N1093A/B DCA-M

Sampling Oscilloscopes

Introduction

The rapid deployment of AI data center networks utilizing 1.6T optical interconnects presents significant measurement challenges due to the extreme data rates and stringent signal integrity requirements. Engineers need to characterize and validate the performance of transceivers across a broad range of challenging operating conditions, requiring precise test equipment with exceptional bandwidth, low noise, and high sensitivity. In manufacturing, automated testing must be efficient, scalable, and precise in order to validate critical parameters across large volumes with high throughput and yield, while ensuring performance to datacenter requirements and maintaining compliance with industry standards.

The Keysight N1093 DCA-M sampling oscilloscope is designed to deliver the highest optical measurement sensitivity and integrated clock recovery up to 120 GBaud. The Keysight N1093A/B DCA-M specifically targets the rigorous demands of 1.6T transceiver optical testing for R&D and manufacturing of next-generation optical interconnects for data centers and AI clusters.



KEYSIGHT

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Optimize Your Data Center Performance and Reliability

The Keysight N1093A/B DCA-M sampling oscilloscopes provide high-speed optical signal analysis at up to 240 Gbps/lane, delivering:

- **Maximize measurement margin** – High sensitivity, low jitter, wide precise bandwidth and leading-edge measurement science maximize measurement margin. Less than 15 µW optical channel noise and 105 fs of intrinsic time-based jitter preserve critical measurement margin at the very high data rates, and challenging signal conditions of 1.6T transceivers enable R&D and manufacturing engineers to meet tight specifications and ensure design reliability with greater throughput.
- **Minimize test system complexity and ensure compliance** – Integrated clock recovery supports baud rates up to 120 GBd, enabling the N1093 DCA-M to recover the clock at the full data rate, as prescribed by the standards, and eliminating the need to configure and route a separate sub-rate signal for clocking.
- **Optimize production test efficiency and throughput** – The N1093BB01A/02A/03AB bundles provide quad-channel scalability at an affordable price, enabling higher throughput and drive down production costs— don't miss the FlexOTO software that completes the optimized production solution offered by Keysight. FlexOTO Optical Test Optimization software integrates seamlessly with the DCA-M sampling oscilloscopes to maximize instrument utilization and test efficiency while reducing total cost-of-test. FlexOTO is built on the industry-leading FlexDCA measurement science platform ensuring the highest quality optical waveform analysis.



Controlling the N1093A/B

There are three ways to control DCA-Ms, including the N1093A/B:

- A PC directly connected to the N1093A/B with a USB cable
- An N1000A mainframe connected to the N1093A/B with a USB cable. (The mainframe can then be controlled via GPIB or LAN)
- For an automated test system environment, the simplest and preferred method to control the N1093A/B is to connect the primary test system PC to a low-cost modern PC via LAN. The FlexDCA interface resides on the second PC. The second PC is then connected to the N1093A/B via USB. This eliminates most issues of compatibility between an existing test system PC and the N1093A/B hardware and can greatly simplify converting an N1000A system to an N1093A/B system

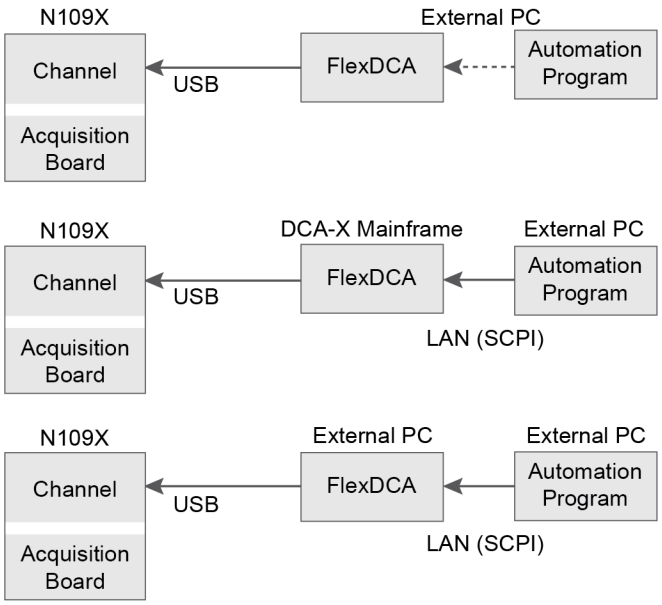


Figure 1. Connection schemes

The N1093A/B user interface and operating system is identical to the modern FlexDCA interface of the N1000A. A user-provided PC running N1010A FlexDCA software controls the N1093A (and other DCA-Ms) over a simple USB 2.0 or 3.0 connection.

