DATA SHEET

N1000A DCA-X

Wide Bandwidth Oscilloscope Mainframe and Modules

KEYSIGHT TECHNOLOGIES

Table of Contents

Introduction

The N1000A DCA-X performs precision measurements on high speed digital designs from 50 MBd to more than 80 GBd on up to 16 channels simultaneously. Applications include:

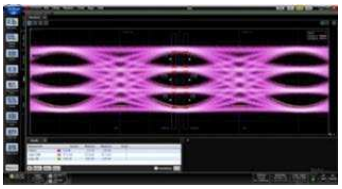
- Optical transceiver design and production test
- Electrical ASIC/FPGA/IC design and characterization
- Serial bus characterization, measurements and trouble-shooting via TDR/TDT and S-parameter measurements of channels, cables and PCBs

Keysight offers complete Digital Communication Analyzer solutions that can be combined with or used alongside the DCA-X, including clock recovery, stand-alone Digital Communication Analyzers (DCA-M) and software. For complete information on Keysight's entire DCA family, please refer to these other helpful documents:

- Keysight DCA Wide Bandwidth Oscilloscope Family Brochure
- Keysight DCA Family FlexDCA Sampling Oscilloscope Software Technical Overview
- Keysight N1000A DCA Wide Bandwidth Oscilloscope Family Configuration Guide, 5992-0038EN
- Keysight DCA Family Clock Data Recovery Solutions Data Sheet, 5991-2340EN
- Keysight N1090A, N1092A/B/C/D/E and N1094A/B DCA-M Optical and Electrical Sampling Oscilloscope Data Sheet, 5992-1454EN.

Optical + Electrical and Electrical Clock Recovery

Optical + Electrical DCA-M



FlexDCA Software

N1000A DCA-X Specifications

General Notes

Note: All specifications describe warranted performance over the temperature range +10° C to + 40° C (unless otherwise noted). The specifications are applicable after the temperature is stabilized, which occurs after 1 hour of continuous operation in final setup configuration, and while module calibration is valid. Many performance parameters are enhanced through frequent, simple user calibrations.

Note: Specifications describe warranted performance. Characteristics provide useful, non-warranted information about the functions and performance of the instrument. Characteristics are printed in green italics.

Note: Factory Calibration Cycle. For optimum performance, the instrument should have a complete verification of specifications once every 12 months.

Note: Nominal Value indicates the expected, but not warranted, value of the parameter.

Computer System and Storage Specifications

Item	Description
CPU	Intel I5 Quad Core
RAM	8 GB
Operating System	Windows 10, 64 bit
Mass Storage	120 GB internal SSD hard disk

Display Specifications

Item	Description
Display Area	• 210.4 mm x 157.8 mm • 10.4-inch diagonal color active matrix LCD module incorporating amorphous silicon TFTs.
Entire Display Resolution	1024 pixels horizontally x 768 pixels vertically
Waveform Colors	Select from over 16 colors. User may change color assignment of all traces (channels, waveform memory, and signal processing functions).
Persistence Modes	Gray scale, color grade, infinite, variable

Connect-the-dots	On/Off selectable
Persistence	Minimum, variable (100 ms to 40s), infinite
Graticule	On/Off
Grid Intensity	0 to 100%
Dialog Boxes	Opaque or transparent
Supports External Display	Supports multiple display configurations via Windows display utility.

Environmental Specifications

Item	Description
Use	Indoor
Temperature	
Operating	10°C to +40°C (50°F to +104°F)
Non-operating	–40°C to +70°C (–40°F to +158°F)
Altitude (Operating)	Up to 4,600 meters (15,000 ft)
Maximum Relative Humidity	80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C
Line Power	100/120Vac 50/60/400 Hz
	220/240Vac 50/60 Hz
	700 Watts Maximum
	The products can operate with mains supply voltage fluctuations up to ±10% of the nominal voltage.
3 Hz to 300kHz	3 Hz to 300kHz
3 Hz to 300kHz	3 Hz to 300kHz
Weight	
Mainframe without modules (characteristic)	*20.5 kg (43 lb)*
Module (characteristic)	*1.2 kg (2.6 lb)*

Dimensions (excluding handle)	
Without front connectors and rear feet	221 mm H x 426 mm W x 530 mm D (8.7 inch x 16.76 inch x 20.9 inch)
With front connectors and rear feet	234 mm H x 426 mm W x 601 mm D (9.23 inch x 16.76 inch x 23.67 inch)
With front cover and rear feet	234 mm H x 426 mm W x 612 mm D (9.23 inch x 16.76 inch x 24.1 inch)

Warning: 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.

Caution: This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2 environment.

Note: Only Keysight approved accessories shall be used.

Horizontal (Timebase) Specifications

Item	Description
Scale Factor	Full scale is ten divisions.
Minimum	100 fs/div
Maximum	50 ms/div
Delay	Time offset relative to the front panel trigger input on the instrument mainframe.
Minimum	16 ns
Maximum	1s
Time Interval Accuracy	1 ps + 1% of Δ time interval for intervals from minimum delay to minimum delay + 1 ns[1] or 6 ps + 1% of Δ time interval[1]
	500 fs + 0.25% of Δ time interval (characteristic)[2]

[1] Dual marker measurement performed at a temperature within ±5° C of horizontal calibration temperature.
[2] Dual marker measurement performed at a temperature within ±1.5° C of horizontal calibration temperature.

Time Interval Accuracy (Pattern Lock Mode)	1 GHz to 32 GHz: 500 fs + 0.5% of 1/(clock input frequency), or 5 ps (whichever is smaller)[3]
	50 MHz to 1 GHz: 500 fs + 0.5% of 1/(clock input frequency), or 30 ps (whichever is smaller)[3]
	250 fs + 0.25% of 1/(clock input frequency) (characteristic)[4]
Jitter Mode Operation	*Time interval accuracy – jitter mode operation 500 fs (characteristic).* Test configuration: PRBS of length 2^7–1 bits, Data and Clock 10 Gb/s.
Time Interval Resolution[5]	*(screen diameter)/(record length) or 60 fs, whichever is larger*
Display Units	Unit Interval or Time
Record length	2 to 131,072 samples. Increments of 1

Input and Output Specifications

Front-Panel Inputs and Outputs

Item	Description
Trigger Input, Connector	2.92 mm (male). Mainframe ships with 2.92 mm female-female connector saver (P/N 1250-4105), Trigger specifications.
Trigger Input, Impedance (Normalized)	50Ω
Trigger Input, Maximum	2 Vpp maximum
Precision Timebase Input, Connector (Option N1000A-PTB only)	2.92 mm (male), Mainframe ships with 2.92 mm female-female connector saver (P/N 1250-4105)
Precision Timebase Input, Impedance (Normalized) (*Option N1000A-PTB only*)	50Ω

[3] Dual marker measurement performed at a temperature within ±5° C of horizontal calibration temperature.

[4] Dual marker measurement performed at a temperature within ±1.5° C of horizontal calibration temperature.

[5] The time interval resolution is the smallest time you can characterize between two points.

Precision Timebase Input, Maximum (*Option N1000A-PTB only*)	1.3 Vpp maximum
DC Cal Output	BNC (female) Range: –2.0V to +2.0V
USB	Three USB 2.0 ports
Ground Connection	Banana plug

Rear-Panel Inputs and Outputs

Item	Description
GPIB	Fully programmable, complies with IEEE 488.2
Display Port	For connecting external displays
VGA Port	Analog, full color, 15 pin D-sub (female)
LAN	Two Gigabit Ethernet ports
USB	Two USB 3.0 ports, Two USB 2.0 ports
USB Device Port	Instrument control over USB
Audio Ports	Audio IN (blue connection), Audio OUT (green connection) Microphone IN (pink connection)

Internal Precision Timebase Specifications (Option PTB)

Specifications

Item	Description
Maximum Input Signal	1.3 Vpp
Input DC Offset Range	± 200 mV
Input Signal Type The internal precision timebase works with typical digital clock signals, such as a BERT output, as well as sine waves. If the rise time or fall time of the clock signal is less than 15% of the period of the clock (for example, less than 15 ps for a 10 GHz clock), reduce the edge speed by using an external low-pass filter or length of cable. For the lowest jitter, use a signal that is as close as possible to the maximum signal amplitude (1.3 Vpp) and minimize any sub-harmonics.	
Timebase Jitter, Input ≥ 750 mVpp (sinusoidal) *(Characteristic)*	

2.4 GHz — <4.0 GHz trigger (tested at 2.4 GHz, 750 mVpp)	*≤ 200 fs rms,* *< 400 fs rms* with 54752, 54754, 83484 or N1045A (non-Option LOJ) module
4 GHz — 9.0 GHz trigger (tested at 5 GHz, 750 mVpp)	*≤ 120 fs rms* *< 400 fs rms* with 54752, 54754, 83484 or N1045A (non-Option LOJ) module
>9.0 GHz — 44.0 GHz trigger (tested at 10, 20, and 40 GHz, 500 mVpp)	*≤ 90 fs rms* *< 200 fs rms* with 54752, 54754, 83484 or N1045A (non-Option LOJ) module
Precision Timebase Input	
Nominal Impedance	*50Ω*
Connector Type	2.92 mm (male)

Trigger Specifications

Specifications

Item	Description
Maximum Trigger Signal	2V peak-to-peak
Trigger Input	
Nominal Impedance	*50Ω*
Reflection	*10% for 100 ps rise time*
Connector Type	2.92 mm (male)

Trigger Mode Specifications

Internal Trigger Mode

Item	Description
Freerun	Freerun trigger mode internally generates an asynchronous trigger that allows viewing the sampled signal amplitude without an external trigger signal but provides no timing information. Freerun is useful in troubleshooting external trigger problems.

Clock Trigger/Pattern Lock Mode

Item	Description[6]
Clock Trigger	50 MHz to 32 GHz, effective divide-by-one, AC coupled
Pattern Lock (Option PLK)	50 MHz to 32 GHz, AC coupled
Pattern Lock Length (Option PLK)	1 to 2^{23} (8,388,608) symbols
Jitter	
50 MHz to < 500 MHz	1.0 ps rms + 10 PPM of horizontal position (maximum), *<800 fs rms + 5 PPM of horizontal position* (typical)
500 MHz to 32 GHz[7,8] (Option STB)	450 fs rms (maximum) *400 fs rms (typical)*
500 MHz to 32 GHz6[7,8] (Option LOJ)	250 fs rms (maximum) *200 fs rms* (typical)
Trigger Sensitivity	200 mV p-p
Trigger Slew rate	≥ 2V/ns

Edge Trigger Mode

Item	Description[6]
Input	DC to 2.5 GHz
Jitter[9]	1.0 ps rms + 10 PPM horizontal position (maximum) *<800 fs rms + 5 PPM horizontal position (characteristic)*
Trigger Sensitivity	200 mV p-p (sinusoidal input or 200 ps minimum pulse width)
Triggering Level Adjustment	–1V to +1V
Edge Select	Positive or negative

[6] These specifications refer to the signal input to the front-panel **Trigger Input** connector. The sampled input signal timing is recreated by using an externally supplied trigger signal that is synchronous with the sampled signal input.
[7] Verified at 10 GHz with a clock and signal slew rate ≥ 15V/ns.
[8] Verified at 28 GHz with a clock and signal slew rate ≥ 20V/ns.
[9] Verified at 2.5 GHz with a clock and signal slew rate ≥ 2V/ns

Vertical (Channel) Specifications

Item	Description
Sample Rate	Up to 250 kHz
Number of Channels	Up to 16 channels
Vertical Resolution	16-bit hardware A/D converter for N10xx-series modules. 14-bit hardware A/D converter for 861xx, 54xxx, and 8348x-series modules.
Full Resolution Channel Scales	Adjusts in a 1-2-5-10 sequence for coarse adjustment or fine adjustment resolution from the front panel knob.
Adjustments	Scale, offset, activate filter, sampler bandwidth, attenuation factor, transducer conversion factors

Module Selection Guide

									Optical Reference Receiver fortypical rates in this range *See specifications for details*					
Module	Option	No. of electrical channels	Highest Electrical bandwidth (GHz)	Step Generator (TDR)	No. of optical channels	Wavelength range (nm)	Unfiltered optical bandwidth (GHz)	Fiber input (µm)	NRZ < 10Gb/s	NRZ 10 Gb/s - 14 Gb/s	NRZ 20 Gb/s - 28 Gb/s	NRZ 39 Gb/s - 43 Gb/s	PAM4 26 GBd (with option IRC)	PAM4 53 GBd (with option IRC)
54754A		2	18	2	0	-	-	-						
86105C	100	1	20	-	1	750 - 1650	8.5	62.5/125	•					
	200	1	20	-	1	750 - 1650	8.5	62.5/125		•				
	300	1	20	-	1	750 - 1650	8.5	62.5/125	•	•				
86105D	141	1	35	-	1	750 - 1650	20	62.5/125		•				
	281	1	50	-	1	750 - 1650	34	62.5/125			•		•	•
86108B	LBW	2	35	-	0	-	-	-						
	HBW	2	50	-	0	-	-	-						
86112A		2	20	-	0	-	-	-						
	HBW	2	30	-	0	-	-	-						
86115D	002/102/142	0	-	-	2	750 - 1650	20	62.5/125		•				
	206/282	0	-	-	2	750 - 1650	34	62.5/125			•		•	•
86116C	25	1	80	-	1	1300 - 1620	40	9/125			•		•	•
	41	1	80	-	1	1300 - 1620	65	9/125				•		•
86118A		2	70	-	0	-	-	-						
N1045A	02x	2	60	-	0	-	-	-						
	04x	4	60	-	0	-	-	-						
N1045B	02x	2	60	-	0	-	-	-						
	04x	4	60	-	0	-	-	-						
N1046A	71F	1	75	-	0	-	-	-						
	72F	2	75	-	0	-	-	-						
	74F	4	75	-	0	-	-	-						
	81F	1	85	-	0	-	-	-						
	82F	2	85	-	0	-	-	-						
	84F	4	85	-	0	-	-	-						
	11F	1	100	-	0	-	-	-						
	12F	2	100	-	0	-	-	-						
	14F	4	100	-	0	-	-	-						
N1055A	32x	2	35	2	0	-	-	-						
	34x	4	35	4	0	-	-	-						
	52x	2	50	2	0	-	-	-						
	54x	4	50	4	0	-	-	-						
N1060A	050	2	50	-	0	-	--	-						
	085	2	85	-	0	-		-						

Module Specifications, General Notes

NOTE: All specifications describe warranted performance over the temperature range +10° C to + 40° C (unless otherwise noted). The specifications are applicable after the temperature is stabilized, which occurs after 1 hour of continuous operation in final setup configuration and while module calibration is valid. Many performance parameters are enhanced through frequent, simple user calibrations.

