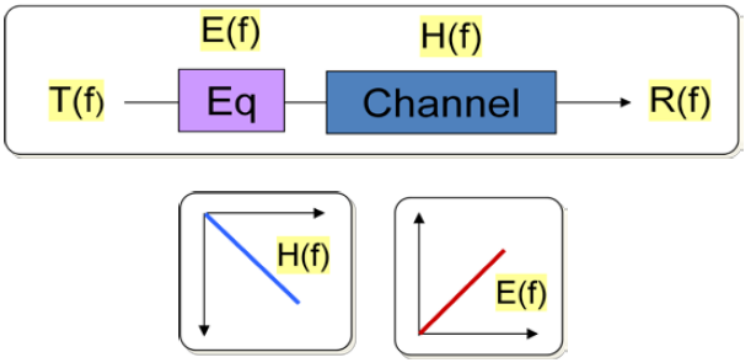


Figure 39. Equalization filter

Where T(f) is the response at the output of the transmitter,
R(f) is the response seen at the input of the receiver
H(f) is the channel loss response
E(f) is the equalizer response
If E(f) = 1/H(f),
then R(f) = T(f)

By applying an equalizer with a transform function approximately the inverse of the channel loss characteristics, the loss is effectively canceled, restoring the eye opening.

The equalizer can be applied at the output of the transmitter, the input of the receiver, or at both locations. When applied to the transmitter output, it is referred to as "pre-emphasis or de-emphasis."

Equalization is applied to the pattern generator output of a BERT when testing receivers to emulate the transmitter equalization characteristics.

4.1.2 Pre-emphasis Versus De-emphasis

Both pre-emphasis and de-emphasis are a type of equalization filter that generate a high pass filter function used to increase the high frequency content and restore the eye opening. Pre-emphasis boosts the amplitude of the transition bit and leaves the succeeding non-transition bits (those of the same logical value) unchanged. De-emphasis reduces the amplitude of the non-transition bits (of the same logical value) and leaves the transition bit unchanged. Systems integrate pre-emphasis or de-emphasis (not both simultaneously) to recover the high frequency content. Regardless of which method is used, the frequency response of the transform function is the same for both.

Emphasis can be implemented with either a linear or digital filter. The N4955A-P12 and N4955A-D12 utilize digital Finite Impulse Response (FIR) filters and de-emphasis to achieve the effects of equalization to restore the high frequency content.

Because de-emphasis attenuates the amplitude of the non-transition bits, it may be necessary to increase the generator Data Amplitude value to assure the resulting amplitude is above the minimum input level of the receiver. If the amplitude is below the range of the receiver, the receiver will not be able to distinguish between bit logic levels.

CAUTION

If it is necessary to increase the generator Data Amplitude setting, beware that disabling de-emphasis could damage the receiver if successive bits of the same value increase in amplitude above the maximum amplitude range of the receiver.

4.1.3 Finite Impulse Response (FIR) Filters

The N4955A-P12 and N4955A-D12 use FIR high pass filters to counteract the effects of high frequency loss. The following terms are used to describe the FIR filter characteristics:

- Tap
- Tap weight
- Tap interval
- Pre-cursor tap (N4955A-D12)
- Cursor tap (N4955A-P12 and N4955A-D12)
- Post-cursor 1 tap (N4955A-P12 and N4955A-D12)
- Post-cursor 2 tap (N4955A-D12)

Each FIR tap is comprised of the FIR filter coefficient (tap weight), a delay element (delayed data sample values), and an adder to accumulate the result of the FIR filter coefficient times the delay element of each tap.

The tap weight is the specified amplitude of each tap in the system.

In the N4955A-P12 and N4955A-D12, the tap interval is fixed to 1 unit interval (UI), corresponding to 1 bit time. The N4955A-P12 has two FIR taps; the N4955A-D12 has four FIR taps. Increasing the number of taps generally increases the resolution of the filter, allowing a closer emulation of the desired transfer function.

The pre-cursor tap adjusts the level of the first bit before a bit transition relative to the previous bit. The positive value represents positive emphasis of the pre-cursor bit. The amount of positive emphasis is relative to the previous bit in the pattern (second-to-last bit before the transition), which is also the level of the second post-cursor bit.

The cursor tap is the location of the transition bit.

The post-cursor 1 tap adjusts the level of the second bit after the transition, relative to the nominal transition bit amplitude determined by the Data Amplitude setting.

The post-cursor 2 tap adjusts the level of the third bit after a bit transition, relative to the level of the second bit after the transition. The second pre-cursor tap weight can be set to 0 dB to effectively remove the last tap from the filter.

Figure 40 shows the relationship of the 4-tap de-emphasis levels for the N4955A-D12.

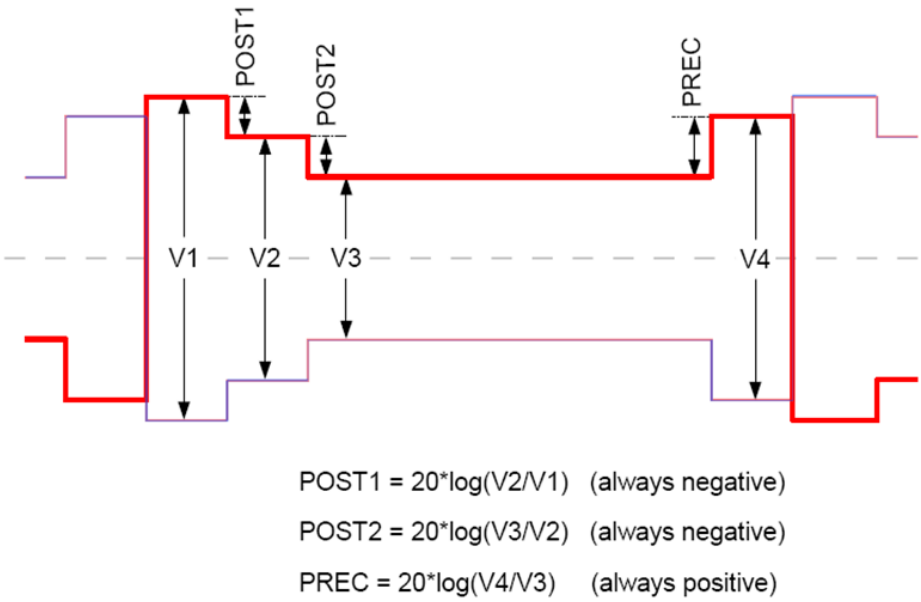


Figure 40. Definition of 4-tap de-emphasis levels

In the N4955A-P12, the first tap is the cursor bit (no weight setting for it) and one post cursor bit. The post cursor bit is always negative relative to the cursor bit.

4.1.4 Demonstrating 4-tap De-Emphasis Capabilities

The following exercise demonstrates the action of de-emphasis. A backplane with suitable loss to result in partial eye closure at a data rate of 10.3 Gb/s is used as the Device Under Test (Agilent Technologies Demonstration Board). The set up assumes the backplane channel impedance is 50 ohms single ended. Matching pads will be required for other nominal impedances. A length of 50 ohm lossy coaxial cable could also be used for the channel. The tap weight values used in this exercise are appropriate to compensate for the losses in one particular backplane. As different backplane channels may have different loss characteristics, it may be necessary to change the tap weight values to optimize the eye shape.

1. Set up the equipment as shown in Figure 41. Tighten cables to 8 lb-in (90 N-cm) and use 50 Ω terminations on all unused ports.

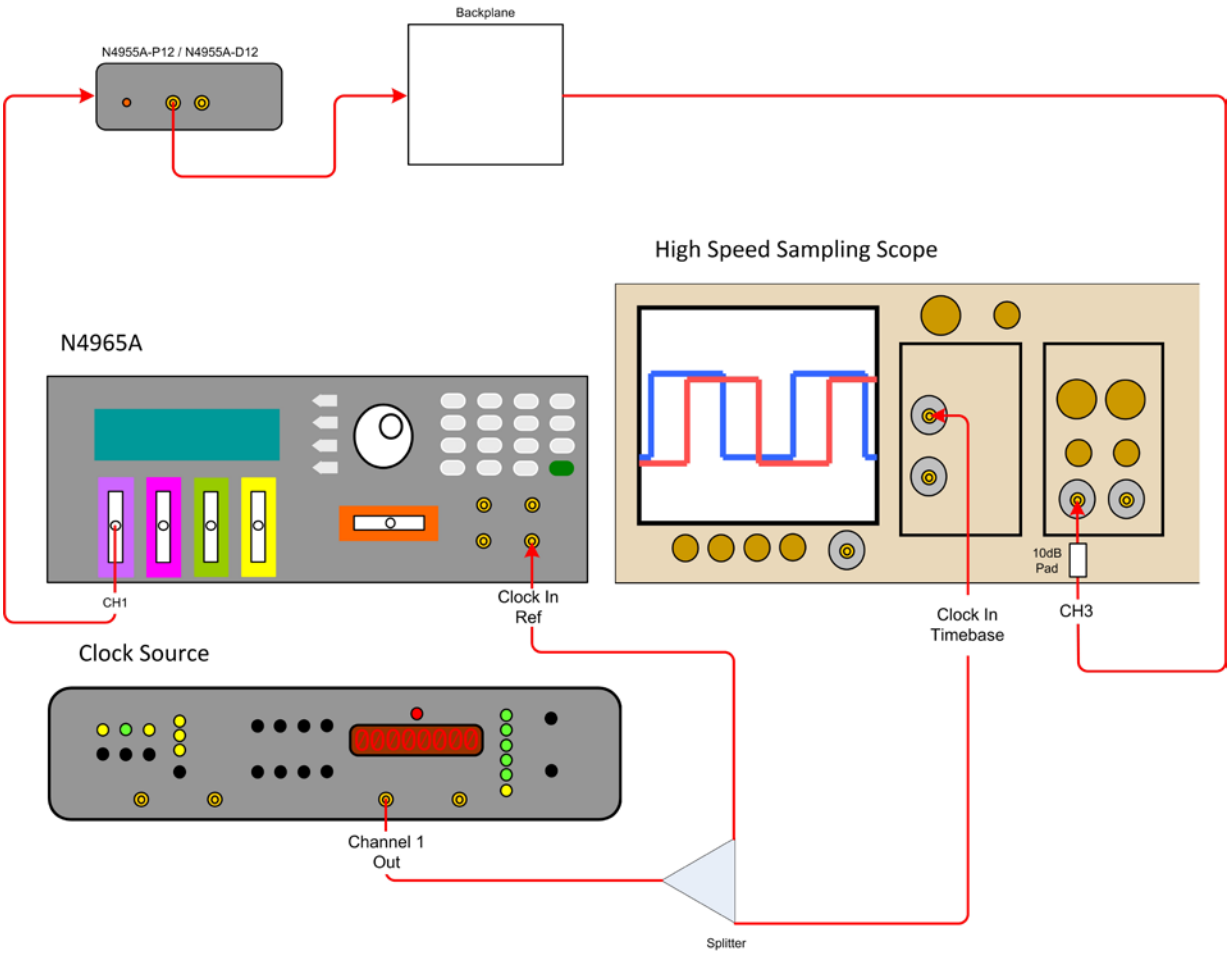


Figure 41. De-emphasis setup

2. Set up the clock source as follows:

   Frequency: 10 GHz
   Level: +6 dBm
   Output: On

3. Set up the high speed sampling scope as follows:

NOTE For purposes of this setup, an Agilent 86100A Infiniium DCA was used. High-speed sampling scope setup option names may differ between models.

Set the high speed sampling scope to Eye/Mask mode

Timebase setup

Scale:	25 ps/div
Reference:	Left
Units:	Time

Channel 3 setup (data)

Attenuation:	20 dB (20 dB pad placed at the input)
Bandwidth:	70 GHz
Display:	On
Scale:	135 mV/Div
Offset:	0 mV

4. Press the **PRST** button on the front panel of the N4965A.
5. When the **OK to Preset?** message appears, press the softkey corresponding to the **YES** label.
6. Press the softkey corresponding to the **BACK** label, if needed, until the **STAT** (Status) menu appears. Refer to Figure 16.
7. On the keypad, press the number **1** to view the **STAT** (Status) menu settings for channel 1.
8. Position the arrow next to the **DatAmp** label on the N4965A then press the softkey corresponding to the **EDIT** label.
9. Adjust the data amplitude to a level that will not damage the DUT and high speed sampling scope.

CAUTION Ensure that the data output amplitude is within the limits of the DUT and the high speed sampling scope to avoid damage to the equipment

10. Position the arrow next to the **Pat Out** label on the N4965A then press the softkey corresponding to the **EDIT** label.
11. Select **On** then press the softkey corresponding to the **EXIT** label to accept the change. This will turn on the data output.
12. If the N4955A-P12 is used, perform the following steps:
13. Position the arrow next to the **DeEm** label on the N4965A then press the softkey corresponding to the **EDIT** label.
14. Adjust the value to read **10.0 dB**.
15. If the N4955A-D12 is used, perform the following steps:

a. Position the arrow next to the Post1 label on the N4965A then press the softkey corresponding to the **EDIT** label.