N1010A FlexDCA software is required on the PC controlling the DCA-Ms. It is available as a free download at www.keysight.com/find/flexdca_download.

System Setup

The following guidelines are the PC requirements when connected to the DCA-M module and running the FlexDCA interface for a single channel setup:

- Intel I3 processor or better with 4 GB memory
- Windows 10 or 11 (64 bit)

For a parallel test setup (multiple instruments or multiple channels):

- Intel I5 or better with 8 GB memory

The communication API between your system controller and the PC is SCPI over LAN, either VXI-11 or HiSlip. If NI-VISA or IO Libraries are used to communicate with GPIB instruments, the switch to SCPI/LAN is very simple. It is important to note that there is no need to do any USB programming. This is all handled by the FlexDCA interface.

The FlexDCA interface is free and can be downloaded at www.keysight.com/find/flexdca_download. Remote programs previously developed using the 86100 or N1000 FlexDCA interface can be leveraged directly to control an automated N1093A/B system.

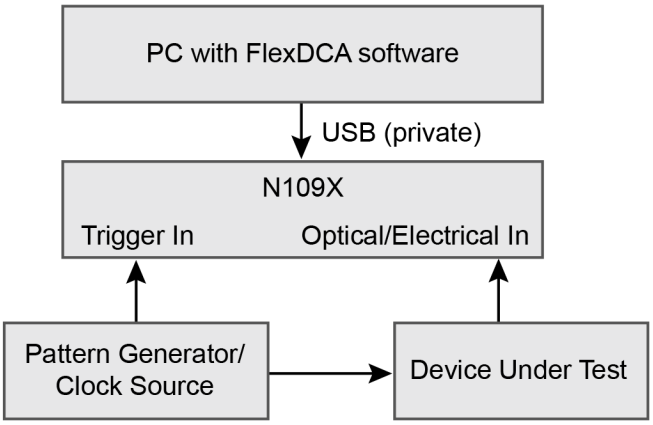


Figure 2. N109X test setup

A reference clock, synchronous with the signal being measured, is required to trigger the N109X. Timebase calibration, previously performed at service centers, can now be performed by users, reducing cost of ownership and instrument down time.

Module SIRC Filters

System Impulse Response Correction (SIRC) filters provide channel SIRC measurement and data files to give an ideal channel response. SIRC correction data is unique to a specific N1093A/B serial number and can be applied in FlexDCA's System Impulse Response Correction dialog. The SIRC correction data feature is a digital filter that is used to:

- Improve the response of module reference filters to more closely match an ideal receiver.
- Enable non-standard reference receiver rates or bandwidths.
- Increase the bandwidth of the channel by up to 50%.
- Ensures that an eye diagram will look identical between different modules.