NOTE: Specifications describe warranted performance. Characteristics provide useful, non-warranted information about the functions and performance of the instrument. Characteristics are printed in green italics.

NOTE: Factory Calibration Cycle. For optimum performance, the instrument should have a complete verification of specifications once every 12 months.

NOTE: Nominal Value indicates the expected, but not warranted, value of the parameter.

54754A Module Specifications

Item	Description
Bandwidth (-3 dB)	dc to 12.4 or 18.0 GHz
The above bandwidths are user selectable. The input sampler is biased differently for increased bandwidth in the 18 GHz bandwidth mode. Channel 1/3 is the TDR input located on the upper left of the module. Channel 2/4 is the electrical input located on the lower left of the module.	
dc Accuracy (single marker when driven from a 0 ohm source)	
12.4 GHz	±0.4% of full scale ±2 mV ±0.6% of reading - channel offset
18 GHz	±0.4% of full scale ±2 mV ±1.2% of reading - channel offset
The above is the DC accuracy when operated within ±2°C (±3.6°F) of the temperature of the last plug-in module calibration. When operated within ±5°C (±9°F) of the temperature of the last module calibration, the final term in the DC accuracy specification is 2.5 times higher.	
dc Difference (two marker accuracy on the same channel)	
12.4 GHz	±0.8% full scale ±1.2% of delta reading
18 GHz	±0.8% full scale ±1.2% of delta reading
The above is the DC difference when operated within ±2°C (±3.6°F) of the temperature of the last plug-in module calibration. When operated within ±5°C (±9°F) of the temperature of the last module calibration, the final term in the DC difference specification is 2.5 times higher.	

Transition Time (10% to 90% calculated from TR = 0.35/BW)	
12.4 GHz	28.2 ps
18 GHz	19.4 ps
RMS Noise Typical	
12.4 GHz	0.25 mV
18 GHz	0.5 mV
Maximum	
12.4 GHz	0.5 mV
18 GHz	1.0 mV
Scale Factor (full height is eight divisions)	
Minimum	1 mV/division
Maximum	100 mV/division
Display Resolution	256 points
dc Offset Range (referenced two divisions from screen bottom)	±500 mV
An effective offset of ± 900 mV can be achieved using the ±500 mV of channel offset and adding ±400 mV of offset using the signal processing math Add function with a constant operand.	
Nominal Impedance	50 ohm
Connectors (channel and trigger)	3.5 mm (m)
Input Reflection/Return Loss	≤ 5% for 30 ps rise time
Number of Channels	2
Dynamic Range/Maximum Specified Input Power	±400 mV relative to channel offset
Maximum Safe Input	±2 V + peak AC (+16 dBm)

TDR System

Normalized information is a characteristic, not a specification. The information is presented here for comparison purposes only. Normalization characteristics are achieved only with the use of the TDR calibration using the firmware routines. Rise time is measured in the Averaged Display mode with best flatness on (default in TDR mode). The rise time of the generator is less than 35 ps, as calculated by:

$$t_r\text{system} = \sqrt{(t_r\text{generator})^2 + (t_r\text{scope})^2}$$

Note: This is a note. Flatness is measured in the Averaged Display mode with best flatness on (default in TDR mode).

Caution: This is a caution. Flatness is measured in the Averaged Display mode with best flatness on (default in TDR mode).

Warning: This is a warning. Flatness is measured in the Averaged Display mode with best flatness on (default in TDR mode).

Item	Description
Rise Time	
Combined Oscilloscope and TDR Performance	< 45 ps
Normalized Characteristic	*Adjustable: allowable values based on time base setting. (characteristic) Minimum: 17 ps or 0.08 x time/div, whichever is greater. (characteristic) Maximum: 5 x time/div. (characteristic)*
Flatness	
Combined Oscilloscope and TDR Performance	< ± 1% after 1 ns from edge. < +5%, –5% to 1 ns from edge.
Normalized Characteristic	*< 0.1% (characteristic)*
Step Levels	
Combined Oscilloscope and TDR Performance	Low: 0.00V ± 2 mV High: +200 mV ± 2 mV
Normalized Characteristic	*Low: 0.00V ± 2 mV (characteristic)* *High: +200 mV ± 2 mV (characteristic)*

86105C Module Specifications

Optical Channel Specifications

Item	Description
Optical Channel Bandwidth (–3 dBo, unfiltered)	8.5 GHz *(9 GHz characteristic)*
Nominal Wavelength Range	750 to 1650 nm
Calibrated Wavelengths (OE conversion gains)	850 nm/1310 nm/1550 nm (±20 nm)
Option 86105C-100 Series Low-Rate Receiver Filters/Data Rates (Four series-100 options installed in 86105C with 86105C-100)	
86105C-110	OC-3/STM-1, 155 Mb/s
86105C-120	OC-12/STM-4, 622 Mb/s, (Also covers 614 Mb/s)
86105C-130	1x Fibre Channel, 1.063 Gb/s
86105C-140	GPON, 1.244Gb/s and Gigabit Ethernet, 1.250 Gb/s (Also covers 1.229 Mb/s)
86105C-150	2x Fibre Channel, 2.125 Gb/s
86105C-160	OC-48/STM-16, 2.488 Gb/s and 2 Gb Ethernet, 2.500 Gb/s (Also covers 2.458 Gb/s)
86105C-170	OC-48/STM-16 FEC, 2.666 Gb/s
86105C-180	10 Gb Ethernet LX-4, 3.125 Gb/s (Also covers 3.072 Gb/s)
86105C-190	4x Fibre Channel, 4.25 Gb/s
86105C-193	PCIe-2/2x InfiniBand, 5.000 Gb/s
86105C-195	2x XAUI, 6.250 Gb/s (Also covers 6.144 Gb/s)
86105C-197	8x Fibre Channel, 8.500 Gb/s
Option 86105C-200 Receiver Filters/Data Rates (Includes all of the following multiple 10 Gb/s Receiver Filters)	OC-192/STM-64, 9.953 Gb/s 10Gb Ethernet, 10.3125 Gb/s 10x Fibre Channel, 10.51875 Gb/s OC-192/STM-64 FEC, 10.664 Gb/s OC-192/STM-64 FEC, 10.709 Gb/s 10 Gb Ethernet FEC, 11.0957 Gb/s 10x Fibre Channel FEC, 11.317 Gb/s

Option 300 Receiver Filters/Data Rates	
Option 86105C-300 is a combination of four series 86105C-100 low-rate receiver filters and the 86105C-200 10 Gb/s receiver filters.	
Measured frequency response data during recertification falls within Performance Test line limits with allowance for system-to-system measurement uncertainty.	
Sensitivity at 850 nm. (Characteristic - smallest average power for mask test)	
≤ 2.666 Gb/s *> 2.666 Gb/s to ≤ 4.25 Gb/s* *> 4.25 Gb/s to 11.3 Gb/s*	*–20 dBm* *–19 dBm* *–16 dBm*
Sensitivity at 1310 nm / 1550 nm. (Characteristic - smallest average power for mask test)	
≤ 2.666 Gb/s *> 2.666 Gb/s to ≤ 4.25 Gb/s* *> 4.25 Gb/s to 11.3 Gb/s*	*–21 dBm* *–20 dBm* *–17 dBm*
Transition Time (10% to 90% calculated from TR = 0.48/BW optical)	56 ps

RMS Noise at 850 nm	
≤ 2.666 Gb/s *> 2.666 Gb/s to ≤ 4.25 Gb/s* *> 4.25 Gb/s to 11.3 Gb/s*	*1.3 µW (Characteristic)* *1.5 µW (Characteristic)* *2.5 µW (Characteristic)*
≤ 2.666 Gb/s > 2.666 Gb/s to ≤ 4.25 Gb/s > 4.25 Gb/s to 11.3 Gb/s	2.0 µW (Maximum) 2.5 µW (Maximum) 4.0 µW (Maximum)
RMS Noise at 1310 nm / 1550 nm	
≤ 2.666 Gb/s *> 2.666 Gb/s to ≤ 4.25 Gb/s* *> 4.25 Gb/s to 11.3 Gb/s*	*0.8 µW (Characteristic)* *1.0 µW (Characteristic)* *1.4 µW (Characteristic)*
≤ 2.666 Gb/s > 2.666 Gb/s to ≤ 4.25 Gb/s > 4.25 Gb/s to 11.3 Gb/s	1.3 µW (Maximum) 1.5 µW (Maximum) 2.5 µW (Maximum)
Scale Factor (per division)	
Minimum	2 µW
Maximum	100 µW
CW Accuracy (single marker, referenced to average power monitor)	
Single Mode	±25 µW ±3%
Multimode	±25 µW ±10%

CW Offset Range (referenced two divisions from screen bottom)	+0.2 mW to –0.6 mW
Average Power Monitor	–30 dBm to 0 dBm
Average Power Monitor Accuracy	
Single Mode	±5% ± 200 nW ± connector uncertainty
Multimode (characteristic)	*±10% ± 200 nW ± connector uncertainty*
Due to variations in mode-filling conditions, the measured power in multimode fiber will vary more than the measured power in single-mode fiber. For users needing the most accurate power measurements, use an optical power meter for multimode power measurements.	
User Calibrated Accuracy (Assumes connector is continually attached)	
Single Mode	±3% ± 200 nW ± power meter uncertainty, < 5°C change
Multimode (characteristic)	*±10% ± 200 nW ± power meter uncertainty, < 5°C change*
Maximum Input Power	
Maximum Non-destruct Average	0.5 mW (–3 dBm)
Maximum Non-destruct Peak	5 mW (+7 dBm)
Input Return Loss (HMS-10 connector fully filled fiber)	
850 nm	> 13 dB
1310 nm / 1550 nm	> 24 dB
Fiber Input	62.5/125 µm
Connector for fiber input is user-selectable.	

Electrical Channel Specifications

Item	Description
Electrical Channel Bandwidth	12.4 and 20 GHz
Transition Time (10% to 90% calculated from TR = 0.35/BW)	
12.4 GHz	28.2 ps
20 GHz	17.5 ps
RMS Noise	
Characteristic	*0.25 mV (12.4 GHz)* *0.5 mV (20 GHz)*
Maximum	0.5 mV (12.4 GHz) 1 mV (20 GHz)

Scale Factor (full height is eight divisions)	
Minimum	1 mV/division
Maximum	100 mV/division
DC Accuracy (single marker)	
12.4 GHz	±0.4% of full scale ± 2 mV ± 1.5% of (reading – channel offset)
20 GHz	±0.4% of full scale ±2 mV ± 3% of (reading – channel offset)
DC Offset Range (referenced to center of display graticule)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	±2 V DC (+16 dBm)
Nominal Impedance	50 ohm
Reflections (for 30 ps rise time)	5%
Electrical Input	3.5 mm (male)

86105D Module Specifications

Optical Channel Specifications

Item	Description
Optical Channel Bandwidth (-3 dBo, unfiltered)	*20 GHz (dBo), characteristic* *34 GHz (dBo), characteristic (Option 281)*
Nominal Wavelength Range	750 to 1650 nm
Calibrated Wavelengths (OE conversion gains)	850 nm/1310 nm/1550 nm (±20 nm)
Receiver Filters/Data Rates	8x Fibre Channel (8.500 Gb/s), per T11 FC-PI-4 OC-192/STM-64 (9.953 Gb/s) 10Gb Ethernet (10.3125 Gb/s) 10x Fibre Channel (10.51875 Gb/s) OC-192/STM-64 FEC (10.664 Gb/s) OC-192/STM-64 FEC (10.709 Gb/s) 10 Gb Ethernet FEC (11.0957 Gb/s) 10x Fibre Channel FEC (11.317 Gb/s) 16x Fibre Channel (14.025 Gb/s) 15 Gb (Option 281) 25 Gb Ethernet (25.78125 Gb/s) (Option 281) 25 Gb Ethernet FEC (27.7393 Gb/s) (Option 281) OTU4 FEC / ITU-T G.959.1 (27.952 Gb) (Option 281) 32x Fibre Channel (28.05 Gb/s) (Option 281)

Optical Sensitivity (smallest average power for mask test) *Characteristic*	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s	*–9 dBm*	*–12 dBm*	*–12 dBm*
14.025 Gb/s	*–6 dBm*	*–9 dBm*	*–9 dBm*
15.0 Gb/s *(Option 281)*	*–9 dBm*	*–8 dBm*	*–8 dBm*
25.78125 Gb/s *(Option 281)*	*–6 dBm*	*–7 dBm*	*–8 dBm*
27.7393 Gb/s to 28.05 Gb/s *(Option 281)*	*–5 dBm*	*–6 dBm*	*–7 dBm*
Transition Time (10% to 90% calculated from TR = 0.48/BW optical in unfiltered BW)	24 ps 15 ps (Option 281)		

RMS Noise *(Characteristic)*	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s	*10 µW*	*5 µW*	*5 µW*
14.025 Gb/s	*16 µW*	*8 µW*	*8 µW*
15.0 Gb/s *(Option 281)*	*9 µW*	*7 µW*	*8 µW*
25.78125 Gb/s *(Option 281)*	*17 µW*	*13 µW*	*15 µW*
27.7393 Gb/s *(Option 281)*	*18 µW*	*15 µW*	*17 µW*
27.952 Gb/s *(Option 281)*	*18 µW*	*15 µW*	*17 µW*
28.05 Gb/s *(Option 281)*	*18 µW*	*15 µW*	*17 µW)*
Unfiltered *(Option 281)*	*25 µW*	*18 µW*	*21 µW*
RMS Noise (Maximum)	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s	12 µW	7 µW	7 µW
14.025 Gb/s	24 µW	12 µW	12 µW
Scale Factor (per division)	20 µW minimum 500 µW maximum		
CW Accuracy over Temperature Range +20 °C to + 30 °C (single marker, referenced to average power monitor)			
8.5 Gb/s to 11.317 Gb/s	±25 µW ±2%		
14.025 Gb/s	±25 µW ±4%		
Unfiltered	±25 µW ±4%		
15.0 Gb/s *(Option 281)* *(characteristic)*	*±25 µW ±4%*		
25.78125 Gb/s *(Option 281)* *(characteristic)*	*±25 µW ±6%*		
27.7393 Gb/s to 28.05 Gb/s *(Option 281)* *(characteristic)*	*±25 µW ±6%*		
Unfiltered *(Option 281)* *(characteristic)*	*±25 µW ±6%*		

