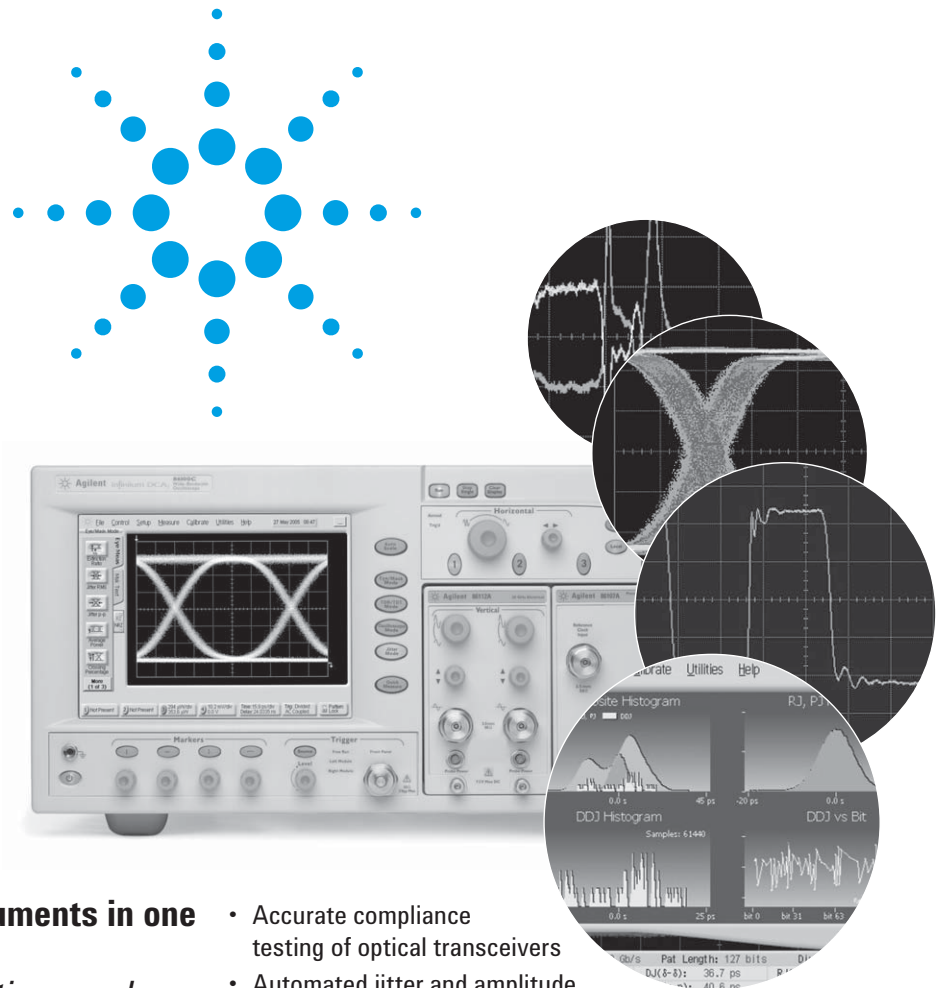


# infiniium DCA-J Agilent 86100C Wide-Bandwidth Oscilloscope Mainframe and Modules

## Technical Specifications



### Four instruments in one

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

- Accurate compliance testing of optical transceivers
- Automated jitter and amplitude interference 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, electrical channels, and clock recovery
- Built-in S-parameters with TDR measurements
- Compatible with Agilent 86100A/B-series, 83480A-series, and 54750-series modules
- < 90 fs intrinsic jitter
- Open operating system – Windows® XP Pro



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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. PatternLock triggering significantly enhances the usability as a general purpose scope.
- A digital communications analyzer
- A time domain reflectometer
- A precision jitter and amplitude interference 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.

### 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 offers 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
16x Fibre channel	14025
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 above. 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. Mask margin can be determined automatically to a user definable hit/error ratio. Transmitter waveform dispersion penalty (TWDP) tests can be performed directly in the 86100C. Exporting the waveform for external post processing is not required. (Option 201 and MATLAB® required. Dispersion penalty script for specific test standards must be loaded into the 86100C.)

MATLAB® is a registered trademark of The MathWorks, Inc.

## Eyeline Mode

Eyeline Mode is available in the 86100C and provides insight into the effects of specific bit transitions within a data pattern. The unique view assists diagnosis of device or system failures due 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 the "middle" of the eye.

Eyeline Mode uses PatternLock triggering (Option 001 required) 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.

## PatternLock Triggering advances the capabilities of the sampling oscilloscope

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 required the pattern source to provide this type of trigger to the scope. With the press of a button, PatternLock automatically detects the pattern length, data rate and clock rate making the complex triggering process transparent to the user.

PatternLock enables the 86100C to behave more like a real-time oscilloscope in terms of user experience. Observation 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 (Option 200)

The “J” in DCA-J represents the ability to perform 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 communications 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 limited as data rates increase.

The DCA-J provides simple, one button setup and execution of jitter 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 provides 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.
- Firmware revision 8.0 allows for accurate jitter measurements on signals with large RJ/PJ components (up to 0.7 UI).

Jitter analysis functionality is available through the Option 200 software package. 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 in both Q and logBER scale
- Adjustable total jitter probability

## Advanced EYE Analysis (Option 401)

### Accurate Jitter Measurements on Long Patterns

When testing jitter performance against specifications, some standards, such as 10 Gigabit Ethernet, often make use of long patterns such as PRBS31. Longer patterns emulate actual data traffic more accurately and can uncover more problems within a device. However, these long patterns can be a challenge for many instruments that measure jitter and estimate Total Jitter (TJ).

86100CU-401 addresses this challenge by making compliant jitter measurements on long patterns, such as PRBS31 or live traffic. Using powerful jitter analysis algorithms, the software measures RJ, DJ, and calculates estimated TJ, on electrical or optical signals.

Additionally, the application measures high probability jitter such as J2 Jitter, sometimes referred to as “99% Jitter” or “all but 1% of jitter”. It also measures J9 Jitter, defined at a BER of 2.5E-10. Data Dependent Pulse Width Shrinkage (DDPWS), a component of Data Dependent Jitter (DDJ), is also reported when the 86100C DCA-J is equipped with 86100C-200 Enhanced Jitter Analysis.

### Compliant Mask Testing using BER Contours

Another feature of 86100CU-401 is its ability to perform mask testing using specifications BER-contours. This method of mask testing is used when specifications, such as OIF-CEI 2.0 and XFP, define mask test requirements based on a defined bit error ratio for the link. While this type of mask can be modified and tested using conventional mask testing techniques, the 86100C can now perform compliant mask testing using both methods. Sampling scopes, due to their unmatched signal fidelity, are the de facto standard for mask testing.

### Flexible Hardware Configuration

The software application runs on an external PC, or 86100C DCA-J, running Microsoft® Office Excel 2003/2007. It uses any 86100C DCA-J hardware configuration to perform a precision waveform measurement and imports the data into MS Excel for further processing. When performing jitter measurements on high performance devices (RJ < 500fs), the application is able to leverage 86100C-200 Enhanced Jitter (Jitter Mode), well known for its speed and accuracy. Alternatively, the application can also operate standalone if Jitter Mode is not installed - the choice is yours!

## Equalization and advanced waveform analysis (Option 201)

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, test, and modeling 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, similar to a very deep memory real-time oscilloscope acquisition.
- 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<sup>®1</sup> analysis capability. User can define a measurement with a MATLAB<sup>®</sup> script. Result can be reported on oscilloscope results display.
- Automatic dispersion penalty analysis (such as transmitter waveform dispersion penalty or TWDP). User-entered MATLAB<sup>®</sup> scripts used to automatically process waveforms and determine penalty values.

## Advanced amplitude analysis/RIN/Q-factor (Option 300)

In addition to jitter, signal quality can also be impacted by impairments in the amplitude domain. Similar to the many types of jitter that exist, noise, inter-symbol interference, and periodic fluctuation can cause eye closure in the amplitude domain. Option 300 can be added to an 86100C mainframe (Option 200 must also be installed) to provide in-depth analysis of the quality of both the zero and one levels of NRZ digital communications signals. Amplitude analysis is performed at a single button press as part of the jitter mode measurement process.

- Measurement results are analogous to those provided for jitter and include Total Interference (TI), Deterministic Interference (dual-Dirac model, DI), Random Noise (RN), Periodic Interference (PI), and Inter-symbol Interference (ISI)
- Tabular and graphical results for both one and zero levels
- Export of interference data to delimited text format
- Save/recall of interference database
- Interference frequency spectrum
- Bathtub curve display
- Q-factor (isolated from deterministic interference)
- Adjustable probability for total interference estimation

## Relative Intensity Noise (RIN)

Relative Intensity Noise (RIN) describes the effects of laser intensity fluctuations on the recovered electrical signal. Like amplitude interference, excessive RIN can close the eye diagram vertically, and therefore affect the power budget or system performance. The DCA-J can measure RIN on square wave as well as industry-standard PRBS and other patterns. In order to avoid having the measurement influenced by inter-symbol interference, the instrument searches the pattern for sequences of consecutive bits (for example, five zeroes or five ones) and measures the random noise and the power levels in the center of this sequence. When a reference receiver filter is turned on RIN is normalized to a 1 Hz bandwidth. The user can also choose between RIN based on the one level or on the optical modulation amplitude (RIN OMA according to IEEE 802.3ae). RIN measurements require Options 001, 200, and 300.