N1093A/B Specifications

N1093A/B Optical Channel Specifications

Description	Specifications
Channel Performance	
Baud rates (as NRZ reference filter) [1,2]	17.7333 GBd to 80.00 GBd 34.6667 GBd to 77.00 GBd *(N1093A/B Option MFG)*
Baud rates (as TDECQ reference filter) [1,3]	26.6 GBd to 120.00 GBd 53.125 GBd to 115.5 GBd *(N1093A/B Option MFG)*
–3 dBe Bandwidth settable range [1]	13.3 GHz to 60.00 GHz (characteristic) 26.56 GHz to 57.75 GHz (characteristic) *(N1093A/B Option MFG)*
Channel noise (53.125 GBd TDECQ reference filter setting) [1]	< 16 µW *11 µW (characteristic)*
Channel noise (106.25 GBd TDECQ reference filter setting) [1]	< 19 µW *13 µW (characteristic)*
Optical CW accuracy [4]	± 30 µW ± 5% of reading ± connector uncertainty [5] *± 10 µW ± 3% of reading ± connector uncertainty (characteristic)* [6]
Average power monitor accuracy [7]	± 5 µW ± 5% of reading ± connector uncertainty [5] *± 2 µW ± 3% of reading ± connector uncertainty (characteristic)* [6]
Vertical scale factor range [8]	5 µW/division to 500 µW/division
Vertical offset range [9]	+1.0 mW to −3.0 mW
ADC precision	16 bits
Optical Parameters	
User calibration wavelength range	1250 nm to 1350 nm
Factory calibrated wavelength	1310 nm [10]
Maximum non-destruct peak power	8 mW (+9 dBm)
TDECQ Variability [11]	
Delta from TDECQ-reference (Refer to *Figure 3* on page 8)	*< 0.35 dB (characteristic)*
Delta between ChanA and ChanB (within one N1093B) (Refer to *Figure 4* on page 8)	*< 0.25 dB (characteristic)*

1. With SIRC enabled.
2. Channel response follows 4-pole Bessel Thompson LPF (–3 dBe at 3/4 * baud rate).
3. Channel response follows 4-pole Bessel LPF (–3 dBe at 1/2 * baud rate).
4. Single marker, referenced to external power sensor.
5. At a temperature within ± 5°C of module calibration temperature.
6. At a temperature within ± 1°C of module calibration temperature.
7. Applies to levels from –30 dBm to +6 dBm. Referenced to external power sensor.
8. Screen height is 8 divisions.
9. Referenced 2 divisions from screen bottom.
10. Calibration wavelength uncertainty is ± 20 nm.
11. Using a 106.25 GBd PAM4 SSPRQ signal at 1310 nm with a TDECQ of 1.75 dB. Characteristic applies over an OMA range of 800 µW – 1300 µW. Variability referenced to TDECQ transfer standards maintained by Keysight.

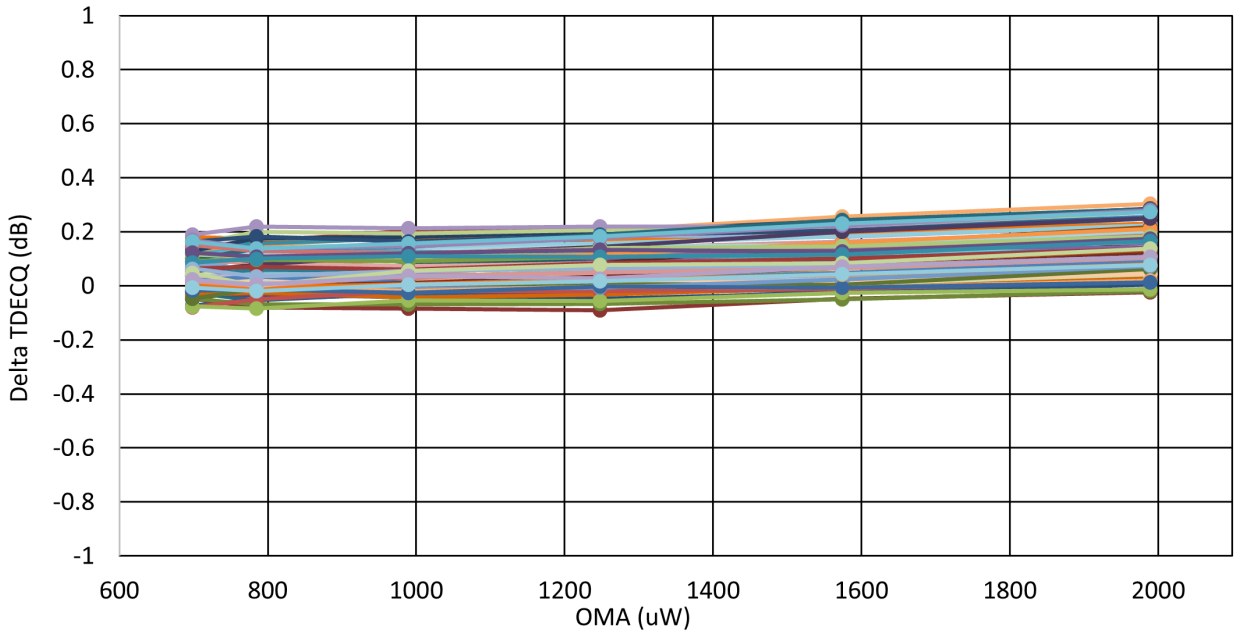


Figure 3. 106.25 GBd TDECQ Delta from TDECQ-Reference (Each line on the graph represents one N1093 channel measured relative to the TDECQ reference.)