CW Offset Range (referenced two divisions from screen bottom)	+1 mW to –3 mW		
Average Power Monitor Operating Range *(characteristic)*	*–30 dBm to +3 dBm*		
Average Power Monitor Range Accuracy for Factory Calibrations *(characteristic)* *Due to variations in mode-filling conditions, the measured power in multimode fiber will vary more than the measured power in single-mode fiber. For users needing the most accurate power measurements, use an optical power meter for multimode power measurements.*			
1550 nm single mode	*±5% ± 200 nW ± connector uncertainty*		
1550 nm single mode *(Option 281)*	*±5% ± 200 nW ± connector uncertainty*		
1310 nm single mode	*±5% ± 200 nW ± connector uncertainty*		
1310 nm single mode *(Option 281)*	*±5% ± 200 nW ± connector uncertainty*		
850 nm multimode	*±10% ± 200 nW ± connector uncertainty*		
850 nm multimode *(Option 281)*	*±10% ± 200 nW ± connector uncertainty*		
Average Power Monitor Range Accuracy for User Calibrations *(characteristic)*. (Assumes connector is continually attached)			
1550 nm single mode	*±3% ± 200 nW ± power meter uncertainty*		
1550 nm single mode *(Option 281)*	*±3% ± 200 nW ± connector uncertainty*		
1310 nm single mode	*±3% ± 200 nW ± power meter uncertainty*		
1310 nm single mode *(Option 281)*	*±3% ± 200 nW ± connector uncertainty*		
850 nm multimode	*±10% ± 200 nW ± power meter uncertainty*		
850 nm multimode *(Option 281)*	*±10% ± 200 nW ± connector uncertainty*		
Maximum Input Power Maximum Non-destruct Average	850 nm	1310 nm	1550 nm
Standard *Option 281*	5 mW (7 dBm) 3 mW (5 dBm)	5 mW (7 dBm) 6 mW (8 dBm)	5 mW (7 dBm) 6 mW (8 dBm)
Maximum Input Power Maximum Non-destruct Peak (<10 ns duration, maximum 50% duty cycle)	850 nm	1310 nm	1550 nm
Standard *Option 281*	10 mW (10 dBm) 5 mW (7 dBm)	10 mW (10 dBm) 10 mW (10 dBm)	10 mW (10 dBm) 10 mW (10 dBm)
Polarization Dependent Loss at 1550 nm	*0.2 dB (characteristic)*		
Input Return Loss (HMS-10 connector fully filled fiber) *(characteristic)*	850 nm	1310 nm	1550 nm
Standard *Option 281*	*> 14 dB* *> 13 dB*	*> 24 dB* *> 24 dB*	*> 24 dB* *> 24 dB*

Fiber Input	62.5/125 µm
Fiber Input Connector	User selectable

Item	Description
Electrical Channel Bandwidth	*25 GHz and 35 GHz (characteristic)* *25 GHz and 50 GHz (characteristic) (Option 281)*
Transition Time (10% to 90% calculated from TR = 0.35/BW)	
35 GHz	10.0 ps
25 GHz	17.5 ps
25 GHz *(Option 281)*	17.5 ps
50 GHz *(Option 281)*	7 ps
RMS Noise	
35 GHz BW setting	1 mV *(0.5 mV characteristic)*
25 GHz BW setting	0.5 mV *(0.25 mV characteristic)*
25 GHz BW setting *(Option 281)*	0.7 mV *(0.4 mV characteristic)*
50 GHz BW setting *(Option 281)*	1.0 mV *(0.6 mV characteristic)*
Scale Factor (full height is eight divisions)	
Minimum	1 mV/division
Maximum	100 mV/division
DC Accuracy (single marker)	
35 GHz BW setting	±0.4% of full scale ± 2 mV ±3% of (reading – channel offset)
25 GHz BW setting	±0.4% of full scale ±2 mV ±1.5% of (reading – channel offset)
25 GHz BW setting *(Option 281)*	±0.4% of full scale ±2 mV ±1.5% of (reading – channel offset)
50 GHz BW setting *(Option 281)*	±0.4% of full scale ±2 mV ± 2% of (reading – channel offset)
DC Offset Range (referenced to center of display graticule)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2V DC (+16 dBm)
Nominal Impedance	50 ohm
Reflections (for 30 ps rise time)	*5% (characteristic)* *5% (characteristic) (Option 281)*
Electrical Input	3.5 mm (male) 2.4 mm (male) (Option 281)

86108B Module Specifications

Item	Option LBW	Option HBW
Bandwidth (two user settings)	*20 GHz (characteristic)* and 35 GHz	*35 GHz (characteristic)* and 50 GHz
Risetime (10% to 90%)	*10 ps (characteristic)*	*7 ps (characteristic)*
RMS noise		
Characteristic	*300 µV (20 GHz)* *500 µV (35 GHz)*	*600 µV (35 GHz)* *800 µV (50 GHz)*
Maximum	350 µV (20 GHz) 700 µV (35 GHz)	750 µV (35 GHz) 0.98 mV (50 GHz)
Scale Factor (per division)		
Minimum	1 mV/division	
Maximum	140 mV/division	
DC accuracy (single marker)	±0.7% of full scale ±2 mV ± 1.5% of (reading – channel offset) (20 GHz) ±0.7% of full scale ±2 mV ± 3% of (reading – channel offset) (35 GHz)	±0.7% of full scale ±2 mV ± 1.5% of (reading – channel offset) (35 GHz) ±0.7% of full scale ±2 mV ± 3% of (reading – channel offset) (50 GHz)
CW offset range (referenced from center of screen)	±560 mV	
Input dynamic range (relative to channel offset)	±560 mV	
Maximum input signal	±2.5 Vdc (+18 dBm)	
Random jitter (clock recovery and precision timebase configuration)	*< 60 fs (characteristic)*, < 90 fs maximum Verified with maximum input signal (approximately 1 Vpp at 8 GHz)	*< 45 fs (characteristic)*, < 70 fs maximum Verified with maximum input signal (approximately 1 Vpp at 16 GHz)
Random jitter (clock recovery without precision timebase active)	*< 1.25 ps (characteristic)*	
Effective trigger-to-sample delay (clock recovery and precision timebase configuration)	*< 200 ps characteristic)*, < 350 ps maximum	

Characteristic jitter (trigger signal applied to precision timebase input) Verified with maximum input signal (approximately 1.2 Vpp @ 12 GHz)	*60 fs (characteristic)*	
Maximum jitter (trigger signal applied to precision timebase input) Verified with maximum input signal (approximately 1.2 Vpp @ 12 GHz)	< 100 fs	
Precision timebase reference input	2 to 13.5 GHz *1 to 18 GHz (characteristic)*	
Precision timebase reference input amplitude	*1.0 to 1.6 Vpp (characteristic)*	
Precision timebase input signal type The precision timebase performs optimally with a sinusoidal input. Non-sinusoidal signals will operate with some degradation in timebase linearity.	Sinusoid	
Precision timebase maximum input level	±2V (16 dBm)	
Precision timebase maximum DC offset level	±200 mV	
Precision timebase input impedance	50 ohm	
Precision timebase connector type	3.5 mm male	
Timebase resolution (with precision timebase active)	0.5 ps/div	
Timebase resolution (precision timebase disabled)	2 ps/div	
Nominal impedance	*50 ohm*	
Reflections (for 30 ps rise time)	*5%*	
Electrical Input	3.5 mm (male)	2.4 mm (male)
CH1 to CH2 skew	*< 10 ps (characteristic)*	

Clock Recovery Specifications

Item	Option LBW	Option HBW
Data rates input range	Continuous tuning 0.05 to 16 Gb/s	Continuous tuning 0.05 to 32 Gb/s
Clock frequency input range	Continuous tuning 0.025 to 8 GHz	Continuous tuning 0.025 to 16 GHz
Minimum input level to acquire lock	175 mVpp to 28 Gb/s, *150 mVpp to 32 Gb/s (typical)*	
Recovered clock random jitter Used as internal trigger or at clock output port. This is not taking advantage of the 86108B precision timebase. With precision timebase enabled, system jitter approaches 60 fs for best performance.	*300 fs @ <2 Gb/s (characteristic)* *200 fs @ ≥2 Gb/s (characteristic)*	
Clock recovery adjustable loop bandwidth range (user selectable)	0.015 to 20 MHz	

Clock recovery loop peaking range	Up to 4 settings (dependent on loop BW)
Loop bandwidth accuracy	*± 30%, characteristic*
Tracking range (includes spread-spectrum tracking)	*± 2500 ppm ± 0.25%, characteristic*
Acquisition range	*± 5000 ppm, characteristic*
Maximum consecutive identical digits to lock	*150, characteristic*
Auto relocking	If signal lock is lost, system can automatically attempt to regain phase lock. User selectable to enable or disable.
Residual spread spectrum	*–84 dB ±3 dB at 33 kHz, characteristic*
Phase noise accuracy	*30%, characteristic*
Front panel recovered clock amplitude	*420 mV @ 1.25 GHz, (characteristic)*
Front panel recovered clock divide ratio (user selectable)	1, 2, 4, 8, 16
Rear panel recovered clock divide ratio (user selectable)	1, 2, 4, 8, 16
Recovered clock front panel connector type	SMA
Internal frequency counter accuracy	± 10 ppm

86112A Module Specifications

Item	Description
Electrical Channel Bandwidth	
Standard	≥12.4 GHz and ≥ 20 GHz
Option HBW	≥12.4 GHz and ≥ 30 GHz
Transition Time (10% to 90% calculated from TR = 0.35/BW)	
12.4 GHz	≤ 28.2 ps
20 GHz	≤ 17.5 ps
30 GHz (Option HBW)	≤ 11.7 ps

RMS Noise	
12.4 GHz	0.5 mV, maximum *0.25 mV, characteristic*
20 GHz	1.0 mV, maximum *0.5 mV, characteristic*
30 GHz (Option HBW)	1.0 mV, maximum *0.5 mV, characteristic*
Scale Factor (full height is eight divisions)	
Minimum	1 mV/division
Maximum	100 mV/division
dc Accuracy (single marker)	
12.4 GHz	±0.4% of full scale ±2 mV ± 1.5% of (reading – channel offset)
20 GHz	±0.4% of full scale ±2 mV ± 3% of (reading – channel offset)
30 GHz (Option HBW)	±0.4% of full scale ±2 mV ± 3% of (reading – channel offset)
Offset Range (referenced to center of display graticule)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2 Vdc (+16 dBm)
Nominal Impedance	50 ohm
Reflections (for 30 ps rise time)	5%
Electrical Input	3.5 mm

86115D Module Specifications

Item	Description
Optical Channel Bandwidth (-3 dBo, unfiltered)	*20 GHz (dBo), characteristic* *34 GHz (dBo), characteristic (Option 282)*
Nominal Wavelength Range	750 to 1650 nm
Calibrated Wavelengths (OE conversion gains)	850 nm/1310 nm/1550 nm (±20 nm)

Receiver Filters/Data Rates	8x Fibre Channel (8.500 Gb/s), per T11 FC-PI-4 OC-192/STM-64 (9.953 Gb/s) 10Gb Ethernet (10.3125 Gb/s) 10x Fibre Channel (10.51875 Gb/s) OC-192/STM-64 FEC (10.664 Gb/s) OC-192/STM-64 FEC (10.709 Gb/s) 10 Gb Ethernet FEC (11.0957 Gb/s) 10x Fibre Channel FEC (11.317 Gb/s) 16x Fibre Channel (14.025 Gb/s) 15 Gb (Option 282) 25 Gb Ethernet (25.78125 Gb/s) (Option 282) 25 Gb Ethernet FEC (27.7393 Gb/s) (Option 282) OTU4 FEC / ITU-T G.959.1 (27.952 Gb) (Option 282) 32x Fibre Channel (28.05 Gb/s) (Option 282)		
Optical Sensitivity (smallest average power for mask test) *Characteristic*	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s *(Option 002)* 8.5 Gb/s to 11.317 Gb/s *(Option 004)*	*–9 dBm* *–8 dBm*	*–12 dBm* *–11 dBm*	*–12 dBm* *–11 dBm*
14.025 Gb/s *(Option 002)* 14.025 Gb/s *(Option 004)*	*–6 dBm* *–5 dBm*	*–9 dBm* *–8 dBm*	*–9 dBm* *–8 dBm*
15.0 Gb/s *(Option 282)*	*–9 dBm*	*–8 dBm*	*–8 dBm*
25.78125 Gb/s *(Option 282)*	*–6 dBm*	*–7 dBm*	*–8 dBm*
27.7393 Gb/s to 28.05 Gb/s *(Option 282)*	*–5 dBm*	*–6 dBm*	*–7 dBm*
Transition Time (10% to 90% calculated from TR = 0.48/BW optical in unfiltered BW)	24 ps 15 ps (Option 282)		

RMS Noise *(Characteristic)*	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s *(Option 002)* 8.5 Gb/s to 11.317 Gb/s *(Option 004)*	*10 µW* *12 µW*	*5 µW* *6 µW*	*5 µW* *6 µW*
14.025 Gb/s *(Option 002)* 14.025 Gb/s *(Option 004)*	*16 µW* *20 µW*	*8 µW* *10 µW*	*8 µW* *10 µW*
15.0 Gb/s *(Option 282)*	*9 µW*	*7 µW*	*8 µW*
25.78125 Gb/s *(Option 282)*	*17 µW*	*13 µW*	*15 µW*
27.7393 Gb/s *(Option 282)*	*18 µW*	*15 µW*	*17 µW*
27.952 Gb/s *(Option 282)*	*18 µW*	*15 µW*	*17 µW*
28.05 Gb/s *(Option 282)*	*18 µW*	*15 µW*	*17 µW*
Unfiltered *(Option 282)*	*25 µW*	*18 µW*	*21 µW*
RMS Noise (Maximum)	850 nm	1310 nm	1550 nm
8.5 Gb/s to 11.317 Gb/s *(Option 002)* 8.5 Gb/s to 11.317 Gb/s *(Option 004)*	12 µW 14 µW	7 µW 8.5 µW	7 µW 8.5 µW
14.025 Gb/s *(Option 002)* 14.025 Gb/s *(Option 004)*	24 µW 30 µW	12 µW 14 µW	12 µW 14 µW
Scale Factor (per division)	20 µW minimum 500 µW maximum		