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1. MATLAB Software is available from Agilent with the purchase of a new DCA-J as Option 061 or Option 062, depending on the Toolboxes you need. MATLAB can also be purchased separately from The MathWorks, Inc. ([www.mathworks.com](http://www.mathworks.com)). If users wish to run MATLAB on the 86100C mainframe, they must purchase MATLAB 2008a or an earlier version. Please see [www.agilent.com/find/matlab\\_oscilloscopes](http://www.agilent.com/find/matlab_oscilloscopes) for more information.

## Phase noise/jitter spectrum analysis

Analysis of jitter in the frequency domain can provide valuable insight into jitter properties and the root causes behind them. The phase locked-loop of the 83496B clock recovery module or 86108A precision waveform analyzer module can effectively be used as a jitter demodulator. Internally monitoring the loop error signal and transforming it into the frequency domain allows the jitter spectrum of a signal to be observed. Through self-calibration, effects of the loop response are removed from the observed signal, allowing accurate jitter spectral analysis over a 300 Hz to 20 MHz span.

This technique provides measurements not available with other test solutions:

- Jitter spectrum/phase noise for both clock or data signals
- Display in seconds or dBc/Hz
- High sensitivity: for input signals > 0.5 Vpp, < -100 dBc/Hz at 10 kHz offset for 5 Gb/s, -106 dBc/Hz for 2.5 Gb/s, -140 dBc/Hz at 20 MHz offset (integrated spectrum of the instrument jitter from 10 kHz to 20 MHz is less than 100 fs)
- High dynamic range: can lock onto and display signals with > 0.5% pp frequency deviation such as spread spectrum clocks and data
- Data rates from 50 Mb/s to 14.2 Gb/s
- Clock rates from 25 MHz to 6.75 GHz

Spectral results can be integrated to provide an estimate of combined jitter over a user-defined span. As both clocks and data signals can be observed, the ratio of data-to-clock jitter can be observed. The displayed jitter spectrum can also be altered through a user-defined transfer function, such as a specific PLL frequency response.

Phase noise analysis is achieved via an external spreadsheet application run on a personal computer communicating to the 83496B/86108A through the 86100C mainframe (typically using a USB-GPIB connection). An 83496A clock recovery module must be upgraded to a "B" version to function in the phase noise system.

## PLL bandwidth/jitter transfer

The on-board phase detector of the 83496B and 86108A allows for a precision measurement of phase-locked loop (PLL) bandwidth, sometimes referred to as jitter transfer. The external software application discussed above for phase noise/jitter spectrum controls several jitter sources including the Agilent N4903 JBERT, 81150A function generator, N5182A MXG, or pattern generators/sources with delay line or phase modulation inputs (modulated with a 33250A function generator) to provide a modulated

stimulus to the device under test (DUT). The application will monitor the internal phase detector of the 83496B or 86108A to measure the stimulus as well as the DUT response. By sweeping the frequency of the jitter stimulus, the ratio of the output jitter to the input jitter provides the PLL bandwidth. The measurement system is extremely flexible and can test input/outputs from 50 Mb/s to 14.2 Gb/s (data signals) and/or 25 MHz to 6.75 GHz (clock signals). Thus several classes of DUTs can be measured including clock extraction circuits, multiplier/dividers, and PLLs. Similar to a phase noise analysis, this capability is achieved via an external application run on a PC.

## S-parameters and time domain reflectometry/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 (including magnitude and group delay) 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 (including magnitude and group delay) 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<sup>1</sup>.

## HDMI/DisplayPort Automated Cable Compliance Test

Leveraging Option 202, the 86100CU-610 and 86100CU-620 HDMI/DisplayPort cable compliance test software allow users to automate HDMI or DisplayPort cable compliance tests using 54754A TDR module on the 86100C DCA-J. The compliance software options offer an intuitive interface with step-by-step diagrammatic guidance yielding accurate results and detailed reports. Pass/fail indicators allow R&D and QA customers to make repeatable compliant measurements without needing detailed knowledge of the specifics of either standard.

## N1024A 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.

1. Picosecond Pulse Labs 4020 Source Enhancement Module ([www.picosecond.com](http://www.picosecond.com))

## 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, [Tmax, Tmin, Tedge—remote commands only]

#### Amplitude

Overshoot, Average Power, V amptd, V p-p, V rms, V top, V base, V max, V min, V avg, OMA (Optical Modulation Amplitude)

### 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, 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, 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

### Advanced measurement options

The 86100C's software options allow advanced analysis. Options 200, 201, and 300 require mainframe Option 001. Option 202 does not require Option 86100-001. Option 401 does not require Options 001 and 200 unless a DDPWS measurement is required.

### Option 200 enhanced jitter analysis software

#### Measurements

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), Asynchronous periodic jitter frequencies, Subrate jitter components.

#### Data displays

TJ histogram, RJ/PJ histogram, DDJ histogram, Composite histogram, DDJ versus Bit position, Bathtub curve (log or Q scale)

### Option 201 advanced waveform analysis

#### Measurements

Deep memory pattern waveform, user-defined measurements through MATLAB® interface, Transmitter Waveform Dispersion Penalty (TWDP)

#### Data displays

Equalized waveform

### Option 202 enhanced impedance and S-parameters

### Option 300 amplitude analysis/RIN/Q-factor (requires Option 200)

#### Measurements

Total Interference (TI), Deterministic Interference (Dual-Dirac model, DI), Random Noise (RN), Periodic Interference (PI), and Inter-symbol Interference (ISI), RIN (dBm or dB/Hz), Q-factor

#### Data Displays

TI histogram, RN/PI histogram, ISI histogram

### Option 400 PLL and jitter spectrum measurement software

#### Jitter spectrum/phase noise measurements

Integrated Jitter: Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ); DJ Amplitude/Frequency, Jitter Spectrum Graph, Jitter vs Time Graph, Frequency vs Time Graph, JitterHistogram, Post Processed Jitter Measurements, Phase Noise Graph dBc/Hz vs Frequency.

#### Phase Locked Loop (PLL) measurements

PLL Bandwidth, PLL Peaking, Data Rate, Jitter Transfer Function (JTF) Graph, Observed Jitter Transfer (OJTF) Graph, JTF Model.

### Option 401 advanced EYE analysis

#### Jitter measurements

Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), J2 Jitter (J2), J9 Jitter (J9), Data Dependent Pulse Width Shrinkage (DDPWS)\*

\* Requires 86100C-200

#### Amplitude measurements

Total Interference (TI), Random Noise (RN), Deterministic Interference (DI), Eye Opening.

#### Mask test

Pass/Fail Status, BER limit.

### TDR/TDT mode (requires TDR module)

Quick TDR, TDR/TDT Setup, Normalize, Response, Rise Time, Fall Time,  $\Delta$  Time, Minimum Impedance, Maximum Impedance, Average Impedance, (Single-ended and Mixed-mode S-parameters with Option 202)

## 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, Save screen image

#### 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, Save screen image, Save summary

#### Mask limit test

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

### Configure measurements

#### Thresholds

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

#### Eye Boundaries

Define boundaries for eye measurements  
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 (dBm)

#### 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, watts, volts, or unit amplitude)  
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, Eye-mask, TDR etc.)

### 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 256 MB 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.

## File security

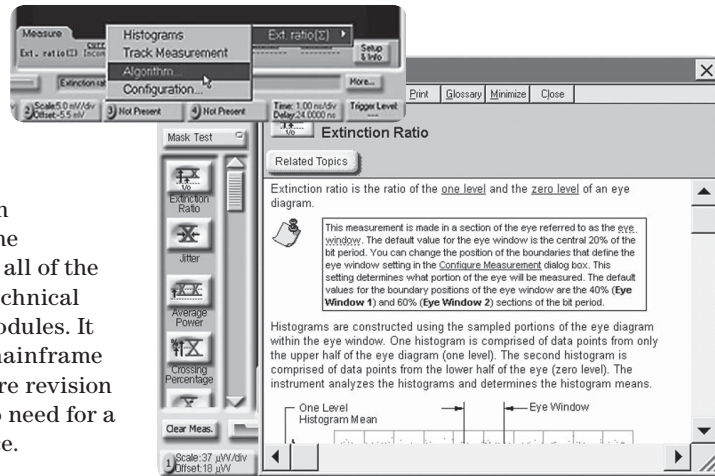
For users requiring security of their data, 86100C Option 090 offers a removable hard drive. This also enables removal of the mainframe from secure environments for calibration and repair.

## 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 83496A/B series of clock recovery modules are available for electrical, multimode optical, and single-mode optical input signals. 83496A/B 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/B can derive triggering from optical and electrical signals at any rate from 50 Mb/s to 14.2 Gb/s.

The 86108A module incorporates the clock recovery capabilities of the 83496B into a module that also has sampling channels. Since the clock recovery system is integrated with the samplers, measurements are achieved with a single instrument connection.

## 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 a wide jitter spectrum
- Wide loop bandwidth in some applications is specified by standards for compliance testing. Wide loop bandwidth settings mimic the performance of communications system receivers

The 83496A/B and 86108A have a continuously adjustable loop bandwidth from as low as 15 kHz to as high as 10 MHz, and can be configured as a golden PLL for standards compliance testing.

## **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 81133A and 81134A 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.

