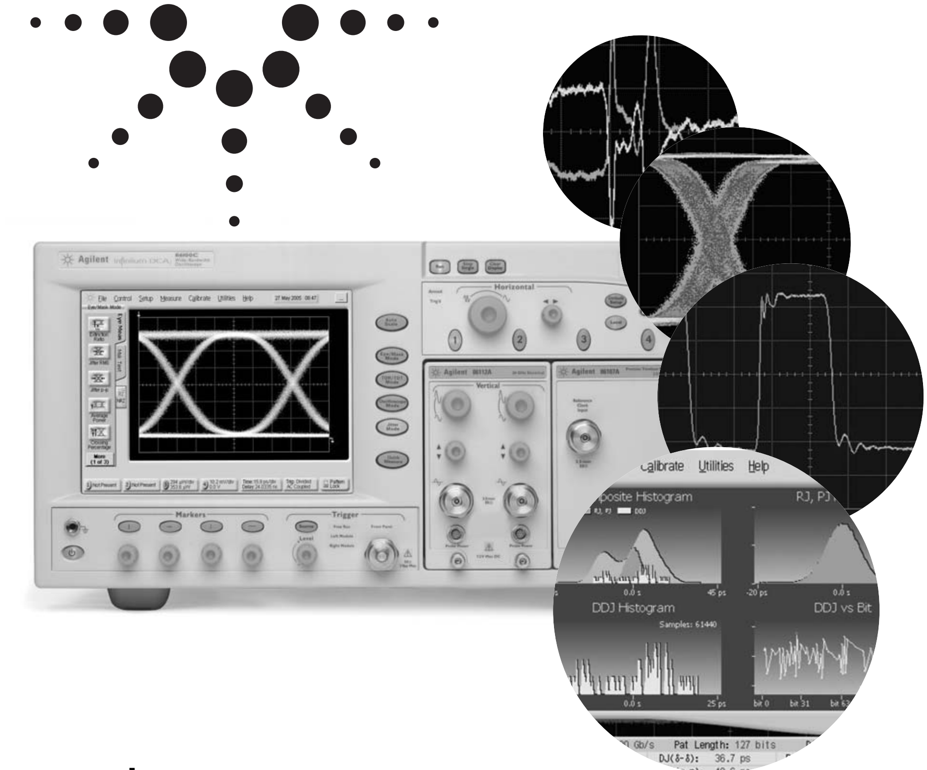
infiniium DCA-J

Agilent 86100C Wide-Bandwidth Oscilloscope

Technical Specifications



Four instruments in one

A digital communications analyzer, a full featured wide-bandwidth oscilloscope, a time-domain reflectometer, and a jitter analyzer

- Automated jitter decomposition
- Internally generated pattern trigger
- Modular platform for testing waveforms to 40 Gb/s and beyond
- Broadest coverage of data rates with optical reference receivers and for clock recovery
- Compatible with Agilent 86100A/B-series, 83480A-series,and 54750-series modules
- < 200 fs intrinsic jitter
- Open operating system – Windows® XP Pro

Agilent Technologies

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Overview of infiniium DCA-J

Features

Four Instruments in One

The 86100C Infiniium DCA-J can be viewed as four high-powered instruments in one:

- A general-purpose wide-bandwidth sampling oscilloscope; the new PatternLock triggering significantly enhances the usability as a general purpose scope
- A digital communications analyzer; the new Eyeline Mode feature adds a powerful new tool to eye diagram analysis
- A time domain reflectometer
- A jitter analyzer

Just select the desired instrument mode and start making measurements.

Configurable to meet your needs

The 86100C supports a wide range of modules for testing both optical and electrical signals. Select modules to get the specific bandwidth, filtering, and sensitivity you need.

PatternLock Triggering

The Enhanced Trigger Option (Option 001) on the 86100C provides a fundamental capability never available before in an equivalent time sampling oscilloscope. This new triggering mechanism enables the DCA-J to generate a trigger at the repetition of the input data pattern – a pattern trigger. Historically, this capability required the pattern source to provide this type of trigger output to the scope. PatternLock automatically detects the pattern length, data rate and clock rate making the complex triggering mechanism transparent to the user.

PatternLock enables the 86100C to behave more like a real-time oscilloscope in terms of user experience. Investigation of specific bits within the data pattern is greatly simplified. Users that are familiar with real-time oscilloscopes, but perhaps less so with equivalent time sampling scopes will be able to ramp up quickly.

PatternLock adds another new dimension to pattern triggering by enabling the mainframe software to take samples at specific locations in the data pattern with outstanding timebase accuracy. This capability is a building block for many of the new capabilities available in the 86100C described later.

Jitter Analysis

The "J" in DCA-J represents jitter analysis. The 86100C is a Digital Communications Analyzer with Jitter analysis capability. The 86100C adds a fourth mode of operation – Jitter Mode. Extremely wide bandwidth, low intrinsic jitter, and advanced analysis algorithms yield the highest accuracy in jitter measurements.

As data rates increase in both electrical and optical applications, jitter is an ever increasing measurement challenge. Decomposition of jitter into its constituent components is becoming more critical. It provides critical insight for jitter budgeting and performance optimization in device and system designs. Many emerging standards require jitter decomposition for compliance. Traditionally, techniques for separation of jitter have been complex and often difficult to configure, and availability of instruments for separation of jitter becomes very limited as data rates increase.

The DCA-J provides simple, one button setup and execution of advanced waveform analysis. Jitter Mode decomposes jitter into its constituent components and presents jitter data in various insightful displays. Jitter Mode operates at all data rates the 86100C supports, removing the traditional data rate limitations from complex jitter analysis. The 86100C brings several key attributes to jitter analysis:

- Very low intrinsic jitter (both random and deterministic) translates to a very low jitter noise floor which provides unmatched jitter measurement sensitivity.
- Wide bandwidth measurement channels deliver very low intrinsic data dependent jitter and allow analysis of jitter on all data rates to 40 Gb/s and beyond.
- PatternLock triggering technology provides sampling efficiency that makes jitter measurements very fast.

Jitter analysis functionality is segmented into two software package options. Option 200 is the enhanced jitter analysis software, and Option 201 is the advanced waveform analysis software. Option 200 includes:

- Decomposition of jitter into Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), Periodic Jitter (PJ), Data Dependent Jitter (DDJ), Duty Cycle Distortion (DCD), and Jitter induced by Intersymbol Interference (ISI).
- Various graphical and tabular displays of jitter data
- Export of jitter data to convenient delimited text format
- Save / recall of jitter database
- Jitter frequency spectrum
- Isolation and analysis of Sub-Rate Jitter (SRJ), that is, periodic jitter that is at an integer sub-rate of the bitrate.
- Bathtub curve display
- Adjustable total jitter probability

Equalization Capabilities

As bit rates increase, channel effects cause significant eye closure. Many new devices and systems are employing equalization and pre/de-emphasis to compensate for channel effects. Option 201 Advanced Waveform Analysis will provide key tools to enable design and test of devices and systems that must deal with difficult channel effects:

- Capture of long single valued waveforms. PatternLock triggering and the waveform append capability of Option 201 enable very accurate pulse train data sets up to 256 megasamples long.
- Equalization. The DCA-J can take a long single valued waveform and route it through a linear equalizer algorithm (default or user defined) and display the resultant equalized waveform in real time. The user can simultaneously view the input (distorted) and output (equalized) waveforms.
- Interface to MATLAB® analysis capability.

Digital communications analysis

Accurate eye-diagram analysis is essential for characterizing the quality of transmitters used from 100 Mb/s to 40 Gb/s. The 86100C is designed specifically for the complex task of analyzing digital communications waveforms. Compliance mask and parametric testing no longer require a complicated sequence of setups and configurations. If you can press a button, you can perform a complete compliance test. The important measurements you need are right at your fingertips, including:

- industry standard mask testing with built-in margin analysis
- extinction ratio measurements with accuracy and repeatability
- eye measurements: crossing %, eye height and width, ‘1’ and ‘0’ levels, jitter, rise or fall times and more

The key to accurate measurements of lightwave communications waveforms is the optical receiver. The 86100C has a broad range of precision receivers integrated within the instrument.

- Built-in photodiodes, with flat frequency responses, yield the highest waveform fidelity. This provides high accuracy for extinction ratio measurements.
- Standards-based transmitter compliance measurements require filtered responses. The 86100C has a broad range of filter combinations. Filters can be automatically and repeatably switched in or out of the measurement channel remotely over GPIB or with a front panel button. The frequency response of the entire measurement path is calibrated, and will maintain its performance over long-term usage.
- The integrated optical receiver provides a calibrated optical channel. With the accurate optical receiver built into the module, optical signals are accurately measured and displayed in optical power units.

Switches or couplers are not required for an average power measurement. Signal routing is simplified and signal strength is maintained.

Eye diagram mask testing

The 86100C provides efficient, high-throughput waveform compliance testing with a suite of standards based eye-diagram masks. The test process has been streamlined into a minimum number of keystrokes for testing at industry standard data rates.

Standard formats

Rate	(Mb/s)
1X Gigabit Ethernet	1250
2X Gigabit Ethernet	2500
10 Gigabit Ethernet	9953.28
10 Gigabit Ethernet	10312.5
10 Gigabit Ethernet FEC	11095.7
10 Gigabit Ethernet LX4	3125
Fibre Channel	1062.5
2X Fibre Channel	2125
4X Fibre Channel	4250
8x Fibre Channel	8500
10X Fibre Channel	10518.75
10X Fibre Channel FEC	11317
Infiniband	2500
STM0/OC1	51.84
STM1/OC3	155.52
STM4/OC12	622.08
STM16/OC48	2488.3
STM16/OC48 FEC	2666
STM64/OC192	9953.28
STM64/OC192 FEC	10664.2
STM64/OC192 FEC	10709
STM64/OC192 Super FEC	12500
STM256/OC768	39813
STS1 EYE	51.84
STS3 EYE	155.52

Other eye-diagram masks are easily created through scaling those listed at left. In addition, mask editing allows for new masks either by editing existing masks, or creating new masks from scratch. A new mask can also be created or modified on an external PC using a text editor such as Notepad, then can be transferred to the instrument’s hard drive using LAN or Flash drive.