CW Accuracy over Temperature Range +20 °C to + 30 °C (single marker, referenced to average power monitor)	
8.5 Gb/s to 11.317 Gb/s	±25 µW ±2%
14.025 Gb/s	±25 µW ±4%
Unfiltered	±25 µW ±4%
15.0 Gb/s *(Option 282)* *(characteristic)*	*±25 µW ±4%*
25.78125 Gb/s *(Option 282)* *(characteristic)*	*±25 µW ±6%*
27.7393 Gb/s to 28.05 Gb/s *(Option 282)* *(characteristic)*	*±25 µW ±6%*
Unfiltered *(Option 282)* *(characteristic)*	*±25 µW ±6%*
CW Offset Range (referenced two divisions from screen bottom)	+1 mW to –3 mW
Average Power Monitor Operating Range *(characteristic)*	*–30 dBm to +3 dBm*
Average Power Monitor Range Accuracy for Factory Calibrations *(characteristic)* *Due to variations in mode-filling conditions, the measured power in multimode fiber will vary more than the measured power in single-mode fiber. For users needing the most accurate power measurements, use an optical power meter for multimode power measurements.*	
1550 nm single mode *(Option 002)*	*±5% ± 200 nW ± connector uncertainty*
1550 nm single mode (*Option 004)*	*±5% ± 200 nW ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*
1550 nm single mode *(Option 282)*	*±5% ± 200 nW ± power meter uncertainty ± connector uncertainty*
1310 nm single mode *(Option 002)*	*±5% ± 200 nW ± connector uncertainty*
1310 nm single mode *(Option 004)*	*±5% ± 200 nW ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*
1310 nm single mode *(Option 282)*	*±5% ± 200 nW ± power meter uncertainty ± connector uncertainty*
850 nm multimode *(Option 002)*	*±10% ± 200 nW ± connector uncertainty*
850 nm multimode *(Option 004)*	*±10% ± 200 nW ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*
850 nm multimode *(Option 282)*	*±10% ± 200 nW ± power meter uncertainty ± connector uncertainty*

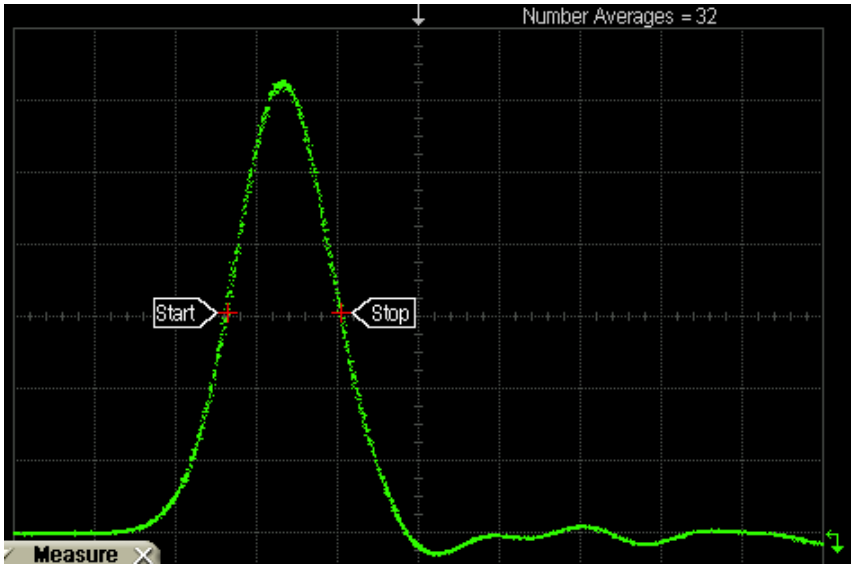
Average Power Monitor Range Accuracy for User Calibrations *(characteristic)*. (Assumes connector is continually attached)			
1550 nm single mode *(Option 002)*	*±3% ± 200 nW ± power meter uncertainty ± connector uncertainty*		
1550 nm single mode *(Option 004)*	*±3% ± 200 nW ± power meter uncertainty ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*		
1550 nm single mode *(Option 282)*	*±3% ± 200 nW ± connector uncertainty*		
1310 nm single mode *(Option 002)*	*±3% ± 200 nW ± power meter uncertainty ± connector uncertainty*		
1310 nm single mode *(Option 004)*	*±3% ± 200 nW ± power meter uncertainty ± connector uncertainty ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*		
1310 nm single mode *(Option 282)*	*±3% ± 200 nW ± connector uncertainty*		
850 nm multimode *(Option 002)*	*±10% ± 200 nW ± power meter uncertainty ± connector uncertainty*		
850 nm multimode *(Option 004)*	*±10% ± 200 nW ± power meter uncertainty ± connector uncertainty ± 0.1% * (ambient temperature – 25°C)*		
850 nm multimode *(Option 282)*	*±10% ± 200 nW ± connector uncertainty*		
Maximum Input Power Maximum Non-destruct Average	850 nm	1310 nm	1550 nm
Standard *Option 282*	5 mW (7 dBm) 3 mW (5 dBm)	5 mW (7 dBm) 6 mW (8 dBm)	5 mW (7 dBm) 6 mW (8 dBm)
Maximum Input Power Maximum Non-destruct Peak (<10 ns duration, maximum 50% duty cycle)	850 nm	1310 nm	1550 nm
Standard *Option 282*	10 mW (10 dBm) 5 mW (7 dBm)	10 mW (10 dBm) 10 mW (10 dBm)	10 mW (10 dBm) 10 mW (10 dBm)
Polarization Dependent Loss at 1550 nm	*0.2 dB (characteristic)*		
Input Return Loss (HMS-10 connector fully filled fiber) *(characteristic)*	850 nm	1310 nm	1550 nm
Standard *Option 282*	*> 14 dB* *> 13 dB*	*> 24 dB* *> 24 dB*	*> 24 dB* *> 24 dB*
Fiber Input	62.5/125 µm		
Fiber Input Connector	User selectable		

86116C Module Specifications

Optical Channel Specifications (option 025):

Item	Description
Wavelength Range	1300 nm to 1620 nm
Fiber Input	9/125 µm, straight. Connector for fiber input is user-changeable.
Reference Receiver Data Rates	17.0, 25.8, 27.7 Gb/s
Calibrated Wavelength (DC Responsivity)	1310 nm and 1550 nm
Optical Bandwidth (Unfiltered) –3 dB optical (–6 dB electrical). Calculated from optical impulse pulse width measurements on a 1550 nm optical impulse: BW = 0.48/FWHM.	> 40 GHz *45 GHz (characteristic)*
Sensitivity at 27.7 Gb/s	
1310 nm 1550 nm	*–7 dBm (characteristic)* *–8 dBm (characteristic)*
Sensitivity at 25.8 Gb/s	
1310 nm 1550 nm	*–8 dBm (characteristic)* *–9 dBm (characteristic)*
Sensitivity at 17 Gb/s	
1310 nm 1550 nm	*–9 dBm (characteristic)* *–10 dBm (characteristic)*
Peak Amplitude	
Non-destructive	10 mW average
Displayed peak	4 mW
Impulse Rise Time at 40 GHz BW (10% to 90% measured from impulse response)	*9 ps (characteristic)*

Optical FWHM at 40 GHz BW. Measured with 1550 nm optical impulse with a pulse of 700 fs FWHM, 5 MHz repetition rate, and 4 mW peak power. System jitter less than 800 fs RMS.
Description: *12 ps (characteristic)*



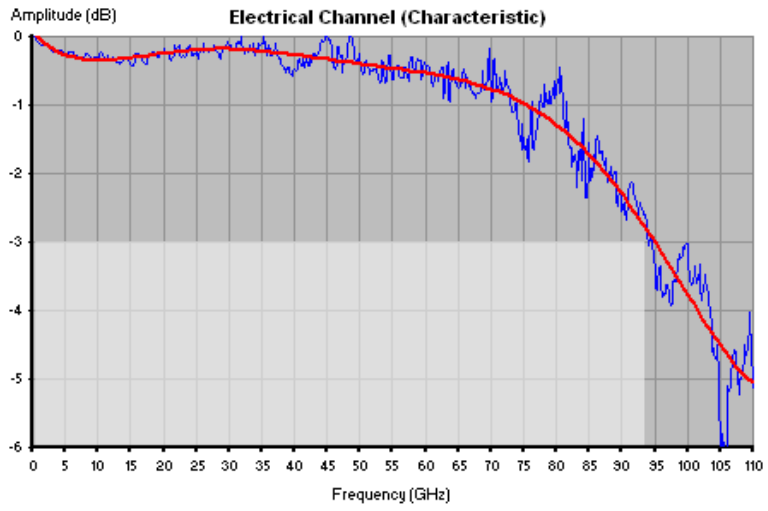
Polarization Dependent Loss (PDL)	*< 0.8 dB (characteristic)*
Optical Noise (1310 nm) The noise specification is over the full temperature range of +10° C to +40° C.	
40 GHz Setting	120 µW *60 µW), characteristic*
27.7 Gb/s Setting	30 µW *20 µW, characteristic*
25.8 Gb/s Setting	20 µW *17 µW, characteristic*
17.0 Gb/s Setting	18 µW *13 µW, characteristic*
Optical Noise (1550 nm) The noise specification is over the full temperature range of +10° C to +40° C.	
40 GHz Setting	80 µW *40 µW), characteristic*
27.7 Gb/s Setting	21 µW *14 µW, characteristic*
25.8 Gb/s Setting	18 µW *12 µW, characteristic*
17.0 Gb/s Setting	15 µW *10 µW, characteristic*
Scale Factor (full height is eight divisions)	
Maximum Minimum	500 µW/division 20 µW/division
CW Optical Power Accuracy (single marker, referenced to average power monitor)	±150 µW ±4% of (reading – channel offset)
CW Optical Power Offset (referenced two divisions from screen bottom)	–3 mW to + 1 mW

Average Optical Power Monitor (1300 nm — 1330 nm, 1480 nm — 1620 nm)	–23 dBm to +6 dBm (5 µW to 4 mW)
Average Optical Power Factory Calibrated Accuracy Conditions: CW optical power only (no modulation)	±5% ± 100 nW ± connector uncertainty, 20°C to 30°C
Average Optical Power User Calibrated Accuracy Conditions: CW optical power only (no modulation)	±5% ± 100 nW ± connector uncertainty, 20° C to 30° C ±2% ± 100 nW power meter uncertainty, < 5° C change
Maximum Input Average Optical Power	
Maximum Displayed Peak	4 mW (+6 dBm)
Maximum Linear Peak	*3 mW (+4.8 dBm) (characteristic)*
Maximum Non-destruct Peak	*40 mW (+16 dBm), or 0.25 pJ per pulse, whichever is less (characteristic)*
Maximum Non-destruct average	*10 mW (+10 dBm) (characteristic)*
Maximum non-destruct power is related to the fill factor (duty cycle) of the RZ waveform. The factory specification is defined by using a 20% filled 40 Gb/s pulse train (in other words, 5 ps FWHM and 25 ps period). This concept can also be specified as maximum non-destruct pulse energy. The factory specification is specified with 5 ps FWHM optical pulses and maximum non-destruct power providing that the individual pulse shape is square.	
Input Return Loss (HMS-10 connector fully filled fiber) Proper connector care is required to maintain this specification.	20 dB

Electrical Channel Specifications (Option 025)

Item	Description
Channel Bandwidth	80 GHz (93 GHz characteristic, see following figure), 55 GHz, and 30 GHz

This graph shows the electrical channel frequency response (characteristic) at the 80 GHz setting.
The blue curve is the unfiltered data, the red curve is a curve fit.



Risetime 10% to 90%. Calculated from tr = 0.35/BW.	
80 GHz Setting	*3.7 ps (characteristic)*
55 GHz Setting	*6.4 ps (characteristic)*
30 GHz Setting	*11.7 ps (characteristic)*

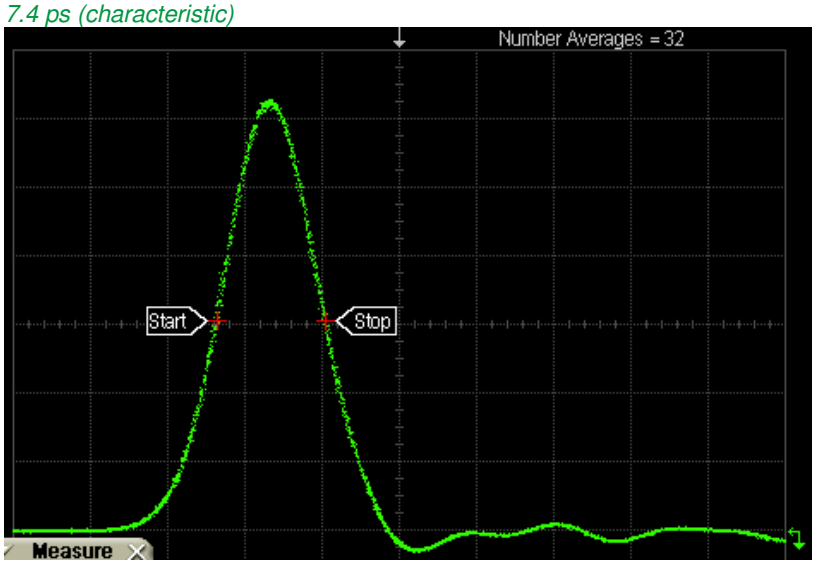
Noise Measured one standard deviation from mean.	
80 GHz Setting (best pulse fidelity)	2.2 mV, maximum *1.1 mV, characteristic*
55 GHz Setting (better sensitivity)	1.2 mV, maximum *0.6 mV, characteristic*
30 GHz Setting (best sensitivity)	0.8 mV, maximum *0.5 mV, characteristic*
Scale Factor (full height is eight divisions)	
Electrical Maximum	100 mV/division
Electrical Minimum	2 mV/division
dc Accuracy (single marker)	± 0.4% of full scale ± 3 mV ± 2% of (reading – channel offset) ± 2% of offset (all bandwidths)
Offset Range (referenced to center of display graticule)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2 Vdc (+16 dBm)
Nominal Impedance	50 ohm
Reflections (for 20 ps rise time)	10% (DC to 70 GHz) 20% (70 to 100 GHz)
Input Connector	1.85 mm, male

Optical Channel Specifications (Option 041)

Item	Description
Wavelength Range	1300 nm to 1620 nm
Fiber Input	9/125 µm, straight. Connector for fiber input is user-changeable.
Reference Receiver Data Rates	
Option 040 Option 041	39.813 Gb/s, 43.018 Gb/s 39.813 Gb/s, 41.25 Gb/s, 43.018 Gb/s
Calibrated Wavelength (DC Responsivity)	1310 nm and 1550 nm

Optical Bandwidth (Unfiltered) –3 dB optical (–6 dB electrical). Calculated from optical impulse pulse width measurements on a 1550 nm optical impulse: BW = 0.48/FWHM.	>65 GHz *70 GHz (characteristic)*
Risetime 10% to 90%. Calculated from tr = 0.35/BW.	
65 GHz Setting 60 GHz Setting 55 GHz Setting	*5.0 ps (characteristic)* *5.8 ps (characteristic)* *6.4 ps (characteristic)*
Sensitivity (at 39.8 Gb/s and 43.0 Gb/s)	
1310 nm 1550 nm	*–3 dBm (characteristic)* *–5 dBm (characteristic)*
Impulse Rise Time at 65 GHz BW (10% to 90% measured from impulse response)	*5.4 ps (characteristic)*