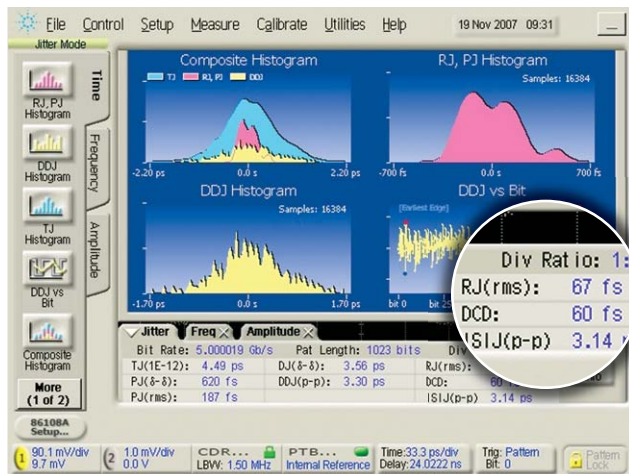
## **VXII.2 and VXII.3 instrument control**

Firmware revision 8.0 provides LAN based instrument control

## Lowest intrinsic jitter

The industry standard for lowest oscilloscope jitter was set with the development of the 86107A precision timebase reference module. Mainframe jitter is reduced to levels below 200 fs. Low oscilloscope jitter allows the true jitter performance of devices to be seen. Oscilloscope jitter can be driven to even lower levels when using the 86108A precision waveform analyzer. Precision timebase hardware has been integrated with the waveform sampling system to reduce residual jitter to less than 100 fs (< 60 fs typical!). The highest performance devices can be tested with pinpoint accuracy.

The 86107A is used in tandem with any of the optical or electrical sampling modules to reduce mainframe trigger jitter. The 86108A includes sampling channels, internal clock recovery, and precision timebase hardware in a single module. The 86108A can derive a clock from the test signal and internally feed the precision timebase section. Or an external timing reference can be provided to the precision timebase. Ultra-low jitter is achieved in either 86108A configuration.



Residual jitter of a 5 Gb/s PRBS signal showing the RJ component at 67 fs, indicating the extremely low jitter level of the oscilloscope system

## 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.

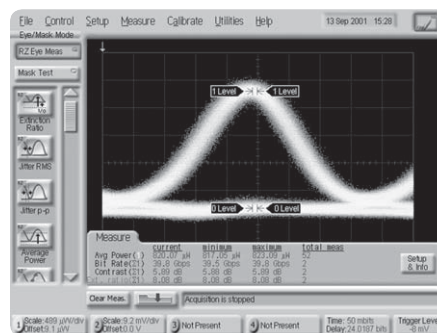
## Meeting your growing need for more bandwidth

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 86116C plug-in module includes an integrated optical receiver designed to provide the optimum in bandwidth, sensitivity, and waveform fidelity. It extends the bandwidth of the 86100C Infiniium DCA-J to 80 GHz electrical (93 GHz typical) and 65 GHz optical in the 1310 and 1550 nm wavelength bands. The 86117A and 86118A modules provide electrical bandwidths of 50 GHz and 70 GHz respectively. You can build a premier solution for 40 Gb/s waveform analysis around the 86100C mainframe.

## 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. Product specifications and descriptions in this document subject to change without notice.

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

## General specifications

<b>Temperature</b> Operating Non-operating <b>Altitude</b> Operating <b>Power</b>	10 °C to +40 °C (50 °F to +104 °F) -40 °C to +65 °C (-40 °F to +158 °F)  Up to 4,600 meters (15,000 ft) 115 V, 5.7 A, 230 V, 3.0 A 50/60 Hz
<b>Weight</b> <i>Mainframe without modules</i> <i>Typical module</i> <b>Mainframe dimensions (excluding handle)</b> <i>Without front connectors and rear feet</i> <i>With front connectors and rear feet</i>	15.5 kg (34 lb) 1.2 kg (2.6 lb)  215 mm H x 425 mm W x 566 mm D (8.47 in x 16.75 in x 22.2 in) 215 mm H x 425 mm W x 629 mm D (8.47 in x 16.75 in x 24.8 in)

## Mainframe specifications

<b>HORIZONTAL SYSTEM (time base)</b> <b>Scale factor</b> (full scale is ten divisions) Minimum Maximum <b>Delay<sup>1</sup></b> Minimum Maximum  <b>Time interval accuracy<sup>2</sup></b>  <b>Time interval accuracy – jitter mode operation<sup>4</sup></b> <b>Time interval resolution</b>  <b>Display units</b>	2 ps/div (with 86107A: 500 fs/div) 1 s/div  24 ns 1000 screen diameters or 10 s, whichever is smaller 1 ps + 1.0% of $\Delta$ time reading <sup>3</sup> or 8 ps, whichever is smaller 1 ps $\leq$ (screen diameter)/(record length) or 62.5 fs, whichever is larger Bits or time (TDR mode—meters)	<b>PATTERN LOCK</b>  250 ns/div  40.1 ns default, 24 ns min 1000 screen diameters or 25.401 $\mu$ s, whichever is smaller
<b>VERTICAL SYSTEM (channels)</b> <b>Number of channels</b> <b>Vertical resolution</b> <b>Full resolution channel</b>  <b>Adjustments</b> <b>Record length</b>	4 (simultaneous acquisition) 14 bit A/D converter (up to 15 bits with averaging) Adjusts in a 1-2-5-10 sequence for coarse adjustment or fine adjustment resolution from the front panel knob Scale, offset, activate filter, sampler bandwidth, attenuation factor, transducer conversion factors 16 to 16384 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  $\pm 5$  °C of horizontal calibration temperature.

3 The maximum delay setting is 100 ns and delta time does not span across  $(28 + N \times 4) \text{ ns} \pm 100 \text{ ps}$  delay setting, where  $N=0,1,2,\dots,18$ . If delta time measurement span exceeds above criteria, time interval accuracy is 8 ps + 0.1% of  $\Delta$  time reading

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)
<b>Trigger Modes</b>		
Internal trigger <sup>1</sup>	Free run	
External direct trigger <sup>2</sup>	DC to 100 MHz	
Limited bandwidth <sup>3</sup>	DC to 3.2 GHz	
Full bandwidth		
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)
<b>Jitter</b>		
Characteristic	$< 1.0 \text{ ps RMS} + 5 \cdot 10^{-5} \text{ of delay setting}^4$	$1.2 \text{ ps RMS for time delays less than } 100 \text{ ns}^6$
Maximum	$1.5 \text{ ps RMS} + 5 \cdot 10^{-5} \text{ of delay setting}^4$	$1.7 \text{ ps RMS for time delays less than } 100 \text{ ns}^6$
<b>Trigger sensitivity</b>	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
<b>Trigger configuration</b>		
Trigger level adjustment	-1 V to +1 V	AC coupled
Edge select	Positive or negative	N/A
Hysteresis <sup>5</sup>	Normal or High sensitivity	N/A
<b>Trigger gating</b>		
Gating input levels (TTL compatible)	<i>Disable: 0 to 0.6 V</i> <i>Enable: 3.5 to 5 V</i> <i>Pulse width &gt; 500 ns, period &gt; 1 μs</i>	
<b>Gating delay</b>	<i>Disable: 27 μs + trigger period + Max time displayed</i> <i>Enable: 100 ns</i>	
<b>Trigger impedance</b>		
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  $\geq 2\text{V/ns}$

## Precision time base 86107A<sup>1</sup>

	86107A Option 010	86107A Option 020	86107A Option 040
<b>Trigger bandwidth</b>	2.0 to 15.0 GHz	2.4 to 25.0 GHz	2.4 to 48.0 GHz
<b>Typical jitter (RMS)</b>	2.0 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
<b>Time base linearity error</b>	< 200 fs		
<b>Input signal type</b>	Synchronous clock <sup>2</sup>		
<b>Input signal level</b>	0.5 to 1.0 V <sub>pp</sub> 0.2 to 1.5 V <sub>pp</sub> (Typical functional performance)		
<b>DC offset range</b>	±200 mV <sup>3</sup>		
<b>Required trigger signal-to-noise ratio</b>	≥ 200 : 1		
<b>Trigger gating</b>	Disable: 0 to 0.6 V Enable: 3.5 to 5 V Pulse width > 500 ns, period > 1 μs		
<b>Gating input levels (TTL compatible)</b>			
<b>Trigger impedance (nominal)</b>	50 Ω		
<b>Connector type</b>	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.

## Precision time base 86108A

The 86108A can be triggered through clock recovery of the observed signal, through an external reference clock into the precision timebase section, or with the precision timebase operating on the clock signal recovered from the observed signal. The following specifications indicate the 86100 system timebase specifications achieved when using the 86108A plug-in module. (The 86100 mainframe and the 86108A module can also be triggered with a signal into the mainframe. In this configuration, the basic mainframe specifications are achieved)

	86108A
<b>Typical jitter (clock recovery and precision timebase configuration)</b>	< 60 fs
<b>Maximum jitter (clock recovery and precision timebase configuration)<sup>1</sup></b>	< 90 fs
<b>Typical jitter (clock recovery without precision timebase active)</b>	< 1.25 ps
<b>Effective trigger-to-sample delay (clock recovery and precision timebase configuration, typical)</b>	< 200 ps
<b>Typical jitter (trigger signal applied to precision timebase input)</b>	< 60 fs
<b>Maximum jitter (trigger signal supplied to precision timebase input)<sup>1</sup></b>	< 100 fs
<b>Precision timebase trigger bandwidth</b>	2 to 13.5 GHz (1 to 17 GHz)
<b>Precision timebase external reference amplitude characteristic</b>	1.0 to 1.6 V <sub>pp</sub>
<b>Precision timebase input signal type<sup>2</sup></b>	Sinusoid
<b>Precision timebase maximum input level</b>	±2V (16 dBm)
<b>Precision timebase maximum DC offset level</b>	±200 mV
<b>Precision timebase input impedance</b>	50 Ω
<b>Precision timebase connector type</b>	3.5 mm male
<b>Timebase resolution (with precision timebase active)</b>	0.5 ps/div
<b>Timebase resolution (precision timebase disabled)</b>	2 ps/div

1 Verified with maximum level input signal (~800 mV<sub>pp</sub>)

2 The precision timebase performs optimally with a sinusoidal input. Non-sinusoidal signals will operate with some degradation in timebase linearity.