Perform these mask conformance tests with convenient user-definable measurement conditions, such as mask margins for guardband testing, number of waveforms tested, and stop/limit actions.

Eyeline Mode

Eyeline Mode is a new feature only available in the 86100C that provides insight into the effects of specific bit transitions within a data pattern. The unique view assists diagnosis of device or system failures do to specific transitions or sets of transitions within a pattern. When combined with mask limit tests, Eyeline Mode can quickly isolate the specific bit that caused a mask violation.

Traditional triggering methods on an equivalent time sampling scope are quite effective at generating eye diagrams. However, these eye diagrams are made up of samples whose timing relationship to the data pattern is effectively random, so a given eye will be made up of samples from many different bits in the pattern taken with no specific timing order. The result is that amplitude versus time trajectories of specific bits in the pattern are not visible. Also, averaging of the eye diagram is not valid, as the randomly related samples will effectively average to zero.

Eyeline Mode uses PatternLock triggering to build up an eye diagram from samples taken sequentially through the data pattern. This maintains a specific timing relationship between samples and allows Eyeline Mode to draw the eye based on specific bit trajectories. Effects of specific bit transitions can be investigated, and averaging can be used with the eye diagram.

Measurement speed

Measurement speed has been increased with both fast hardware and a user-friendly instrument. In the lab, don't waste time trying to figure out how to make a measurement. With the simple-to-use 86100C, you don't have to relearn how to make a measurement each time you use it.

Manufacturers are continually forced to reduce the cost per test. Solution: Fast PC-based processors, resulting in high measurement throughput and reduced test time.

Measurements

The following measurements are available from the tool bar, as well as the pull down menus. The available measurements depend on the DCA-J operating mode.

Oscilloscope mode

Time
Rise Time, Fall Time, Jitter RMS, Jitter p-p, Period, Frequency, + Pulse Width, - Pulse Width, Duty Cycle, Delta Time, [T_{max}, T_{min}, T_{edge}—remote commands only]

Amplitude
Overshoot, Average Power, V amptd, V p-p, V rms, V top, V base, V max, V min, V avg

Eye/mask mode

NRZ eye measurements
Extinction Ratio, Jitter RMS, Jitter p-p, Average Power, Crossing Percentage, Rise Time, Fall Time, One Level, Zero Level, Eye Height, Eye Width, Signal to Noise (Q-Factor), Duty Cycle Distortion, Bit Rate, Eye Amplitude

RZ Eye Measurements
Extinction Ratio, Jitter RMS, Jitter p-p, Average Power, Rise Time, Fall Time, One Level, Zero Level, Eye Height, Eye Amplitude, Opening Factor, Eye Width, Pulse Width, Signal to Noise (Q-Factor), Duty Cycle, Bit Rate, Contrast Ratio

Mask Test

Open Mask, Start Mask Test, Exit Mask Test, Filter, Mask Test Margins, Mask Test Scaling, Create NRZ Mask

Jitter Mode

Jitter Mode requires Option 001 Enhanced Trigger hardware.

There are two analysis software packages for the DCA-J. Option 200 is the enhanced jitter analysis software, and Option 201 is the advanced waveform analysis software.

Measurements (Option 200 Jitter Analysis)
Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), Periodic Jitter (PJ), Data Dependent Jitter (DDJ), Duty Cycle Distortion (DCD), Intersymbol Interference (ISI), Sub-Rate Jitter (SRJ)

Data Displays (Option 200 Jitter Analysis)
TJ histogram, RJ/PJ histogram, DDJ histogram, Composite histogram, DDJ versus Bit position, Bathtub curve, SRJ analysis

Measurements (Option 201 Advanced Waveform Analysis)
Pattern waveform

Data Displays (Option 201 Advanced Waveform Analysis)
Equalized waveform

TDR/TDT Mode (requires TDR module)

Quick TDR, TDR/TDT Setup, Normalize, Response, Rise Time, Fall Time, Δ Time, Minimum Impedance, Maximum Impedance, Average Impedance, Single-ended and Mixed-mode S-parameters.

Additional Capabilities

Standard Functions

Standard functions are available through pull down menus and soft keys, and some functions are also accessible through the front panel knobs.

Markers

Two vertical and two horizontal (user selectable)

TDR Markers

Horizontal – seconds or meter
Vertical – volts, ohms or Percent Reflection
Propagation – Dielectric Constant or Velocity

Limit tests

Acquisition limits
Limit Test Run Until Conditions – Off, # of Waveforms, # of Samples

Report Action on Completion – Save waveform to memory or disk, Save screen image to disk

Measurement limit test
Specify Number of Failures to Stop Limit Test
When to Fail Selected Measurement – Inside Limits, Outside Limits, Always Fail, Never Fail
Report Action on Failure - Save waveform to memory or disk, Save screen image to disk, Save summary to disk

Mask limit test
Specify Number of Failed Mask Test Samples
Report Action on Failure – Save waveform to memory or disk, Save screen image to disk, Save summary to disk

Configure measurements

Thresholds
10%, 50%, 90% or 20%, 50%, 80% or Custom

Eye Boundaries
Define boundaries for eye measurments
Define boundaries for alignment

Format Units for
Duty Cycle Distortion – Time or Percentage
Extinction/Contrast Ratio – Ratio, Decibel or Percentage
Eye Height – Amplitude or Decibel (dB)
Eye Width – Time or Ratio
Average Power – Watts or Decibels (dB)

Top Base Definition
Automatic or Custom

Δ Time Definition
First Edge Number, Edge Direction, Threshold
Second Edge Number, Edge Direction, Threshold

Jitter Mode
Units (time or unit interval)
Signal type (data or clock)
Measure based on edges (all, rising only, falling only)
Graph layout (single, split, quad)

Quick Measure Configuration

4 User Selectable Measurements for Each Mode

Default Settings (Eye/Mask Mode)
Extinction Ratio, Jitter RMS, Average Power, Crossing Percentage

Default Settings (Oscilloscope Mode)
Rise Time, Fall Time, Period, V amptd

Histograms

Configure
Histogram scale (1 to 8 divisions)
Histogram axis (vertical or horizontal)
Histogram window (adjustable Window via marker knobs)

Math measurements

4 User definable functions Operator – magnify, invert, subtract, versus, min, max

Source – channel, function, memory, constant, response (TDR)

Calibrate

All calibrations

Module (amplitude)
Horizontal (time base)
Extinction ratio
Probe
Optical channel

Front panel calibration output level

User selectable –2V to 2V

Utilities

Set time and date

Remote interface

Set GPIB interface

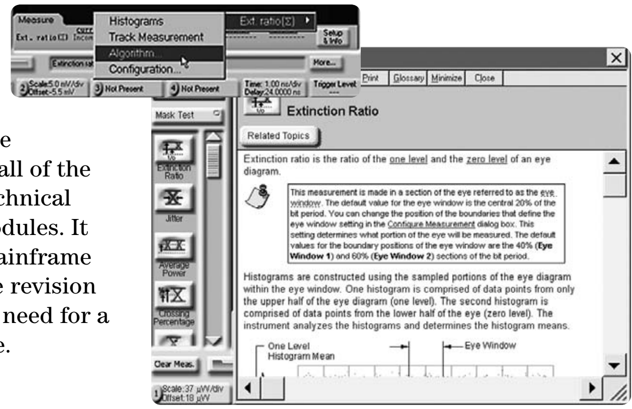
Touch screen configuration/calibration

Calibration
Disable/enable touch screen

Upgrade software

Upgrade mainframe
Upgrade module

Built-in information system



The 86100C has a context-sensitive on-line manual providing immediate answers to your questions about using the instrument. Links on the measurement screen take you directly to the information you need including algorithms for all of the measurements. The on-line manual includes technical specifications of the mainframe and plug-in modules. It also provides useful information such as the mainframe serial number, module serial numbers, firmware revision and date, and hard disk free space. There is no need for a large paper manual consuming your shelf space.

File sharing and storage

Use the internal 40 GB hard drive to store instrument setups, waveforms, or screen images. A 64MB USB memory stick is included with the mainframe. Combined with the USB port on the front panel this provides for quick and easy file transfer. Images can be stored in formats easily imported into various programs for documentation and further analysis. LAN interface is also available for network file management and printing. An external USB CD-RW drive is included with the mainframe. This enables easy installation of software applications as well as storage of large amounts of data.

File security

For users requiring security of their data, 86100C Option 090 offers a removable hard drive. This also enables removal of the mainframe from secure environments for calibration and repair.

Powerful display modes

Use gray scale and color graded trace displays to gain insight into device behavior. Waveform densities are mapped to color or easy-to-interpret gray shades. These are infinite persistence modes where shading differentiates the number of times data in any individual screen pixel has been acquired.

Direct triggering through clock recovery

Typically an external timing reference is used to synchronize the oscilloscope to the test signal. In cases where a trigger signal is not available, clock recovery modules are available to derive a timing reference directly from the waveform to be measured. The Agilent 8349XA series of clock recovery modules are available for electrical, multimode optical, and single-mode optical input signals. All 8349XA modules have excellent jitter performance to ensure accurate measurements. Each clock recovery module is designed to synchronize to a variety of common transmission rates. The 83496A can derive triggering from optical and electrical signals at any rate from 50 Mb/s to 13.5 Gb/s.

Clock recovery loop bandwidth

The Agilent clock recovery modules have adjustable loop bandwidth settings. Loop bandwidth is very important in determining the accuracy of your waveform when measuring jitter, as well as testing for compliance. When using recovered clocks for triggering, the amount of jitter observed will depend on the loop bandwidth. As the loop bandwidth increases, more jitter is “tracked out” by the clock recovery resulting in less observed jitter.

- Narrow loop bandwidth provides a “jitter free” system clock to observe all the jitter
- Wide loop bandwidth in some applications is specified in the standards for compliance testing. Wide loop bandwidth settings mimic the performance of communications system receivers

The 83496A has a continuously adjustable loop bandwidth from as low as 30 kHz to as high as 10 MHz, and can be configured as a golden PLL for standards compliance testing.

S-parameters and time domain reflectometery/time domain transmission (TDR/TDT)

High-speed design starts with the physical structure. The transmission and reflection properties of electrical channels and components must be characterized to ensure sufficient signal integrity, so reflections and signal distortions must be kept at a minimum. Use TDR and TDT to optimize microstrip lines, backplanes, PC board traces, SMA edge launchers and coaxial cables.