NOTE The combination of Post1 and Post2 cannot be greater than –10 dB.

b. Adjust the value to read **-3.00 dB**.

c. Position the arrow next to the **Post2** label on the N4965A then press the softkey corresponding to the **EDIT** label.

d. Adjust the value to read **-3.00 dB**.

e. Position the arrow next to the **Prec** label on the N4965A then press the softkey corresponding to the **EDIT** label.

f. Adjust the value to read **0.00 dB**.

Figure 42 is an example of an eye without/with de-emphasis applied using the N4955A-P12. Figure 43 is an example of an eye without/with de-emphasis applied using the N4955A-D12.

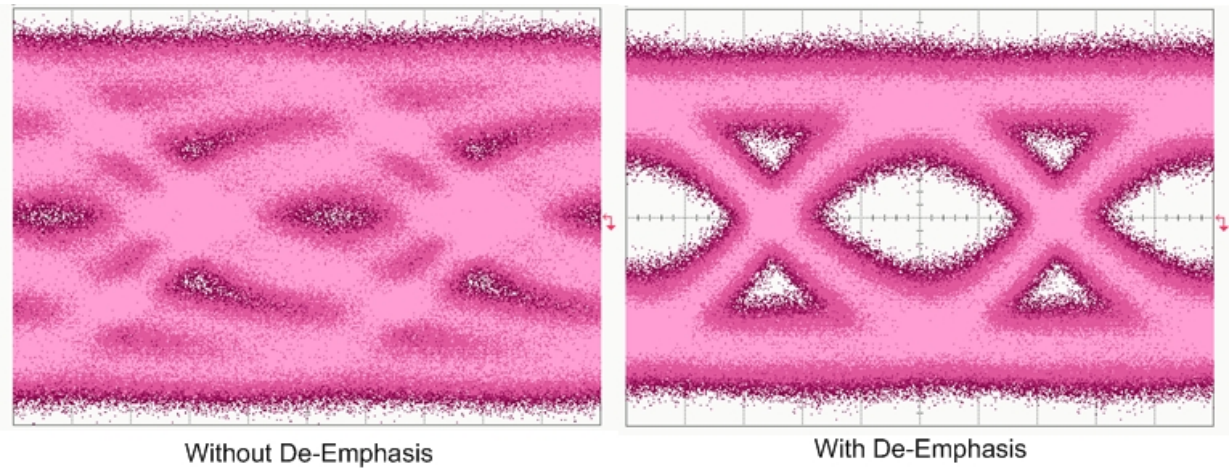


Figure 42. Eye waveform example without/with de-emphasis - N4955A-P12 (2-tap)

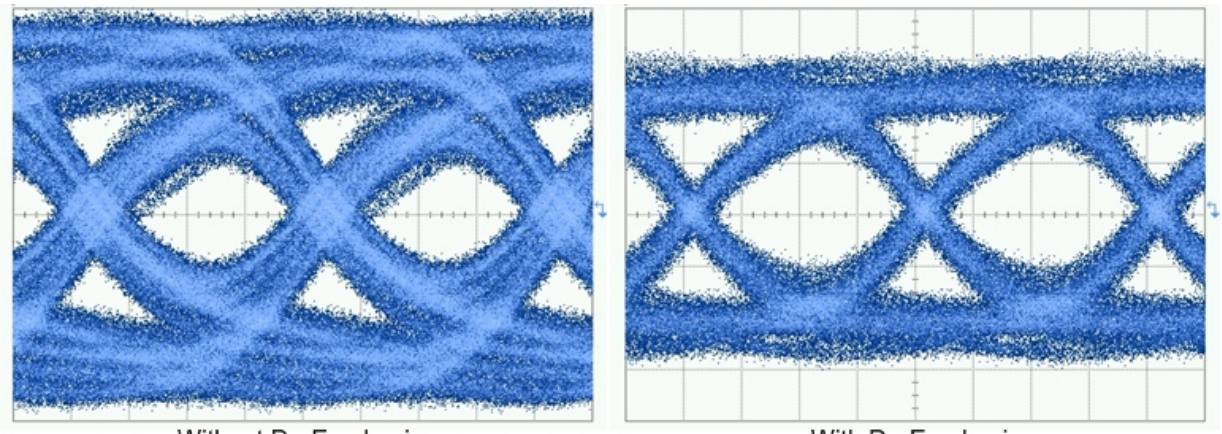


Figure 43. Eye waveform example without/with de-emphasis - N4955A-D12 (4-tap)

4.2 Setting Up BER Measurements Using the N4956A-E12

The setup shown in Figure 44 is used for performing bit error rate (BER) measurements using the N4956A-E12. A BER measurement is a ratio of the number of erroneous bits to the total number of bits received.

NOTE

Before performing the following procedure, it is recommended that the procedure in section 1.10 be performed to ensure proper data and clock output from the N4965A.

Connect the equipment as shown in Figure 44. Tighten cables to 8 lb-in (90 N-cm) and use 50 Ω terminations on all unused ports. Use appropriate matching pads if the characteristic impedance of the DUT input and output is not 50 Ω.

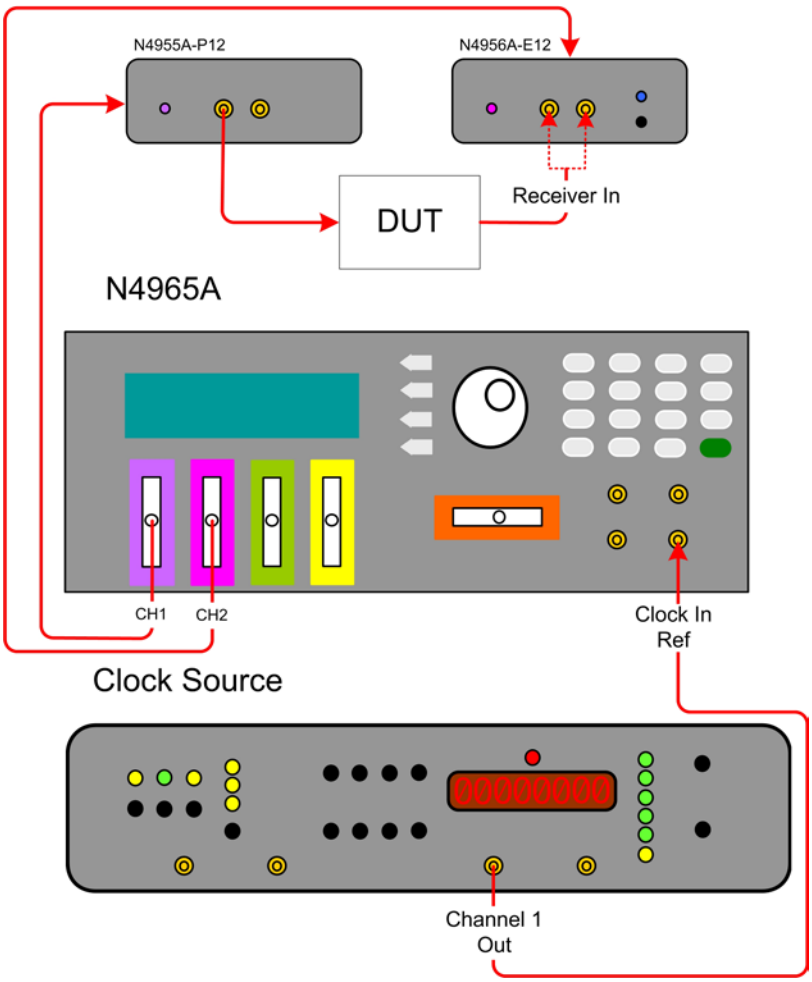


Figure 44. BER setup using the N4956A-E12

1. Set up the clock source as follows:

   Frequency: <DUT data rate>
   Level: +3 dBm
   Output: On

2. Press the **PRST** button on the front panel of the N4965A.
3. When the **OK to Preset?** message appears, press the softkey corresponding to the **YES** label.
4. Press the softkey corresponding to the **BACK** label, if needed, until the **STAT** (Status) menu appears. Refer to Figure 16.
5. On the keypad, press the number **1** to view the **STAT** (Status) menu settings for channel 1 (N4955A-D12).
6. Position the arrow next to the **DatAmp** label on the N4965A then press the softkey corresponding to the **EDIT** label.
7. Adjust the data amplitude to a level that will not damage the DUT.

CAUTION Ensure that the data output amplitude is within the limits of the DUT to avoid damaging the DUT.

8. Press the softkey corresponding to the **EXIT** label to accept the change.
9. Position the arrow next to the **ErInj** label on the N4965A then press the softkey corresponding to the **EDIT** label.
10. Select **On** then press the softkey corresponding to the **EXIT** label to accept the change. This will enable error injection. The default error injection rate of 10^-3 will be used in this procedure.
11. Position the arrow next to the **Pat Out** label on the N4965A then press the softkey corresponding to the **EDIT** label.
12. Select **On** then press the softkey corresponding to the **EXIT** label to accept the change. This will turn on the data output.
13. On the keypad, press the number **2** to view the **STAT** (Status) menu settings for channel 2. These are the N4956A-E12 Error Detector settings.
14. Position the arrow next to the **Pat** label on the N4965A then press the softkey corresponding to the **EDIT** label.
15. Select the same pattern as the one for the N4955A-D12.
16. Position the arrow to the label immediately following the **Dly** label then press the softkey corresponding to the **ALGN** label. When properly centered, the **SYNC** label will be displayed.
17. Press the softkey corresponding to the **EXIT** label to accept the change.
18. Position the arrow next to the **T** label on the N4965A then press the softkey corresponding to the Edit label.
19. Enter the duration for the measurement (in seconds).
20. Press the softkey corresponding to the **EXIT** label.
21. Position the arrow next to the **BER** label on the N4965A then press the softkey corresponding to the **Run** label to start the measurement.
22. Note the following:
    - The **T** field displays the elapsed time of the measurement.
    - The **BER** field displays the results of the measurement (should be close to 1E-3 as error injection is on).
    - The **Errs** field displays the number of errors in the measurement.
    - The **Bits** field displays the number of bits tested in the measurement.

4.3 Measuring Crosstalk

Multi-channel devices suffer from crosstalk impairments caused by neighboring channels. Crosstalk closes eyes and can cause bit errors. Refer to Figure 45.

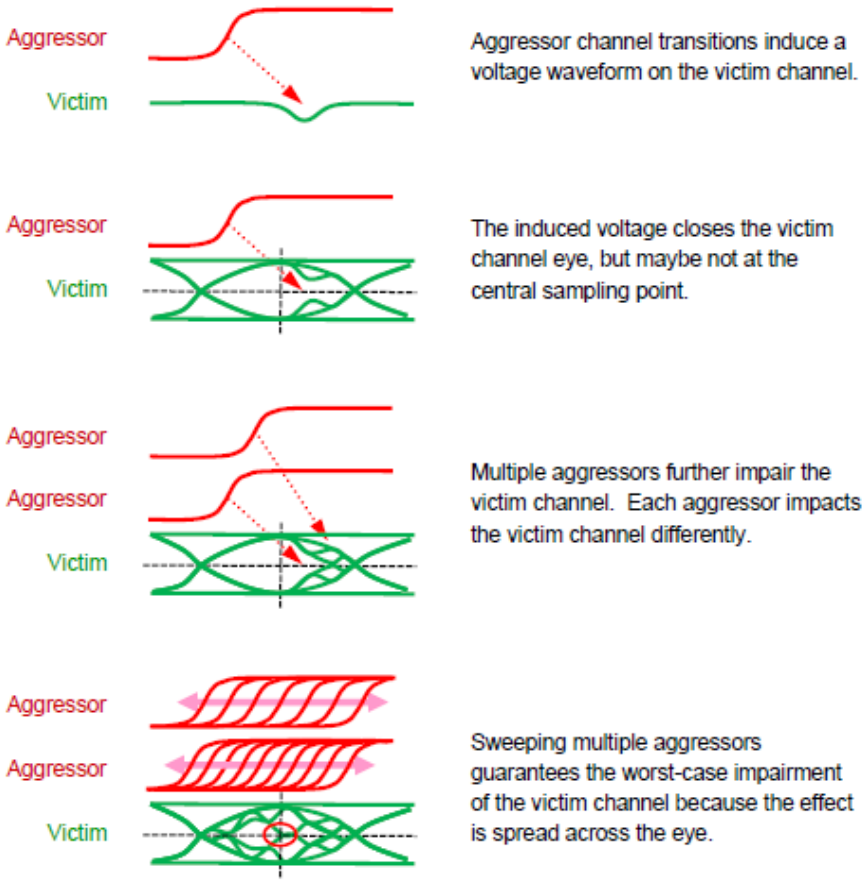


Figure 45. Crosstalk impairments

Figure 46 shows a typical crosstalk configuration.

Figure 46. Crosstalk configuration

Sweeping the aggressors relative to the victim channel ensures the worst-case transition alignment because all combinations of edges impact the victim channel. The Agilent Technologies N4965A does this automatically with the unique DelaySweep feature that slews the phase alignment of each aggressor at a unique rate.

Figure 47 shows the victim channel bathtub curve with three near-end aggressors and four far-end aggressors. All patterns are PRBS31, all amplitudes 1.2 V-d. The 30s measurements give 1E-11 BER depth at 95% confidence interval.