## Computer system and storage

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

<sup>1</sup> Supports external display. Supports multiple display configurations via Windows® XP Pro display utility.

<sup>2</sup> USB Keyboard and mouse included with mainframe. Keyboard has integrated, 2-port USB hub.

## Module overview

### Optical/electrical modules

#### 750–1650 nm

The 86105C has the widest coverage of data rates with optical modulation bandwidth of 9 GHz and electrical bandwidth of 20 GHz. The outstanding sensitivity (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.

The 86105D is the premier solution for optical waveform analysis for high-speed signals using short or long wavelength technologies. The optical receiver bandwidth exceeds 20 GHz and the electrical bandwidth exceeds 35 GHz, providing excellent waveform fidelity. Switchable compliance filters are available at all common rates from 8.5 to 14.025 Gb/s (16XFC). Sensitivity to -12 dBm.

#### 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 modulation bandwidth. Each module also has an electrical channel with 20 GHz of bandwidth.

The 86105B provides high pulse fidelity, 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 modulation bandwidth with multiple 10 Gb/s compliance filters, and has an electrical channel with 40 GHz of bandwidth.

##### 40 GHz and greater optical and electrical channels:

The 86116C is the widest bandwidth optical module with more than 65 GHz optical modulation bandwidth (1300 to 1620 nm) and more than 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 20 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 very high bit rate applications where signal fidelity is crucial.

The 86108A has two electrical channels with over 32 GHz (typically 35 GHz) of bandwidth. Clock recovery (similar to the 83496B) and a precision timebase (similar to the 86107A) are integrated into the module to provide the highest precision electrical waveform measurements. Residual jitter can be < 60 fs and trigger to sample delay is effectively < 200 ps.

### Clock recovery modules

Unlike real-time 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 and B provide the highest performance/flexibility as they are capable of operation at any data rate from 50 Mb/s to 13.5 Gb/s, (14.2 Gb/s for 83496B<sup>1</sup>) on single-ended and differential electrical signals, single-mode (1250 to 1620nm) 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 83496B has higher gain than the 83496A, allowing it to track most spread-spectrum signals. The 86108A module has internal clock recovery similar to the 83496B.

### Time domain reflectometry (TDR)

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

TDR/TDT analyses are commonly performed by signal-integrity (SI) engineers during the design and validation of high-speed serial links and components. TDR/TDT measurements are also invaluable for maintaining consistent quality in printed circuit board (PCB) and passive-component manufacturing.

The Agilent N1021B TDR 18 GHz differential TDR probe kit connects printed circuit boards and other devices without connectors to the 54754A differential TDR/TDT module in the 86100C Infiniium DCA-J wideband oscilloscope mainframe. In conjunction with these hardware components, engineers can use the optional 86100C-202 enhanced impedance and S-parameter software to accurately characterize differential impedances in the time- and frequency domains (for example, reflections and impedances versus time or distance, or magnitude/phase/group delay of S-parameters like SDD11/SDD21).

<sup>1</sup> Requires 86100C firmware revision 8.1



## Module specifications: single-mode & multimode optical/electrical

Multiple and single-mode optical/electrical modules	86105B	86105C	86105D
<b>OPTICAL CHANNEL SPECIFICATIONS</b>			
<b>Optical channel unfiltered bandwidth</b>	15 GHz	8.5 GHz (9 GHz)	20 GHz
<b>Wavelength range</b>	1000 to 1600 nm	750 to 1650 nm	750 to 1650 nm
<b>Calibrated wavelengths</b>	1310 nm/1550 nm	850 nm/1310 nm/1550 nm ( $\pm 20$ nm)	850 nm/1310 nm/1550 nm
<b>Optical sensitivity<sup>1</sup></b>	-12 dBm	850 nm $\leq 2.666$ Gb/s, -20 dBm $> 2.666$ Gb/s to $\leq 4.25$ Gb/s, -19 dBm $> 4.25$ Gb/s to 11.3 Gb/s, -16 dBm 1310 nm/1550 nm $\leq 2.666$ Gb/s, -21 dBm $> 2.666$ Gb/s to $\leq 4.25$ Gb/s, -20 dBm $> 4.25$ Gb/s to 11.3 Gb/s, -17 dBm	-11 dBm (850 nm) -12 dBm (1310/1550 nm)
<b>Transition time</b> (10% to 90% calculated from TR = 0.48/BW optical)	32 ps	56 ps	24 ps
<b>RMS noise</b>			
Characteristic	5 $\mu$ W, (10 GHz) 12 $\mu$ W, (15 GHz)	850 nm $\leq 2.666$ Gb/s, 1.3 $\mu$ W $> 2.666$ Gb/s to $\leq 4.25$ Gb/s, 1.5 $\mu$ W $> 4.25$ Gb/s to 11.3 Gb/s, 2.5 $\mu$ W 1310 nm/1550 nm $\leq 2.666$ Gb/s, 0.8 $\mu$ W $> 2.666$ Gb/s to $\leq 4.25$ Gb/s, 1.0 $\mu$ W $> 4.25$ Gb/s to 11.3 Gb/s, 1.4 $\mu$ W	850 nm 8.5 to 11.3 Gb/s, 10 $\mu$ W 14.025 Gb/s, 16 $\mu$ W 310/1550 nm 8.5 to 11.3 Gb/s, 5 $\mu$ W 14.025 Gb/s, 8 $\mu$ W
Maximum	8 $\mu$ W, (10 GHz) 15 $\mu$ W (15 GHz)	850 nm $\leq 2.666$ Gb/s, 2.0 $\mu$ W $> 4.25$ Gb/s to 11.3 Gb/s, 4.0 $\mu$ W 1310 nm/1550 nm $\leq 2.666$ Gb/s, 1.3 $\mu$ W $> 2.666$ Gb/s to $\leq 4.25$ Gb/s, 1.5 $\mu$ W $> 4.25$ Gb/s to 11.3 Gb/s, 2.5 $\mu$ W	850 nm 8.5 to 11.3 Gb/s, 12 $\mu$ W 14.025 Gb/s, 24 $\mu$ W 1310/1550 nm 8.5 to 11.3 Gb/s, 7 $\mu$ W 14.025 Gb/s, 12 $\mu$ W
<b>Scale factor</b> (per division)			
Minimum	20 $\mu$ W	2 $\mu$ W	20 $\mu$ W
Maximum	500 $\mu$ W	100 $\mu$ W	500 $\mu$ W
<b>CW<sup>2</sup> accuracy</b> (single marker, referenced to average power monitor)	$\pm 25$ $\mu$ W $\pm 2\%$ (10 GHz) $\pm 25$ $\mu$ W $\pm 4\%$ (15 GHz)	$\pm 25$ $\mu$ W $\pm 3\%$ (single-mode) $\pm 25$ $\mu$ W $\pm 10\%$ (multimode)	$\pm 25$ $\mu$ W $\pm 2\%$ (8/10 Gb/s), 4% (14 Gb/s) 6% unfiltered ) single-mode $\pm 25$ $\mu$ W $\pm 10\%$ multimode
<b>CW offset range</b> (referenced two divisions from screen bottom)	+1 $\mu$ W to -3 $\mu$ W	+0.2 $\mu$ W to -0.6 $\mu$ W	+1 $\mu$ W/-3 $\mu$ W
<b>Average power monitor</b> (specified operating range)	-30 dBm to +3 dBm	-30 dBm to 0 dBm	-30 dBm to +3 dBm