Analyze return loss, attenuation, crosstalk, and other S-parameters with one button push using the 86100C Option 202 Enhanced Impedance and S-parameter software, either in single-ended or mixed-mode signals.

Calibration techniques, unique to the 86100C, provide highest precision by removing cabling and fixturing effects from the measurement results. Translation of TDR data to complete single-ended, differential, and mixed mode S-parameters are available through Option 202 and the N1930A Physical Layer Test System software. Higher two-event resolution and ultra high-speed impedance measurements are facilitated through TDR pulse enhancers from Picosecond Pulse Labs[1].

N1024 TDR calibration kit

The N1024A TDR calibration kit contains precision standard devices based on SOLT (Short-Open-Load-Through) technology to calibrate the measurement path.

Waveform autoscaling

Autoscaling provides quick horizontal and vertical scaling of both pulse and eye-diagram (RZ and NRZ) waveforms.

Gated triggering

Trigger gating port allows easy external control of data acquisition for circulating loop or burst-data experiments. Use TTL-compatible signals to control when the instrument does and does not acquire data.

Easier calibrations

Calibrating your instrument has been simplified by placing all the performance level indicators and calibration procedures in a single high-level location. This provides greater confidence in the measurements made and saves time in maintaining equipment.

Stimulus response testing using the Agilent N490X BERTs

Error performance analysis represents an essential part of digital transmission test. The Agilent 86100C and N490X BERT have similar user interfaces and together create a powerful test solution. If stimulus only is needed, the 81141A and 81142A pattern generators work seamlessly with the 86100C.

Transitioning from the Agilent 83480A and 86100A/B to the 86100C

While the 86100C has powerful new functionality that its predecessors don't have, it has been designed to maintain compatibility with the Agilent 86100A, 86100B and Agilent 83480A digital communications analyzers and Agilent 54750A wide-bandwidth oscilloscope. All modules used in the Agilent 86100A/B, 83480A and 54750A can also be used in the 86100C. The remote programming command set for the 86100C has been designed so that code written for the 86100A or 86100B will work directly. Some code modifications are required when transitioning from the 83480A and 54750A, but the command set is designed to minimize the level of effort required.

IVI-COM capability

Interchangeable Virtual Instruments (IVI) is a group of new instrument device software specifications created by the IVI Foundation to simplify interchangeability, increase application performance, and reduce the cost of test program development and maintenance through design code reuse. The 86100C IVI-COM drivers are available for download from the Agilent website.

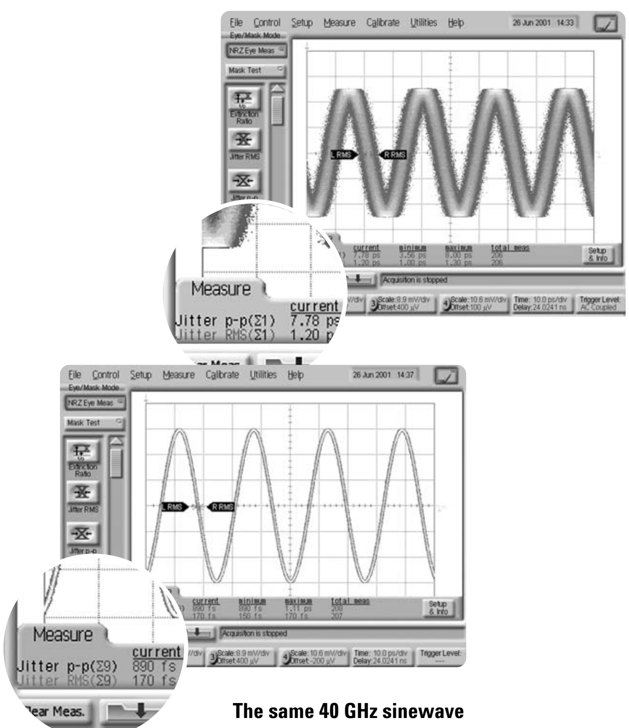
1 Picosecond Pulse Labs (www.picosecond.com)

Lowest intrinsic jitter

The patented 86107A precision timebase reference module represents one of the most significant improvements in wide-bandwidth sampling oscilloscopes in over a decade. Jitter performance has been reduced by almost an order of magnitude to < 200 fs RMS. Oscilloscope jitter is virtually eliminated! The reduced jitter of the 86107A precision timebase module allows you to measure the true jitter of your signal. When using the 86107A, the minimum timebase resolution for oscilloscope and eye/mask displays is 500 fs/division, rather than 2 ps/div with the standard timebase.

The standard timebase of the 86100C has very low intrinsic jitter compared to other advanced waveform analysis solutions. However, for users who need the most accurate sensitivity for their jitter measurements, the 86107A provides the ultimate timebase performance. Using the 86107A with Jitter Mode requires the Option 200 Enhanced Jitter software package. Jitter measurements with the 86107A are targeted at users who are trying to accurately measure very low levels of jitter and need to minimize the jitter contribution of the scope.

The 86107A requires an electrical reference clock that is synchronous with the signal under test. For specific requirements of the clock signal, see the 86107A specifications on page 11.



The same 40 GHz sinewave captured using current DCA (top) and now with 86107A precision timebase module (bottom).

Accurate views of your 40 Gb/s waveforms

When developing 40 Gb/s devices, even a small amount of inherent scope jitter can become significant since 40 Gb/s waveforms only have a bit period of 25 ps. Scope jitter of 1ps RMS can result in 6 to 9 ps of peak-to-peak jitter, causing eye closure even if your signal is jitter-free. The Agilent 86107A reduces the intrinsic jitter of 86100 family mainframes to the levels necessary to make quality waveform measurements on 40 Gb/s signals.

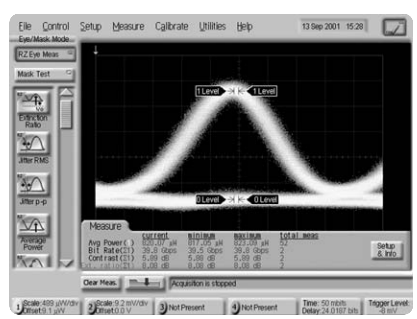
Meeting your growing need for more bandwidth

Today's communication signals have significant frequency content well beyond an oscilloscope's 3-dB bandwidth. A high-bandwidth scope does not alone guarantee an accurate representation of your waveform. Careful design of the scope's frequency response (both amplitude and phase) minimizes distortion such as overshoot and ringing.

The Agilent 86116A and 86116B are plug-in modules that include an integrated optical receiver designed to provide the optimum in bandwidth, sensitivity, and waveform fidelity. The 86116B extends the bandwidth of the 86100C infiniium DCA-J to 80 GHz electrical, 65 GHz optical in the 1550 nm wavelength band. The 86116A covers the 1300 nm and 1550 nm wavelength bands with 63 GHz of electrical bandwidth and 53 GHz of optical bandwidth. The 86117A and 86118A modules provide electrical bandwidth to 50 GHz and 70 gHz respectively. You can build the premier solution for 40 Gb/s waveform analysis around the 86100 mainframe that you already own.

Performing return-to-zero (RZ) waveform measurements

An extensive set of automatic RZ measurements are built-in for the complete characterization of return-to-zero (RZ) signals at the push of a button.



Specifications

Specifications describe warranted performance over the temperature range of +10 °C to +40 °C (unless otherwise noted). The specifications are applicable for the temperature after the instrument is turned on for one (1) hour, and while self-calibration is valid. Many performance parameters are enhanced through frequent, simple user calibrations. ***Characteristics*** *provide useful, non-warranted information about the functions and performance of the instrument. Characteristics are printed in italic typeface.*

Factory Calibration Cycle -For optimum performance, the instrument should have a complete verification of specifications once every twelve (12) months.

General specifications

This instrument meets Agilent Technologies' environmental specifications (section 750) for class B-1 products with exception as described for temperature and condensation. Contact your local field engineer for complete details. Product specifications and descriptions in this document subject to change without notice.

Temperature	
Operating	10 °C to +40 °C (50 °F to +104 °F)
Non-operating	–40 °C to +65 °C (–40 °F to +158 °F)
Humidity	
Operating	Up to 90% humidity (non-condensing) at +40 °C (+104 °F)
Non-operating	Up to 95% relative humidity at +65 °C (+149 °F)
Altitude	
Operating	Up to 4,600 meters (15,000 ft)
Non-operating	Up to 15,300 meters (50,000 ft)
Vibration	
Operating	Random vibration 5 to 500 Hz, 10 minutes per axis, 0.21 g (rms)
Non-operating	Random vibration 5 to 500 Hz, 10 minutes per axis, 0.3 g (rms); Resonant search, 5 to 500 Hz swept sine, 1 octave/min sweep rate, 0.5 g, 5 minute resonant dwell at 4 resonances/axis
Power requirements	
Voltage	90 to 132 or 198 to 264 Vac, 48 to 66 Hz
Power (including modules)	604 VA; 391 W
Weight	
Mainframe without modules	15.5 kg (34 lb)
Typical module	1.2 kg (2.6 lb)
Mainframe dimensions (excluding handle)	
Without front connectors and rear feet	215.1 mm H x 425.5 mm W x 566 mm D (8.47 in x 16.75 in x 22.2 in)
With front connectors and rear feet	215.1 mm H x 425.5 mm W x 629 mm D (8.47 in x 16.75 in x 24.8 in)

Mainframe specifications

HORIZONTAL SYSTEM (time base)		**PATTERN LOCK**
Scale factor (full scale is ten divisions)		
Minimum	2 ps/div (with 86107A: 500 fs/div)	
Maximum	1 s/div	250 ns/div
Delay[1]		
Minimum	24 ns	40.1 ns
Maximum	1000 screen diameters or 10 s, whichever is smaller	1000 screen diameters or 25.401 µs, whichever is smaller
Time interval accuracy[2]	1 ps + 1.0% of Δ time reading[3] 8 ps + 0.1% of Δ time reading	
Time interval accuracy – jitter mode operation[4]	*1 ps*	
Time interval accuracy – with 86107A precision timebase	< 200 fs	
Time interval resolution	≤ (screen diameter)/(record length) or 62.5 fs, whichever is larger	
Display units	Bits or time (TDR mode–meters)	

VERTICAL SYSTEM (channels)	
Number of channels	4 (simultaneous acquisition)
Vertical resolution	14 bit A/D converter (up to 15 bits with averaging)
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
Record length	16 to 4096 samples – increments of 1

1 Time offset relative to the front panel trigger input on the instrument mainframe.
2 Dual marker measurement performed at a temperature within ±5 °C of horizontal calibration temperature.
3 Delay settings: Δ time is in the range (26 + N*4 ns) ±1.9 ns, where N = 0, 1, 2, ... 17.
4 Characteristic performance. Test configuration: PRBS of length $2^7 - 1$ bits, Data and Clock 10 Gb/s.