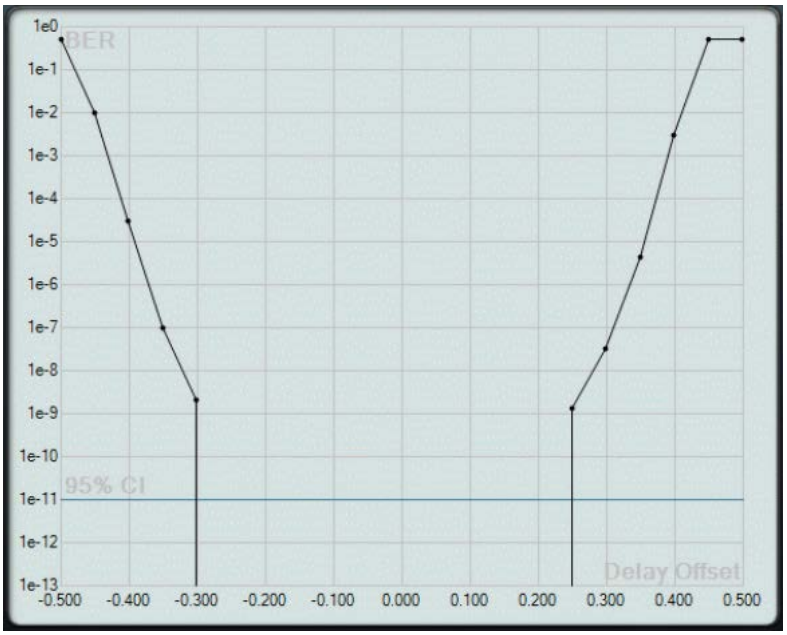


Figure 47. Measurement without DelaySweep

Figure 48 shows the same measurement and DUT, but with DelaySweep turned on for all seven aggressor channels. This feature shows bit errors occur when the transition edges are aligned in the worst-case scenario.

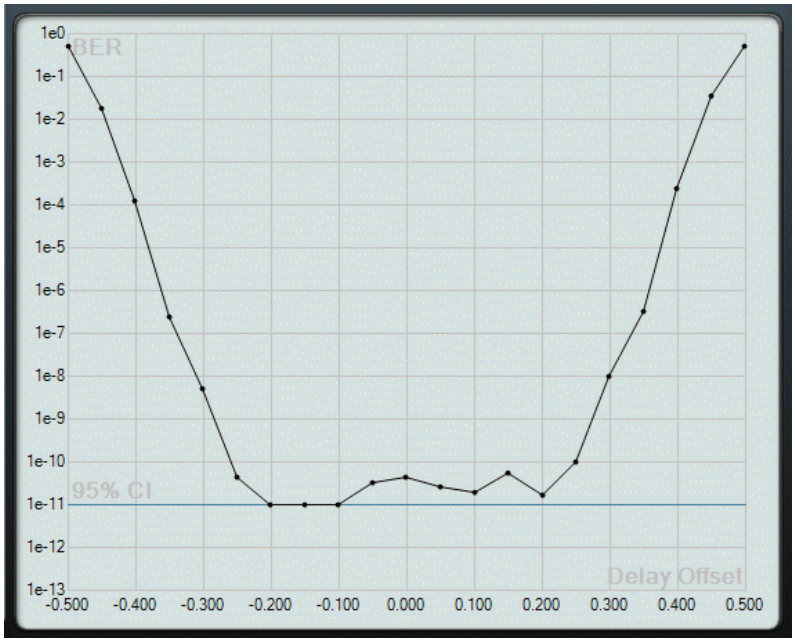
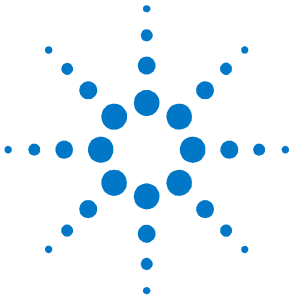


Figure 48. Measurement with DelaySweep



5 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 period.

5.1 N4965A Controller Specifications

Table 21. N4965A controller specifications

Parameter	Specification
Input clock frequency	1.0 GHz to 12.5 GHz
Input clock amplitude	
Reference input	–5 to +10 dBm (350 mV to 2 V p-p) for frequencies < 6.5 GHz 0 to +10 dBm (630 mV to 2 V p-p) for frequencies ≥ 6.5 GHz
Auxiliary input	–10 to +10 dBm (200 mV to 2 V p-p) at all frequencies
Residual jitter	1.2 ps rms typical[1]
Divided clock output	
Divider ratio	1, 2, 4, 8 to 512 in steps of 1 514 to 1024 in steps of 2 1028 to 2048 in steps of 4 2056 to 4088 in steps of 8 NOTE Waveshape of divided clock slower than ~1 MHz will be differentiated.
Configuration	Differential; will operate in single ended mode
Amplitude	0.3 to 0.7 V in 5 mV steps, single ended
Output offset	–2.0 to +2.0 V in 5 mV steps
Termination voltage	–2.0 to +2.0 V in 5 mV steps

Parameter	Specification
Rise/fall time (20% to 80%)	25 ps maximum[2]
Clock input/output connectors	SMA female

[1] *From 1.5 to 12.5 GHz, using the N4960A clock/controller as the external clock source.*

[2] *At 12.5 GHz, amplitude = 0.7 V, division ratio = 1.*

5.2 External Clock

An external clock is required for the operation of the N4965A. Refer to 2.6.2 External Clock Generator for the compatible clock generator options.

5.3 External Jitter

Refer to 2.6.2 External Clock Generator for the compatible clock generator options. Jitter can be applied to the AUX and/or REF Clock inputs. Note that the divided clock outputs are derived from the REF input.

5.4 N4955A 12.5 Gb/s Pattern Generator Remote Head Specifications

Table 22 shows the N4955A Pattern Generator specifications.

Table 22. N4955A pattern generator specifications

Parameter	Specification
Signal configuration	Differential; will operate in single-ended mode
Data line coding	Non-return to zero (NRZ)
Output data rate	1.0 to 12.5 Gb/s (timing parameter determined by N4965A controller)
Patterns	
PRBS	2^N-1, N= 7, 10, 15, 23, 31
Divided clock patterns	
N4955A-P12:	Divide by 2, 4; for example, ÷2 = 1010 pattern, ÷4 = 1100 pattern
N4955A-D12:	Divide by 2, 4; 8, 16, 32, 64; for example, ÷2 = 1010 pattern, ÷4 = 1100 pattern, ÷64 = 32 x 1's followed by 32 x 0's
Pattern invert	Available on all pattern except Divided Clock patterns
Output amplitude	
N4955A-P12:	0.2 to 2.0 V p-p single-ended in 5 mV steps
N4955A-D12:	0.6 to 1.2 V p-p single-ended in 5 mV steps
Rise/fall times (20% to 80%)	
N4955A-P12:	30 ps maximum, 24 ps typical[1]
N4955A-D12:	25 ps maximum, 20 ps typical[2]
Additive jitter	2.5 ps rms typical for data rates < 1.5 Gb/s[3] 1.2 ps rms typical for data rates ≥ 1.5 Gb/s[3]
Output offset	–2.0 to +2.0 V in 5 mV steps
Termination voltage	–2.0 to +2.0 V in 5 mV steps
Cross over	20 to 80% in 1% steps

Parameter	Specification
De-emphasis	
N4955A-P12:	2-tap (1 post cursor) 0 to 20 dB in 0.1 dB steps
N4955A-D12:	4-tap (1 pre-cursor, 2 post-cursor) Pre-cursor 0 to +8 dB in 0.1 dB steps Post1 cursor 0 to –10 dB in 0.1 dB steps Post2 cursor 0 to –8 dB in 0.1 dB steps (Combination of post1 and post2 limited to –10 dB)
Error injection (N4955A-D12 only)	Single error injection or injection rates with BER = 10^-N, N = 3, 4, 5, 6, 7, 8, 9
Delay range	±1,000 UI, 1 mUI steps (timing parameter determined by N4965A controller)
Skew range	±99.999 UI, 1 mUI steps (timing parameter determined by N4965A controller)
Delay sweep	0, 1, 2, 4 UI p-p (timing parameter determined by N4965A controller)

[1] *From 1.5 to 12.5 Gb/s at 1 V p-p amplitude.*

[2] *At 0.7 V p-p amplitude.*

[3] *Using the N4960A clock/controller as the external clock source.*

5.5 N4956A 12.5 Gb/s Error Detector Remote Head Specifications

Table 23 shows the N4956A Error Detector specifications.

Table 23. N4956A error detector specifications

Parameter	Specification
Signal configuration	Differential; will operate in single-ended mode
Data line coding	Non-return to zero (NRZ)
Output data rate	1.0 to 12.5 Gb/s (timing parameter determined by N4965A controller)
Patterns	
PRBS	2^N-1, N= 7, 10, 15, 23, 31
Maximum input amplitude	2.0 V p-p single-ended

Parameter	Specification
Input sensitivity	< 0.1 V p-p single-ended
Threshold adjustment	−1.0 to +1.0 V in 1 mV steps
Termination voltage	−2.0 to +2.0 V in 5 mV steps
Delay range	±1,000 UI, in 1 mUI steps (timing parameter determined by N4965A controller)
Autoalign Threshold Delay	Set optimum 0/1 threshold and data delay Search step size range 5 to 20 mV in 1 mV steps 5 to 20 mUI in 1 mUI steps
BER measurement period	0 to 99,999.999 seconds in 1 msec steps
BER results	Bit error rate, error count, bit count, measurement seconds
Phase margin	> 0.6 UI typical @ 10 Gb/s, 2^{31}-1 PRBS
Data connectors	2.92 mm female

6 Remote Operation

The N4965A can be controlled and queried with the rear-panel GPIB or USB interface.

6.1 GIPB Interface

The GPIB (General Purpose Interface Bus) interface complies with IEEE standard 488.2-1992. To learn more about the GPIB interface, consult the following books from the IEEE:

- The International Institute of Electrical and Electronic Engineers. IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation. New York, NY, 1987.
- The International Institute of Electrical and Electronic Engineers. IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols and Communication Commands for Use with ANSI/IEEE Std 488.1-1987. New York, NY, 1987.

A GPIB interface requires that all devices on a common bus have different addresses. The address of the N4965A is set up using the System Settings softkey menu. The range is 0 to 30.

NOTE Wait until the instrument has completed the power on boot cycle before sending any GPIB commands to the instrument.

Table 24. N4965A GPIB capabilities

Mnemonic	Function
SH1	Complete source handshake capability
AH1	Complete acceptor handshake capability
T6	Basic talker; serial poll; unaddressed to talk if addressed to listen; no talk only
L4	Basic listener; unaddressed to listen if addressed to talk; no listen only
SR1	Complete service request capability
RL2	Remote/local capability with local lockout (LLO)
PP0	No parallel poll capability
DC1	Device clear capability
DT1	Device trigger capability (accepted but ignored)
C0	No controller capability
E2	Tristate outputs (except the handshake line)

6.2 USB Interface

The USB interface connects to an external PC controller to control the N4965A and for data transfers. The USB interface allows the N4965A to be connected and disconnected without rebooting the computer or turning off the N4965A (hot swapping).

Connect a Type-A to Type-B 5 pin cable from the USB port of the PC controller to the USB port on the rear panel of the N4965A.

6.2.1 USB Driver

Installation of the appropriate driver is required. The N4965A USB port can be accessed from a PC as a virtual COM port (VCP). Virtual COM port drivers cause the USB device to appear as an additional COM port available to the PC. Application software can access the USB device in the same way as it would access a standard COM port.

The N4965A uses a hardware interface chip manufactured by Future Technologies Devices International (FTDI). VCP drivers are available for several operating systems at their web site www.ftdichip.com/FTDrivers.htm.

6.2.2 USB Programming Note

The FTDI chip, which enables serial port communication over a USB connection, boots at power-on, or preset, with the setting Local Echo = ON. The function returns a text string of each command sent over USB. It is recommended to set the Local Echo = OFF prior to sending any remote commands over USB. The command syntax to turn Local Echo OFF for the FTDI chip is:

```
!ECHO OFF
```

Progamming example:

```
*RST                    ! reset the N4965A
!ECHO OFF               ! turn Local Echo OFF
*IDN?                   ! request the instrument ID
```

6.3 Remote Command Syntax

The commands and queries are documented in the Backus-Naur Form notation, detailed in Table 25.

Table 25. Remote command and query syntax

Symbol	Meaning
<>	Defined element (eg: <arg>)
::=	Is defined as (eg: <arg> ::= argument)
|	Exclusive OR
{ }	One of this group is required
[ ]	Optional item
...	Previous elements may be repeated

6.3.1 Command Structure

The GPIB and USB interfaces allow commands that tell the instrument to take a specific action. In addition, these interfaces allow queries, which ask the instrument to return information.

Commands are composed of syntactic elements:

- Header – the command name; if it ends with a question mark, it's a query.
- Delimiter – a space ' ', colon ':', comma ',', or semi-colon ';'.
- Link – a command sub-function. Not all commands have links.
- Argument – a quantity, quality, or limit associated with the header or the link

Commands are case insensitive, although they are documented in an uppercase and lowercase manner that indicates the minimum characters required to make the command. The commands can be shortened to the minimum length illustrated by the uppercase letters in the documentation.