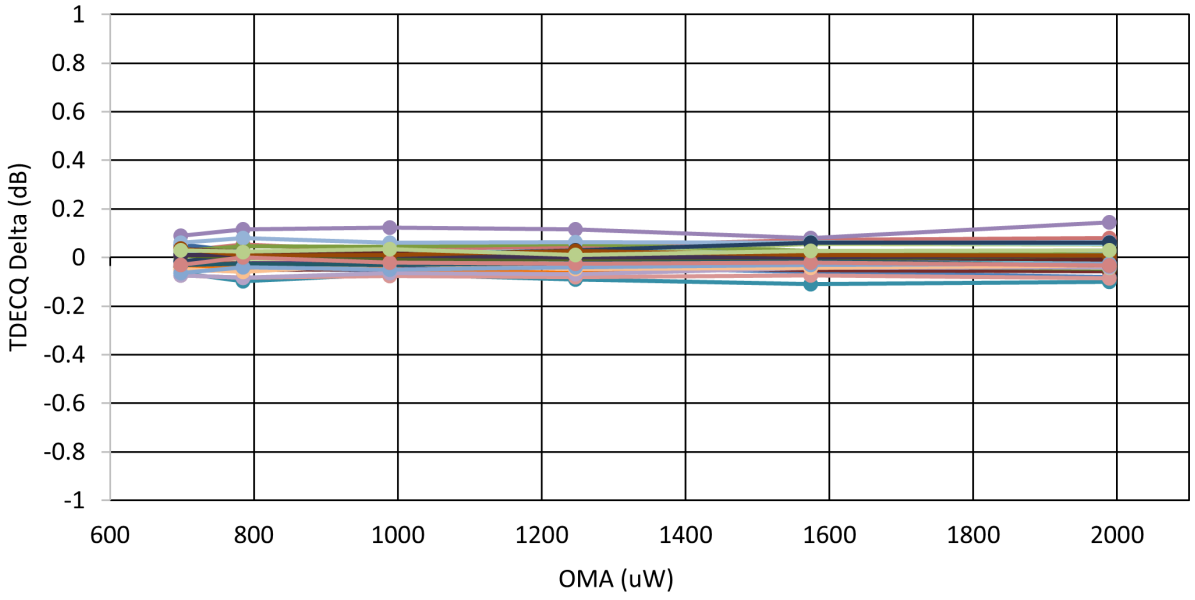


Figure 4. 106.25 GBd TDECQ ChanA Delta from ChanB (Each line on the graph represents the difference in TDECQ measurement results between Channel A and Channel B of one N1093 unit.)

N1096A/B Clock Recovery Specifications (requires Option CDR)

Description	Specifications
Clock Recovery Performance	
Baud rate lock range	104 GBd to 115.5 GBd 52 GBd to 57.75 GBd
Option CRX baud rate lock range	88 GBd to 120 GBd 48 GBd to 58 GBd
User selectable loop bandwidth range	0.5 MHz to 10 MHz [3] 4 MHz to 4.5 MHz *(N1093A/B Option MFG)*
4 MHz loop bandwidth accuracy [1] (106.25 GBd PAM4 SSPRQ signal at 1310 nm)	± *10% (characteristic)*
Loop bandwidth accuracy [2] (other signal conditions)	± *30% (characteristic)*
Lock acquisition range	± 2 MHz
Lock hold range	± *2500 ppm (characteristic)*
Internal frequency counter accuracy	± 10 ppm ± *4 ppm (characteristic)*
Auto relocking	On / Off (user selectable)
Locking Sensitivity (OMA) [4]	
Baud rates between 52 GBd and 57.75 GBd	600 µW *350 µW (characteristic)*
Baud rates between 104 GBd and 115.5 GBd	200 µW *100 µW (characteristic)*
Jitter Spectrum Analysis [5]	
Jitter accuracy [6]	± *30% (characteristic)*
Recovered Clock Out	
Amplitude	≥ 200 mV_{pp} *450 mV_{pp} (characteristic)*
Divide ratio (user selectable) as TDECQ receiver	48 GBd to 58 GBd rates: 2, 4, 8, 16, 32 88 GBd to 120 GBd rates: 4, 8, 16, 32, 64
Maximum random jitter	160 fs rms *100 fs rms (characteristic)*