Mainframe specifications *(continued)*

	Standard (direct trigger)	Option 001 (enhanced trigger)
Trigger Modes		
Internal trigger[1]	Free run	
External direct trigger[2]		
Limited bandwidth[3]	DC to 100 MHz	
Full bandwidth	DC to 3.2 GHz	
External Divided Trigger	N/A	3 GHz to 13 GHz *(3 GHz to 15 GHz)*
PatternLock	N/A	50 MHz to 13 GHz *(50 MHz to 15 GHz)*
Jitter		
Characteristic	*< 1.0 ps RMS + 5*10E-5 of delay setting[4]*	*1.2 ps RMS for time delays less than 100 ns[6]*
Maximum	1.5 ps RMS + 5*10E-5 of delay setting[4]	1.7 ps RMS for time delays less than 100 ns[6]
Trigger sensitivity	200 m Vpp (sinusoidal input or 200 ps minimum pulse width)	200 m Vpp sinusoidal input: 50 MHz to 8 GHz 400 m Vpp sinusoidal input: 8 GHz to 13 GHz *600 m Vpp sinusoidal input: 13 GHz to 15 GHz*
Trigger configuration		
Trigger level adjustment	–1 V to + 1 V	AC coupled
Edge select	Positive or negative	N/A
Hysteresis[5]	Normal or high sensitivity	N/A
Trigger gating		
Gating input levels (TTL compatible)	*Disable: 0 to 0.6 V* *Enable: 3.5 to 5 V* *Pulse width > 500 ns, period > 1 µs*	
Gating delay	*Disable: 27 ns + trigger period + Max time displayed* *Enable: 100 ns*	
Trigger impedance		
Nominal impedance	*50 Ω*	
Reflection	*10% for 100 ps rise time*	
Connector type	3.5 mm (male)	
Maximum trigger signal	2 V peak-to-peak	

1 The 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.
2 The sampled input signal timing is recreated by using an externally supplied trigger signal that is synchronous with the sampled signal input.
3 The DC to 100 MHz mode is used to minimize the effect of high frequency signals or noise on a low frequency trigger signal.
4 Measured at 2.5 GHz with the triggering level adjusted for optimum trigger.
5 High Sensitivity Hysteresis Mode improves the high frequency trigger sensitivity but is not recommended when using noisy, low frequency signals that may result in false triggers without normal hysteresis enabled.
6 Slew rate ≥ 2V/ns

Precision time base 86107A[1]

	86107A Option 010	86107A Option 020	86107A Option 040
Trigger bandwidth	2.4 to 15.0 GHz	2.4 to 25.0 GHz	2.4 to 48.0 GHz
Typical jitter (RMS)	2.4 to 4.0 GHz trigger: < 280 fs 4.0 to 15.0 GHz trigger: < 200 fs	2.4 to 4.0 GHz < 280 fs 4.0 to 25.0 GHz < 200 fs	2.4 to 4.0 GHz < 280 fs 4.0 to 48.0 GHz < 200 fs
Time base linearity error	< 200 fs		
Input signal type	Synchronous clock[2]		
Input signal level	0.5 to 1.0 Vpp 0.2 to 1.5 Vpp (Typical functional performance)		
DC offset range	±200 mV[3]		
Required trigger signal-to-noise ratio	≥ 200 : 1		
Trigger gating **Gating input levels (TTL compatible)**	Disable: 0 to 0.6 V Enable: 3.5 to 5 V Pulse width > 500 ns, period > 1 µs		
Trigger impedance (nominal)	50 Ω		
Connector type	3.5 mm (male)		3.5 mm (male) 2.4 mm (male)

1 Requires 86100 software revision 4.1 or above.
2 Filtering provided for Option 010 bands 2.4 to 4.0 GHz and 9.0 to 12.6 GHz, for Option 020 9.0 to 12.6 GHz and 18 to 25.0 GHz, for Option 40 9.0 to 12.6 GHz, 18.0 to 25.0 GHz, and 39.0 to 48.0 GHz. Within the filtered bands, a synchronous clock signal should be provided (clock, sinusoid, BERT trigger, etc.). Outside these bands, filtering is required to minimize harmonics and sub harmonics and provide a sinusoid to the 86107 input.
3 For the 86107A with Option 020, the Agilent 11742A (DC Block) is recommended if the DC offset magnitude is greater than 200 mV.

Computer system and storage

CPU	1 GHz microprocessor
Mass storage	40 GByte internal hard drive External USB CD-RW drive 64 MB USB pen memory
Operating System	Microsoft Windows® XP Pro
DISPLAY[1]	
Display area	170.9 mm x 128.2 mm (8.4 inch diagonal color active matrix LCD module incorporating amorphous silicon TFTs)
Active display area	171mm x 128 mm (21,888 square mm) 6.73 in x 5.04 in (33.92 square inches)
Waveform viewing area	103 mm x 159 mm (4.06 in x 6.25 in)
Entire display resolution	640 pixels horizontally x 480 pixels vertically
Graticule display resolution	451 pixels horizontally x 256 pixels vertically
Waveform colors	Select from 100 hues, 0 to 100% saturation and 0 to 100% luminosity
Persistence modes	Gray scale, color grade, variable, infinite
Waveform overlap	When two waveforms overlap, a third color distinguishes the overlap area
Connect-the-dots	On/Off selectable
Persistence	Minimum, variable (100 ms to 40 s), infinite
Graticule	On/Off
Grid intensity	0 to 100%
Backlight saver	2 to 8 hrs, enable option
Dialog boxes	Opaque or transparent
FRONT PANEL INPUTS AND OUTPUTS	
Cal output	BNC (female) and test clip, banana plug
Trigger input	APC 3.5 mm, 50 Ω, 2 Vpp base max
USB[2]	
REAR PANEL INPUTS AND OUTPUTS	
Gated trigger input	TTL compatible
Video output	VGA, full color, 15 pin D-sub (female) 10
GPIB	Fully programmable, complies with IEEE 488.2
RS-232	Serial printer, 9 pin D-sub (male)
Centronics	Parallel printer port, 25 pin D-sub (female)
LAN	
USB[2] **(2)**	

1 Supports external display. Supports multiple display configurations via Windows® XP Pro display utility.
2 USB Keyboard and mouse included with mainframe. Keyboard has intergrated, 2-port USB hub.

Module overview

Optical/electrical modules

750-1650 nm

The 86105C has the widest coverage of data rates with optical bandwidth of 9 GHz and electrical bandwidth of 20 GHz. The outstanding sensitivity up to –21 dBm makes the 86105C ideal for a wide range of design and manufacturing applications. Available filters cover all common data rates from 155 Mb/s through 11.3 Gb/s.

750-860 nm

The 86102U module supports waveform compliance testing of short wavelength signals with up to 15 GHz of optical bandwidth and 20 GHz of electrical bandwidth.

1000–1600 nm

< 20 GHz Optical and Electrical Channels:

The 86105B module is optimized for testing long wavelength signals with up to 15 GHz of optical bandwidth. Each module also has an electrical channel with 20 GHz of bandwidth.

The 86105B provides the high pulse fidelity and sensitivity, and flexible data rates. It is the recommended module for 10 Gb/s compliance applications.

20 to 40 GHz Optical and Electrical Channels:
The 86106B has 28 GHz of optical bandwidth with multiple 10Gb/s compliance filters, and has an electrical channel with 40 GHz of bandwidth.

40 GHz and Greater Optical and Electrical Channels:
The 86116A is optimized for testing 40 Gb/s signals. The 86116A has more than 50 GHz of optical bandwidth and 60 GHz of electrical bandwidth. The 86116B is the widest bandwidth optical module with more than 65 GHz optical (1550nm band only) and 80 GHz electrical bandwidth.

Dual electrical modules

86112A has two low-noise electrical channels with 20 GHz of bandwidth.

86117A has two electrical channels with up to 50 GHz of bandwidth ideal for testing signals up to 10 Gb/s.

86118A has two electrical channels, each housed in a compact remote sampling head, attached to the module with separate light weight cables. With over 70 GHz of bandwidth, this module is intended for high bit rate applications where signal fidelity is crucial.

Clock recovery modules

Unlike realtime oscilloscopes, equivalent time sampling oscilloscopes like the 86100 require a timing reference or trigger that is separate from the signal being observed. This is often achieved with a clock signal that is synchronous to the signal under test. Another approach is to derive a clock from the test signal with a clock recovery module.

The 83496A provides the highest performance/flexibility as it is capable of operation at any data rate from 50 Mb/s to 13.5 Gb/s, on single-ended and differential electrical signals, single-mode (1250 to 1620 nm) and multimode (780 to 1330 nm) optical signals, with extremely low residual jitter. PLL loop bandwidth is adjustable to provide optimal jitter filtering according to industry test standards.

The 83495A works for optical and electrical signals and has either multimode (750 to 860 nm) or single mode (1000 to 1600 nm) inputs. It operates over a continuous range of rates from 9.95 Gb/s to 11.3 Gb/s and has both low and high loop BW settings.

Time domain reflectometry (TDR)

The infiniium DCA-J may also be used as a powerful, high accuracy TDR, using the 54754A differential TDR module.

86100 family plug-in module matrix

The 86100 has a large family of plug-in modules designed for a broad range of data rates for optical and electrical waveforms. The 86100 can hold up to 2 modules for a total of 4 measurement channels.