Optical FWHM at 65 GHz BW.
Measured with 1550 nm optical impulse with a pulse of 700 fs FWHM, 5 MHz repetition rate, and 10 mW peak power. System jitter less than 800 fs RMS.
Description:
7.4 ps (characteristic)

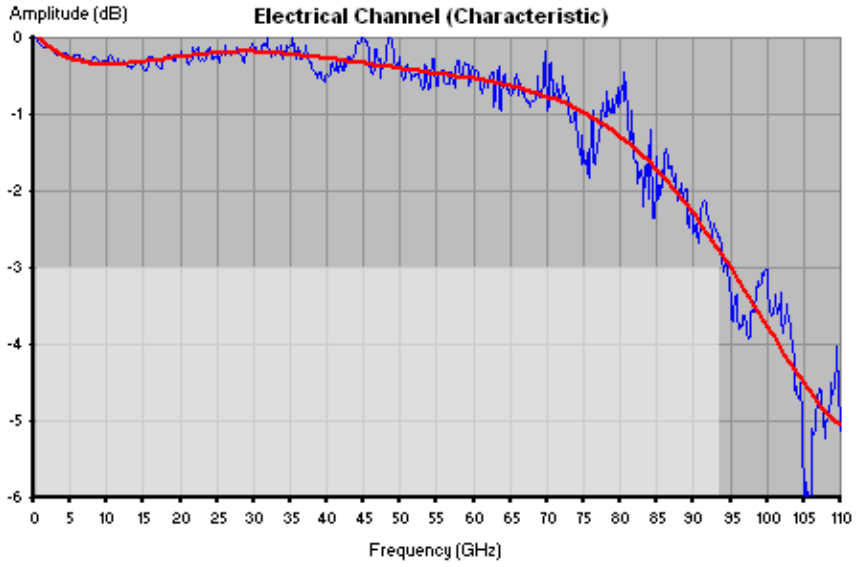


Impulse Distortion Impulse distortion (%) = [(distortion peak-to-peak)/impulse height] x 100%.	*< 10% (characteristic)*
Average Input Power for Linear Operation using 40 Gb/s RZ Signals Tested with 40 Gb/s RZ signals with pulses of 6 ps (FWHM).	*< 5 mW (characteristic)*
Polarization Dependent Loss (PDL)	*< 0.8 dB (characteristic)*

Optical Noise (1310 nm) The noise specification is over the full temperature range of +10° C to +40° C.	
65 GHz Setting	300 µW *187 µW), characteristic*
60 GHz Setting	225 µW *105 µW, characteristic*
55 GHz Setting	127 µW *75 µW, characteristic*
39.8 Gb/s and 43.0 Gb/s reference receivers	102 µW *54 µW, characteristic*
Optical Noise (1550 nm) The noise specification is over the full temperature range of +10° C to +40° C.	
65 GHz Setting	200 µW *125 µW), characteristic*
60 GHz Setting	150 µW *70 µW, characteristic*
55 GHz Setting	85 µW *50 µW, characteristic*
39.8 Gb/s and 43.0 Gb/s reference receivers	68 mµW *36 µW, characteristic*
Scale Factor (full height is eight divisions)	
Maximum	5 mW/division
Minimum	200 µW/division
CW Optical Power Accuracy (single marker, referenced to average power monitor)	±150 µW ±4% of (reading – channel offset)
CW Optical Power Offset (referenced two divisions from screen bottom)	–12 mW to +8 mW

Average Optical Power Monitor (1300—1330 nm, 1480—1620 nm)	–23 dBm to +9 dBm (5 µW to 8 mW)
Average Optical Power Factory Calibrated Accuracy Conditions: CW optical power only (no modulation).	±5% ±100 nW ±connector uncertainty, 20°C to 30°C
Average Optical Power User Calibrated Accuracy Conditions: CW optical power only (no modulation).	±5% ± 100 nW ± connector uncertainty, 20° C to 30° C ±2% ± 100 nW power meter uncertainty, < 5° C change
Maximum Input Average Optical Power	
Maximum Displayed Peak	40 mW (+16 dBm)
Maximum Linear Peak	*30 mW (+14.8 dBm), or 0.15 pJ per pulse, whichever is less (characteristic)*
Maximum Non-destruct Peak	*40 mW (+16 dBm), or 0.25 pJ per pulse, whichever is less (characteristic)*
Maximum Non-destruct average	*10 mW (+10 dBm) (characteristic)*
Maximum non-destruct power is related to the fill factor (duty cycle) of the RZ waveform. The factory specification is defined by using a 20% filled 40 Gb/s pulse train (in other words, 5 ps FWHM and 25 ps period). This concept can also be specified as maximum non-destruct pulse energy. The factory specification is specified with 5 ps FWHM optical pulses and maximum non-destruct power providing that the individual pulse shape is square.	
Input Return Loss (HMS-10 connector fully filled fiber) Proper connector care is required to maintain this specification.	20 dB

Electrical Channel Specifications (Option 041)

Item	Description
Channel Bandwidth	80 GHz (93 GHz characteristic, see following figure), 55 GHz, and 30 GHz
This graph shows the electrical channel frequency response (characteristic) at the 80 GHz setting. The blue curve is the unfiltered data, the red curve is a curve fit. 	
Risetime. 10% to 90%. Calculated from tr = 0.35/BW.	
80 GHz Setting	*3.7 ps (characteristic)*
55 GHz Setting	*6.4 ps (characteristic)*
30 GHz Setting	*11.7 ps (characteristic)*

Noise Measured one standard deviation from mean.	
80 GHz Setting (best pulse fidelity)	2.2 mV, maximum *1.1 mV, characteristic*
55 GHz Setting (better sensitivity)	1.1 mV, maximum *0.6 mV, characteristic*
30 GHz Setting (best sensitivity)	0.8 mV, maximum *0.5 mV, characteristic*
Scale Factor (full height is eight divisions)	
Electrical Maximum	100 mV/division
Electrical Minimum	2 mV/division
dc Accuracy (single marker)	± 0.4% of full scale ± 3 mV ± 2% of (reading – channel offset) ± 2% of offset (all bandwidths)
Offset Range (referenced to center of display graticule)	±500 mV

Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2Vdc (+16 dBm)
Nominal Impedance	50 ohm
Reflections (for 20 ps rise time)	10% (DC to 70 GHz) 20% (70 to 100 GHz)
Input Connector	1.85 mm, male

86118A Module Specifications

Item	Description
Electrical Channels	Two 70 GHz
Channel Skew *(Option H01 only)*	
Channel-to-Channel Skew (Internal Skew)	40 ps
Deskew Adjustment Range (Skew Range – Internal Skew)	100 ps
Bandwidth (user selectable)	
Low (Characteristic)	*> 50 GHz*
High	> 70 GHz
Transition Time (10% to 90% calculated from TR = 0.35/BW	
> 50 GHz (Characteristic)	*7.0 ps*
> 70 GHz	5.0 ps
RMS Noise	
Specified	1.3 mV, > 50 GHz 2.5 mV, > 70 GHz
Characteristic	*700 mV, > 50 GHz* *1.3 mV, > 70 GHz*
Scale Factor (full height is eight divisions)	

Minimum	2 mV/division
Maximum	100 mV/division
DC Accuracy (single marker). Specified at calibration temperature and relative humidity.	
> 50 GHz	±0.4% of full scale ±2 mV ± 2% of (reading – channel offset)
> 70 GHz	±0.4% of full scale ±2 mV ± 4% of (reading – channel offset)
DC Accuracy (single marker). Characteristic Variation from Calibration Temperature.	
> 50 GHz	*±0.1% of (reading – channel offset) per °C change from calibration*
> 70 GHz	*±0.2% of (reading – channel offset) per °C change from calibration*
DC Accuracy (single marker).. Characteristic Variation from Calibration Relative Humidity (RH).	
> 50 GHz	*±0.1% of (reading – channel offset) per 10% change from calibration*
> 70 GHz	*±0.2% of (reading – channel offset) per 10% change from calibration*
Offset Range (referenced to center of display graticule)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2Vdc (+16 dBm)
Nominal Impedance (Characteristic)	50 ohm
Reflections (Characteristic for 30 ps rise time)	20%
Electrical Input *(All options except H02)*	
Connector	1.85 mm (female)
Maximum Torque	5 lb-in
Electrical Input *(Option H02 only)*	
Connector	1.0 mm (female)
Maximum Torque	4 lb-in

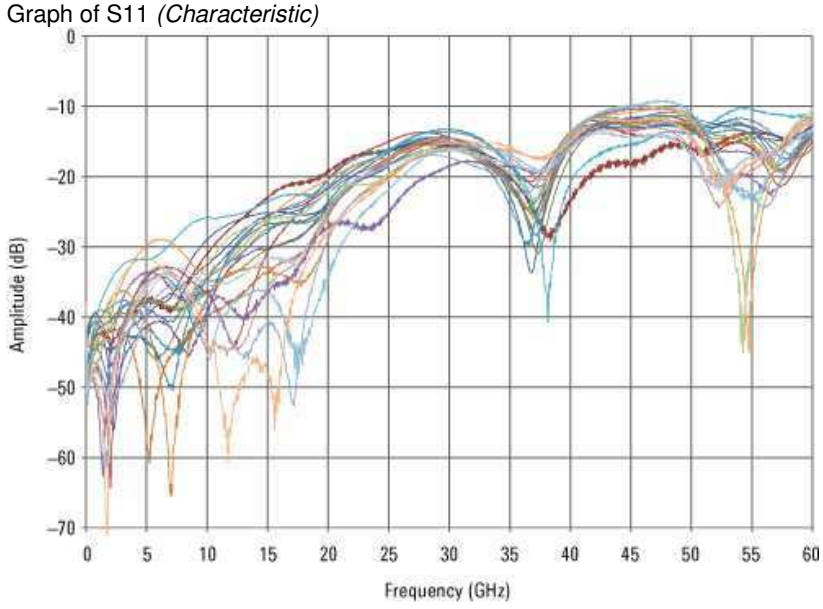
N1045A Module Specifications

Item	Description
Electrical Input Channels (per option)	
02F	2 Channel Remote Head with 1.85 mm (f) connectors.
02M	2 Channel Remote Head with 1.85 mm (m) connectors.
04F	4 Channel Remote Head with 1.85 mm (f) connectors.
04M	4 Channel Remote Head with 1.85 mm (m) connectors.
Remote Head Cable Length	The nominal length of the remote head cables is 1270 mm as measured from the module's front panel to the remote head's casing
Bandwidth, 3 dB (user selectable)	*20 GHz (Characteristic)* *35 GHz (Characteristic)* *45 GHz (Characteristic)* 60 GHz
Transition Time (10% to 90% calculated from TR = 0.35/BW)	
20 GHz BW	*17.5 ps (Calculated)*
35 GHz BW	*10 ps (Calculated)*
45 GHz BW	*7.8 ps (Calculated)*
60 GHz BW	*5.8 ps (Calculated)*
Channel-to-Channel Skew Range	±100 ps
RMS Noise	
20 GHz BW	*310 µV (Characteristic)*
35 GHz BW	*450 µV (Characteristic)*
45 GHz BW	*530 µV (Characteristic)*
60 GHz BW	*875 µV (Characteristic)*
RMS Noise *(Maximum)*	975 µV (60 GHz BW setting)

Scale Factor (per division)	
Minimum	1 mV/division
Maximum	100 mV/division
DC Accuracy (VAVG Measurement). Specified at calibration temperature ±0.5 °C. (Perform a new module calibration if hardware skew has been applied.)	
20, 35, 45, 60 GHz	*±1.15 mV (Characteristic)*
DC Accuracy (VAVG Measurement). Specified at calibration temperature ±5 °C.	
20, 35, 45, 60 GHz	±2 mV ± 4% of (reading – channel offset)
DC Offset Range (referenced to center of screen)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2V (+16 dBm)
Nominal Input Impedance	*50Ω (Characteristic)*
Reflections (for 30 ps rise time)	*20% (Characteristic)*

Input Impedance

Graph of S11 *(Characteristic)*



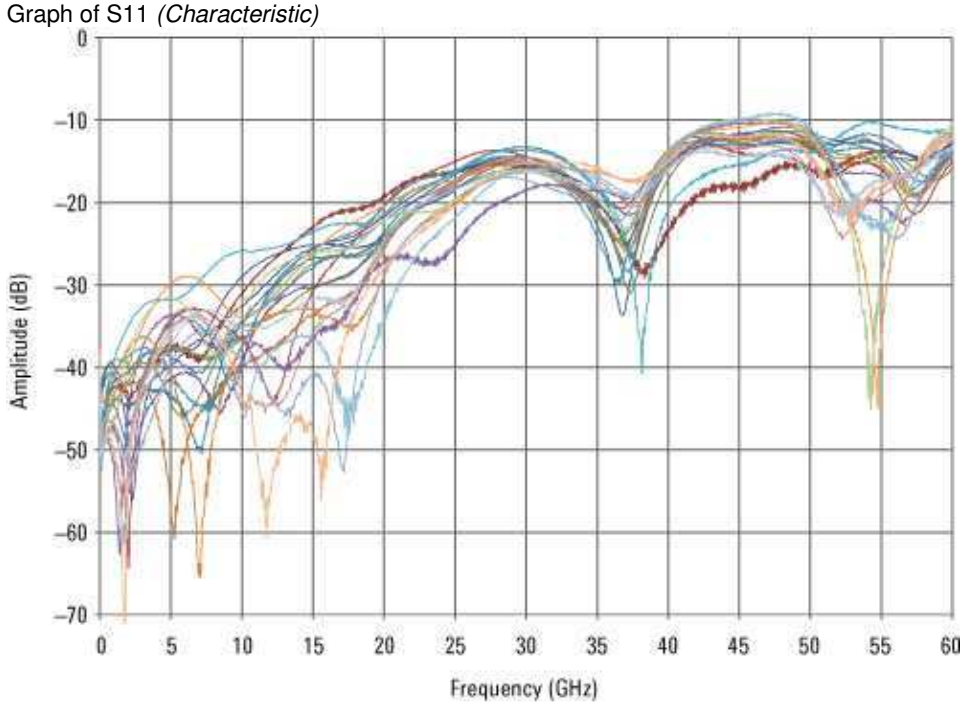
N1045B Module Specifications

Item	Description
Electrical Input Channels (per option)	
02F	2 Channel Remote Head with 1.85 mm (f) connectors.
02M	2 Channel Remote Head with 1.85 mm (m) connectors.
04F	4 Channel Remote Head with 1.85 mm (f) connectors.
04M	4 Channel Remote Head with 1.85 mm (m) connectors.
Remote Head Cable Length	The nominal length of the remote head cables is 1270 mm as measured from the module's front panel to the remote head's casing
Bandwidth, 3 dB (user selectable)	*20 GHz (Characteristic)* *35 GHz (Characteristic)* *45 GHz (Characteristic)* 60 GHz
Transition Time (10% to 90% calculated from TR = 0.35/BW)	
20 GHz BW	*17.5 ps (Calculated)*
35 GHz BW	*10 ps (Calculated)*
45 GHz BW	*7.8 ps (Calculated)*
60 GHz BW	*5.8 ps (Calculated)*
Channel-to-Channel Skew Range	±100 ps
RMS Noise	
20 GHz BW	*310 µV (Characteristic)*
35 GHz BW	*450 µV (Characteristic)*
45 GHz BW	*530 µV (Characteristic)*
60 GHz BW	*875 µV (Characteristic)*
RMS Noise *(Maximum)*	975 µV (60 GHz BW setting)