The command

- `:GENerator:DATA:PATTern:NAME`

Can be written in lowercase

- `:generator:data:pattern:name`

And it can be shortened

- `:GEN:DATA:PATT:NAME`

6.4 IEEE Common Commands

The IEEE 488.2 standard has a list of reserved commands that must be implemented by all instruments using the standard. The N4965A implements all of the required commands, listed in
Table 26.

Table 26. IEEE common commands

Command	Function
*CLS	Clear status
*RST	Reset
*WAI	Wait to continue
*IDN?	Identification query
*STB?	Status byte query
*TST?	Self test query
*ESR?	Event status register query
*ESE	Event status enable register set
*ESE?	Event status enable register query
*OPC	Operation complete clear flag
*OPC?	Operation complete query
*SRE	Service request enable set
*SRE?	Service request enable query
*PSC	Power on status clear flag set
*STB?	Status byte query
IEEE optional commands	
*SAV	1-5
*RCL	1-5

6.5 SCPI Mandated Commands

The N4965A also conforms to the Standard Commands for Programmable Instrumentation (SCPI 1999.0) command set. Two SCPI mandated commands are implemented, listed in Table 27.

Table 27. SCPI mandated commands

Command	Function
:SYSTEM:ERROR?	Returns the oldest event/error number and message from error queue
:SYSTEM:VERSION?	Returns SCPI protocol version number (“1999.0”)
:SYSTEM:ERROR:ALL?	Returns all events/error log reports

6.6 SCPI Protocol Description

The N4965A supports a simple SCPI syntax. SCPI has an associated hierarchy with it. The top level is referred as the Root mode. SCPI remembers the current hierarchy so you do not need to repeat it for subsequent commands.

6.6.1 SCPI Example

The capital letters in the commands denote the required subset of pneumonic. The lower case letters are optional but if they are used they must be spelled correctly

```
:GENerator:DATA:DELay?
```

Query data delay value.

```
:GENerator:DATA:DELay 9.8 UI
```

Set delay value.

```
DELay?
```

Query data delay value. Only the DELay? command is required since it is part of the GENerator:DATA group and the preceding command has put it already in that group.

`LLEVel?`	Query data logic family. Only the LLEVel? command is required since it is part of the GENerator:DATA group.
`:CONTroller:CLOCk:DIVClock:LLEVel:AMPLitude?`	Query the clock amplitude level.
`AMPLitude .2 V`	Set the clock amplitude to 200 mV. Only the AMPLitude command is required since it is part of the CONTroller:CLOCk:DIVClock:LLEVel group.
`TERMination 135 mV`	Set the clock termination voltage to 135 mV. Only the TERMination command is required since it is part of the CONTroller:CLOCk:DIVClock:LLEVel group.

6.7 SCPI Numeric Parameters and Optional Units

The following are examples of SCPI numeric parameters for SCPI commands that have numeric values:

.2	digits before decimal point not required
500.	digits after decimal point not required
500	no decimal point required
–1000	accepts negative (–) or positive (+) signs
200E-3	accepts uppercase E or lowercase e to specify exponent

The following are examples of optional units:

200 mV	mV used in place of e-3 or E-3
5 MHz	MHz used in place of e6 or E6
–1000 UI	unit interval of negative 1000

6.8 N4965A Command Summary

The following conventions are used in the following summary:

Generator indicates that the GEN keyword is required and that the keyword may optionally appear as GENERATOR instead. No other spellings are valid.

[(@ <channel list>)] defines the channel(s) to apply the command. The channel list is defined within parentheses and always begins with the 'at' character followed by either a comma separated set of channels and/or colon separated channel range. Refer to the following examples:

None	affects channel 0 only
(@ 1)	affects channel 1
(@ 0, 1, 2, 4)	affects channels 0, 1, 2, and 4
(@ 1:3)	affects channels 1 through 3
(@)	affects previously defined channel list

If no channel list is specified, then the command applies to the default channel. The default channel is the reference channel (channel 0).

Results to queries are always returned in ascending order (channel 0 first, channel 4 last), regardless of the order in the request.

When sending commands to one or more channels, a verification check is performed to ensure that the command and the type of channel match. For queries, if the types do not match, a "?" is returned to indicate mismatch, e.g.

>:det:data:delay:skew ? (@0:4) <1.000UI,1.000UI,1.000UI,1.000UI,? Indicates that channel 4 is not a detector.

For commands that set parameters, if there is a mismatch in one or more the remote heads in the channel list, then error code -221, "Settings Conflict" is returned and no action is taken on the command.

value is a placeholder in the command and is described elsewhere in the text for the command.

[unit] indicates that the unit placeholder is optional; it may or may not appear in the command.

string is a placeholder in the command and is described elsewhere in the text for the command.

ON | OFF indicates a choice may be made between ON or OFF.

{ ON | OFF } indicates that a choice must be made between ON or OFF; one or the other must appear in the command.

6.9 N4965A Device Commands

Command **:CONTroller:CLOCk:AUXChannel:FREQuency**

Description Set the frequency for the AUX clock source as required for internal calibration. A frequency value MUST be set by the user if the AUX clock input is selected.

Example :CONT:CLOC:AUXC:FREQ 10GHz

Command **:CONTroller:CLOCk:AUXChannel:FREQuency?**

Description Return the AUX clock frequency value.

Example
:CONT:CLOC:AUXC:FREQ?
10000MHz

Command **:CONTroller:CLOCk:AUXChannel:SOURce**

Description Set the clock source to REF (reference) or AUX (auxiliary).

Example :CONT:CLOC:AUXC:SOUR AUX

Command **:CONTroller:CLOCk:AUXChannel:SOURce?**

Description Return the status of the clock source. The returned string is either REF or AUX.

Example
:CONT:CLOC:AUXC:SOUR?
AUX

Command **:CONTroller:CLOCk:DIVClock:LLEVel?**

Description Return the status of the logic level. The returned string will be AC, or CUST.

Example :CONT:CLOC:DIVC:LLEV?
AC

Command **:CONTroller:CLOCk:DIVClock:LLEVel:AMPLitude**

Description Set the amplitude of the clock logic level from 0.300 V to 0.700 V in 0.005 V increments. The optional units are V (default) and mV.

Example : CONT:CLOC:DIVC:LLEV:AMPL .7V

Command **:CONTroller:CLOCk:DIVClock:LLEVel:AMPLitude?**

Description Return the amplitude value of the clock logic level. The amplitude range is 0.300 V to 0.700 V.

Example :CONT:CLOC:DIVC:LLEV:AMPL?
0.700V

Command **:CONTroller:CLOCk:DIVClock:LLEVel:OFFSet**

Description Set the offset voltage of the clock logic level from –2.0 V to +2.0 V in 0.005 V increments. The optional units are V (default) and mV.

Example :CONT:CLOC:DIVC:LLEV:OFFS 0V

Command **:CONTroller:CLOCk:DIVClock:LLEVel:OFFSet?**

Description Return the offset value of the clock logic level. The clock offset range is –2.0 V to +2.0 V.

Example
:CONT:CLOC:DIVC:LLEV:OFFS?
0.000V

Command **:CONTroller:CLOCk:DIVClock:LLEVel:TERMination**

Description Set the termination voltage of the clock logic level from –2.0 V to +2.0 V in 0.005 V increments. The optional units are V (default) and mV.

Example :CONT:CLOC:DIVC:LLEV:TERM 2V

Command **:CONTroller:CLOCk:DIVClock:LLEVel:TERMination?**

Description Return the termination value of the clock logic level. The clock termination range is –2.0 V to +2.0 V.

Example
:CONT:CLOC:DIVC:LLEV:TERM?
2.000V

Command **:CONTroller:CLOCk:DIVClock:OUTPut**

Description Turn the clock output ON or OFF. The default is OFF.

Example :CONT:CLOC:DIVC:OUTP ON

Command **:CONTroller:CLOCk:DIVClock:OUTPut?**

Description Return the status of the clock output. The returned string is either ON or OFF.

Example

:CONT:CLOC:DIVC:OUTP?
ON

Command **:CONTroller:CLOCk:DIVClock:RATio**

Description Set the divider factor for the divided sub-rate clock output. Clk_Out = Clk_In/N where N ranges from 1 to 4088. Available divide rates are:

N= 1, 2, 4

8 to 512, in resolution of 1

514 to 1024, in resolution of 2

1028 to 2048, in resolution of 4

2056 to 4088, in resolution of 8

Example

:CONT:CLOC:DIVC:RAT 32

Command **:CONTroller:CLOCk:DIVClock:RATio?**

Description Return the divider factor value set to produce the sub-rate clock output.

Example

:CONT:CLOC:DIVC:RAT?
32

Command **:CONTroller:CLOCk:REFChannel:FREQuency**

Description Set the REF clock frequency from 1.0 GHz to 12.5 GHz as required to support internal calibration. A frequency value MUST be set by the user if the REF clock is in the "MANUAL" mode.

The optional [units] are Hz, kHz, MHz (default), and GHz.

Example :CONT:CLOC:REFC:FREQ 2GHz

Command **:CONTroller:CLOCk:REFChannel:FREQuency?**

Description Return the REF clock frequency value.

Example :CONT:CLOC:REFC:FREQ?

2000MHz

Command **:CONTroller:CLOCk:REFChannel:MODE**

Description Set the clock mode to AUTO or MANual. AUTO automatically updates the N4965A when the clock frequency is changed. MANual requires manual updating of the N4965A when the clock frequency is changed.

Example :CONT:CLOC:REFC:MODE man

Command **:CONTroller:CLOCk:REFChannel:MODE?**

Description Return the status of the clock mode. The returned string is either AUTO or MAN.

Example :CONT:CLOC:REFC:MODE?

MAN

Command **:SYSTem:ERRor?**

Description Responds with oldest Event/Error Log Report.

Example :SYST:ERR?
-222, “Data out of range

Command **:SYSTem:ERRor:ALL?**

Description Responds with all Event/Error Log Reports.

Example :SYST:ERR:ALL?
-100, “Command error”, -222, ”Data out of range”

Command **:SYSTem:ERRor:NEXT?**

Description Gives the next Event/Error code. If the event/error queue is empty, the following is returned.

Example :SYST:ERR:NEXT?
0, ”No error”

Command **: SYSTem:LLOCk**

Description Place the instrument in local lockout (remote mode) with front panel locked out. The user must use the below command to set the instrument back to local or power down to re-start the instrument.

Example :SYST:LLOC
The following message is displayed on the front panel:
LOCAL LOCKOUT
FRONT PANEL DISABLED

Command **:SYSTem:LOCal**

Description Places instrument from local lockout to local mode.

Example :SYST:LOC

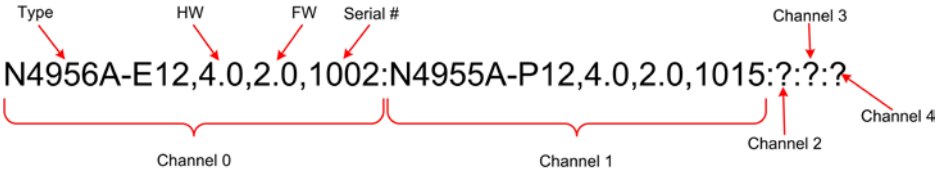
Command **:SYSTem:PODS?**

Description Read the status of the remote head (pod). The returned value is a string of 5 sets of comma separated numeric values that indicate the type of remote heads installed into each channel.

The returned values are:

- Channel Number
- Type: TG5P1A, N4955A-P12, TG7P1A, N4955A-D12, TR2P1A, N4956A-E12, TG3C1A, or N4957A-C12
- HW Version
- FW Version
- Serial Number

Example N4956A-E12 Error Detector Head in channel 0, N4955A-P12 Pattern Generator Head in channel 1, and there are no remote heads connected to channel 2, channel 3, and channel 4. The return values of this command should be:



Command **:SYSTem:PRESet**

Description Reset the instrument to the default state.

Command **:SYSTem:VERSion?**

Description Responds with current version of SCPI commands.

Example :SYST:VERS?
1999.0

6.10 N4955A-P12 Device Commands

The N4955A-P12 commands are preceded by either :GENerator or :TG5P. The following example shows the two ways a N4955A-P12 command can be written:

```
:GENerator:DATA:DELay
Or
:TG5P:DATA:DELay
```

Command **:TG5P:DATA:DEEMphasis**

Description Set the data de-emphasis from 0 dB to 20 dB in 0.1 dB increments. The optional unit is dB.

Example :TG5P:DATA:DEEM 10

Command **:TG5P:DATA:DEEMphasis?**

Description Return the value of the data de-emphasis. The de-emphasis range is 0 dB to 20 dB.

Example :TG5P:DATA:DEEM?
10.0dB

Command **:TG5P:DATA:DELay**

Description Set the data delay from –1000 UI to +1000 UI in 0.001 UI increments. The optional unit is UI (Unit Interval).

Example :TG5P:DATA:DEL 1

Command **:TG5P:DATA:DELay?**

Description Return the value of the data delay. The data delay range is –1000 UI to +1000 UI.

Example :TG5P:DATA:DEL?
1.000UI

Command **:TG5P:DATA:DELay:PRECision**

Description Set the precision delay on or off. The default is off.

Example :TG5P:DATA:DEL:PREC on

Command **:TG5P:DATA:DELay:PRECision?**

Description Return the status of precision delay. The returned string is either ON or OFF.