	Module	Option	No. of optical channels	No. of electrical channels	Wavelength range (nm)	Unfiltered optical bandwidth (GHz)	Electrical bandwidth (GHz)	Fiber input (µm)	Mask test sensitivity (dBm)	Filtered data rates: 155 Mb/s	622 Mb/s	1063 Mb/s	1244/1250 Mb/s	2125 Mb/s	2488/2500 Mb/s	2.666 Gb/s	2.72 Gb/s	3.125 Gb/s	3.1875 Gb/s	3.32 Gb/s	4.25 Gb/s	8.500 Gb/s	9.953 Gb/s	10.3125 Gb/s	10.51875 Gb/s	10.664 Gb/s	10.709 Gb/s	11.095 Gb/s	11.317 Gb/s
Optical/ electrical	86102U	201	1	1	750-860	15	20	62.5	–7.5				■		■														
		202	1	1	750-860	15	20	62.5	–7.5						■			■											
		203	1	1	750-860	15	20	62.5	–7.5									■					■						
	86105B	101	1	1	1000-1600	15	20	9	–12														■	■	■	■	■		
		102	1	1	1000-1600	15	20	9	–12	■	■				■	■							■	■	■	■	■		
		103	1	1	1000-1600	15	20	9	–12			■	■	■	■								■	■	■	■	■		
	86105C	100*	1	1	750-1650	8.5	20	62.5	–20	■	■	■	■	■	■	■		■			■	■							
		200	1	1	750-1650	8.5	20	62.5	–16														■	■	■	■	■	■	■
		300*	1	1	750-1650	8.5	20	62.5	–16	■	■	■	■	■	■	■		■			■	■	■	■	■	■	■	■	■
	86106B		1	1	1000-1600	28	40	9	–7														■						
		410	1	1	1000-1600	28	40	9	–7														■	■		■	■		
	86116A		1	1	1000-1600	53	63	9	N/A																				
	86116B		1	1	1480-1620	65	80	9	N/A																				
Dual electrical	54754A		0	2		N/A	18																						
	86112A		0	2		N/A	20																						
	86117A		0	2		N/A	50																						
	86118A		0	2		N/A	70																						

*Pick any 4 rates (155 Mb/s to 8.5 Gb/s)

Module specifications: single-mode & multimode optical/electrical

Multimode and single-mode	86102U
OPTICAL CHANNEL SPECIFICATIONS	
Optical channel unfiltered bandwidth	15 GHz
Wavelength range	750 to 860 nm
Calibrated wavelengths	850 nm
Optical sensitivity[1]	*–7.5 dBm*
Transition time (10% to 90% calculated from TR = 0.48/BW optical)	
Unfiltered	*32 ps*
RMS noise	
Characteristic	*14 μW*
Maximum	20 μW
Scale factor (per division)	
Minimum	20 μW
Maximum	500 μW
CW accuracy (single marker, referenced to average power monitor, <50 μW/division)	±25 μW ±2% of (reading-channel offset), 15 GHz
CW offset range (referenced two divisions from screen bottom)	+1 mW to –3 mW
Average power monitor (specified operating range)	–27 dBm to +3 dBm
Factory calibrated accuracy	±5% ±100 nW ±connector uncertainty, 20 °C to 30 °C
User calibrated accuracy	±2% ±100 nW ±power meter uncertainty, < 5 °C change
Maximum input power	
Maximum non-destruct average	2 mW (+3 dBm)
Maximum non-destruct peak	10 mW (+10 dBm)
Fiber input	62.5/125 μm, user selectable connector
Input return loss (HMS-10 connector fully filled fiber)	20 dB

ELECTRICAL CHANNEL SPECIFICATIONS	
Electrical channel bandwidth	12.4 and 20 GHz
Transition time (10% to 90%, calculated from TR = 0.35/BW)	28.2 ps (12.4 GHz) 17.5 ps (20 GHz)
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	
Minimum	1 mV/division
Maximum	100 mV/division
DC accuracy (single marker)	±0.4% of full scale ± 2 mV ±1.5% of (reading-channel offset), 12.4 GHz ±0.4% of full scale ± 2 mV ±3% of (reading-channel offset), 20 GHz
DC offset range (referenced to center of screen)	±500 mV
Input dynamic range (relative to channel offset)	±400 mV
Maximum input signal	±2 V (+16 dBm)
Nominal impedance	50 Ω
Reflections (for 30 ps rise time)	5%
Electrical input	3.5 mm (male)

1 Smallest average optical power required for mask test. Values represent typical sensitivity of NRZ eye diagrams. Assumes mask test with complicance filter switched in.

Module specifications: single-mode & multimode optical/electrical *(continued)*

Multimode and single-mode Optical/electrical modules	86105B	86105C
OPTICAL CHANNEL SPECIFICATIONS		
Optical channel unfiltered bandwidth	15 GHz	8.5 GHz *(9 GHz)*
Wavelength range	1000 to 1600 nm	750 to 1650 nm
Calibrated wavelengths	1310 nm/1550 nm	850 nm/1310 nm/1550 nm (±20 nm)
Optical sensitivity[1]	*–12 dBm*	*850 nm* *≤ 2.666 Gb/s, –20 dBm* *> 2.666 Gb/s to ≤ 4.25 Gb/s, –19 dBm* *> 4.25 Gb/s to 11.3 Gb/s, –16 dBm* *1310 nm/1550 nm* *≤ 2.666 Gb/s, –21 dBm* *> 2.666 Gb/s to ≤ 4.25 Gb/s, –20 dBm* *> 4.25 Gb/s to 11.3 Gb/s, –17 dBm*
Transition time (10% to 90% calculated from TR = 0.48/BW optical)	*32 ps*	*56 ps*
RMS noise		
Characteristic	*5 µW, (10 GHz)* *12 µW, (15 GHz)*	*850 nm* *≤ 2.666 Gb/s, 1.3 µW* *> 2.666 Gb/s to ≤ 4.25 Gb/s, 1.5 µW* *> 4.25 Gb/s to 11.3 Gb/s, 2.5 µW* *1310 nm/1550 nm* *≤ 2.666 Gb/s, 0.8 µW* *> 2.666 Gb/s to ≤ 4.25 Gb/s, 1.0 µW* *> 4.25 Gb/s to 11.3 Gb/s, 1.4 µW*
Maximum	8 µW, (10 GHz) 15 µW (15 GHz)	850 nm ≤ 2.666 Gb/s, 2.0 µW > 2.666 Gb/s to ≤ 4.25 Gb/s, 2.5 µW > 4.25 Gb/s to 11.3 Gb/s, 4.0 µW 1310 nm/1550 nm ≤ 2.666 Gb/s, 1.3 µW > 2.666 Gb/s to ≤ 4.25 Gb/s, 1.5 µW > 4.25 Gb/s to 11.3 Gb/s, 2.5 µW
Scale factor (per division)		
Minimum	20 µW	2 µW
Maximum	500 µW	100 µW
CW accuracy (single marker, referenced to average power monitor)	±25 µW ±2% (10 GHz) ±25 µW ±4% (15 GHz)	±25 µW ±3% ±25 µW ±10%
CW offset range (referenced two divisions from screen bottom)	+1 µW to –3 µW	+0.2 µW to –0.6 µW
Average power monitor (specified operating range)	–30 dBm to +3 dBm	–30 dBm to 0 dBm
Average power monitor accuracy		
Single mode	±5% ±100 nW ±connector uncertainty (20 °C to 30 °C)	±5% ±200 nW ±connector uncertainty
Multi mode (characteristic)	N/A	±10% ±200 nW ±connector uncertainty
User calibrated accuracy		
Single mode	±2% ±100 nW ±power meter uncertainty, < 5 °C change	±3% ±200 nW ±power meter uncertainty, < 5 °C change
Multi mode (characteristic)	N/A	±10% ±200 nW ±power meter uncertainty, < 5 °C change
Maximum input power		
Maximum non-destruct average	2 mW (+3 dBm)	0.5 mW (–3 dBm)
Maximum non-destruct peak	10 mW (+10 dBm)	5 mW (+7 dBm)
Fiber input	9/125 µm user selectable connector	62.5/125 µm
Input return loss (HMS-10 connector fully filled fiber)	33 dB	850 nm > 13 dB , 1310 nm/1550 nm >24 dB

1 Smallest average optical power required for mask test. Values represent typical sensitivity of NRZ eye diagrams. Assumes mask test with complicance filter switched in.

Module specifications: single-mode & multimode optical/electrical *(continued)*

Multimode and single-mode Optical/electrical modules	86105B	86105C
ELECTRICAL CHANNEL SPECIFICATIONS		
Electrical channel bandwidth	12.4 and 20 GHz	
Transition time (10% to 90%, calculated from TR = 0.35/BW)	28.2 ps (12.4 GHz) 17.5 ps (20 GHz)	
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		
Minimum	1 mV/division	
Maximum	100 mV/division	
DC accuracy (single marker)	±0.4% of full scale ±2 mV ±1.5% of (reading-channel offset), 12.4 GHz ±0.4% of full scale ±2 mV ±3% of (reading-channel offset), 20 GHz	
DC offset range (referenced to center of screen)	±500 mV	
Input dynamic range (relative to channel offset)	±400 mV	
Maximum input signal	±2 V (+16 dBm)	
Nominal impedance	50 Ω	
Reflections (for 30 ps rise time)	5%	
Electrical input	3.5 mm (male)	

Module specifications: single-mode optical/electrical

High bandwidth, single-mode Optical/electrical modules	86106B	86116A[1]	86116B[1]
OPTICAL CHANNEL SPECIFICATIONS			
Optical channel unfiltered bandwidth	*28 GHz*	*53 GHz*	*65 GHz (best pulse fidelity)*
Wavelength range	1000 to 1600 nm		55 GHz (best sensitivity)
Calibrated wavelengths	1310/1550 nm		1480 to 1620 nm
Optical sensitivity[3]	*–7 dBm*		
Transition time (10% to 90%, calculated from TR = 0.48/BW optical)	*18 ps*	9.0 ps (FWHM)[2]	7.4 ps (FWHM)[2]
RMS noise			
Characteristic	*13 µW (Filtered)* *23 µW (Unfiltered)*	*60 µW (50 GHz)* *190 µW (53 GHz)*	*50 µW (55 GHz)* *140 µW (65 GHz)*
Maximum	15 µW (Filtered) 30 µW (Unfiltered)	90 µW (50 GHz) 260 µW (53 GHz)	85 µW (55 GHz) 250 µW (65 GHz)
Scale factor			
Minimum	20 µW/division	200 µW/division	
Maximum	500 µW/division	2.5 mW/division	5 mW/division
CW accuracy (single marker, referenced to average power monitor)	±50 µW ±4% of (reading-channel offset)	± 150 µW ± 4% of (reading-channel offset)	
CW offset range (referenced two divisions from screen bottom)	+1 mW to –3 mW	+5 mW to –15mW	+8 to –12 mW
Average power monitor (specified operating range)	–27 dBm to +3 dBm	–23 dBm to +9 dBm	
Factory calibrated accuracy	±5% ±100 nW ±connector uncertainty, 20 °C to 30 °C		
User calibrated accuracy	±2% ±100 nW ±power meter uncertainty, < 5 °C change		
Maximum input power			
Maximum non-destruct average	2 mW (+3 dBm)	10 mW (+10 dBm)	
Maximum non-destruct peak	10 mW (+10 dBm)	50 mW (+17 dBm)	
Fiber input	9/125 µm, user selectable connector		
Input return loss (HMS-10 connector fully filled fiber)	30 dB		20 dB

1 86116A and 86116B requires the 86100 software revision A.3.0 or above.