Scale Factor (per division)	
Minimum	1 mV/division
Maximum	100 mV/division
DC Accuracy (V_{AVG} Measurement). Specified at calibration temperature ±0.5 °C. (Perform a new module calibration if hardware skew has been applied.)	
20, 35, 45, 60 GHz	*±1.15 mV (Characteristic)*
DC Accuracy (V_{AVG} Measurement). Specified at calibration temperature ±5 °C.	
20, 35, 45, 60 GHz	±2 mV ± 4% of (reading – channel offset)
DC Offset Range (referenced to center of screen)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	± 2V (+16 dBm)
Maximum Sample Rate	250 kSa/s (N1000A Mainframe) 40 kSa/s (86100D Mainframe)
Nominal Input Impedance	*50Ω (Characteristic)*
Reflections (for 30 ps rise time)	*20% (Characteristic)*

Input Impedance

Graph of S11 *(Characteristic)*



N1046A Module Specifications

Maximum Bandwidth per Option

Option	*Maximum* BW								
	1 Channel			2 Channel		4 Channel			
	75 GHz	85 GHz	100 GHz	75 GHz	85 GHz	100 GHz	75 GHz	85 GHz	100 GHz
71F	♦								
81F		♦							
11F			♦						
72F				♦					
82F					♦				
12F						♦			
74F							♦		
84F								♦	
14F									♦

Specifications

Item	Description		
Bandwidth[10], 3dB (user selectable)	Options		
	71F, 72F, 74F	81F, 82F, 84F	11F, 12F, 14F
45 GHz	♦	♦	♦
60 GHz	♦	♦	♦
75 GHz	♦	♦	♦
85 GHz		♦	♦
100 GHz			♦
122 GHz (Characteristic)			♦

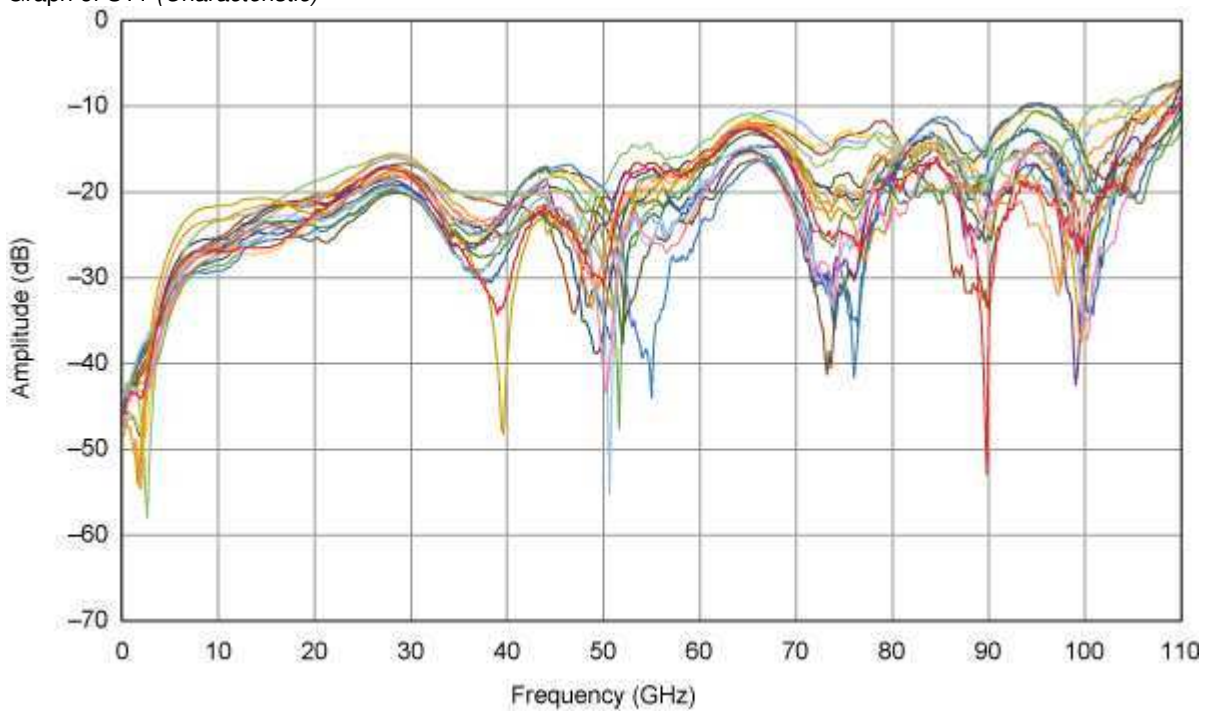
[10] Tuned to be –3 dB (±measurement uncertainty) at stated bandwidth(s), except for 122 GHz which is tuned for highest bandwidth while keeping channel noise ≤ 2.5 mV RMS.

Transition Time (10% to 90% calculated from t_r = 0.35/BW)	Options		
	71F, 72F, 74F	81F, 82F, 84F	11F, 12F, 14F
45 GHz	7.8 ps	7.8 ps	7.8 ps
60 GHz	5.9 ps	5.9 ps	5.9 ps
75 GHz	4.7 ps	4.7 ps	4.7 ps
85 GHz	—	4.2 ps	4.2 ps
100 GHz	—	—	3.5 ps
122 GHz (Characteristic)	—	—	< 3.2 ps
Remote Head Cable Length	The nominal length of the remote head cables is 1270 mm as measured from the module's front panel to the remote head's casing		
Channel-to-Channel Skew Range	±100 ps		
RMS Noise	Options		
	71F, 72F, and 74F	81F, 82F, and 84F	11F, 12F, and 14F
45 GHz	600 µV *440 µV (Characteristic)*	600 µV *440 µV (Characteristic)*	600 µV *440 µV (Characteristic)*
60 GHz	750 µV *580 µV (Characteristic)*	750 µV *580 µV (Characteristic)*	750 µV *580 µV (Characteristic)*
75 GHz	1 mV *780 µV (Characteristic)*	1 mV *780 µV (Characteristic)*	1 mV *780 µV (Characteristic)*
85 GHz	—	1200 µV *900 µV (Characteristic)*	1200 µV *900 µV (Characteristic)*
100 GHz	—	—	1400 µV *1050 µV (Characteristic)*
122 GHz (Characteristic)	—	—	*2000 µV (Characteristic)*
Scale Factor (per division)			
Minimum	1 mV/division		
Maximum	100 mV/division		
DC Accuracy (V_{AVG} Measurement)			
Specified at calibration temperature 0.5 C. (Perform a new module calibration if hardware skew has been applied.)	*±2 mV (Characteristic)*		
Specified at calibration temperature ±5 °C.	±2 mV ± 4% of (reading – channel offset)		
DC Offset Range (referenced to center of screen)	±500 mV		
Input Dynamic Range (relative to channel offset)	±400 mV		

Maximum Input Signal	± 2V (+16 dBm)
Nominal Input Impedance	*50Ω (Characteristic)*

Input Impedance

Graph of S11 *(Characteristic)*



N1055A Module Specifications

Item	Module Options (Connectors: F = female, M = male)			
	N1055A-32F N1055A-32M	N1055A-34F N1055A-34M	N1055A-52F N1055A-52M	N1055A-54F N1055A-54M
Number of Channels	2[11]	4	2[11]	4
Electrical Input[12]	2.92 mm (female or male)		1.85 mm (female or male)	
Electrical Channel Bandwidth	35 GHz[13,14]		35 GHz or 50 GHz[14]	
Receiver Transition Time (10% to 90% calculated from $T_R = 0.35/BW$)	*10 ps, characteristic*		*10 ps (35 GHz BW setting), characteristic* *7 ps (50 GHz BW setting), characteristic*	
Remote Head Cable Length	The nominal length of the remote head cables is 1270 mm as measured from the module's front panel to the remote head's casing			
Channel-to-Channel Skew Range	±150 ps			
Vertical Resolution	16 bit A/D converter			
RMS Noise	*600 µV, characteristic* 730 µV, maximum		*600 µV (35 GHz BW setting), characteristic* *750 µV (50 GHz BW setting), characteristic* 950 µV (50 GHz BW setting), maximum	
Scale Factor (Per Division)				
Minimum	1 mV / division			
Maximum	100 mV / division			

[11] Upgradable from 2 channel to 4 channel after purchase (return to Keysight).
[12] Connector style is the same on all channels and is selected at time of order.
[13] Upgradable from 35 GHz to 50 GHz after purchase (return to Keysight).
[14] Tuned to be –3 dB (±measurement uncertainty) at stated bandwidth(s) using NIST traceable swept-sine test system

DC Accuracy (V_{AVG} Measurement)	*±800 uV, characteristic* Specified at calibration temperature ±0.5° C. (Perform a new module calibration if hardware skew has been applied.)
	±2 mV ±4% of (reading–channel offset) Specified at calibration temperature ±10° C
DC Offset Range (referenced from center of screen)	±500 mV
Input Dynamic Range (relative to channel offset)	±400 mV
Maximum Input Signal	+2V / –1V
Nominal Impedance	50 ohm
Sample rate, module timebase[15]	
Option-FS1	*250 kSa/s, characteristic*
standard	*80 kSa/s, characteristic*
TDR Step Repetition Rate[15]	
Mainframe Timebase	*1 kHz to 250 kHz, characteristic*
Module timebase (standard)	*1 kHz to 80 kHz, characteristic*
Module timebase (Option FS1)	*1 kHz to 250 kHz, characteristic*

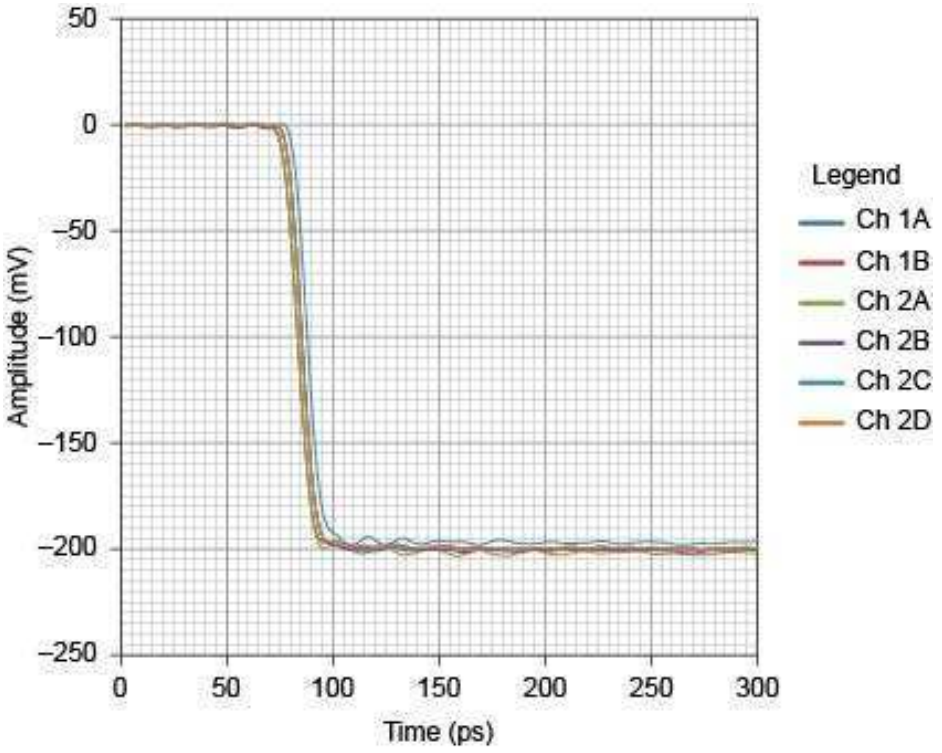
TDR System Specifications

Item	Module Options (Connectors: F = female, M = male)	
	N1055A-32F N1055A-32M N1055A-34F N1055A-34M	N1055A-52F N1055A-52M N1055A-54F N1055A-54M
Incident[16,17] TDR Step Transition Time (10 % to 90 %)		
Without TDR Calibration	< 18 ps	< 7 ps
With TDR Calibration	*Adjustable from 15 ps, characteristic*	*Adjustable from 6 ps, characteristic*
Reflected[17] TDR Step Transition Time (10% to 90%)		
Without TDR Calibration	< 20 ps	< 11 ps
With TDR Calibration	< 18 ps	*9.5 ps, characteristic*

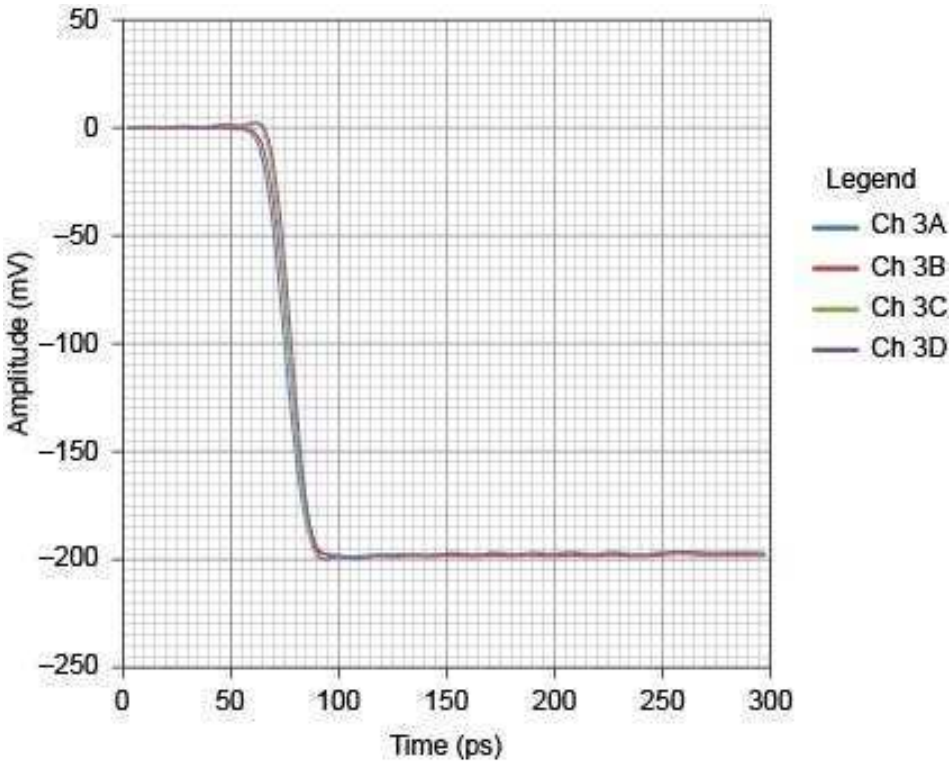
[15] FlexDCA software auto-selects the mainframe or module timebase based on DUT setup.
[16] Incident TDR edge speed is defined as the transition time at the output of the remote head. It is calculated by de-convolving the receiver transition time from the measured transition time when the remote head is terminated with a short.
[17] Measured on a negative TDR step, terminated in a short.