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

2 CW refers to an unmodulated optical signal.

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

Multiple and single-mode optical/electrical modules	86105B	86105C	86105D
<b>Average power monitor accuracy</b>			
Single-mode	$\pm 5\% \pm 100 \text{ nW} \pm \text{connector uncertainty (20 to } 30 \text{ }^\circ\text{C)}$	$\pm 5\% \pm 200 \text{ nW} \pm \text{connector uncertainty}$	$\pm 5\% \pm 200 \text{ nW} \pm \text{connector uncertainty}$
Multimode (characteristic)	N/A	$\pm 10\% \pm 200 \text{ nW} \pm \text{connector uncertainty}$	$\pm 5\% \pm 200 \text{ nW} \pm \text{connector uncertainty}$
<b>User calibrated accuracy</b>			
Single-mode	$\pm 2\% \pm 100 \text{ nW} \pm \text{power meter uncertainty, } < 5 \text{ }^\circ\text{C change}$	$\pm 3\% \pm 200 \text{ nW} \pm \text{power meter uncertainty, } < 5 \text{ }^\circ\text{C change}$	$\pm 2\% \pm 100 \text{ nW} \pm \text{power meter uncertainty}$
Multimode (characteristic)	N/A	$\pm 10\% \pm 200 \text{ nW} \pm \text{power meter uncertainty, } < 5 \text{ }^\circ\text{C change}$	$\pm 10\% \pm 200 \text{ nW} \pm \text{power meter uncertainty}$
<b>Maximum input power</b>			
Maximum non-destruct average	2 mW (+3 dBm)	0.5 mW (-3 dBm)	5 mW (7 dBm)
Maximum non-destruct peak	10 mW (+10 dBm)	5 mW (+7 dBm)	10 mW (10 dBm)
<b>Fiber input</b>	9/125 $\mu\text{m}$ user-selectable connector	62.5/125 $\mu\text{m}$	62.5/125 $\mu\text{m}$ user-selectable connector
<b>Input return loss</b> (HMS-10 connector fully filled fiber)	33 dB	850 nm >13 dB 1310 nm/1550 nm >24 dB	27 dB single-mode 14 dB multimode
<b>ELECTRICAL CHANNEL SPECIFICATIONS</b>			
<b>Electrical channel bandwidth</b>	12.4 and 20 GHz		25 and 35 GHz
<b>Transition time</b> (10% to 90% calculated from TR = 0.35/BW)	28.2 ps (12.4 GHz) 17.5 ps (20 GHz)		14 ps (25 GHz) 10 ps (35 GHz)
<b>RMS noise</b>			
<i>Characteristic</i>	0.25 mV (12.4 GHz) 0.5 mV (20 GHz)		0.25 mV (25 GHz) 0.5 mV (35 GHz)
Maximum	0.5 mV (12.4 GHz) 1 mV (20 GHz)		0.5 mV (25 GHz) 1 mV (35 GHz)
<b>Scale factor</b> (per division)			
Minimum	1 mV/division		
Maximum	100 mV/division		
<b>DC accuracy</b> (single marker)	$\pm 0.4\%$ of full scale $\pm 2 \text{ mV} \pm 1.5\%$ of (reading-channel offset), 12.4 GHz $\pm 0.4\%$ of full scale $\pm 2 \text{ mV} \pm 3\%$ of (reading-channel offset), 20 GHz		
<b>DC offset range</b> (referenced to center of screen)	$\pm 500 \text{ mV}$		
<b>Input dynamic range</b> (relative to channel offset)	$\pm 400 \text{ mV}$		
<b>Maximum input signal</b>	$\pm 2 \text{ V}$ (+16 dBm)		
<b>Nominal impedance</b>	50 $\Omega$		
<b>Reflections</b> (for 30 ps rise time)	5%		
<b>Electrical input</b>	3.5 mm (male)		

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

Module specifications: single-mode optical/electrical				
High bandwidth single-mode				
optical/electrical modules		86106B	86116C <sup>1</sup>	
OPTICAL CHANNEL SPECIFICATIONS			option 025	option 040
Optical channel unfiltered bandwidth		28 GHz	45 GHz	65 GHz
Wavelength range		1000 nm to 1600 nm	1300 nm to 1620 nm <sup>4</sup>	
Calibrated wavelengths		1310 nm/1550 nm	1310 nm/1550 nm	
Optical sensitivity		-7 dBm		
	1310 nm		-9 dBm (17 Gb/s) -8 dBm (25.8 Gb/s) -7 dBm (27.7 Gb/s)	-3 dBm (39.8/43.0 Gb/s)
	1550 nm		-10 dBm (17 Gb/s) -9 dBm (25.8 Gb/s) -8 dBm (27.7 Gb/s)	-5 dBm (39.8/43.0 Gb/s)
Transition time (10% to 90% calculated from $T_r = 0.48/BW$ optical)		18 ps	7.4 ps (FWHM) <sup>2</sup>	
RMS noise				
Characteristic		13 $\mu$ W (Filtered) 23 $\mu$ W (Unfiltered)		
	1310 nm		13 $\mu$ W (17 Gb/s) 17 $\mu$ W (25.8 Gb/s) 20 $\mu$ W (27.7 Gb/s) 60 $\mu$ W (40 GHz)	54 $\mu$ W (39.8/43.0 Gb/s) 75 $\mu$ W (55 GHz) 105 $\mu$ W (60 GHz) 187 $\mu$ W (65 GHz)
	1550 nm		10 $\mu$ W (17 Gb/s) 12 $\mu$ W (25.87 Gb/s) 14 $\mu$ W (27.7 Gb/s) 40 $\mu$ W (40 GHz)	36 $\mu$ W (39.8/43.0 Gb/s) 50 $\mu$ W (55 GHz) 70 $\mu$ W (60 GHz) 125 $\mu$ W (65 GHz)
Maximum		15 $\mu$ W (Filtered) 30 $\mu$ W (Unfiltered)		
	1310 nm		18 $\mu$ W (17 Gb/s) 20 $\mu$ W (25.8 Gb/s) 30 $\mu$ W (27.7 Gb/s) 120 $\mu$ W (40 GHz)	102 $\mu$ W (39.8/43.0 Gb/s) 127 $\mu$ W (55 GHz) 225 $\mu$ W (60 GHz) 300 $\mu$ W (65 GHz)
	1550 nm		15 $\mu$ W (17 Gb/s) 18 $\mu$ W (25.8 Gb/s) 21 $\mu$ W (27.7 Gb/s) 80 $\mu$ W (40 GHz)	68 $\mu$ W (39.8/43.0 Gb/s) 85 $\mu$ W (55 GHz) 150 $\mu$ W (60 GHz) 200 $\mu$ W (65 GHz)

<sup>1</sup> 86116C requires an 86100C mainframe and software revision 7.0 or above.

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

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

<sup>4</sup> Contact Agilent for broader wavelength specifications.

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

High bandwidth single-mode optical/electrical modules	86106B	86116C <sup>1</sup>
<b>OPTICAL CHANNEL SPECIFICATIONS</b> <i>continued</i>		
<b>Scale factor</b>		
Minimum	20 $\mu$ W/division	200 $\mu$ W/division
Maximum	500 $\mu$ W/division	5 $\mu$ W/division
<b>CW<sup>2</sup> accuracy</b> (single marker, reference to average power monitor)	$\pm 50 \mu$ W $\pm 4\%$ of (reading-channel offset)	$\pm 150 \mu$ W $\pm 4\%$ (reading-channel offset)
<b>CW offset range</b> (referenced two divisions from screen button)	+1 to $-3$ mW	+8 to $-12$ mW
<b>Average power monitor</b> (specified operating range)	$-27$ to $+3$ dBm	$-23$ to $+9$ dBm
<b>Factory calibrated accuracy</b>	$\pm 5\% \pm 100$ nW $\pm$ connector uncertainty, 20 to 30 °C	
<b>User calibrated accuracy</b>	$\pm 2\% \pm 100$ nW $\pm$ power meter uncertainty, $< 5$ °C change	
<b>Maximum input power</b>		
Maximum non-destruct average	2 mW ( $+3$ dBm)	10 mW ( $+10$ dBm)
Maximum non-destruct peak	10 mW ( $+10$ dBm)	50 mW ( $+17$ dBm)
<b>Fiber input</b>	9/125 $\mu$ m, user-selectable connector	
<b>Input return loss</b> (HMS-10 connector fully filled fiber)	30 dB	20 dB
<b>ELECTRICAL CHANNEL SPECIFICATIONS</b>		
<b>Electrical channel bandwidth</b>	18 and 40 GHz	80 (93), 55 and 30 GHz
<b>Transition time</b> (10% to 90% calculated from $T_r = 0.35/BW$ )	19.5 ps (18 GHz) 9 ps (40 GHz)	6.4 ps (55 GHz) 4.4 ps (80 GHz)
<b>RMS noise</b>		
<i>Characteristic</i>	0.25 mV (18 GHz) 0.5 mV (40 GHz)	0.5 mV (30 GHz) 0.6 mV (55 GHz) 1.1 mV (80 GHz)
Maximum	0.5 mV (18 GHz) 1.0 mV (40 GHz)	0.8 mV (30 GHz) 1.1 mV (55 GHz) 2.2 mV (80 GHz)
<b>Scale factor</b>		
Minimum	1 mV/division	2 mV/division
Maximum	100 mV/division	
<b>DC accuracy</b> (single marker)	$\pm 0.4\%$ of full scale $\pm 2$ mV $\pm 1.5\%$ of (reading-channel offset), 18 GHz $\pm 0.4\%$ of full scale $\pm 2$ mV $\pm 3\%$ of (reading-channel offset), 40 GHz	$\pm 0.4\%$ of full scale $\pm 3$ mV $\pm 2\%$ of (reading-channel offset), $\pm 2\%$ of offset (all bandwidths)
<b>DC offset range</b> (referenced to center of screen)	$\pm 500$ mV	
<b>Input dynamic range</b> (relative to channel offset)	$\pm 400$ mV	
<b>Maximum input signal</b>	$\pm 2$ V ( $+16$ dBm)	
<b>Nominal impedance</b>	50 $\Omega$	
<b>Reflections</b> (for 20 ps rise time)	5%	10% (DC to 70 GHz) 20% (70 to 100 GHz)
<b>Electrical input</b>	2.4 mm (male)	1.85 mm (male)

<sup>1</sup> 86116C requires an 86100C mainframe and software revision 7.0 or above.

<sup>2</sup> CW refers to an unmodulated optical signal.