1. Loop Tuning enabled.
2. Loop Tuning enabled; over full loop bandwidth range and baud rate input range.
3. Nominally a second-order Type-2 PLL response. Loop Tuning is recommended for best accuracy to mitigate LBW dependencies on input signal characteristics such as: amplitude, baud rate, transition density, encoding format, eye closure, and spectral content.
4. Verified using a 1310 nm PAM4 SSPRQ signal with TDECQ of 1.75 dB (as measured by a TDECQ Reference receiver).
5. Jitter Spectrum Analysis (JSA) will be enabled by either the N1010100A or N1010300A software licenses. JSA is not available with Option MFG.
6. Using 106.25 GBd PAM4 SSPRQ signal with 0.1 UI of sinusoidal jitter. Verified using 500 KHz LBW and the JSA Spectrum Type set to "Input".

N1093A/B Timebase Specifications

Description	Specifications
Timebase Performance	
Trigger-to-sample delay [1]	< 10 ns
Time interval resolution [2]	Screen diameter / record length or 50 fs (whichever is larger)
Time interval accuracy (pattern lock enabled)	± 150 fs ± 1% of 1/(clock input frequency) *or* ± 4 ps (whichever is smaller) [3] *± 0.3% of 1/(clock input frequency) or ± 1.2 ps (whichever is smaller) (characteristic)* [4]
Time interval accuracy (pattern lock disabled)	± 150 fs ± 1% of timespan *or* ± 4 ps (whichever is smaller) [3] *± 0.3% of timespan or ± 1.2 ps (whichever is smaller) (characteristic)* [4]
Scale factor range	100 fs/division to 50 ms/division
Record length range [5] (pattern lock disabled)	16 samples to 131,072 samples
Record length range [5] (pattern lock and acquire entire pattern enabled)	1 sample to 269,435,456 samples
Maximum sample rate [6]	250 kHz
Acquisition time for a 106.25 GBd SSPRQ waveform [7]	*7.3 seconds (characteristic)*
Jitter Performance	
Maximum jitter [8]	200 fs rms *160 fs rms (characteristic)*
Maximum jitter (with options PTB and CDR enabled) [9]	135 fs rms *105 fs rms (characteristic)*
Clock Input	
Maximum non-destruct voltage	1.4 V_{pp}
Input frequency range	500 MHz to 32.0 GHz (full rate or sub-rate clocks) 100 MHz to 500 MHz (sub-rate clocks only, Pattern Lock off, provided the baud rate exceeds 500 MBd and the clock divide ratio is a power of two.)
Clock input sensitivity	200 mV_{pp}
Minimum clock slew rate	0.5 V/ns

1. Time delay between the front panel clock input and when a sample is taken on the front panel channel input.
2. Time spacing between 2 adjacent sample points.
3. Dual marker measurement performed at a temperature within ± 5°C of module calibration temperature.
4. Dual marker measurement performed at a temperature within ± 1°C of module calibration temperature.
5. With 1 active input channel.
6. With Option FS1. Each channel samples at the specified sample rate regardless of the number of active channels.
7. With Option FS1, Pattern Lock on, using 19 points/UI, with Acquire Entire Pattern enabled, with SIRC enabled, not including clock recovery relock time. Subsequent TDECQ measurement time depends on many factors such as CPU speed and TDECQ filter settings.
8. Verified with a clock slew rate greater than 40 V/ns and optical signal slew rate greater than 150 µW/ps.
9. Requires Option CDR and Option PTB.