Step Flatness (Graphs of Combined Oscilloscope and TDR Performance)

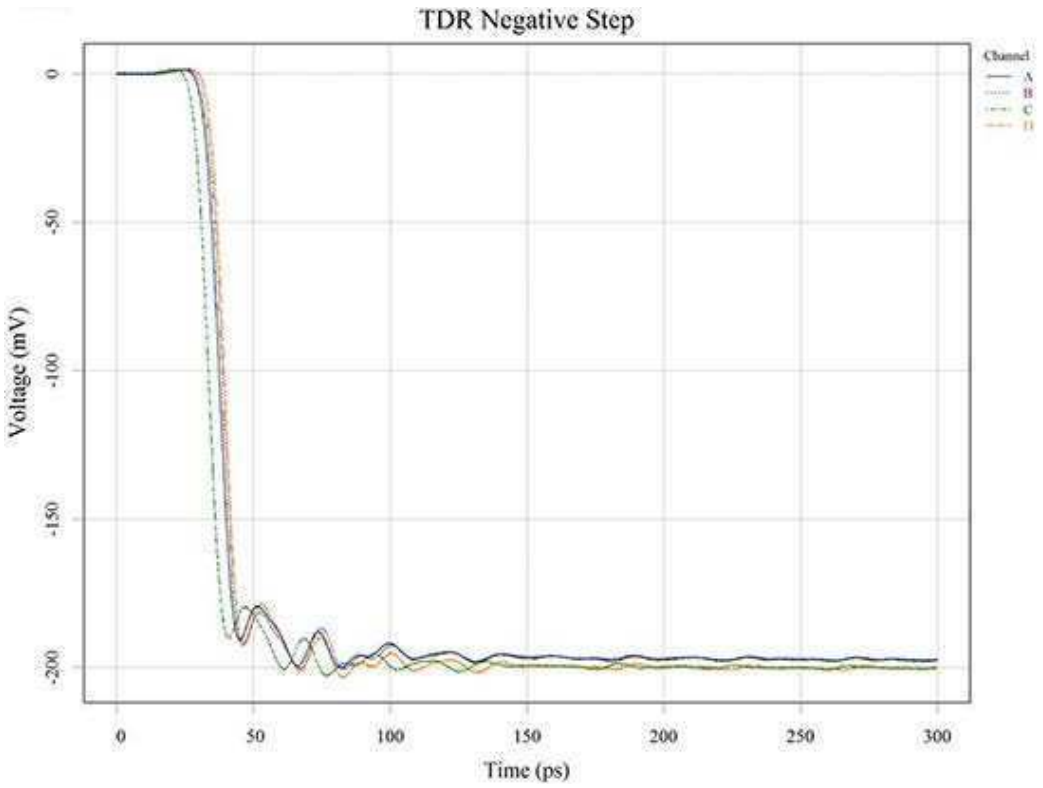
Options 52F, 52M, 54F, and 54M With TDR Calibration (Characteristic)



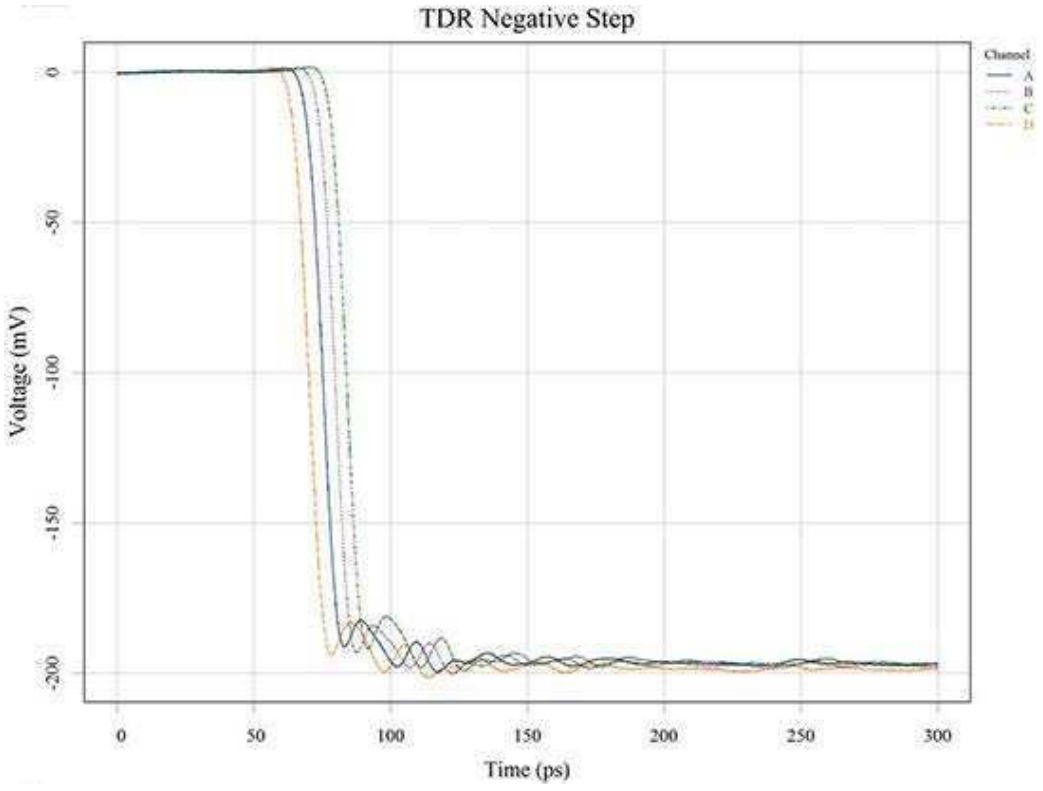
Options 32F, 32M, 34F, and 34M With TDR Calibration (Characteristic)



Options 52F, 52M, 54F, and 54M Without TDR Calibration (Characteristic)



Options 32F, 32M, 34F, and 34M Without TDR Calibration (Characteristic)



Item	N1055A-32F N1055A-32M N1055A-34F N1055A-34M	N1055A-52F N1055A-52M N1055A-54F N1055A-54M
TDR Step Amplitude (Combined Oscilloscope and TDR Performance)	100 mV Setting: 0 mV to ±100 mV 200 mV Setting: 0 mV to ±200 mV	100 mV Setting: 0 mV to ±100 mV 200 mV Setting: 0 mV to ±200 mV

N1060A Module PRELIMINARY

Specifications

Item	Option050	Option 085
Bandwidth[18], 3 dB (user selectable)	50 GHz	50 GHz 70 GHz 85 GHz *95 GHz (characteristic)*
Risetime (10% to 90%, calculated from TR = 0.35/BW)	*7 ps (characteristic)*	*4 ps (characteristic)*
RMS noise		
Characteristic	*680 µV (50 GHz)*	*680 µV (50 GHz)* *1100 µV (75 GHz)* *1200 µV (85 GHz)* *1600 µV (95GHz)*
Maximum	800 µV (50 GHz)	800 µV (50 GHz) 1300 µV (75 GHz) 1400 µV (85 GHz) 2000 µV (95GHz)
Scale Factor (per division)		
Minimum	1 mV/division	
Maximum	140 mV/division	

[18] Tuned to be –3 dB (±measurement uncertainty) at stated bandwidth(s), except for 95 GHz which is tuned for highest bandwidth while keeping channel noise ≤ 2 mV RMS.

DC Accuracy (V_{AVG} Measurement). Specified at calibration temperature ±5 °C.	±2 mV ± 4% of (reading – channel offset)	
CW offset range (referenced from center of screen)	±560 mV	
Input dynamic range (relative to channel offset)	±560 mV	
Maximum input signal	±1 V (+10 dBm)	
Random jitter (clock recovery without precision timebase active)	*< 200 fs (characteristic) with N1000A-LOJ mainframe* *< 400 fs (characteristic) with N1000A-STD mainframe*	
Effective trigger-to-sample delay (clock recovery and precision timebase configuration)	*< 350 ps characteristic)*	
Random jitter (clock recovery and precision timebase configuration) Verified with input signal 1 Vpp @ 10 GHz and 26.56 GHz with channel BW=50 GHz	< 80 fs (≥8 GHz) *40 fs (characteristic)@26.56GHz* *60 fs (characteristic)@10 GHz*	
Random jitter (External trigger signal applied to precision timebase input) Verified with input signal 1 Vpp @10 GHz, 0.8 Vpp @26.56 GHz with channel BW=50 GHz, ~1Vpp to PTB input	< 100 fs (≥8 GHz) *45 fs (characteristic)@26.56GHz* *60 fs (characteristic)@10 GHz*	
Precision timebase reference input	2.4 to 32 GHz	
Precision timebase reference input amplitude	*1.0 to 1.6 Vpp (characteristic)*	
Precision timebase input signal type The precision timebase performs optimally with a sinusoidal input. Non-sinusoidal signals will operate with some degradation in timebase linearity.	Sinusoid	
Precision timebase maximum input level	±2V (16 dBm)	
Precision timebase maximum DC offset level	±200 mV	
Precision timebase nominal input impedance	*50 Ω*	
Precision timebase connector type	2.92 mm male	
Timebase resolution (with precision timebase active)	100 fs/div	
Timebase resolution (precision timebase disabled)	100 fs/div	
Channel nominal impedance	*50 Ω*	
Electrical Input	1 mm (male)	1 mm (male)

Channel-to-Channel Skew Range	±100 ps

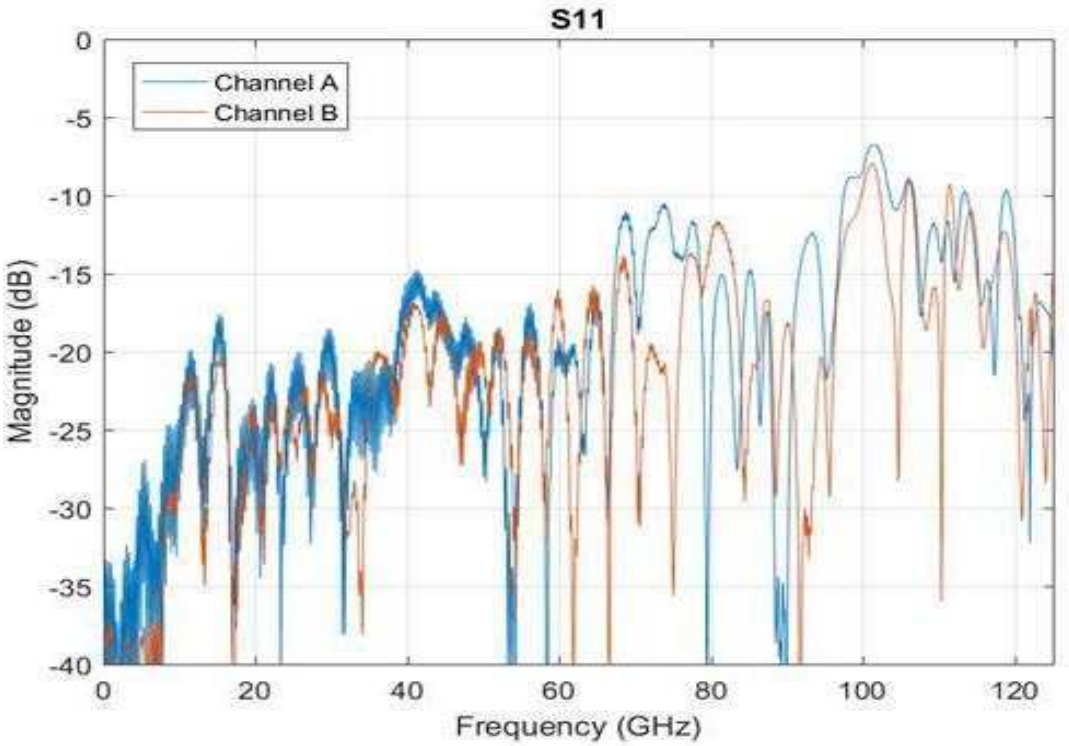
1. Tuned to be –3 dB (±measurement uncertainty) at stated bandwidth(s), except for 95 GHz which is tuned for highest bandwidth while keeping channel noise ≤ 2 mV RMS.