## Module specifications: dual electrical

Dual electrical channel modules	86112A	54754A
<b>Electrical channel bandwidth</b>	12.4 and 20 GHz	12.4 and 18 GHz
<b>Transition time</b> (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)
<b>RMS noise</b>		
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)
<b>Scale factor</b> (per division)		
Minimum	1 mV/division	
Maximum	100 mV/division	
<b>DC accuracy</b> (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 ±2 mV ±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)
<b>DC offset range</b> (referenced from center of screen)	±500 mV	
<b>Input dynamic range</b> (relative to channel offset)	±400 mV	
<b>Maximum input signal</b>	±2 V (+16 dBm)	
<b>Nominal impedance</b>	50 Ω	
<b>Reflections</b> (for 30 ps rise time)	5%	
<b>Electrical input</b>	3.5 mm (male)	

Dual electrical channel modules	86117A	86118A
<b>Electrical channel bandwidth</b>	30 and 50 GHz	50 and 70 GHz
<b>Transition time</b> (10% to 90% calculated from $TR = 0.35/BW$ )	11.7 ps (30 GHz) 7 ps (50 GHz)	
<b>RMS noise</b>		
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)
<b>Scale factor</b> (per division)		
Minimum	1 mV/division	
Maximum	100 mV/division	
<b>DC accuracy</b> (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)
<b>DC offset range</b> (referenced from center of screen)	±500 mV	
<b>Input dynamic range</b> (relative to channel offset)	±400 mV	
<b>Maximum input signal</b>	±2 V (+16 dBm)	
<b>Nominal impedance</b>	50 Ω	
<b>Reflections</b> (for 30 ps rise time)	5%	20%
<b>Electrical input</b>	2.4 mm (male)	1.85 mm (male)

## Module specifications: dual electrical *(continued)*

<b>86108A</b>	
<b>Bandwidth<sup>1</sup></b>	16 GHz and < 32 GHz, (35 GHz)
<b>Transition time</b> (10% to 90% calculated from $T_r = 0.35/BW$ )	10 ps
<b>RMS noise</b>	
Characteristic	240 $\mu$ V (16 GHz) 420 $\mu$ V (32 GHz)
Maximum	350 $\mu$ V (16 GHz) 700 $\mu$ V (32 GHz)
<b>Scale factor</b> (per division)	
Minimum	2 mV/division
Maximum	100 mV/division
<b>DC accuracy</b> (single marker)	$\pm 0.7\%$ of full scale, $\pm 2$ mV $\pm 1.5\%$ of (reading-channel offset) (16 GHz) $\pm 0.7\%$ of full scale, $\pm 2$ mV $\pm 3\%$ of (reading-channel offset) (32 GHz)
<b>CW offset range</b> (referenced from center of screen)	$\pm 500$ mV
<b>Input dynamic range</b> (relative to channel offset)	$\pm 400$ mV
<b>Maximum input signal</b>	$\pm 2$ V (+16 dBm)
<b>Nominal impedance</b>	50 $\Omega$
<b>Reflections</b> (for 30 ps rise time)	5%
<b>Electrical input</b>	3.5 mm (male)
<b>CH1 to CH2 skew</b>	< 12 ps

### Clock Recovery

<b>Data rates input range</b>	Continuous tuning 0.05 to 14.2 Gb/s (requires FW revision 8.1 or higher)
<b>Clock frequency input range</b>	Continuous tuning 0.025 to 6.75 GHz
<b>Minimum input level to acquire lock</b>	175 m Vpp
<b>Minimum input level to acquire lock and achieve jitter specifications</b>	125 m Vpp
<b>Recovered clock random jitter</b> (used as internal trigger) <sup>2</sup>	<b>Internal recovered clock trigger</b> < 500 fs at 2 Gb/s < 400 fs at 5 and 10 Gb/s
<b>Clock recovery adjustable loop bandwidth range</b> (user selectable)	0.015 to 10 MHz
<b>Clock recovery loop peaking range</b>	Up to 4 settings (dependent on loop BW)
<b>Loop bandwidth accuracy</b>	$\pm 30\%$
<b>Tracking range</b> (includes spread spectrum tracking)	$\pm 2500$ ppm $\pm 0.25\%$
<b>Acquisition range</b>	$\pm 5000$ ppm
<b>Maximum consecutive identical digits to lock</b>	150
<b>Auto relocking</b>	If signal lock is lost, system can automatically attempt to regain phase-lock. User selectable to enable/disable
<b>Residual spread spectrum</b>	-72 $\pm 3$ dB @ 33 kHz
<b>Front panel recovered clock amplitude</b>	0.15 to 1.0 Vpp (0.3 to 1.0 Vpp)
<b>Front panel recovered clock divide ratio</b> (user selectable)	1, 2, 4, 8, 16 2, 4, 8, 16
<b>Recovered clock front panel connector type</b>	SMA
<b>Internal frequency counter accuracy</b>	$\pm 10$ ppm

<sup>1</sup> Derived from time domain analysis.

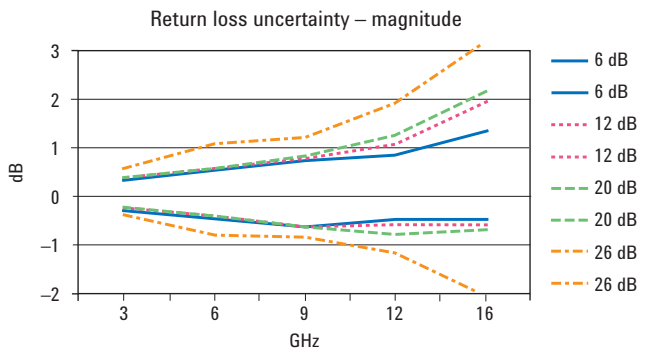
<sup>2</sup> This is not taking advantage of the 86108A precision timebase. With precision timebase enabled, system jitter approaches 60 fs for best performance.

## TDR system

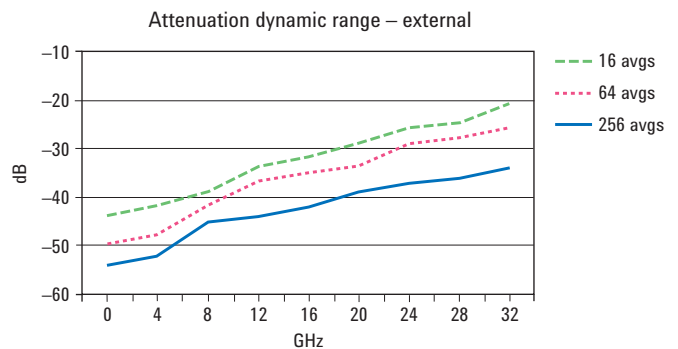
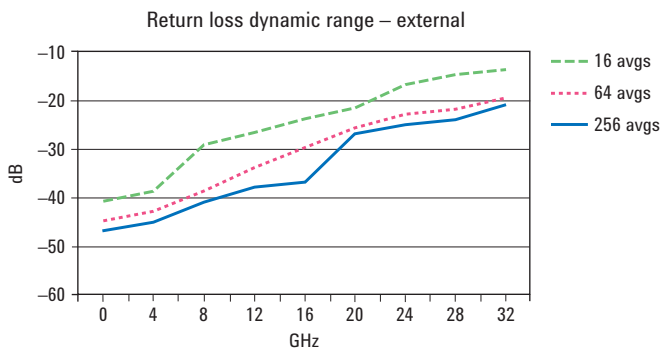
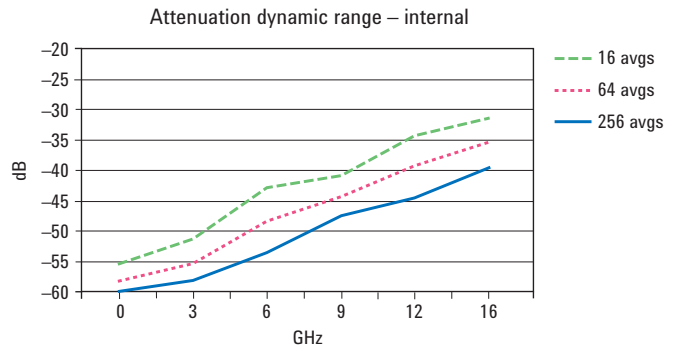
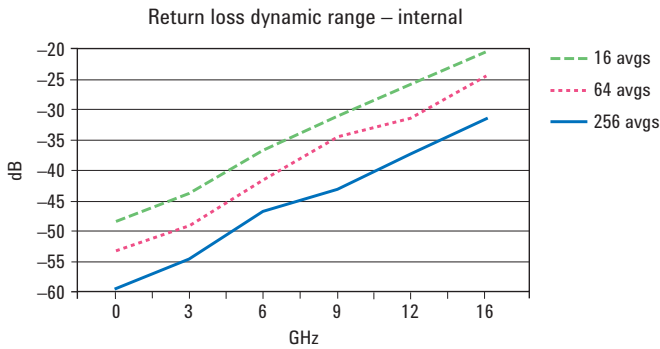
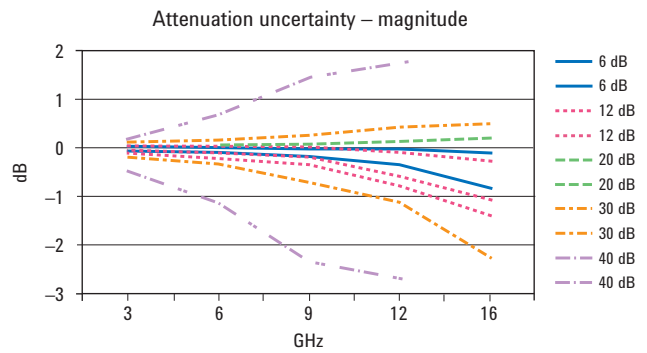
TDR system (Mainframe with 54754A module)	Oscilloscope/TDR performance	Normalized characteristics
<b>Rise time</b>	40 ps nominal < 25 ps normalized	Adjustable from larger of 10 ps or 0.08 x time/div Maximum: 5 x time/div
<b>TDR step flatness</b>	$\leq \pm 1\%$ after 1 ns from edge $\leq \pm 5\%$ , $-3\%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