N1093A/B Front-Panel Ports Specifications

Description	Specifications
Optical Input Ports	
Channel count	1 (N1093A) 2 (N1093B)
Fiber input connector	FC/PC
Fiber type	Single-mode 9/125 µm
Recovered Clock Output Port	
Connector type	2.92 mm (f)
Nominal output impedance	50 Ω (AC coupled)
Clock Input Port	
Connector type	2.92 mm (f)
Nominal input impedance	50 Ω (AC coupled)
Chassis Ground Port	
Connector type	Banana Jack: 4 mm (5/16 in)

N1093A/B Rear-Panel Ports Specifications

Description	Specifications
USB	
Connector type	USB Type-B (f)
Speed	USB 2.0

N1093A/B Absolute Maximum Specifications

Description	Specifications
Optical Input Ports	
Maximum non-destruct peak input power	8 mW (+9 dBm)
Clock Input Port	
Maximum non-destruct voltage	1.4 V_{pp}
Environmental	
Maximum operating temperature	+10°C to +40°C (+50°F to +104°F)
Maximum non-operating temperature	−40°C to +70°C (−40°F to +158°F)
Maximum operating altitude	Up to 4,600 meters (15,000 ft)
Humidity	Type tested at 95%, +40°C (non-condensing)
Power Consumption	
Power supply maximum power draw	290 Watts (under maximum output loading conditions)

N1093A/B LINE Power Specifications

Description	Specifications
Voltage and/or range	100–120 Vac, 50/60/400 Hz 200–240 Vac, 50/60 Hz
Power in Watts	290 Watts Maximum
The products can operate with mains supply voltage fluctuations up to ± 10% of the nominal voltage.	

N1093A/B Environmental Specifications

Description	Specifications
Environmental [1]	
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)
Humidity	Type tested at 95%, +40°C (non-condensing)
Use	Indoor
Weight	
N1093A	*6.9 kg (15.3 lb) (characteristic)*
N1093B	*7.1 kg (15.6 lb) (characteristic)*
Dimensions	
Without front connectors and rear feet	88.26 mm H x 207.40 mm W x 485 mm D (3.48 inch x 8.17 inch x 19.01 inch)
With front connectors and rear feet	103.31 mm H x 219.56 mm W x 517.80 mm D (4.07 inch x 8.64 inch x 20.39 inch)
With front cover and rear feet	110.18 mm H x 219.56 mm W x 550.71 mm D (4.34 inch x 8.64 inch x 21.68 inch)

1. Samples of this product have been type tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of storage, transportation and end-use; those stresses include but are not limited to temperature, humidity, shock, vibration, altitude, and power line conditions. Test methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.

Ordering Information — N1093A/B

The following FlexDCA Software Packages can be installed on the PC controlling your DCA-M or on the DCA-M (node-locked and device-locked licenses). Support subscriptions are available for FlexDCA software Packages which enable both bug fixes and new functionality. For additional details regarding configuring your N1093A/B DCA-M, refer to the *DCA Wide-Bandwidth Oscilloscope Family Configuration Guide* available on *Keysight.com*.

N1010100A research and development package for FlexDCA software

This package is Intended for R&D engineers who want to characterize their design and gain more insights into why a signal deviates from the expected performance.

N1010200A manufacturing package for FlexDCA software

This package focuses on cost of test in Optical Transceiver manufacturing applications with capabilities like FlexEye. FlexEye is an independent eye acquisition and analysis feature that operates DCA channels as independent single-channel instruments to maximize the throughout and provide more flexibility for your manufacturing design.

N1010300A signal integrity package for FlexDCA software

This package adds powerful tools to measure impedances, transfer characteristics and S-parameter calculations to the basic TDR/TDT measurements.