Clock Recovery Specifications

Item	Option 216	Option 232	Option264
Data rates input range	125 MBd to 16 GBd *125 MBd to 16.4 GBd (characteristic)*	125 MBd to 32 GBd *125 MBd to 32.8 GBd (characteristic)*	125 MBd to 64 GBd *125 MBd to 65.8 GBd (characteristic)*
Clock frequency input range	62.5MHz to 16 GHz *62.5 MBd to 16.4 GBd (characteristic)*	62.5MHz to 32 GHz *62.5 MBd to 32.8 GBd (characteristic)*	62.5MHz to 32 GHz *62.5 MBd to 32.8 GBd (characteristic)*
Minimum input level to acquire lock (NRZ, & PAM4, single-ended, open eye)	100 mV pp (rate ≤53.125 GBd) 200 mV pp (rate > 53.125 GBd) *40 mV pp at 10.3125 GBd (characteristic)*	100 mV pp (rate ≤53.125 GBd) 200 mV pp (rate > 53.125 GBd) *40 mV pp at 10.3125 GBd (characteristic)* *50 mV pp at 26.56 GBd (characteristic)*	100 mV pp (rate ≤53.125 GBd) 200 mV pp (rate > 53.125 GBd) *40 mV pp at 10.3125 GBd (characteristic)* *50 mV pp at 26.56 GBd (characteristic)* *80 mV pp at 53.125 GBd (characteristic)* *100 mV pp at 56 GBd (characteristic)* *150 mV pp at 64 GBd (characteristic)*
Minimum input level to acquire lock (PAM4, closed eye)	N/A	*200 mV pp at 26.56 GBd with 20 dB channel loss at 13.28 GHz (characteristic)*	*200 mV pp at 26.56 GBd with 20 dB channel loss at 13.28 GHz (characteristic)* *200 mV pp at 53.125 GBd with 10 dB channel loss at 26.56 GHz (characteristic)*
Recovered clock random jitter Verified by connecting a clean sinewave to N1060A Channel A, then measure RJ on the Recovered Clock signal connected to Channel B (PTB enabled).	280 fs Maximum ≥2.5GHz *180 fs @ 10 GHz (characteristic)*	280 fs Maximum ≥2.5GHz *150 fs @ 26.56 GHz (characteristic)* *180 fs @10 GHz (characteristic)*	
Clock recovery adjustable loop bandwidth range (user selectable)	0.015 to 20 MHz		

Clock recovery loop peaking range	Up to 4 settings (dependent on loop BW)		
Loop bandwidth accuracy	*± 30%, characteristic*		
Tracking range (includes spread-spectrum tracking)	*± 2500 ppm (± 0.25%) characteristic*		
Acquisition range Standard Signals: Spread Spectrum Signals	*± 300 ppm, characteristic* *± 5000 ppm, characteristic*		
Maximum consecutive identical digits to lock	*150, characteristic*		
Auto relocking	Yes		
Phase noise accuracy	*30%, characteristic*		
Front panel recovered clock amplitude	≥200 mV pp *450 mV @ 5 GHz, (characteristic)*	≥200 mV pp *450 mV @ 5 GHz, (characteristic)* *300 mV @ 26.56 GHz, (characteristic)*	≥200 mV pp *450 mV @ 5 GHz, (characteristic)* *300 mV @ 26.56 GHz, (characteristic)*
Front panel recovered clock divide ratio (user selectable)	1, 2, 4, 8, 16, 32		
Recovered clock front panel connector type	2.92mm (m)		
Internal frequency counter accuracy	± 10 ppm		

Input Impedance Graph of S11 (Characteristic)



Modules no longer available but supported by the N1000A DCA-X Mainframe

54752A 20 GHz Dual Channel Electrical

83484A Dual Channel 50 GHz Electrical

83496A Optical/Electrical Clock Recovery, 50 Mb/s-7.1 Gb/s

83496B Optical/Electrical Clock Recovery with Phase Noise Analysis

86117B 65 GHz Dual Channel Electrical

86107A Precision Timebase Reference

86108A Precision Waveform Analyzer

86116C option 040

86117A 50 GHz Dual Channel Electrical

Ordering Information

The below tables offer helpful information about the DCA-X software, mainframe and plug-in modules and their options but are not intended to serve as a configuration guide.

When configuring a solution, please also refer to the following helpful documents:
Keysight DCA Wide-Bandwidth Oscilloscope Family Configuration Guide
Keysight DCA Family FlexDCA Sampling Oscilloscope Software Technical Overview
Keysight DCA Family Clock Data Recovery Solutions Data Sheet

N1000A DCA-X Hardware Options

N1000A	Infiniium DCA-X mainframe
N1000A-PLK	Pattern Lock
N1000A-STB	Standard timebase
N1000A-LOJ	Low jitter timebase
N1000A-PTB	Precision timebase integrated in the mainframe
N1000A-GPI	PPIB card installed (mandatory option)

N1000A Miscellaneous Options

N1000A-AFP	Module slot filler panel
N1000A-AX4	Rack mount flange kit
N1000A-AXE	Rack mount flange kit with handles
N1000A-UK6	Commercial calibration certificate with test data

N1000A DCA-X Hardware Upgrade Options (if you already own an N1000A)

N1000AU-PLK	Add Pattern Lock
N1000A-LOJ	Add low jitter timebase
N1000A-PTB	Add precision timebase integrated in the mainframe

FlexDCA Software Packages

N1010100A[1]	Research and Development Package for FlexDCA
N1010200A[1]	Manufacturing Package for FlexDCA
N1010300A	Signal Integrity Package for FlexDCA
1. Requires option ETR on 86100D or option PLK on N1000A	

Compliance Application Software

N1012A	OIF CEI compliance and debug application
N1014A	SFF-8431 compliance and debug application
N1019A	User-defined application
N1081A	IEEE 802.3 KR/KR4 application
N1082A	IEEE 802.3bj XLAUI, CAUI-10 and nPPI; IEEE 802.3bm CAUI-4 (Option -4TP)
N1083A	IEEE 802.3 40GBASE-CR4 and 100GBASE-CR10

N1084A	IEEE802.3 KR4/CR4 application
N1085A	PAM4 Pre-Compliance Measurement application for Ethernet and OIF-CEI IEEE Measurements option 1TP OIF-CEI Measurements option 4TP
N1091BSCA	PAM4 Compliance Measurement Application for IEEE 802.3bs/cd
N1091BSUA	N1091BSUA IEEE 802.3bs/cd SW Upgrade (N1085A-1TP license must also be present)
N109256CA	PAM4 Compliance Measurement Application for CEI-56G-VSR/MR/LR
N109256UA	N109256UA OIF-CEI 4.0-56G-VSR/MR/LR SW Upgrade (N1085A-4TP license must also be present)

Optical/Electrical Modules

86105C	9 GHz optical channel; single-mode and multimode, amplified (750 to 1650 nm) 20 GHz electrical channel
86105C-100	155 Mb/s through 8.5 Gb/s (choose 4 filter rates from Options 86105C-110 through 86105C-195)
86105C-110	155 Mb/s
86105C-120	622 Mb/s (also covers 614 Mb/s)
86105C-130	1.063 Gb/s
86105C-140	1.244/1.250 Gb/s (also covers 1.229 Mb/s)
86105C-150	2.125 Gb/s
86105C-160	2.488/2.500 Gb/s (also covers 2.458 Gb/s)
86105C-170	2.666 Gb/s
86105C-180	3.125 Gb/s (also covers 3.072 Gb/s)
86105C-190	4.250 Gb/s
86105C-193	5.0 Gb/s
86105C-195	6.250 Gb/s (also covers 6.144 Gb/s)
86105C-200	8.5, 9.953, 10.3125, 10.519, 10.664, 10.709, 11.096, 11.317 Gb/s
86105C-300	Combination of rates available in 86105C-100 and 86105C-200
86105C-IRC[1]	System Impulse Response Correction calibration
86105D	20 GHz optical channel; single-mode and multimode, (750 to 1650 nm); filters for 8.5, 9.953, 10.3125, 10.519, 10.664, 10.709, 11.096, 11.317, 14.025 Gb/s; 35 GHz electrical channel
86105D-100	Identical capability as 86105D, 14.025 Gb/s filter not included
86105D-200	Identical capability as 86105D, only filter provided is 14.025 Gb/s
86105D-IRC [1]	System impulse response correction calibration

86105D-281	34 GHz optical channel, filters for 15, 25.78 , 27.95, 28.05 Gb/s (contact Keysight for additional 14.025 Gb/s filter) [4]. 50 GHz electrical channel
86115D	20 GHz multi-optical port plug-in module; single-mode and multimode (750 to 1650 nm); filters for 8.5, 9.953, 10.3125, 10.519, 10.664, 10.709, 11.096, 11.317, 14.025 Gb/s
86115D-002	Two optical channels with filters for all rates listed (8.5 to 14.025 Gb/s)
86115D-102	Identical capability as 86115D-002, 14.025 Gb/s filters not included
86115D-142	Identical capability as 86115D-002, only filters provided are 14.025 Gb/s
86115D-282	Two optical channels with filters for 15, 25.78, 27.95, 28.05 Gb/s (contact Keysight for 14.025 Gb/s filter) [4]
86115D-IRC[1]	System impulse response correction calibration
86116C-025	40 GHz optical/80 GHz electrical channels, see specifications for filters
86116C-041	65 GHz optical/80 GHz electrical channels, see specifications for filters
86116C-IRC[1]	System impulse response correction calibration
1. Requires option ETR on 86100D or option PLK on N1000A	

Dual/Quad Electrical Channel Modules

86112A	Dual 20 GHz electrical channels
86112A-HBW	Dual 30 GHz electrical channels
86118A	Dual 70 GHz electrical remote sampling channels
86118A-H01	Differential de-skew
N1045A	2/4 port 60 GHz electrical remote head
N1045A-02F	2 channel remote head, 1.85 mm, female
N1045A-02M	2 channel remote head, 1.85 mm, male
N1045A-04F	4 channel remote head, 1.85 mm, female
N1045A-04M	4 channel remote head, 1.85 mm, male
N1046A	100 GHz, 1/2/4 port electrical remote sampling head
N1046A-71F	1 channel, 75 GHz remote head, 1 mm, female
N1046A-81F	1 channel, 85 GHz remote head, 1 mm, female
N1046A-11F	1 channel, 100 GHz remote head, 1 mm, female
N1046A-72F	2 channel, 75 GHz remote head, 1 mm, female
N1046A-82F	2 channel, 85 GHz remote head, 1 mm, female
N1046A-12F	2 channel, 100 GHz remote head, 1 mm, female
N1046A-74F	4 channel, 75 GHz remote head, 1 mm, female
N1046A-84F	4 channel, 85 GHz remote head, 1 mm, female

N1046A-14F	4 channel, 100 GHz remote head, 1 mm, female

TDR/TDT Modules

54754A [1]	Differential TDR module with dual 18 GHz TDR/electrical channels
N1055A [1]	35/50 GHz, 2/4 port, TDR/TDT remote head
N1055A-FS1	Fast sampling, mandatory option
N1055A-32F	35 GHz, 2 channel remote head, 2.92 mm, female
N1055A-32M	35 GHz, 2 channel remote head, 2.92 mm, male
N1055A-34F	35 GHz, 4 channel remote head, 2.92 mm, female
N1055A-34M	35 GHz, 4 channel remote head, 2.92 mm, male
N1055A-52F	50 GHz, 2 channel remote head, 1.85 mm, female
N1055A-52M	50 GHz, 2 channel remote head, 1.85 mm, male
N1055A-54F	50 GHz, 4 channel remote head, 1.85 mm, female
N1055A-54M	50 GHz, 4 channel remote head, 1.85 mm, male

1. When used in an 86100D, 86100D option ETR is recommended if more than 1 TDR module is connected to the same DUT

Precision Waveform Analyzer Modules

86108B-LBW[1]	Dual 35 GHz electrical channels
86108B-HBW[1]	Dual 50 GHz electrical channels
86108B-216	Clock recovery 50 Mb/s to 16 Gb/s
86108B-232	Clock recovery 50 Mb/s to 32 Gb/s
86108B-300	Adjustable loop bandwidth/peaking
86108B-400	Auxiliary clock recovery input
86108B-PTB	Integrated precision timebase
86108B-JSA	Jitter spectrum analysis and software clock recovery emulation
86108B-A23	Two adapters, 2.4 mm (f) to 3.5 mm (f)
86108B-CA2	Matched cable pair, 2.4 to 2.4 mm, 24 inch
86108B-CA3	Matched cable pair, 3.5 to 3.5 mm, 18 inch
86108B-DC2	Two DC blocks, 2.4 mm, 16 V, 50 kHz to 50 GHz
86108B-DC3	Two DC blocks, 3.5 mm, 16 V, 50 kHz to 26.5 GHz
86108B-PT2	Two 2.4 mm phase trimmers for ext. skew adjustment
86108B-PT3	Two 3.5 mm phase trimmers for ext. skew adjustment
N1060A-050[1]	Dual 50 GHz electrical channels

N1060A-085[1]	Dual 85 GHz electrical channels
N1060A-216	Clock recovery 125 MBd to 16 GBd
N1060A-232	Clock recovery 125 MBd to 32 GBd
N1060A-264	Clock recovery 125 MBd to 64 GBd
N1060A-PTB	Integrated precision timebase (mandatory option)
N1060A-EVA	Integrated variable equalizers in clock path (mandatory option)
N1060A-JSA	Jitter Spectrum Analysis (mandatory option)
N1060A-A1F	Two 1mm (f) to 1mm (f) adapters
N1060A-A1M	Two 1mm (m) to 1mm (m) adapters
N1060A-A1X	Two 1mm (m) to 1mm (f) adapters
N1060A-CA1	Cable pair, 1 mm(m) to 1 mm (f), 160 mm length
N1060A-CA2	Matched cable pair, 2.4 mm(m) to 2.4 mm (m), 24 inch length
N1060A-DC2	Two DC blocks, 2.4mm connectors, 16V, 50 kHz to 50 GHz

1. 86100D option ETR recommended when used in an 86100D mainframe, N1000A option PLK recommended when used in an N1000A mainframe

External Clock Recovery Solutions

N1076A Electrical Clock Recovery

N1076A-216	Clock recovery range: 50 MBd to 16 GBd
N1076A-232	Clock recovery range: 50 MBd to 32 GBd
N1076A-JSA	Jitter spectrum analysis

N1076B Electrical Clock Recovery

N1076B-216	Clock recovery range: 125 MBd to 16 GBd
N1076B-232	Clock recovery range: 125 MBd to 32 GBd
N1076B-264	Clock recovery range: 125 MBd to 64 GBd (56 GBd for PAM4 signals)
N1076B-EVA	Integrated variable equalizers (mandatory option)
N1076B-JSA	Jitter Spectrum Analysis

N1077A Optical/Electrical Clock Recovery

N1077A-216	Clock recovery range: 50 MBd to 16 GBd
N1077A-232	Clock recovery range: 50 MBd to 16 GBd
N1077A-SMS	Internal SM and MM splitters

N1077A-SXT	No splitter (supplied by user)
N1077A-JSA	Jitter spectrum analysis

N1078A Optical/Electrical Clock Recovery

N1078A-216	Clock recovery range: 125 MBd to 16 GBd
N1078A-225	Clock recovery range: 25 to 29 GBd
N1078A-232	Clock recovery range: 125 MBd to 32 GBd
N1078A-253	Clock recovery range: 53 to 58 GBd
N1078A-264	Clock recovery range: 125 MBd to 64 GBd
N1078A-S50	Internal 50-50 SM optical splitter
N1078A-SXT	No splitter (splitter supplied by user)
N1078A-JSA	Jitter spectrum analysis
N1078A-EVA	Integrated variable equalizers in electrical input path (mandatory option)

Warranty Options (for All Products)

R1280A	Customer return repair service
R1282A	Customer return calibration service

Accessories

See the "DCA Accessories" Guide for available accessories

Connectivity Solutions

For a wide range of test adapters to connect to one or more lanes for SFP+, QSFP+, fibre channel, PCIe and many others, please see adapters information from Wilder Technologies at: http://www.wilder-tech.com/ Call Keysight for connectivity and probing solutions not listed above.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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