2 FWHM (Full Width Half Max) as measured from optical pulse with 700 fs FWHM, 5 MHz repetition rate and 10 mW peak power.

3 Smallest average optical power required for mask test. Values represent typical sensitivity of NRZ eye diagrams. Assumes mask test with compliance filter switched in.

ELECTRICAL CHANNEL SPECIFICATIONS			
Electrical channel bandwidth	18 and 40 GHz	43 and 63 GHz	80, 55 and 30 GHz
Transition time (10% to 90%, calculated from TR = 0.35/BW)	*19.5 ps (18 GHz)* *9 ps (40 GHz)*	*8.1 ps (43 GHz)* *5.6 ps (63 GHz)*	*6.4 ps (55 GHz)* *4.4 ps (80 GHz)*
RMS noise			
Characteristic	*0.25 mV (18 GHz)* *0.5 mV (40 GHz)*	*0.6 mV (43 GHz)* *1.7 mV (63 GHz)*	*0.6 mV (55 GHz)* *1.1 mV (80 GHz)*
Maximum	0.5m V (18 GHz) 1.0 mV (40 GHz)	0.9 mV (43 GHz) 2.5 mV (63 GHz)	1.1 mV (55 GHz) 2.2 mV (80 GHz)
Scale factor			
Minimum	1 mV/division	2 mV/division	
Maximum	100 mV/division	100 mV/division	
DC accuracy (single marker)	±0.4% of full scale ±2 mV ±1.5% of (reading-channel offset), 18 GHz ±0.4% of full scale ±2 mV ±3% of (reading-channel offset), 40 GHz	±0.8% of full scale ±2 mV ±1.5% of (reading-channel offset), 43 GHz ±2.5% of full scale ±2 mV ±2% of (reading-channel offset), 63 GHz	±0.4% of full scale ±3 mV ±2% of (reading-channel offset), ±2% of offset (all bandwidths)
DC offset range (referenced to center of screen)	±500 mV		
Input dynamic range (relative to channel offset)	±400 mV		
Maximum input signal	±2 V (+16 dBm)		
Nominal impedance	50 Ω		
Reflections (for 20 ps rise time)	5%		10% (DC to 70 GHz) 20% (70 to 100 GHz)
Electrical input	2.4 mm (male)	1.85 mm (male)	

Module specifications: dual electrical

Dual electrical channel modules	86112A	54754A
Electrical channel bandwidth	12.4 and 20 GHz	12.4 and 18 GHz
Transition time (10% to 90%, calculated from TR = 0.35/BW)	*28.2 ps (12.4 GHz);* *17.5 ps (20 GHz)*	*28.2 ps (12.4 GHz);* *19.4 ps (18 GHz)*
RMS noise		
Characteristic	*0.25 mV (12.4 GHz);* *0.5 mV (20 GHz)*	*0.25 mV (12.4 GHz);* *0.5 mV (18 GHz)*
Maximum	0.5 mv (12.4 GHz); 1 mV (20 GHz)	0.5 mv (12.4 GHz); 1 mV (18 GHz)
Scale factor		
Minimum	1 mV/division	
Maximum	100 mV/division	
DC accuracy (single marker)	±0.4% of full scale ±2 mV ±1.5% of (reading-channel offset), 12.4 GHz ±0.4% of full scale ±2 mV ±3% of (reading-channel offset), 20 GHz	±0.4% of full scale ±2mV ±0.6% of (reading-channel offset), 12.4 GHz ±0.4% of full scale or marker reading (whichever is greater) ±2 mV ±1.2% of (reading-channel offset), 18 GHz
CW offset range (referenced from center of screen)	±500 mV	
Input dynamic range (relative to channel offset)	±400 mV	
Maximum input signal	±2 V (+16 dBm)	
Nominal impedance	50 Ω	
Reflections (for 30 ps rise time)	5%	
Electrical input	3.5 mm (male)	

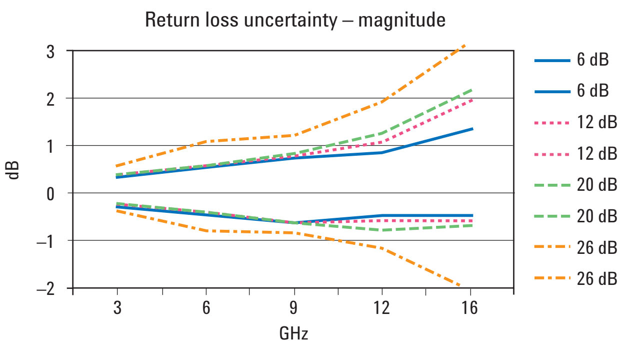
Dual electrical channel modules	86117A	86118A
Electrical channel bandwidth	30 and 50 GHz	50 and 70 GHz
Transition time (10% to 90%, calculated from TR = 0.35/BW)	*11.7 ps (30 GHz)* *7 ps (50 GHz)*	
RMS noise		
Characteristic	*0.4 mV (30 GHz)* *0.6 mV (50 GHz)*	*0.7 mV (50 GHz)* *1.3 mV (70 GHz)*
Maximum	0.7 mv (30 GHz); 1.0 mV (50 GHz	1.8 mV (50 GHz) 2.5 mV (70 GHz)
Scale factor		
Minimum	1 mV/division	
Maximum	100 mV/division	
DC accuracy (single marker)	±0.4% of full scale ±2 mV ±1.2% of (reading-channel offset) (30 GHz) ±0.4% of full scale ±2 mV ±2% of (reading-channel offset) (50 GHz)	±0.4% of full scale ±2 mV ±2% of (reading-channel offset) (50 GHz) ±0.4% of full scale ±2 mV ±4% of (reading-channel offset) (70 GHz)
CW offset range (referenced from center of screen)	±500 mV	
Input dynamic range (relative to channel offset)	±400 mV	
Maximum input signal	±2 V (+16 dBm)	
Nominal impedance	50 Ω	
Reflections (for 30 ps rise time)	5%	20%
Electrical input	2.4 mm (male)	1.85 mm (female)

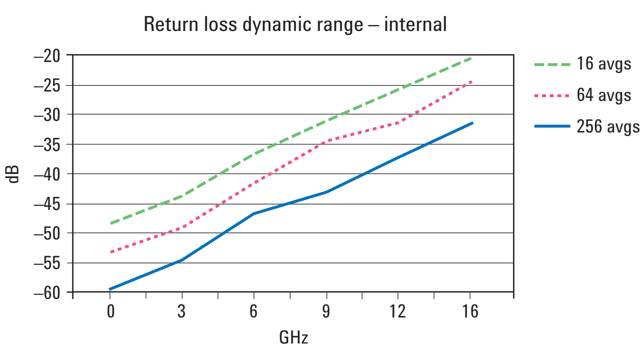
TDR system

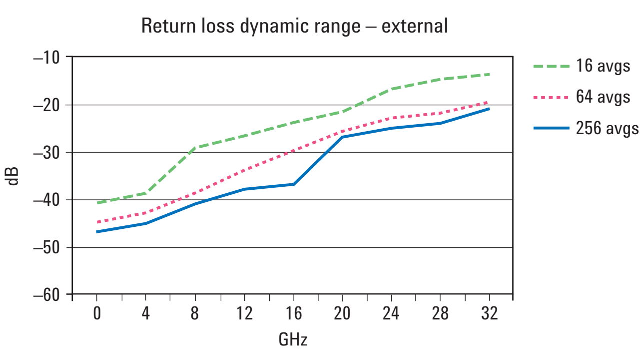
TDR system (Mainframe with 54754A module)	Oscilloscope/TDR performance	Normalized characteristics
Rise time	40 ps nominal < 25 ps normalized	Adjustable from larger of 10 ps or 0.08 x time/div Maximum: 5 x time/div
TDR step flatness	≤ ±1% after 1 ns from edge ≤ ±5%, –3% 1 ns from edge	≤ 0.1%
Low level **High level**	0.00 V ±2 mV ±200 mV ±2 mV	