## 86100C Option 202 enhanced impedance and S-parameter software characteristics

### Return loss

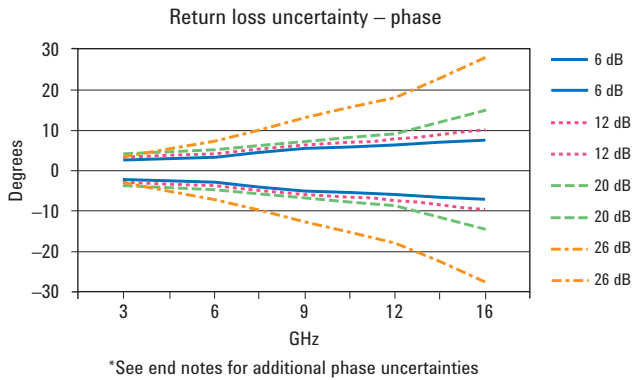


### Attenuation

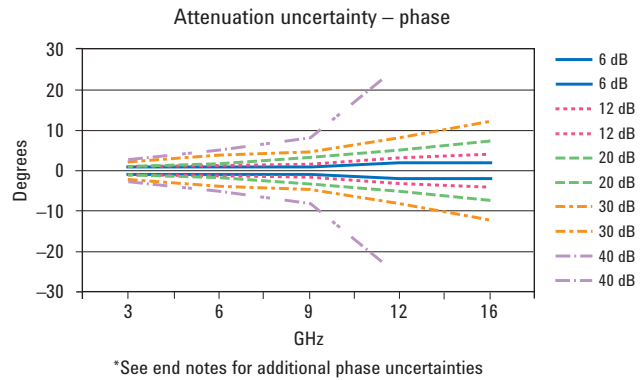


## 86100C Option 202 characteristics

### Return loss



### Attenuation



## 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 the sampling points record length<sup>1</sup> 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:

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

$$\text{Simplified version} = \text{time per division (sec)} * f(\text{Hz}) / 2.28$$

- 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:

$$\text{Uncertainty in degrees (temp drift)} = \text{time diff (sec)} * \text{frequency (Hz)} * 360$$

<sup>1</sup> Record length is user-defined from 16 to 16384 (firmware 8.0 or above). However, the minimum record length used for S-parameters is 4096, independent of user settings.

## Specifications

	83496A/B-100	83496A/B-101
<b>Channel type</b>	Differential or single-ended electrical	Single-mode or multimode optical, differential or single-ended electrical (no internal electrical splitters)
<b>Data rates</b> (divide by 2 for clock signals)	Standard: 50 Mb/s to 7.1 Gb/s continuous tuning Option 200: 50 Mb/s (14.2 Gb/s for 83496B with firmware revision 8.1 or higher) Option 201: 7.1 to 14.2 Gb/s continuous tuning	
<b>Minimum input level in acquire lock</b> (voltage or OMA <sup>1</sup> )	150 m Vpp	<p><b>single-mode (OMA<sup>1</sup>):</b>            –11 dBm @ 50 Mb/s to 11.4 Gb/s            –8 dBm @ &gt; 11.4 Gb/s            –12 dBm @ 7.1 Gb/s to 14.2 Gb/s (w/Opt 200)            –14 dBm @ 1 Gb/s to 7.1 Gb/s            –15 dBm @ 50 Mb/s to 1 Gb/s</p> <p><b>multimode 1310 nm (OMA<sup>1</sup>):</b>            –10 dBm @ 50 Mb/s to 11.4 Gb/s            –7 dBm @ &gt; 11.4 Gb/s            –11 dBm @ 7.1 Gb/s to 14.2 Gb/s (w/Opt 200)            –13 dBm @ 1 Gb/s to 7.1 Gb/s            –14 dBm @ 50 Mb/s to 1 Gb/s</p> <p><b>multimode 850 nm (OMA<sup>1</sup>):</b>            –8 dBm @ 50 Mb/s to 11.4 Gb/s            –7 dBm @ &gt; 11.4 Gb/s            –9 dBm @ 7.1 Gb/s to 14.2 Gb/s (w/Opt 200)            –11 dBm @ 1 Gb/s to 7.1 Gb/s            –12 dBm @ 50 Mb/s to 1 Gb/s</p> <p><b>electrical:</b> 150 m Vpp</p>
<b>Output random jitter (RMS)<sup>2</sup></b>	<p><b>Internal recovered clock trigger</b>            &lt; 500 fs 7.2 Gb/s to 11.4 Gb/s (300 fs @ 10 Gb/s)            &lt; 700 fs 4.2 Gb/s to 7.2 Gb/s, 11.4 Gb/s to 14.2 Gb/s (400 fs @ 4.25 Gb/s, 500 fs @ 2.5 Gb/s)            &lt; 3 mUI 50 Mb/s to 4.2 Gb/s (700 fs @ 1.25 Gb/s)</p> <p><b>Front panel recovered clock</b>            &lt; 700 fs 7.2 Gb/s to 11.4 Gb/s (300 fs @ 10 Gb/s)            &lt; 900 fs 4.2 Gb/s to 7.2 Gb/s, 11.4 Gb/s to 14.2 Gb/s (400 fs @ 4.25 Gb/s, 500 fs @ 2.5 Gb/s)            &lt; 4 mUI 50 Mb/s to 4.2 Gb/s (700 fs @ 1.25 Gb/s)</p>	
<b>Clock recovery adjustable loop bandwidth range</b> (user selectable)	Standard: 270 kHz or 1.5 MHz <sup>3</sup> ; Option 300: 15 kHz to 10 MHz <sup>4</sup> continuous tuning (fixed value or a constant rate/N ratio)	
<b>Loop bandwidth accuracy</b>	Standard: ±30% 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)	
<b>Tracking range</b>	±2500 ppm 83496B, ±1000 ppm 83496A	
<b>Acquisition range</b>	±5000 ppm	
<b>Internal splitter ratio</b>	50/50	50/50 single-mode 30/70 multimode Electrical signals have input only (no internal power dividers)
<b>Input return loss</b>	22 dB (DC to 12 GHz) electrical 16 dB (12 to 20 GHz) electrical	20 dB single-mode, 16 dB multimode 22 dB min (DC to 12 GHz) electrical 16 dB min (12 to 20 GHz) electrical
<b>Input insertion loss</b>	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 multimode optical (no electrical data output signal path)

See footnotes on page 28.

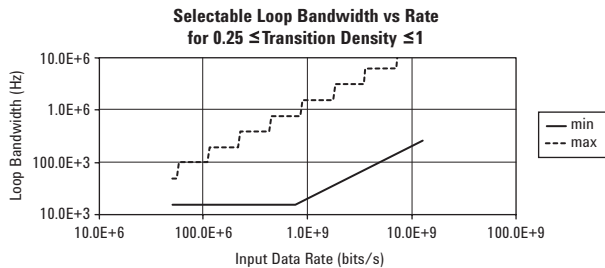
## Specifications *(continued)*

	83496A/B-100	83496A/B-101
<b>Electrical through-path digital amplitude attenuation<sup>5</sup></b>	7.5 dB	(no electrical data output signal path)
<b>Wavelength range</b>		750 to 1330 nm multimode 1250 to 1650 nm single-mode
		<b>electrical:</b> 150 m Vpp
<b>Front panel recovered clock output amplitude</b>	1 Vpp max, 220 mVpp min, 300 mVpp	
<b>Consecutive identical digits (CID)</b>	150 max	
<b>Front panel recovered clock output divide ratio (user selectable)<sup>6</sup></b>	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 14.2 Gb/s	
<b>Data input/output connectors</b>	3.5 mm male	FC/PC <sup>7</sup> 9/125 μm single-mode optical FC/PC <sup>7</sup> 62.5/125 μm multimode optical 3.5 mm male electrical (input only)
<b>Front panel recovered clock output connector</b>	SMA	

1 To convert from OMA to average power with an extinction ratio of 8.2 dB use:

$$P_{avgdBm} = OMA_{dBm} - 1.68 \text{ dB}$$

- 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/B can be affected by jitter on the input test signal. The 83496A/B 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. Higher loop bandwidths can be achieved when average data transition density is maintained at or above 50%.