N1093A/B Options

Model/Option Number	Description
N1093A	Single optical channel oscilloscope
N1093B	Dual optical channel oscilloscope
N1093A/B-CDR	Integrated Clock Recovery
N1093A/B-CRX	Extended Clock Recovery Range
N1093A/B-FS1	Fast Sampling Rate
N1093A/B-IRC	Impulse Response Correction
N1093A/B-LOJ	Low Jitter Timebase
N1093A/B-PLK	Pattern Lock Trigger Capability
N1093A/B-PTB	Integrated Precision Timebase
N1093A/B-C0C	Certificate of Calibration
N1093A/B-UK6	Commercial calibration certificate with test data
N1093A/B-1CM	Single instrument rack mount kit
N1093A/B-1CN	Dual instrument side-by-side rack mount kit
N1093A-MFG	N1093A Manufacturing Option Adjustment
N1093B-MFG [1]	N1093BB MFG Bundle Unit

1. Option MFG is included on all N1093B units in N1093BB01A/02A/03A bundles.

Application software

See the application software datasheet to confirm hardware requirements.

SW Application Model	SW Application Description
D9010UDAA	User Defined Application Software (for DCA-X and RT Scopes)
N1095DJCA	224G Optical Transmitter Conformance Test SW for IEEE 802.3dj

Confidently Covered by Keysight Services

Prevent delays caused by technical questions, or system downtime due to instrument maintenance and repairs with Keysight Services. Keysight Services are here to support your test needs with expert technical support, instrument repair and calibration, software support, training, alternative acquisition program options, and more.

A KeysightCare agreement provides dedicated, proactive support through a single point of contact for instruments, software, and solutions. KeysightCare covers an extensive group of instruments, application software, and solutions and ensures optimal uptime, faster response, faster access to experts, and faster resolution.

Keysight Services

Offering	Benefits
KeysightCare KEYSIGHTCARE	KeysightCare provides elevated support for Keysight instruments and software, with access to technical support experts that respond within a specified time and ensure committed repair and calibration turnaround times (TAT). KeysightCare offers multiple service agreement tiers, including KeysightCare Assured, Enhanced, and Application Software Support. See the KeysightCare data sheet for details.
KeysightCare Assured	KeysightCare Assured goes beyond basic warranty with repair services that include committed TAT and unlimited access to technical experts.
KeysightCare Enhanced	KeysightCare Enhanced includes all the benefits of KeysightCare Assured plus Keysight's accurate and reliable calibration services, accelerated, and committed TAT, and technical response.
Keysight Support Portal & Knowledge Center	All KeysightCare tiers include access to the Keysight Support Portal where you can manage support and service resources related to your assets such as service requests, and status, or browse the Knowledge Center.
Education Services	Build confidence and gain new skills to make accurate measurements, with flexible Education Services developed by Keysight experts. Including Start-up Assistance.
Alternative Acquisition Options	
KeysightAccess	Reduce budget challenges with a subscription service enabling you to get the instruments, software, and technical support you want for your test needs.

Recommended Services

Maximize your test system up-time by securing technical support, repair, and calibration services with committed response and turnaround times. 1-year KeysightCare Assured is included in every new instrument purchase. Obtain multi-year KeysightCare upfront to eliminate the need for lengthy and tedious paperwork and yearly requests for maintenance budget. Plus, you benefit from secured service for 2, 3, or 5 years.

Keysight Services

Service	Function
KeysightCare Enhanced[1]	Includes tech support, warranty and calibration
R-55B-001-1	KeysightCare Enhanced – Upgrade 1 year
R-55B-001-2	KeysightCare Enhanced – Extend to 2 years
R-55B-001-3	KeysightCare Enhanced – Extend to 3 years (Recommended)
R-55B-001-5	KeysightCare Enhanced – Extend to 5 years (Recommended)
KeysightCare Assured	Includes tech support and warranty
R-55A-001-2	KeysightCare Assured – Extend to 3 years
R-55A-001-3	KeysightCare Assured – Extend to 3 years
R-55A-001-5	KeysightCare Assured – Extend to 5 years
Start-Up Assistance	
PS-S40-01 *or* -04	Instrument fundamentals and operations starter
PS-S40-02	Optional – technology and measurement science standard learning

1. Available in select countries. For details, please view the datasheet. R-55B-001-2/3/5 must be ordered with R-55B-001-1.



As a mission-critical design enablement partner, Keysight connects design, emulation, and test so customers can solve the world's most complex engineering challenges. Accelerate innovation at www.keysight.com.

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