86100C Option 202 characteristics

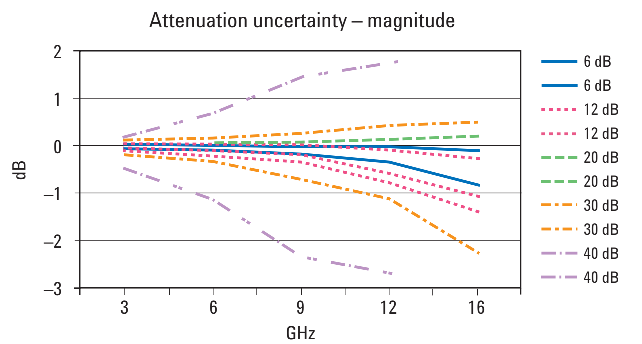
Return loss

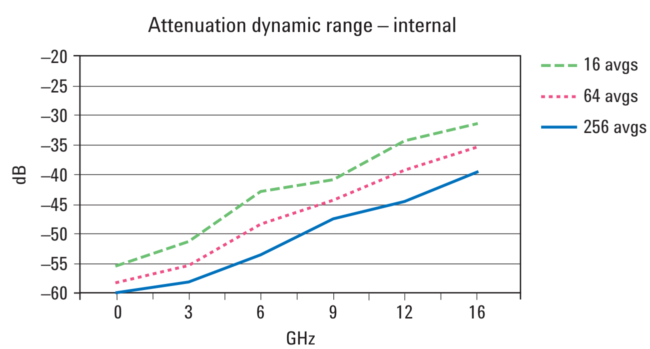


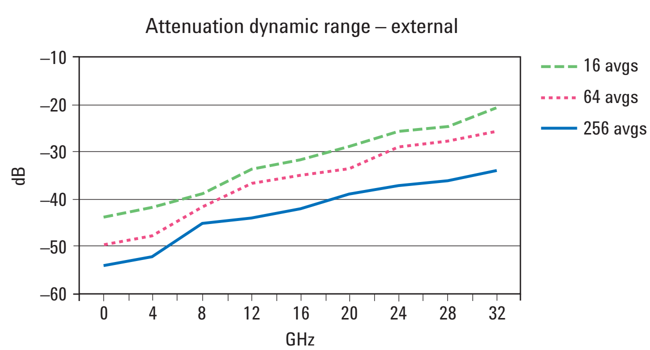




Attenuation

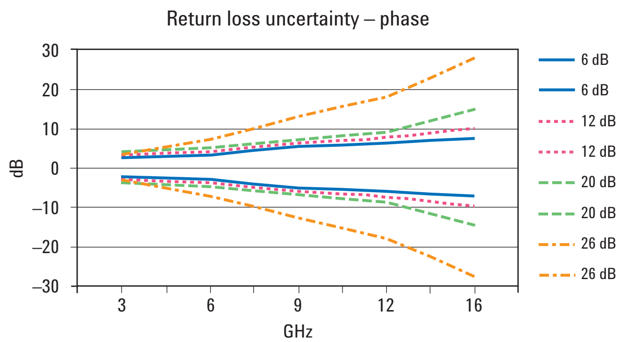






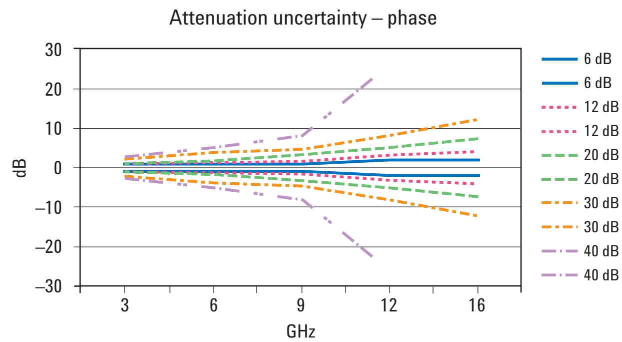
86100C Option 202 characteristics

Return loss



*See end notes for additional phase uncertainties

Attenuation



*See end notes for additional phase uncertainties

Performance characteristics for 86100C Option 202

Test conditions

- Mainframe and module have been turned on for at least one hour and have been calibrated
- TDR calibration has been performed using N1024A
- Internal measurements use 54754A as stimulus and either 54754A or 86112A as receiver
- External measurements use 54754A and Picosecond Pulse Labs Accelerator as stimulus and 86118A as receiver
- All characteristics apply to single-ended and differential
- Derived from measurements of wide range of devices compared to vector network analyzer measurements
- Averages of 256 except as noted in dynamic range

Phase uncertainty

- Longer equipment warm-up times and careful calibration provide the best phase performance – perform module and TDR calibrations again if temperatures change
- Phase uncertainty is the sum of the uncertainty from the desired graph plus the two additional components which are estimated below
- Sampling points - S-parameters are determined from 4096 sampling points over the time interval, which is time per division multiplied by ten divisions. The reference plane is determined to nearest sampling point with uncertainty given by this equation:

$$\text{Uncertainty in degrees (sampling points)} = \frac{\text{time per division (sec)} * 10 \text{ divisions} * \text{f (Hz)} * 360}{4096 * 2}$$

Simplified version = time per division (sec) * f(Hz) / 2.28

- Time base drift with temperature - the amount of drift can be observed by placing the calibration short at the reference plane and reading the amount of time difference in picoseconds. The phase uncertainty is given by this equation:

Uncertainty in degrees (temp drift) = time diff (sec) •frequency (Hz) * 360

Clock recovery

Clock recovery single mode, Multimode and electrical modules	83495A-100	83495A-101
Channel type	Single mode optical and electrical	Multimode optical and electrical
Wavelenth range	1000 to 1600 nm	750 to 860 nm
Clock recovery phase locked loop bandwidth		
Internal path triggering[2]	*< 300 KHz* or < 4 MHz *(3.5 MHz[1])* user selectable	
External output[2]	*< 300 KHz* or < 4 MHz *(3.5 MHz[1])* user selectable	
Data rates (Gb/s)	9.953 to 11.32	
Tracking range	*±30 MHz*	
Acquisition range	Continuous within data rate range	
Internal splitter ratio	20/80	30/70[5]
Clock output jitter[3]	0.008 UI *(0.006 UI)* RMS	
Input level for clock recovery[4]	–12 dBm *(–14 dBm)* to +0 dBm optical *0.20 to 2.0 Vp-p electrical*	–9 dBm *(–11 dBm)* to +0 dBm optical[5] *0.20 to 2.0 Vp-p electrical*
Input/output connectors	FC/PC, 9/125 µm & Type N	FC/PC, 62.5/125 µm & Type N
Auxiliary recovered clock and regenerated data outputs	Type N with SMA adapters (no data output)	
Input return loss	28 dB maximum optical DC to 2.5 GHz, 20 dB electrical 2.5 GHz to 11.32 GHz, 15 dB electrical	
Input insertion loss	2.0 dB maximum optical	2.5 dB maximum optical

1 Achieved with input power ≥ –8 dBm for Option 100; ≥ –5 dBm for Option 101.

2 Loop BW transfer function is guaranteed to be less than a low pass response with the specified corner frequency rolling off –20 dB/dec.

3 Measured with a PRBS 2^{23}-1 pattern. For total scope jitter, RSS clock output jitter with mainframe jitter.

4 For optical input power, source extinction ratio ≥ 8.2 dB when measured per TIA/EIA OFSTP-4A. For extinction ratio equal to 8.2 dB, OMA is defined as $(P_1 - P_0)$ and is equal to average input power (dBm) + 1.68 dB.

5 Input is a fully filled multimode signal.

Specifications

	83496A-100	83496A-101
Channel type	Differential or single-ended electrical	Single-mode or multimode optical, differential or single-ended electrical (no internal electrical splitters)
Data rates	Standard: 50 Mb/s to 7.1 Gb/s continuous tuning Option 200: 50 Mb/s to 13.5 Gb/s continuous tuning)	
Minimum input level to aquire lock (voltage or OMA[1])	150 m Vpp	**single-mode (OMA[1]):** –11 dBm @ 50 Mb/s to 11.4 Gb/s *–8 dBm @ > 11.4 G/bs* *–12 dBm @ 7.1 Gb/s to 13.5 Gb/s (w/Opt 200)* *–14 dBm @ 1 Gb/s to 7.1 Gb/s* *–15 dBm @ 50 Mb/s to 1 Gb/s* **multimode 1310 nm (OMA[1]):** –10 dBm @ 50 Mb/s to 11.4 Gb/s *–7 dBm @ > 11.4 G/bs* *–11 dBm @ 7.1 Gb/s to 13.5 Gb/s (w/Opt 200)* *–13 dBm @ 1 Gb/s to 7.1 Gb/s* *–14 dBm @ 50 Mb/s to 1 Gb/s* **multimode 850 nm (OMA[1]):** –8 dBm @ 50 Mb/s to 11.4 Gb/s *–7 dBm @ > 11.4 G/bs* –9 *dBm @ 7.1 Gb/s to 13.5 Gb/s (w/Opt 200)* *–11 dBm @ 1 Gb/s to 7.1 Gb/s* *–12 dBm @ 50 Mb/s to 1 Gb/s*
		electrical: 150 mVpp
Output random jitter (RMS)[2]	**Internal recovered clock trigger** < 500 fs 7.2 Gb/s to 11.4 Gb/s *(300 fs @ 10 Gb/s)* < 700 fs 4.2 Gb/s to 7.2 Gb/s, 11.4 GB/s to 13.5 Gb/s *(400 fs @ 4.25 Gb/s, 500 fs @ 2.5 Gb/s)* < 3 mUI 50 Mb/s to 4.2 Gb/s *(700 fs @ 1.25 Gb/s)*	
	Front panel recovered clock < 700 fs 7.2 Gb/s to 11.4 Gb/s *(300 fs @ 10 Gb/s)* < 900 fs 4.2 Gb/s to 7.2 Gb/s, 11.4 Gb/s to 13.5 Gb/s *(400 fs @ 4.25 Gb/s, 500 fs @ 2.5 Gb/s)* < 4 mUI 50 Mb/s to 4.2 Gb/s *(700 fs @ 1.25 Gb/s)*	
Clock recovery adjustable loop bandwidth range (user selectable)	Standard: *270 KHz or 1.5 MHz*[3] ; Option 300: 15 kHz to 10 MHz[4] continuous tuning (fixed value or a constant rate/N ratio)	
Loop bandwidth accuracy	Option 300: ±25% for transition density = 0.5 and data rate 155 Mb/s to 11.4 Gb/s *(±30% for 0.25 ≤ transition density ≤1.0 and all data rates)* Standard: *±30%*	
Tracking range	*±1000 ppm*	
Acquisition range	*±5000 ppm*	
Internal splitter ratio	*50/50*	*20/80 single-mode* *30/70 multi-mode* *Electrical signals have input only* *(no internal power dividers)*
Input return loss	*22 dB (DC to 12 GHz) electrical* *16 dB (12 to 20 GHz) electrical*	20 dB single-mode, 16 dB multi-mode *22 dB min (DC to 12 GHz) electrical* *16 dB min (12 to 20 GHz) electrical*
Input insertion loss	*7.2 dB max (DC to 12 GHz) electrical* *7.8 dB max (12 to 20 GHz) electrical*	2.5 dB max single-mode optical, 3 dB max multi-mode optical (no electrical data output signal path)

See footnotes on page 23.