Example :TG5P:DATA:DEL:PREC?
ON

Command **:TG5P:DATA:DELay:SKEW**

Description Set the data skew from –99.999 UI to +99.999 UI in .001 UI increments. The optional unit is UI (Unit Interval).

Example :TG5P:DATA:DEL:SKEW 1

Command **:TG5P:DATA:DELay:SKEW?**

Description Return the data skew value. The data skew range is –99.999 UI to +99.999 UI.

Example :TG5P:DATA:DEL:SKEW
1.000UI

Command **:TG5P:DATA:DELay:SWPoutput**

Description Set the data swept delay. The valid values are OFF, 1 UI, 2 UI, and 4 UI.
The channel list applies to this command.

Example :TG5P:DATA:DEL:SWP 1UI

Command **:TG5P:DATA:DELay:SWPoutput?**

Description Return the data swept delay value. The returned string will be OFF, 1 UI, 2 UI, or 4 UI.

Example :TG5P:DATA:DEL:SWP?
1UI

Command **:TG5P:DATA:FREQuency?**

Description Return the channel frequency in MHz. The channel list applies to this command.

Example
:TG5P:DATA:FREQ? (@2)
2000MHz
Query the frequency applied at channel 2

Command **:TG5P:DATA:LLEVel**

Description
Set the data logic level. The options include:
LVPECL
LVNECL
LVDS
SCFL
AC
CUSTom
The CUSTom option is set when the amplitude, offset, and termination combination do not match a particular logic family.
The channel list applies to this command.

Example :TG5P:DATA:LLEV lvpecl

Command **:TG5P:DATA:LLEVel?**

Description Return the status of the logic level. The returned string will be LVPECL, LVNECL, LVDS, SCFL, AC, or CUST.

Example
:TG5P:DATA:LLEV?
LVPECL

Command **:TG5P:DATA:LLEVel:AMPLitude**

Description Set the amplitude of the data logic level from 200 mV to +2.000 V in 0.005 V increments. The optional units are V (default) and mV.

Example :TG5P:DATA:LLEV:AMPL 750mV

Command **:TG5P:DATA:LLEVel:AMPLitude?**

Description Return the amplitude value of the data logic level. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
0.800 V (LVPECL)
0.750 V (LVNECL)
0.400 V (LVDS)
0.900 V (SCFL)
Current amplitude value (AC)

Example :TG5P:DATA:LLEV:AMPL?
0.750V

Command **:TG5P:DATA:LLEVel:OFFSet**

Description Set the offset voltage of the data logic level from –2.0 to +2.0 V in 0.005 V increments. The optional units are V (default) and mV. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
2.0 V (LVPECL)
-1.335 V (LVNECL)
1.25 V (LVDS)
-0.45 V (SCFL)
NA (AC)

Example :TG5P:DATA:LLEV:OFFS 2V

Command **:TG5P:DATA:LLEVel:OFFSet?**

Description Return the offset value of the data logic level. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
2.0 V (LVPECL)
-1.335 V (LVNECL)
1.25 V (LVDS)
-0.45 V (SCFL)
NA (AC)

Example :TG5P:DATA:LLEV:OFFS?
2.000V

Command **:TG5P:DATA:LLEVel:TERMination**

Description Set the termination voltage of the data logic level from –2.0 V to +2.0 V in 0.005 V increments. The optional units are V (default) and mV. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
1.3V (LVPECL)
-2.0V (LVNECL)
1.25V (LVDS),
0.00V (SCFL)
NA (AC)

Example :TG5P:DATA:LLEV:TERM 1.3V

Command **:TG5P:DATA:LLEVel:TERMination?**

Description Return the termination value of the data logic level. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
1.3V (LVPECL)
-2.0V (LVNECL)
1.25V (LVDS),
0.00V (SCFL)
NA (AC)

Example :TG5P:DATA:LLEV:TERM?
1.300V

Command **:TG5P:DATA:OUTPut**

Description Turn the data output ON or OFF. The default is OFF.

Example :TG5P:DATA:OUTP on

Command **:TG5P:DATA:OUTPut?**

Description Return the status of the data output. The returned string is either ON or OFF.

Example :TG5P:DATA:OUTP?
ON

Command **:TG5P:DATA:PATTern:NAME**

Description Select the data pattern name. The options include:
DISABLED
HIGH
LOW
1010
1100
PRBS7 (2^7-1)
PRBS10 (2^10-1)
RBS15 (2^15-1)
PRBS23 (2^23-1)
PRBS31 (2^31-1)
The channel list applies to this command.

Example :TG5P:DATA:PATT:NAME PRBS7

Command **:TG5P:DATA:PATTern:NAME?**

Description Return the selected data pattern name. The returned string will be DISABLED, HIGH, LOW, 1010, 1100, PRBS7, PRBS10, PRBS15, PRBS23, or PRBS31.

Example :TG5P:DATA:PATT:NAME?
PRBS7

Command **:TG5P:DATA:PATTern:POLarity**

Description Set the data pattern polarity to INVert or NONInvert. The channel list applies to this command.

Example :TG5P:DATA:PATT:POL NONI

Command **:TG5P:DATA:PATTern:POLarity?**

Description Return the data pattern polarity. The returned string is either INV or NONI.

Example
:TG5P:DATA:PATT:POL?
NONI

Command **:TG5P:DATA:XOVer**

Description Set the data crossover from 20% to 80% in 1% increments (integers only).

Example
:TG5P:DATA:XOV 50
:TG5P:DATA:XOV 50PCT
:TG5P:DATA:XOV 50%

Command **:TG5P:DATA:XOVer?**

Description Return the data crossover value. The data crossover range is 20% to 80%.

Example
:TG5P:DATA:XOV?
50%

6.11 N4955A-D12 Device Commands

The N4955A-D12 commands are preceded by either :GENerator or :TG7P. The following example shows the two ways a N4955A-D12 command can be written:

```
:GENerator:DATA:DELay
Or
:TG7P:DATA:DELay
```

Command **:TG7P:DATA:DEEMphasis:POST1**

Description Set the 4-tap data de-emphasis POST1 cursor from 0 dB to –10 dB in 0.1 dB increments. The optional unit is dB.

Example :TG7P:DATA:DEEM:POST1 –3

Command **:TG7P:DATA:DEEMphasis:POST1?**

Description Return the value of the 4-tap data de-emphasis POST1 cursor. The de-emphasis range is 0 dB to –10 dB.

Example :TG7P:DATA:DEEM:POST1?

–3.0dB

Command **:TG7P:DATA:DEEMphasis:POST2**

Description Set the 4-tap data de-emphasis POST2 cursor from 0 dB to –8 dB in 0.1 dB increments. The optional unit is dB.

Example :TG7P:DATA:DEEM:POST2 –3

Command **:TG7P:DATA:DEEMphasis:POST2?**

Description Return the value of the 4-tap data de-emphasis POST2 cursor. The de-emphasis range is 0 dB to –8 dB.

Example

```
:TG7P:DATA:DEEM:POST2?
–3.0dB
```

Command **:TG7P:DATA:DEEMphasis:PRECursor**

Description Set the 4-tap data de-emphasis PRECursor from 0 dB to +8 dB in 0.1 dB increments. The optional unit is dB.

Example

```
:TG7P:DATA:DEEM:PREC 0
```

Command **:TG7P:DATA:DEEM:PRECursor?**

Description Return the value of the 4-tap data de-emphasis PRECursor. The de-emphasis range is 0 dB to +8 dB.

Example

```
:TG7P:DATA:DEEM:PREC?
0.0dB
```

Command **:TG7P:DATA:DELay**

Description Set the data delay from –1000 UI to +1000 UI in 0.001 UI increments. The optional unit is UI (Unit Interval).

Example

```
:TG7P:DATA:DEL 1
```

Command **:TG7P:DATA:DELay?**

Description Return the value of the data delay. The data delay range is –1000 UI to +1000 UI.

Example
:TG7P:DATA:DEL?
1.000UI

Command **:TG7P:DATA:DELay:PRECision**

Description Set the precision delay on or off. The default is off.

Example :TG7P:DATA:DEL:PREC on

Command **:TG7P:DATA:DELay:PRECision?**

Description Return the status of precision delay. The returned string is either ON or OFF.

Example
:TG7P:DATA:DEL:PREC?
ON

Command **:TG7P:DATA:DELay:SKEW**

Description Set the data skew from –99.999 UI to +99.999 UI in .001 UI increments. The optional unit is UI (Unit Interval).

Example :TG7P:DATA:DEL:SKEW 1

Command **:TG7P:DATA:DELay:SKEW?**

Description Return the data skew value. The data skew range is –99.999 UI to +99.999 UI.

Example
:TG7P:DATA:DEL:SKEW
1.000UI

Command **:TG7P:DATA:DELay:SWPoutput**

Description Set the data swept delay. The valid values are OFF, 1 UI, 2 UI, and 4 UI.
The channel list applies to this command.

Example :TG7P:DATA:DEL:SWP 1UI

Command **:TG7P:DATA:DELay:SWPoutput?**

Description Return the data swept delay value. The returned string will be OFF, 1 UI, 2 UI, or 4 UI.

Example
:TG7P:DATA:DEL:SWP?
1UI

Command **:TG7P:DATA:FREQuency?**

Description Return the channel frequency in MHz. The channel list applies to this command.

Example
:TG7P:DATA:FREQ? (@2)
2000MHz
Query the frequency applied at channel 2

Command **:TG7P:DATA:LLEVel**

Description Set the data logic level. The options include:
LVPECL
LVNECL
SCFL
AC
CUSTom
The CUSTom option is set when the amplitude, offset, and termination combination do not match a particular logic family.
The channel list applies to this command.

Example :TG7P:DATA:LLEV lvpecl

Command **:TG7P:DATA:LLEVel?**

Description Return the status of the logic level. The returned string will be LVPECL, LVNECL, SCFL, AC, or CUST.

Example :TG7P:DATA:LLEV?
LVPECL

Command **:TG7P:DATA:LLEVel:AMPLitude**

Description Set the amplitude of the data logic level from 0.6 V to 1.2 V in 0.005 V increments. The optional units are V (default) and mV.

Example :TG7P:DATA:LLEV:AMPL 750mV

Command **:TG7P:DATA:LLEVel:AMPLitude?**

Description Return the amplitude value of the data logic level. The values for LVPECL, LVNECL, SCFL, and AC are as follows:
0.800 V (LVPECL)
0.750 V (LVNECL)
0.900 V (SCFL)
Current amplitude value (AC)

Example :TG7P:DATA:LLEV:AMPL?
0.750V

Command **:TG7P:DATA:LLEVel:OFFSet**

Description Set the offset voltage of the data logic level from –2.0 to +2.0 V in 0.005 V increments. The optional units are V (default) and mV. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
2.0 V (LVPECL)
-1.335 V (LVNECL)
1.25 V (LVDS)
-0.45 V (SCFL)
NA (AC)

Example :TG7P:DATA:LLEV:OFFS 2V

Command **:TG7P:DATA:LLEVel:OFFSet?**

Description Return the offset value of the data logic level. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
2.0 V (LVPECL)
-1.335 V (LVNECL)
1.25 V (LVDS)
-0.45 V (SCFL)
NA (AC)

Example :TG7P:DATA:LLEV:OFFS?
2.000V

Command **:TG7P:DATA:LLEVel:TERMination**

Description Set the termination voltage of the data logic level from –2.0 V to +2.0 V in 0.005 V increments. The optional units are V (default) and mV. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
1.3V (LVPECL)
-2.0V (LVNECL)
0.00V (SCFL)
NA (AC)

Example :TG7P:DATA:LLEV:TERM 1.3V

Command **:TG7P:DATA:LLEVel:TERMination?**

Description Return the termination value of the data logic level. The values for LVPECL, LVNECL, LVDS, SCFL, and AC are as follows:
1.3V (LVPECL)
-2.0V (LVNECL)
1.25V (LVDS),
0.00V (SCFL)
NA (AC)

Example :TG7P:DATA:LLEV:TERM?
1.300V

Command **:TG7P:DATA:OUTPut**

Description Turn the data output ON or OFF. The default is OFF.

Example :TG7P:DATA:OUTP on

Command **:TG7P:DATA:OUTPut?**

Description Return the status of the data output. The returned string is either ON or OFF.

Example :TG7P:DATA:OUTP?
ON

Command **:TG7P:DATA:PATTern:ERRinjection:RATE**

Description Set the constant error injection rate. The channel list applies to this command. The error injection rates are as follows:
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

Example :TG7P:DATA:PATT:ERR:RATE 10^-3

Command **:TG7P:DATA:PATTern:ERRinjection:RATE?**

Description Return the error injection rate value. The error injection rate values are as follows:
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

Example :TG7P:DATA:PATT:ERR:RATE?
10^-3

Command **:TG7P:DATA:PATTern:ERRinjection:STATe**

Description Set the constant error injection ON, OFF, or to SINGle (for a single error injection). The channel list applies to this command.

Example :TG7P:DATA:PATT:ERR:STAT on

Command **:TG7P:DATA:PATTern:ERRinjection:STATe?**

Description Return the state of the error injection. The returned string will be ON, OFF, or SINGle.