5  $20 \cdot \log(V_{amp\_out}/V_{amp\_in})$  measured with PRBS23 at 14.2 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

<b>86100C</b>	Infiniium DCA-J mainframe
86100C-001	Enhanced trigger
86100CS-001	Enhanced trigger upgrade kit
86100C-061	MATLAB - Basic Oscilloscope Package
86100C-062	MATLAB - Standard Oscilloscope Package
86100C-701	Standard trigger (default)
86100C-090	Removable hard drive
86100C-092	Internal hard drive (default)
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-300	Amplitude analysis/RIN/Q-factor
86100CU-300	Amplitude analysis/RIN/Q-factor upgrade
86100CU-400	PLL and Jitter Spectrum software
86100CU-401	Advanced EYE analysis software
86100CU-610	HDMI Cable Compliance Test Software
86100CU-620	DisplayPort Cable Compliance Test Software
86100C-AFP	Module slot filler panel
86100C-AX4	Rack mount flange kit
86100C-AXE	Rack mount flange kit with handles
86100C-UK6	Commercial cal certificate with test data

*NOTE: Options 200 and 201 require Option 001 (enhanced trigger).  
Option 300 requires Options 200 and 001.  
Option 400 and 401 require Microsoft® Office Excel 2003/2007.  
Option 401 requires Options 001/200 for DDPWS measurement.  
Options 610 and 620 require a 54754A module and Option 202*

## Optical/electrical modules

<b>86105B</b>	15 GHz optical channel; single-mode, unamplified (1000 to 1600 nm) 20 GHz electrical channel
86105B-111	9.953, 10.3125, 10.51875, 10.664, 10.709, 11.096, 11.317 Gb/s
86105B-112	155, 622 Mb/s 2.488, 2.5, 2.666, 9.953, 10.3125, 10.51875, 10.664, 10.709, 11.096, 11.317 Gb/s
86105B-113	1.063, 1.250, 2.125, 2.488, 2.5, 9.953, 10.3125, 10.51875, 10.664, 10.709, 11.096, 11.317 Gb/s

<b>86105C</b>	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-197)
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-193	5.0 Gb/s
86105C-195	6.250 Gb/s
86105C-197	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
<b>86105D</b>	20 GHz optical channel; single-mode and multimode, (750-1650 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

<b>86106B</b>	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

<b>86116C<sup>1</sup></b>	40 to 65 GHz optical / 80 GHz electrical sampling module, 1300 to 1620 nm.
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*Select exactly one reference receiver option:*

86116C-025:	40 GHz opt./80 GHz elec. channels, 17.0/25.8/27.7 Gb/s reference receiver
86116C-040:	65 GHz opt./80 GHz elec. channels, 39.8/42.0 Gb/s reference receiver

This module is not compatible with the 86100A and 86100B DCA mainframes. If you want to upgrade older DCAs, contact Agilent Technologies to discuss current trade-in deals.

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

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

## TDR/TDT modules

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

<b>54754A</b>	Differential TDR module with dual 18 GHz TDR/electrical channels
<b>N1020A</b>	6 GHz TDR probe kit
<b>N1021B</b>	18 GHz Differential TDR Probe Kit
<b>83480AK02</b>	Static Protection Unit
<b>N1024A</b>	TDR Calibration kit

## Precision timebase module

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<b>86107A</b>	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

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

<b>83496A</b>	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 to 1620 nm) and multimode (780 to 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 14.2 Gb/s
83496AU-200	Upgrade data rate 0.05 Gb/s to 14.2 Gb/s
83496A-300	Add tunable loop bandwidth "golden PLL" capability
83496AU-300	Upgrade adjustable loop bandwidth
<b>83496B</b>	50 Mb/s to 7.1 Gb/s Clock recovery module. This module is not compatible with the 86100A and 86100B DCA mainframes. If you want to upgrade older DCAs, contact Agilent Technologies and ask for current trade-in deals.
83496B-100	Single-ended and differential electrical with integrated signal taps
83496B-101	Single-mode (1250 to 1620 nm) and multimode (780 to 1330 nm) optical. Integrated signal taps. Single-ended or differential electrical inputs (no signal taps)
83496B-200	Increase operating range to 50 Mb/s to 14.2 Gb/s
83496BU-200	Upgrade data rate 0.05 Gb/s to 14.2 Gb/s
83496B-201	Shift operating range to 7.1 to 14.2 Gb/s
83496BU-201	Upgrade shift operating range to 7.1 to 14.2 Gb/s
83496B-300	Add tunable loop bandwidth "golden PLL" capability
83496BU-300	Upgrade adjustable loop bandwidth

## Precision waveform analyzer module

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Dual electrical channel module with integrated clock recovery and precision timebase.

<b>86108A-100</b>	Dual 32 GHz electrical channels, integrated clock recovery (50 Mb/s to 14.2 Gb/s) with integrated precision timebase
<b>86108A-001</b>	Two 3.5 mm phase trimmers for skew adjustment
<b>86108A-002</b>	Two precision 3.5 mm 18 inch cables
<b>86108A-003</b>	Two 3.5 mm 3 dB attenuators
<b>86108A-006</b>	Two 3.5 mm 6 dB attenuators
<b>86108A-010</b>	Two 3.5 mm 10 dB attenuators
<b>86108A-020</b>	Two 3.5 mm 20 dB attenuators

## Warranty options (for all products)

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<b>R1280A</b>	Customer return repair service
<b>R1282A</b>	Customer return calibration service

## Accessories

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<b>86101-60005</b>	Filler panel
<b>0960-2427</b>	USB keyboard (included with 86100C)
<b>1150-7799</b>	USB mouse (included with 86100C)
<b>9300-1308</b>	ESD Heel strap
<b>9300-1367</b>	ESD Wrist strap
<b>9300-1484</b>	ESD Desk mat
<b>9300-0980</b>	ESD Wrist strap ground cord

## Optical connector adapters

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*Note: Optical modules come standard with one FC/PC connector adapter*

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

## RF/Microwave accessories

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<b>11636B</b>	Power divider, DC to 26.5 GHz, APC 3.5 mm
<b>11636C</b>	Power divider, DC to 50 GHz, 2.4 mm
<b>11742A</b>	45 MHz to 26.5 GHz DC blocking capacitor
<b>11742A-K01</b>	50 GHz DC blocking capacitor
<b>8490D-020</b>	2.4 mm 20 dB attenuator
<b>11900B</b>	2.4 mm (f-f) adapter
<b>11901B</b>	2.4 mm (f) to 3.5 mm (f) adapter
<b>11901C</b>	2.4 mm (m) to 3.5 mm (f) adapter
<b>11901D</b>	2.4 mm (f) to 3.5 mm (m) adapter
<b>5061-5311</b>	3.5 mm (f-f) adapter
<b>1250-1158</b>	SMA (f-f) adapter
<b>1810-0118</b>	3.5 mm termination
<b>0960-0055</b>	Short
<b>1250-1666</b>	SMA (f-f) adapter feedthru

## Passive probe

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<b>54006A</b>	6 GHz passive probe
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### Infiniimax I active probes (1.5 to 7 GHz)

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*Note: The N1022A probe adapter is required to use these probes with the 86100 DCA*

#### Infiniimax I probe amplifiers

*Note: Order 1 or more Infiniimax I probe head or connectivity kit for each amplifier*

<b>1130A</b>	1.5 GHz probe amp
<b>1131A</b>	3.5 GHz probe amp
<b>1132A</b>	5 GHz Iprobe amp
<b>1134A</b>	7 GHz probe amp

#### Infiniimax I probe heads

<b>E2675A</b>	Infiniimax differential browser probe head and accessories. Includes 20 replaceable tips and ergonomic handle. Order E2658A for replacement accessories.
<b>E2676A</b>	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.
<b>E2677A</b>	Infiniimax differential solder-in probe head and accessories. Includes 20 full bandwidth and 10 medium bandwidth damping resistors. Order E2670A for replacement accessories.
<b>E2678A</b>	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.
<b>E2679A</b>	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.

#### Infiniimax I connectivity kits (popular collections of the above probe heads)

<b>E2669A</b>	Infiniimax connectivity kit for differential measurements
<b>E2668A</b>	Infiniimax connectivity kit for single-ended measurements

### Infiniimax II active probes (10 to 13 GHz)

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*Note: The N1022A probe adapter is required to use these probes with the 86100 DCA*

#### Infiniimax II probe amplifiers

*Note: Order 1 or more Infiniimax II probe heads for each amplifier. Infiniimax I probe heads and connectivity kits can also be used but will have limited bandwidth.*

<b>1168A</b>	10 GHz probe amp
<b>1169A</b>	13 GHz probe amp

#### Infiniimax II probe heads

<b>N5380A</b>	Infiniimax II 12 GHz differential SMA adapter
<b>N5381A</b>	Infiniimax II 12 GHz solder-in probe head
<b>N5382A</b>	Infiniimax II 12 GHz differential browser

### Probe adapters

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**N1022A** Adapts 113x/115x/116x active probes to 86100 Infiniium DCA

### Connectivity solutions

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#### HDMI

<b>N1080A H01</b>	High performance coax based HDMI fixture with plug (TPA-P)
<b>N1080A H02</b>	High performance coax based HDMI fixture with receptacle (TPA-R)
<b>N1080A H03</b>	HDMI low frequency board

#### SATA

*Note: These are available from COMAX Technology, see [www.comaxtech.com](http://www.comaxtech.com)*

**iSATA plug to SMA** – COMAX P/N H303000104

**iSATA receptacle to SMA** – COMAX P/N H303000204

#### ATCA

*Note: These are available from F9 Systems, see [www.f9-systems.com](http://www.f9-systems.com)*

**Advanced TCA Tx/Rx Signal Blade™**

**Advanced TCA Tx/Rx Bench Blade™**

Call Agilent for connectivity and probing solutions not listed above.

### Firmware and software

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Firmware and software upgrades are available through the Web or your local sales office. [www.agilent.com/find/dcaj](http://www.agilent.com/find/dcaj)



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October 1, 2009

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Printed in USA, January 06, 2010  
5989-0278EN



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