Specifications *(continued)*

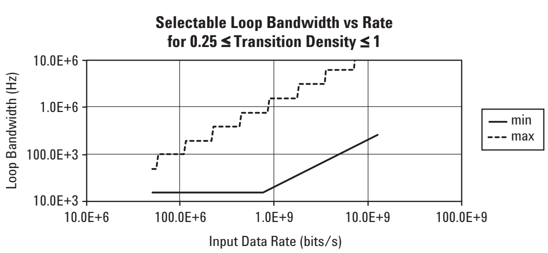
	83496A-100	83496A-101
Electrical through-path digital amplitude attenuation[5]	7.5 dB	(no electrical data output signal path)
Wavelength range		750 to 1330 nm multimode 1250 to 1650 nm single-mode
Front panel recovered clock output amplitude	1 Vpp max, 220 mVpp min, *300 mVpp*	
Consecutive identical digits (CID)	*150 max*	
Front panel recovered clock output divide ratio (user selectable)[6]	N=1 to 16 @ data rates 50 Mb/s to 7.1 Gb/s N=2 to 16 @ data rates 7.1 Gb/s to 13.5 Gb/s	
Data input/output connectors	3.5 mm male	FC/PC[7] 9/125 µm single-mode optical FC/PC[7] 62.5/125 µm multimode optical 3.5 mm male electrical (input only)
Front panel recovered clock output connector	SMA	

1 To convert from OMA to average power with an extinction ratio of 8.2 dB use: $Pavg_{dBm} = OMA_{dBm} - 1.68$ dB.

2 Verified with PRBS7 pattern, electrical inputs > 150 mVp-p and optical inputs > 3 dB above specification for minimum input level to acquire lock. Output jitter verification results of the 83496A can be affected by jitter on the input test signal. The 83496A will track jitter frequencies inside the loop bandwidth, and the jitter will appear on the recovered clock output. Vertical noise (such as laser RIN) on the input signal will be converted to jitter by the limit amplifier stage on the input of the clock recovery. These effects can be reduced by lowering the Loop bandwidth setting.

3 At rates below 1 Gb/s, loop bandwidth is fixed at 30 KHz when Option 300 is not installed.

4 Without Option 200 loop bandwidth is adjustable from 15 KHz to 6 MHz. Available loop bandwidth settings also depend on the data rate of the input signal. For transition density from 0.25 to 1, the Loop Bandwidth vs Rate chart shows available loop bandwidth settings.



5 20*log($Vamp_{out}/Vam_{pin}$) measured with PRBS23 at 13.5 Gb/s.

6 Minimum frequency of divided front panel clock output is 25 MHz.

7 Other types of optical connectors are also available.

Ordering Information

86100C	infiniium DCA-J mainframe
86100C-001	Enhanced trigger
86100CS-001	Enhanced trigger upgrade kit
86100C-090	Removable hard drive
86100C-200	Jitter analysis software
86100CU-200	Enhanced Jitter analysis software upgrade
86100C-201	Advanced waveform analysis software
86100CU-201	Advanced waveform analysis software upgrade
86100C-202	Enhanced impedance and S-parameter software
86100CU-202	Enhanced impedance and S-parameter software upgrade
86100C-AFP	Accessory filler panel
86100C-AX4	Rack mount flange kit
86100C-AXE	Rack mount flange kit with handles
86100C-UK6	Commercial cal certificate with test data

Optical/electrical modules

86102U	15 GHz optical channel; multimode, unamplified (750 to 860 nm) 20 GHz electrical channel
86102U-201	1.25, 2.488 Gb/s
86102U-202	2.488, 3.125 Gb/s
86102U-203	3.125, 10.3125 Gb/s
86105B	15 GHz optical channel; single-mode, unamplified (1000 to 1600 nm) 20 GHz electrical channel
86105B-101	9.953, 10.3125, 10.51875, 10.664, 10.709 Gb/s
86105B-102	155, 622 Mb/s 2.488, 2.5, 2.666, 9.953, 10.3125, 10.51875, 10.664, 10.709 Gb/s
86105B-103	1.063, 1.250, 2.125, 2.488, 2.5, 9.953, 10.3125, 10.51875, 10.664, 10.709 Gb/s
86105C	9 GHz optical channel; multimode, amplified (750 to 1650 nm) 20 GHz electrical channel
86105C-100	155 Mb/s through 8.5 Gb/s (choose 4 data rates)
86105C-110	155 Mb/s
86105C-120	622 Mb/s
86105C-130	1.063 Gb/s
86105C-140	1.244/1.250 Gb/s
86105C-150	2.125 Gb/s
86105C-160	2.488, 2.500 Gb/s
86105C-170	2.666 Gb/s
86105C-180	3.125 Gb/s
86105C-190	4.250 Gb/s
86105C-H97	8.500 Gb/s
86105C-200	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
86106B	28 GHz optical channel; single-mode, unamplified (1000 to 1600 nm) 9.953 Gb/s 40 GHz electrical channel
86106B-410	9.953, 10.3125, 10.664, 10.709 Gb/s
86116A	53 GHz optical channel; single-mode, unamplified (1000 to 1600 nm) 63 GHz electrical channel
86116B	65 GHz optical channel; single-mode, unamplified (1480 to 1620 nm) 80 GHz electrical channel

All optical modules have FC/PC connectors installed on each optical port. Other connector adapters available as options are: Diamond HMS-10, DIN, ST and SC.

Dual electrical channel modules

86112A	Dual 20 GHz electrical channels
86117A	Dual 50 GHz electrical channels
86118A	Dual 70 GHz electrical remote sampling channels
86118A-H01	Differential De-Skew

TDR/TDT modules

Included with each of these TDR modules is a TDR demo board, programmers guide, two 50 Ω SMA terminations and one SMA short.

54754A	Differential TDR module with dual 18 GHz TDR/electrical channels
N1020A	6 GHz TDR probe kit
N1024A	TDR Calibration kit

Trigger module

86107A	Precision timebase reference module
86107A-010	2.5 and 10 GHz clock input capability
86107A-020	10 and 20 GHz clock input capability
86107A-040	10, 20 and 40 GHz clock input capability

Clock recovery modules

The following modules provide a recovered clock from the data signal for triggering at indicated data rates:

83495A	10 Gb/s Clock recovery module
83495A-100	Single-mode signals (1000–1600 nm) and electrical
83495A-101	Multimode signals (750–860 nm) and electrical
83495A-200	Continuous data rates from 9.953 Gb/s to 11.32 Gb/s
83496A	50 Mb/s to 7.1 Gb/s Clock recovery module
83496A-100	Single-ended and differential electrical with integrated signal taps
83496A-101	Single-mode (1250–1620 nm) and multimode (780-1330 nm) optical. Integrated signal taps. Single-ended or differential electrical inputs (no signal taps)
83496A-200	Increase operating range to 50 Mb/s to 13.5 Gb/s
83496AU-200	Upgrade data rate 0.05 Gb/s to 13.5 Gb/s
83496A-300	Add tunable loop bandwidth "golden PLL" capability
83496AU-300	Upgrade adjustable loop bandwidth

Warranty options (for all products)

R1280A	Customer return repair service
R1282A	Customer return calibration service

Connector options (for all optical modules)

81000 AI	Diamond HMS-10 connector
81000 FI	FC/PC connector adapter
81000 SI	DIN connector adapter
81000 VI	ST connector adapter
81000 KI	SC Connector Adapter

Accessories

11667B	Power splitter, DC to 26.5 GHz, APC 3.5 mm
11667C	Power splitter, DC to 50 GHz, 2.4mm
11742A	45 MHz to 26.5 GHz DC blocking capacitor
11742A-K01	50 GHz DC blocking capacitor
83440B/C/D	Optical-to-electrical converters (6/20/32 GHz)
8490D-020	2.4 mm 20dB attenuator
11901B	2.4 mm (f) to 3.5 mm (f) adapter
11901C	2.4 mm (m) to 3.5 mm (f) adapter
11901D	2.4 mm (f) to 3.5 mm (m) adapter
86101-60005	Filler panel
0960-2427	USB keyboard (included with 86100C)
1150-7799	USB mouse (included with 86100C)

Probes

1169A	13 Ghz probe
1168A	10 Ghz probe
N5380A	InfiniiMax II 12 GHz differential SMA adapter
N5381A	InfiniiMax II 12 GHz solder-in probe head
N5382A	InfiniiMax II 12 GHz differential browser

1130 Series InfiniiMax probing systems

(Requires N1022A – see below)

1134A	7 GHz InfiniiMax probe amp – order one or both E266xA connectivity kits per amp
1132A	5 GHz InfiniiMax probe amp – order one or both E266xA connectivity kits per amp
1131A	3.5 GHz InfiniiMax probe amp – order one or both E266xA connectivity kits per amp

Connectivity kits model

E2669A	InfiniiMax connectivity kit for differential measurements
E2668A	InfiniiMax connectivity kit for single-ended measurements

Additional Components

E2675A	InfiniiMax differential browser probe head and accessories. Includes 20 replaceable tips and ergonomic handle. Order E2658A for replacement accessories.
E2676A	InfiniiMax single-ended browser probe head and accessories. Includes 2 ground collar assemblies, 10 replaceable tips, a ground lead socket and ergonomic browser handle. Order E2663A for replacement accessories.
E2677A	InfiniiMax differential solder-in probe head and accessories. Includes 20 full bandwidth and 10 medium bandwidth damping resistors. Order E2670A for replacement accessories.
E2678A	InfiniiMax single-ended/differential socketed probe head and accessories. Includes 48 full bandwidth damping resistors, 6 damped wire accessories, 4 square pin sockets and socket heatshrink. Order E2671A for replacement accessories.
E2679A	InfiniiMax single-ended solder-in probe head and accessories. Includes 16 full bandwidth and 8 medium bandwidth damping resistors and 24 zero ohm ground resistors. Order E2672A for replacement accessories.

Adapters

N1022A	Adapts 113x/115x active probes to 86100 Infiniium DCA

Other compatible probes

54006A	6 GHz passive probe

Adapters for electrical channels

11900B	2.4mm (f-f) adapter
11901B	2.4mm (f) to 3.5mm (f) adapter
11901C	2.4mm (m) to 3.5mm (f) adapter
5061-5311	3.5mm (f-f) adapter
1250-1158	SMA (f-f) adapter
1810-0118	3.5mm termination

Firmware and software

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