Example
```
:TG7P:DATA:PATT:ERR:STAT
ON
```

Command **:TG7P:DATA:PATTern:NAME**

Description Select the data pattern name. The options include:
DISABLED
HIGH
LOW
Divided clock patterns (divide by 2, 4, 8, 16, 32, 64)
PRBS7 (2^7-1)
PRBS10 (2^10-1)
RBS15 (2^15-1)
PRBS23 (2^23-1)
PRBS31 (2^31-1)
The channel list applies to this command.

Example
```
:TG7P:DATA:PATT:NAME PRBS7
```

Command **:TG7P:DATA:PATTern:NAME?**

Description Return the selected data pattern name. The returned string will be DISABLED, HIGH, LOW, divided clock patterns (divide by 2, 4, 8, 16, 32, or 64), PRBS7 (2^7-1), PRBS10 (2^10-1), RBS15 (2^15-1), PRBS23 (2^23-1), or PRBS31 (2^31-1).

Example
```
:TG7P:DATA:PATT:NAME?
PRBS7
```

Command **:TG7P:DATA:PATTern:POLarity**

Description Set the data pattern polarity to INVert or NONInvert. The channel list applies to this command.

Example :TG7P:DATA:PATT:POL NONI

Command **:TG7P:DATA:PATTern:POLarity?**

Description Return the data pattern polarity. The returned string is either INV or NONI.

Example
:TG7P:DATA:PATT:POL?
NONI

Command **:TG7P:DATA:XOVer**

Description Set the data crossover from 20% to 80% in 1% increments (integers only).

Example
:TG7P:DATA:XOV 50
:TG7P:DATA:XOV 50PCT

Command **:TG7P:DATA:XOVer?**

Description Return the data crossover value. The data crossover range is 20% to 80%.

Example
:TG5P:DATA:XOVer?
50PCT

6.12 N4956A-E12 Device Commands

The N4956A-E12 commands are preceded by either :DETector or :TR2P. The following example shows the two ways a N4956A-E12 command can be written:

```
:DETector:DATA:DELay
```

or

```
:TR2P:DATA:DELay
```

Command **:TR2P:DATA:DELay**

Description Set the detector data delay from –1000 UI to +1000 UI in 0.001 UI increments. The optional unit is UI (Unit Interval).
The channel list applies to this command.

Example :TR2P:DATA:DEL 1

Command **:TR2P:DATA:DELay?**

Description Return the value of the detector data delay. The data delay range is –1000 UI to +1000 UI.
The channel list applies to this command.

Example :TR2P:DATA:DEL?
1.000UI

Command **:TR2P:DATA:DELay:PRECision**

Description Set the precision delay on or off. The default is on.

Example :TR2P:DATA:DEL:PREC on

Command **:TR2P:DATA:DELay:PRECision?**

Description Return the status of precision delay. The returned string is either ON or OFF.

Example

:TR2P:DATA:DEL:PREC?

ON

Command **:TR2P:DATA:DELay:SKEW**

Description Set the detector data delay skew value per channel from –99.999 UI to +99.999 UI in .001 UI increments. The optional unit is UI (Unit Interval). The channel list applies to this command.

Example : TR2P:DATA:DEL:SKEW 1

Command **:TR2P:DATA:DELay:SKEW?**

Description Return the detector data delay skew value. The data delay skew range is –99.999 UI to +99.999 UI.

Example

:TR2P:DATA:DEL:SKEW?

1.000UI

Command **:TR2P:DATA:EYE:ACENter**

Description Start (ON) or stop (OFF) the amplitude centering alignment. The default is OFF.

Example

:TR2P:DATA:EYE:ACEN ON

This command that can take several seconds to complete. *OPC? should be used to determine if the command is complete before sending additional commands to the instrument.

Command **:TR2P:DATA:EYE:ACENter?**

Description Return the status of the detector amplitude centering alignment. The returned string is either ON or OFF.

Example :TR2P:DATA:EYE:ACEN?
ON

Command **:TR2P:DATA:EYE:ALIGn**

Description Start (ON) or stop (OFF) the alignment process. The default is OFF.

Example :TR2P:DATA:EYE:ALIG ON
This command that can take several seconds to complete. For example if all 5 channels of the N4965A are configured with Error Detector heads and the ALIGn command is sent to all heads simultaneously, then the operation can take up to 40 seconds to complete. *OPC? should be used to determine if the command is complete before sending additional commands to the instrument.

Command **:TR2P:DATA:EYE:ALIGn?**

Description Return the status of the detector alignment process. The returned string is either ON or OFF.

Example :TR2P:DATA:EYE:ALIG?
ON

Command **:TR2P:DATA:EYE:ASTep**

Description Set the step size in mV for the amplitude centering alignment. The range is 5 mV to 20 mV in 1 mV resolution. The default value is 20 mV.

Example :TR2P:DATA:EYE:AST 20mV

Command **:TR2P:DATA:EYE:ASTep?**

Description Return the status of the detector amplitude centering alignment. The returned data range will be from 5 mV to 20 mV.

Example :TR2P:DATA:EYE:AST?
20mV

Command **:TR2P:DATA:EYE:DCENter**

Description Start (ON) or stop (OFF) the delay centering alignment. The default is OFF.

Example :TR2P:DATA:EYE:DCEN ON
This command that can take several seconds to complete. *OPC? should be used to determine if the command is complete before sending additional commands to the instrument.

Command **:TR2P:DATA:EYE:DCENter?**

Description Return the status of the detector delay centering alignment. The returned string is either ON or OFF.

Example :TR2P:DATA:EYE:DCEN?
ON

Command **:TR2P:DATA:EYE:DSTep**

Description Set the step size in mUI for the delay centering alignment. The range is 5 mUI to 20 mUI in 1 mUI resolution. The default value is 20 mUI.

Example :TR2P:DATA:EYE:DST 20mUI

Command **:TR2P:DATA:EYE:DSTep?**

Description Return the status of the detector step size for the delay centering alignment. The returned data range is from 5 mUI to 20 mUI.

Example

:TR2P:DATA:EYE:DST?

20mUI

Command **:TR2P:DATA:EYE:THReshold**

Description Set the measurement depth for both centering alignments by adjusting the gate time for each step. The range is 1.00E-006 to 1.00E-012. The default value is 6(1E-6).

Example

:TR2P:DATA:EYE:THR 1e-6

Command **:TR2P:DATA:EYE:THReshold?**

Description Return the status of the detector measurement depth. The returned data range is 1.00E-006 to 1.00E-012.

Example

:TR2P:DATA:EYE:THR?

1e-6

Command **:TR2P:DATA:FETCh:ALL?**

Description Return the current bit count, error count, bit error rate, elapsed time, and state.

Example

:TR2P:DATA:FETC:ALL?

2.000e10,0.000e0,0.000e0,10.000S,OFF

Command **:TR2P:DATA:FETCh:BCOunt?**

Description Return the current bit count.

Example
:TR2P:DATA:FETC:BCO?
2.000e10

Command **:TR2P:DATA:FETCh:ECOunt?**

Description Return the current error count.

Example
:TR2P:DATA:FETC:ECO?
0.000e0

Command **:TR2P:DATA:FETCh:ELAP?**

Description Return the gate period elapsed time in seconds.

Example
:TR2P:DATA:FETC:ELAP?
10.000S

Command **:TR2P:DATA:FETCh:ERATio?**

Description Return the current bit error rate.

Example
:TR2P:DATA:FETC:ERAT?
0.000e0

Command **:TR2P:DATA:FREQuency?**

Description Read the channel frequency in MHz.

Example
:TR2P:DATA:FREQ?
2000MHz

Command **:TR2P:DATA:GATE:PERiod**

Description Set the gate period in seconds or ms. The range is 1ms to 99999.999 s.

Example
:TR2P:DATA:GATE:PER 10s

Command **:TR2P:DATA:GATE:PERiod?**

Description Return the detector gate period. The returned range is 1ms to 99999.999 s.

Example
:TR2P:DATA:GATE:PER
10S

Command **:TR2P:DATA:GATE:STATe**

Description Start (ON) or stop (OFF) the gate period. The default is OFF.

Example
:TR2P:DATA:GATE:STAT ON

Command **:TR2P:DATA:GATE:STATe?**

Description Return the detector gate period. The returned string is either ON or OFF.

Example

```
:TR2P:DATA:GATE:STAT
ON
```

Command **:TR2P:DATA:PATTern:NAME**

Description Select the detector data pattern name. The options include:
PRBS7 (2^7-1)
PRBS10 (2^10-1)
PRBS15 (2^15-1)
PRBS23 (2^23-1)
PRBS31 (2^31-1)
The channel list applies to this command.

Example

```
:TR2P:DATA:PATTERN:NAME PRBS7
```

Command **:TR2P:DATA:PATTern:NAME?**

Description Return the selected detector data pattern name. The returned string will be PRBS7, PRBS10, PRBS15, PRBS23, or PRBS31.

Example

```
:TR2P:DATA:PATTERN:NAME
PRBS7
```

Command **:TR2P:DATA:SYNC?**

Description Read the synchronization and bit error states. The returned string is consists of two fields separated by comma.

The values for the first field are as follows:

NO DATA	(There is no data signal detected).
SYNC	(The reference pattern is aligned with the incoming data pattern).
NO-SYNC	(The reference pattern is not aligned with the incoming data pattern).

The values for the second field are either:

ON	(One or more bit errors has been detected).
OFF	(No bit errors have been detected).

The channel list applies to this command.

Command **:TR2P:DATA:TERMination**

Description Set the detector termination voltage of the data logic level from –2.0 V to +2.0 V in 0.005 V increments. The optional units are V (default) and mV.
The channel list applies to this command.

Example :TR2P:DATA:TERM 0V

Command **:TR2P:DATA:TERMination?**

Description Return the detector termination value of the data logic level. The data termination range is –2.0 V to +2.0 V.

Example :TR2P:DATA:TERM?
0.000V

Command **:TR2P:DATA:VOLTage:ZOTHreshold**

Description Set the voltage level for determining whether a bit is a 1 or a 0. The range is –1.000 V to +1.000 V in 1mV resolution. The default value is 0 V.

Example :TR2P:DATA:VOLT:ZOTH 80mV

Command **:TR2P:DATA:VOLTage:ZOTHreshold?**

Description Return the detector voltage level value. The returned range will be from –1.000 V to +1.000 V.

Example
:TR2P:DATA:VOLT:ZOTH
0.080V

Command **:TR2P:DATA:VTERmination**

Description Sets the termination voltage on or off. Start (ON) or stop (OFF). The default is OFF.

Example :TR2P:DATA:VTER ON

Command **:TR2P:DATA:VTERmination**

Description Return the detector termination voltage. The returned string is either ON or OFF.

Example
:TR2P:DATA:VTER
ON

6.13 Command Summary

Table 28 is a summary of the N4965A device commands listed in alphabetical order.

Table 28. N4965A command summary

Command	Parameters / Results
:CONTroller:CLOCk:AUXChannel:FREQuency	value <unit> ::= 1.0 GHz to 12.5 GHz, resolution=1 MHz
:CONTroller:CLOCk:AUXChannel:FREQuency?	
:CONTroller:CLOCk:AUXChannel:SOURce	{REF | AUX}
:CONTroller:CLOCk:AUXChannel:SOURce?	
:CONTroller:CLOCk:DIVClock:LLEVel?	{ AC | CUSTom }
:CONTroller:CLOCk:DIVClock:LLEVel:AMPlitude	value <unit> ::= 0.3 V to 0.7 V, resolution=0.005 V
:CONTroller:CLOCk:DIVClock:LLEVel:AMPlitude?	
:CONTroller:CLOCk:DIVClock:LLEVel:OFFSet	value <unit> ::= -2 V to +2 V, resolution=0.005 V
:CONTroller:CLOCk:DIVClock:LLEVel:OFFSet?	
:CONTroller:CLOCk:DIVClock:LLEVel:TERMination	value <unit> ::= -2 V to +2 V, resolution=0.005 V
:CONTroller:CLOCk:DIVClock:LLEVel:TERMination?	
:CONTroller:CLOCk:DIVClock:OUTPut	{ON | OFF}
:CONTroller:CLOCk:DIVClock:OUTPut?	
:CONTroller:CLOCk:DIVClock:RATio	{ N= 1, 2, 4 8 to 512, in resolution of 1 514 to 1024, in resolution of 2 1028 to 2048, in resolution of 4 2056 to 4088, in resolution of 8}
:CONTroller:CLOCk:DIVClock:RATio?	
:CONTroller:CLOCk:REFChannel:FREQuency	value <unit> ::= 1.0 GHz to 12.5 GHz, resolution=1 MHz
:CONTroller:CLOCk:REFChannel:FREQuency?	

Command	Parameters / Results
:CONTroller:CLOCk:REFChannel:MODE	{AUTO | MANual}
:CONTroller:CLOCk:REFChannel:MODE?	
:SYSTem:ERRor?	Responds with the oldest Event/Error log report
:SYSTem:ERRor:ALL?	Responds with all Event/Error log reports
:SYSTem:ERRor:NEXT?	Gives the next Event/Error log report
:SYSTem:LLOCk	Local Lockout (panel locked out)
:SYSTem:LOCal	Places instrument in local mode
:SYSTem:PODS?	Read the status of the remote head
:SYSTem:PRESet	System Reset
:SYSTem:VERSion	Responds with current version of SCPI commands

Table 29 is a summary of the N4955A-P12 device commands listed in alphabetical order.

Table 29. N4955A-P12 command summary

Command	Parameters / Results
:TG5P:DATA:DEEMphasis	value <unit> ::= 0 to 20 dB, resolution=0.1 dB
:TG5P:DATA:DEEMphasis?	
:TG5P:DATA:DELay	value <unit> ::= –1000 UI to +1000 UI, resolution=0.001 UI
:TG5P:DATA:DELay?	
:TG5P:DATA:DELay:PRECision	{ON | OFF}
:TG5P:DATA:DELay:PRECision?	
:TG5P:DATA:DELay:SKEW	value <unit> ::= –99.999 UI to +99.999 UI, resolution=0.001 UI
:TG5P:DATA:DELay:SKEW?	
:TG5P:DATA:DELay:SWPoutput	{OFF|1UI|2UI|4UI}
:TG5P:DATA:DELay:SWPoutput?	
:TG5P:DATA:FREQuency?	Channel frequency, query only

Command	Parameters / Results
:TG5P:DATA:LLEVel	{LVPECL | LVNECL | LVDS | SCFL | AC | CUSTom}
:TG5P:DATA:LLEVel?	
:TG5P:DATA:LLEVel:AMPLitude	value <unit> ::= 0.2 V to +2.0 V, resolution=0.005 V
:TG5P:DATA:LLEVel:AMPLitude?	
:TG5P:DATA:LLEVel:OFFSet	value <unit> ::= –2.0 V to +2.0 V, resolution=0.005 V
:TG5P:DATA:LLEVel:OFFSet?	
:TG5P:DATA:LLEVel:TERMination	value <unit> ::= –2.0 V to +2.0 V, resolution=0.005 V
:TG5P:DATA:LLEVel:TERMination?	
:TG5P:DATA:OUTPut	{ON | OFF}
:TG5P:DATA:OUTPut?	
:TG5P:DATA:PATTern:NAME	{DISABLED | HIGH | LOW | 1010 | 1100 | PRBS7 | PRBS10 | PRBS15 | PRBS23 | PRBS31}
:TG5P:DATA:PATTern:NAME?	
:TG5P:DATA:PATTern:POLarity	{INVert | NONInvert}
:TG5P:DATA:PATTern:POLarity?	
:TG5P:DATA:XOVer	value <unit> ::= 20% to 80%, resolution=1%
:TG5P:DATA:XOVer?	

Table 30 is a summary of the N4955A-D12 device commands listed in alphabetical order.

Table 30. N4955A-D12 command summary

Command	Parameters / Results
:TG7P:DATA:DEEMphasis:POST1	value <unit> ::= 0 to -10 dB, resolution=0.1 dB
:TG7P:DATA:DEEMphasis:POST1?	
:TG7P:DATA:DEEMphasis:POST2	value <unit> ::= 0 to -8 dB, resolution=0.1 dB
:TG7P:DATA:DEEMphasis:POST2?	

Command	Parameters / Results
:TG7P:DATA:DEEMphasis:PRECursor	value <unit> ::= 0 to +8 dB, resolution=0.1 dB
:TG7P:DATA:DEEMphasis:PRECursor?	
:TG7P:DATA:DELay	value <unit> ::= –1000 UI to +1000 UI, resolution=0.001 UI
:TG7P:DATA:DELay?	
:TG7P:DATA:DELay:PRECision	{ON | OFF}
:TG7P:DATA:DELay:PRECision?	
:TG7P:DATA:DELay:SKEW	value <unit> ::= –99.999 UI to +99.999 UI, resolution=0.001 UI
:TG7P:DATA:DELay:SKEW?	
:TG7P:DATA:DELay:SWPoutput	{OFF|1UI|2UI|4UI}
:TG7P:DATA:DELay:SWPoutput?	
:TG7P:DATA:FREQuency?	Channel frequency, query only
:TG7P:DATA:LLEVel	{LVPECL | LVNECL | SCFL | AC | CUSTom}
:TG7P:DATA:LLEVel?	
:TG7P:DATA:LLEVel:AMPLitude	value <unit> ::= 0.6 V to 1.2 V, resolution=0.005 V
:TG7P:DATA:LLEVel:AMPLitude?	
:TG7P:DATA:LLEVel:OFFSet	value <unit> ::= –2.0 V to +2.0 V, resolution=0.005 V
:TG7P:DATA:LLEVel:OFFSet?	
:TG7P:DATA:LLEVel:TERMination	value <unit> ::= –2.0 V to +2.0 V, resolution=0.005 V
:TG7P:DATA:LLEVel:TERMination?	
:TG7P:DATA:OUTPut	{ON | OFF}
:TG7P:DATA:OUTPut?	
:TG7P:DATA:PATTern:ERRinjection:RATE	{10^-3 | 10^-4 | 10^-5 | 10^-6 | 10^-7 | 10^-8 | 10^-9 }
:TG7P:DATA:PATTern:ERRinjection:RATE?	
:TG7P:DATA:PATTern:ERRinjection:STATe	{ON | OFF | SINGle}
:TG7P:DATA:PATTern:ERRinjection:STATe?	

Command	Parameters / Results
:TG7P:DATA:PATTern:NAME	{DISABLED | HIGH | LOW | DIV2 | DIV4 | DIV8 | DIV16 | DIV32 | DIV64 | PRBS7 | PRBS10 | PRBS15 | PRBS23 | PRBS31}
:TG7P:DATA:PATTern:NAME?	
:TG7P:DATA:PATTern:POLarity	{INVert | NONInvert}
:TG7P:DATA:PATTern:POLarity?	
:TG7P:DATA:XOVer	value <unit> ::= 20% to 80%, resolution=1%
:TG7P:DATA:XOVer?	

Table 31 is a summary of the N4956A-E12 device commands listed in alphabetical order.

Table 31. N4956A-E12 command summary

Command	Parameters / Results
:TR2P:DATA:DELay	value <unit> ::= –1000 UI to +1000 UI, resolution=0.001 UI
:TR2P:DATA:DELay?	
:TR2P:DATA:DELay:PRECision	{ON | OFF}
:TR2P:DATA:DELay:PRECision?	
:TR2P:DATA:DELay:SKEW	value <unit> ::= –99.999 UI to +99.999 UI, resolution=0.001 UI
:TR2P:DATA:DELay:SKEW?	
:TR2P:DATA:EYE:ACENter	{ON | OFF}
:TR2P:DATA:EYE:ACENter?	
:TR2P:DATA:EYE:ALIGn	{ON | OFF}
:TR2P:DATA:EYE:ALIGn?	
:TR2P:DATA:EYE:ASTep	value <unit> ::= 5 mV to 20 mV, resolution=1 mV
:TR2P:DATA:EYE:ASTep?	

Command	Parameters / Results
:TR2P:DATA:EYE:DCENter	{ON | OFF}
:TR2P:DATA:EYE:DCENter?	
:TR2P:DATA:EYE:DSTep	value <unit> ::= 5 mUI to 2 0mUI, resolution=1 mUI
:TR2P:DATA:EYE:DSTep?	
:TR2P:DATA:EYE:THReshold	value <unit> ::= 1.00E-006 to 1.00E-012
:TR2P:DATA:EYE:THReshold?	
:TR2P:DATA:FETCh:ALL?	bit count, error count, bit error rate, elapsed time, and state, query only
:TR2P:DATA:FETCh:BCOunt?	bit count, query only
:TR2P:DATA:FETCh:ECOunt?	error count, query only
:TR2P:DATA:FETCh:ELAP?	gate period elapsed time, query only
:TR2P:DATA:FETCh:ERATio?	bit error rate, query only
:TR2P:DATA:FREQuency?	channel frequency, query only
:TR2P:DATA:GATE:PERiod	value <unit> ::= 1 ms to 99999.999 s
:TR2P:DATA:GATE:PERiod?	
:TR2P:DATA:GATE:STATe	{ON | OFF}
:TR2P:DATA:GATE:STATe?	
:TR2P:DATA:PATTern:NAME	{PRBS7 | PRBS10 | PRBS15 | PRBS23 | PRBS31}
:TR2P:DATA:PATTern:NAME?	
:TR2P:DATA:SYNC?	{NO DATA | SYNC | NO-SYNC}, {ON | OFF} query only
:TR2P:DATA:TERMination	value <unit> ::= –2.0 V to +2.0 V, resolution=0.005 V
:TR2P:DATA:TERMination?	
:TR2P:DATA:VOLTage:ZOTHreshold	value <unit> ::= –1.000 V to +1.000 V, resolution=0.001 V
:TR2P:DATA:VTERmination	{ON | OFF}
:TR2P:DATA:VTERmination?	

6.14 Communication Timeouts

Most SCPI commands for N4965A are processed fairly quickly and completed within several milliseconds. However, there are several commands that require more time to process and complete. The user must account for the wait time requirements when working with these commands:

Command to issue the delay with large value:

":TG5P:DATA:DEL 1000 (@1)"

From the default state (0UI), this command sets the delay of Channel 1 to 1000 UI. It will take approximately 10 seconds to complete, since it takes approximately 1 second per 100 UI of change per channel.

":TG5P:DATA:DEL 1000 (@0:4)"

This command will take approximately 50 seconds to process from the default state (delay = 0UI).

Command to issue the skew with large value:

It will take approximately 5 seconds to complete this command from the default state (skew = 0 UI) for Channel 0 to Channel 4:

":TG5P:DATA:DEL:SKEW 99.999 (@0:4)"

Command to issue the swept delay for 5 channels:

":TG5P:DATA:DEL:SWP 4UI (@0:4)"

From the default state (swept delay = OFF); it will take approximately 3 seconds to complete this command.

Command to enable precision delay for 5 channels:

:DETector:DATA:DELay:PREC ON (@0:4)

It will take approximately 30 seconds to perform an internal calibration on channel 0 to channel 4 when precision delay is enabled.

System Preset:

":SYST:PRES"

"*RST"

These commands restore the N4965A to its default state, and can take up to 10 seconds to complete, depending on the number of parameters that differ from the default setting.

Recall command:

"*RCL X" with X = 1 to 5.

In the case that a recalled instrument state has large Delay or Skew values, or Swept Delay, it will take an accumulated amount of time as mentioned above to complete it.

The user must account for a 5 second wait time when the input frequency is changed, before making any measurements at the new frequency setting. This requirement applies regardless of AUTO or MANUAL mode on the REF input, and also applies to the AUX input.

For all commands from 1-5, the user should use "*OPC?" or "*WAI" after the SCPI command or "*OPC" followed by "*ERS?". Furthermore, the bus interface timeout needs to be modified to ensure that all commands can complete without triggering the communication timeout

Example:

":TG5P:DATA:DEL 1000 (@0:4); *OPC?"

These commands will lock the GPIB remote interface until the delay 1000 UI of 5 channels is complete and "*OPC?" returns 1.

":TG5P:DATA:DEL 1000 (@0:4); *WAI"

These commands prevent the N4965A from executing any further commands or queries until the 1000 UI of 5 channels is complete and don't lock the GPIB remote interface.

6.15 Programming Example

The following programming example assumes the user is programming with Agilent. BASIC, is a simple interpretative language that is convenient for instrument programming. For the example programs below, the device being programmed is located at GPIB device address 710. The actual address varies according to how you have configured the GPIB bus for your own application.

This first block of code shows how to reset the instrument, ask for the instrument ID, check the system for errors, read the status of the remote head (pod) and set the local mode of the instrument.

```
10 OUTPUT 710; "*RST"                    ! reset the N4965A
20 OUTPUT 710; "*IDN?"                   ! request the instrument ID
30 ENTER 710; result$                    ! read the return
40 PRINT result$                         ! print the results to stdout
50 DIM $error [89]                       ! Dimension variable
60 OUTPUT 710; ":SYST:ERR:ALL?"          ! check for all errors and clear the
                                           error log
70 ENTER 710; error$                     ! read the return
80 PRINT error$                          ! print the error
90 DIM $pod [89]                         ! Dimension variable
100 OUTPUT 710; ":SYST:PODS?"            ! check remote head status
```

```
110 ENTER 710; pod$                          ! read the return
120 PRINT pod$                               ! print the error
130 OUTPUT 710; ":SYST:LLOC"                 ! place the instrument in remote
                                               mode.
140 OUTPUT 710; ":SYST:LOC"                  ! place the instrument in local mode.
```

The next block shows how to save the instrument state in one of the save/recall registers (1-5), how to change the amplitude of the sub-rate clock, save the previous instrument state into the register 1 and recall the saved instrument state from the saved register.

```
150 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:AMPL 500mV"
                                             ! set the clock output amplitude = 500mV
160 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:AMPL?"
                                             ! query the clock output amplitude
170 ENTER 710; ampl$                         ! read the return
180 PRINT ampl$                              ! print the clock output amplitude 190
                                               OUTPUT 710; "*SAV 1" ! save current
                                               inst. state in register 1

200 OUTPUT 710; ":SYST:PRES"                 ! reset the N4965A, the clock
                                               amplitude is set back to the default
                                               value = 700mV
210 OUTPUT 710; "*RCL 1"                     ! recall the prior state of amplitude
220 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:AMPL?" ! query the clock output amplitude
230 ENTER 710; ampl$                         ! read the return
240 PRINT ampl$                              ! print the clock output amplitude, the
                                               amplitude value is now 500mV.
```

This block shows how to turn the sub-rate clock ON.

```
250 OUTPUT 710; ":CONT:CLOC:DIVC:OUTP ON"    ! set the clock output ON
260 OUTPUT 710; ":CONT:CLOC:DIVC:OUTP?"      ! query the clock output state
270 ENTER 710; output                        ! read the return
280 PRINT output$                            ! print the output state
```

This block shows how to select the different input clock source for CH1 to CH4. The AUX Input Clock doesn't have the capability to detect the input frequency automatically; a frequency value MUST be entered by the user (see section Operation).

```
290 OUTPUT 710; ":CONT:CLOC:AUXC:SOUR AUX"  ! choose the clock source input
                                              AUX for CH1 to CH4
300 OUTPUT 710; ":CONT:CLOC:AUXC:SOUR?"     ! query the clock input source for
                                              CH1 to CH4
310 ENTER 710; source$                       ! read the return
320 PRINT source$                            ! print the return
330 OUTPUT 710; ":CONT:CLOC:AUXC:FREQ 5000MHz"
                                             ! send the frequency 5GHz which
                                              applied for the clock input AUX.

340 OUTPUT 710; ":CONT:CLOC:AUXC:FREQ?"     ! query the AUX clock input
350 ENTER 710; aux_freq$                     ! read the return
360 PRINT aux_freq$                          ! print the return
```

This block shows how to select the clock mode of the REF Clock Input and set the clock frequency in the clock mode “MANUAL” for the REF Clock Input. A frequency value MUST be entered by the user in the “MANUAL” mode.

```
370 OUTPUT 710; ":CONT:CLOC:REFC:MODE MAN”  ! set the REF clock in manual mode
380 OUTPUT 710; ":CONT:CLOC:REFC:MODE?”     ! query the REF clock mode
390 ENTER 710; mode$                        ! read the return
400 PRINT mode$                             ! print the REF clock mode
410 OUTPUT 710; ":CONT:CLOC:REFC:FREQ 10 GHz”  ! set the REF clock frequency 10 GHz
420 OUTPUT 710; ":CONT:CLOC:REFC:FREQ?”     ! query the REF clock frequency
430 ENTER 710; freq$                        ! read the return
440 PRINT freq$                             ! print the clock frequency
450 OUTPUT 710; ":CONT:CLOC:REFC:MODE AUTO”! set the REF clock in auto mode
460 OUTPUT 710; ":CONT:CLOC:REFC:MODE?”     ! query the clock mode
470 ENTER 710; mode$                        ! read the return
480 PRINT mode$                             ! print the clock mode
490 OUTPUT 710; ":CONT:CLOC:REFC:FREQ?”     ! query the auto-detected frequency from
                                              auto mode
500 ENTER 710; freq$                        ! read the return
510 PRINT freq$                             ! print the clock frequency
```

This block shows how to select the clock mode of the REF Clock Input and set the clock frequency in the clock mode “MANUAL” for the REF Clock Input. A frequency value MUST be entered by the user in the “MANUAL” mode.

```
520 OUTPUT 710; ":CONT:CLOC:DIVC:RAT 4088"  ! set the clock output divide ratio=4088
530 OUTPUT 710; ":CONT:CLOC:DIVC:RAT?"      ! query the clock divide ratio
540 ENTER 710; ratio$                       ! read the return
550 PRINT ratio$                            ! print the divide ratio
560 OUTPUT 710; ":CONT:CLOC:DIVC:RAT 3333"  ! set the clock output divide ratio to
                                              3333
```

```
570 OUTPUT 710; ":CONT:CLOC:DIVC:RAT?"      ! query the clock divide ratio
580 ENTER 710; ratio$                       ! read the return
590 PRINT ratio$                            ! print the divide ratio. The return
```

value is the previous value 4088 because the entered divide ratio value 3333 is invalid (see section Operation)

```
600 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:AMPL 0.5" ! set the clock output amplitude=0.5V
610 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:AMPL?"! query the clock output amplitude
620 ENTER 710; ampl$                        ! read the return
630 PRINT ampl$                             ! print the clock output amplitude
640 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:OFFS -1" ! set the clock offset=-1V
650 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:OFFS?"! query the clock offset
660 ENTER 710; offset$                      ! read the return
670 PRINT offset$                           ! print the clock offset voltage
680 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:TERM -0.5"! set the clock
                                            termination=-0.5V
690 OUTPUT 710; ":CONT:CLOC:DIVC:LLEV:TERM?"! query the clock term
700 ENTER 710; term$                        ! read the return
710 PRINT term$                             ! print the clock termination voltage
```

This section below shows how to work with all the features of 5 channels. CH0, CH1, CH2, CH3 and CH4.

```
720 OUTPUT 710; ":TG5P:DATA:OUTP ON (@0:4)"! set the data outputs of all channels on
730 DIM $out[89]                                    ! Dimension variable
740 OUTPUT 710; " TG5P:DATA:OUTP? (@)"      ! query the output state of CH0
                                                    to CH4
750 ENTER 710; out$                            ! read the return
760 PRINT out$                              ! print the output state of the all
                                                    channels
770 OUTPUT 710; ":TG5P:DATA:PATT:NAME 1010”! set the pattern 1010 on channel 0
780 OUTPUT 710; " TG5P:DATA:PATT:NAME?"     ! query the pattern of CH0
790 ENTER 710; patt$                           ! read the return
800 PRINT patt$                                     ! print the pattern of CH0

810 OUTPUT 710; ":TG5P:DATA:PATT:NAME PRBS31 (@1:3)”! set the pattern PRBS31
                                                    on channel 1 through channel 3
820 DIM $pattern [89]                          ! Dimension variable
830 OUTPUT 710; "TG5P:DATA:PATT:NAME? (@1,2,3)" ! query the pattern on CH1
                                                    through CH3
840 ENTER 710; patttern$                      ! read the return
850 PRINT patttern$                            ! print the pattern on CH1, CH2
                                                    and CH3

860 OUTPUT 710; ":TG5P:DATA:PATT:POL INV (@1)” ! invert the pattern’s polarity on
                                                    channel 1
870 DIM $pol[50]                                    ! Dimension variable
880 OUTPUT 710; " TG5P:DATA:PATT:POL? (@)"  ! query the pattern’s polarity on CH1.
```

```
890 ENTER 710; pol$                                ! read the return
900 PRINT pol$                                   ! print the pattern's polarity on CH1

910 OUTPUT 710; ":TG5P:DATA:LLEV LVDS"      ! set the data output of CH0 at logic
                                                        LVDS
920 OUTPUT 710; ":TG5P:DATA:LLEV?"          ! query the data output logic family of
                                                        CH0
930 ENTER 710; log$                              ! read the return
940 PRINT log$                                          ! print the logic family
950 OUTPUT 710; ":TG5P:DATA:LLEV:AMPL 0.55 (@1:2)"! set the data output
                                                        amplitude=0.55V on CH1 and CH2
960 DIM $am[89]                                         ! Dimension variable
970 OUTPUT 710; ":TG5P:DATA:LLEV:AMPL? (@)"! query the data output amplitude on CH1
                                                        and CH2
980 ENTER 710; am$                               ! read the return
990 PRINT am$                                           ! print the return
1000 OUTPUT 710; ":TG5P:DATA:LLEV:OFFS 0.1 (@)"! set the data offset=0.1V on the
                                                        previous channel list (CH1 and
                                                        CH2)
1010 DIM $off[89]                                       ! Dimension variable
1020 OUTPUT 710; ":TG5P:DATA:LLEV:OFFS? (@)"! query the data offset on CH1 and CH2
1030 ENTER 710; off$                             ! read the return
1040 PRINT off$                                         ! print the clock offset
                                                        voltage
1050 OUTPUT 710; ":TG5P:DATA:LLEV:TERM 1 (@4)" ! set the data output termination
                                                        voltage = 1V on CH4
1060 DIM $termination[89]                       ! Dimension variable
1070 OUTPUT 710; ":TG5P:DATA:LLEV:TERM? (@4)"  ! query the termination voltage
                                                        on CH4
1080 ENTER 710; termination$                    ! read the return
1090 PRINT termination$                          ! print the termination voltage
1100 OUTPUT 710; ":TG5P:DATA:DEEM 15 (@3:4)"! set the data output de-emphasis level
                                                        = 15dB on CH3 and CH4
1110 DIM $deemp[89]                              ! Dimension variable
1120 OUTPUT 710; ":TG5P:DATA:DEEM? (@)"     ! query the de-emphasis value of CH3 and
                                                        CH4
1130 ENTER 710; deemp$                           ! read the return
1140 PRINT deemp$                                       ! print the de-emphasis values
1150 OUTPUT 710; ":TG5P:DATA:XOV 35 (@0:4)"! set the data output
                                                        cross-over=35%  on all channels
1160 DIM $xo[89]                                        ! Dimension variable
1170 OUTPUT 710; ":TG5P:DATA:XOV? (@)"      ! query the cross-over value of all
                                                        channels
1180 ENTER 710; xo$                              ! read the return
1190 PRINT xo$                                          ! print the cross-over values
1200 OUTPUT 710; ":TG5P:DATA:DEL 1000 (@0:4);*OPC?"! set the data output delay
1000UI on all channels. It will take approximately 50 seconds to complete this
                                                        command for 5 channels.
1210 DIM $del[89]                                       ! Dimension variable
1220 OUTPUT 710; ":TG5P:DATA:DEL? (@)"      ! query the delay values of all channels
1230 ENTER 710; del$                             ! read the return
1240 PRINT del$                                         ! print the delay values
1250 OUTPUT 710; ":TG5P:DATA:DEL:SKEW 0.25 (@1)" ! set the data
```

```
                                                    output skew=0.25UI  on CH1
1260 DIM $skew[89]                                ! Dimension variable
1270 OUTPUT 710; ":TG5P:DATA:DEL:SKEW? (@)"! query the skew value of CH1
1280 ENTER 710; skew$                             ! read the return
1290 PRINT skew$
1300 OUTPUT 710; ":TG5P:DATA:DEL:SWP 4UI (@0:4);*WAI” ! set the data
output swept delay 4UI  on all channels.
1310 DIM $sweep[89]                               ! Dimension variable
1320 OUTPUT 710; ":TG5P:DATA:DEL:SWP? (@)"  ! query the swept delay for all
                                                    channels.
1330 ENTER 710; sweep$                            ! read the return
1340 PRINT sweep$
1350 OUTPUT 710; ":TG5P:DATA:DEL:SWP OFF (@0:4)” ! turn off the
data output swept delay on all channels.
1360 DIM $sweep[89]                               ! Dimension variable
1370 OUTPUT 710; ":TG5P:DATA:DEL:SWP? (@)"  ! query the swept delay for all channels.
1380 ENTER 710; sweep$                          ! read the return. The return value
                                                    should be ‘OFF’
1390 PRINT sweep$                                   ! print the return.
```

7 Returning the N4965A

If the N4965A fails system verification and you cannot correct the problem, return the N4965A to Agilent Technologies for repair following the steps shown below.

1. Record all symptoms.
2. Contact Agilent Technologies using the “Request an RMA” form at http://www.agilent.com/find/assist.
3. Use the original packing material or similar packing material to ship the N4965A to Agilent Technologies.

8 Appendix A: Preset State

The following settings are the default values after performing an instrument preset:

Table 32. N4955A-P12 pattern generator settings preset state

Setting	Preset state
Pattern output	Off
Data test pattern	PRBS 2^7-1
Data amplitude	+1.000 V
Data offset	+0.000 V
Data termination voltage	+0.000 V
De-emphasis	00.0 dB
Data crossover	50%
Pattern invert	Off
Data delay	+0000.000 UI
Dly sweep	Off
Data logic family	AC
Precision delay	Off
Delay skew	+00.000 UI

Table 33. N4955A-D12 pattern generator settings preset state

Setting	Preset state
Pattern output	Off
Data test pattern	PRBS 2^7-1
Data amplitude	+1.000 V
Data offset	+0.000 V
Data termination voltage	+0.000 V

Setting	Preset state
De-emphasis post1 cursor	00.0 dB
De-emphasis post2 cursor	00.0 dB
De-emphasis precursor	00.0 dB
Data crossover	50%
Error injection state	Off
Error injection rate	10^-3
Pattern invert	Off
Data delay	+0000.000 UI
Dly sweep	Off
Data logic family	AC
Precision delay	Off
Delay skew	+00.000 UI

Table 34. Clock settings preset state

Setting	Preset state
Clock output	Off
Frequency mode	Auto
Frequency	Current clock input frequency
Clock amplitude	700 mV
Clock offset	AC
Clock termination voltage	AC
Clock logic family	AC
Divided clock ratio	0008
Clock source	Reference
Ax Frq	00.0 GHz

Table 35. N4956A-E12 error detector settings preset state

Setting	Preset state
Data threshold	+0.000 V
Data termination	+0.000 V
Skew	+00.000 UI
Delay	+0000.000
Data test pattern	PRBS 2^7-1
Bit error rate duration	00010.000 seconds
Auto align	Off
Auto align delay step size	20 mUI
Auto align amplitude step size	20 mV
Auto align threshold	1.0E-06
Auto align delay	+0000.000
V termination	Off
Precision delay	On
Time delay	00010.000 s

Fifth edition, April 2014
Printed in Germany

N4965-91021

Agilent Technologies