CX3300A Series Device Current Waveform Analyzer

Measure Dynamic Current and Voltage with Confidence

The Keysight CX3300A series is an all-in-one measurement and analysis solution to solve your power rail, power delivery network, and power integrity challenges. The CX3300A series integrates an oscilloscope's bandwidth and sampling rate, a DMM's sensitivity, and data logger's extended duration measurement recording with waveform analytics to reveal accurate current and voltage waveforms.

KEYSIGHT

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Power Rail Characterization

IoT (Internet of Things) requires various devices to sense and process the data and to connect with the network. Accordingly, IoT increases the number of embedded electronic components dramatically — it is critical to optimize the cost, power efficiency, and reliability.

Next-generation devices for IoT operate for an extended period at lower supply voltage and power. These devices have integrated capabilities for function, performance, network connectivity, and cybersecurity. These devices are typically configured by power source, DC/DC converter, power management IC, ASIC/MCU, sensor, display, wireless circuit block, and more. The devices are programmed to operate intermittently through the mode transition among idle/sleep/dormant, power-on (wake-up) and active to extend the device operating time at lower supply power.

Characterizing the power rail current and voltage is critical to reveal how the device operates to improve the performance and optimize the circuit design to ensure reliability. For example, the power rail current and voltage characterization help the R&D engineer to perform these tasks:

- Validate the circuit design against the component margin, peak, and inrush current
- Monitor the power consumption trend for mission-critical devices such as a pacemaker
- Characterize, debug, and optimize the power consumption along with firmware power management for controlling active to sleep operation
- Design power rail design with precise current and voltage waveform both for power integrity
- Determine the problematic device behavior that is not visible by voltage measurement
- Detect a malicious code execution such as the side-channel attack for cyber-security

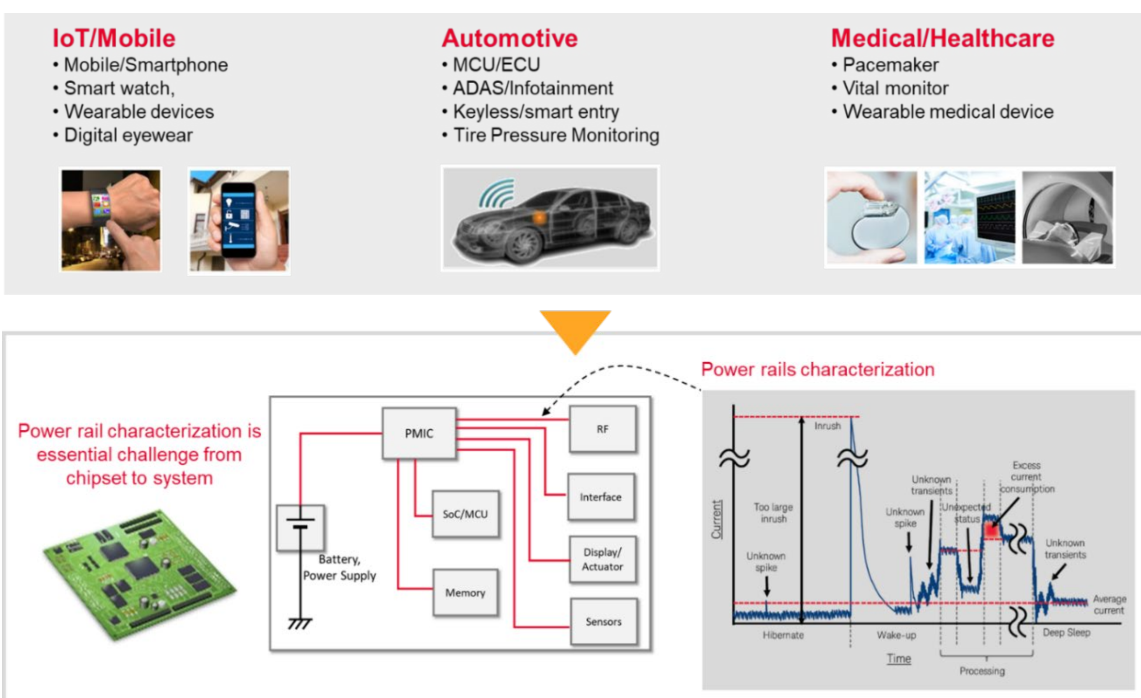


Figure 1. Power rail characterization from chipset to system

How to Solve Power Rail Challenges

The current waveform quickly changes from sub-µA to mA, depending on the device operation. A digital multimeter (DMM), current probe, and differential probe on a shunt-resistor are standard tools to measure current. However, these conventional instruments are getting insufficient to capture the dynamic current and voltage waveforms on the power rail due to trade-offs with bandwidth, sampling rate, sensitivity, and noise.

The CX3300A series — CX3322A with two channels, and CX3324A with four channels —are solutions to help you measure dynamic current and voltage characterization. They integrate the advantages of an oscilloscope's bandwidth and sampling rate, a DMM's sensitivity and low noise, and data logger's long-duration measurement in a single instrument. It enables you to characterize power rail, power integrity, or dynamic current and voltage behavior for a broad range of devices more accurately, precisely, and quickly than a measurement performed by other conventional methods.

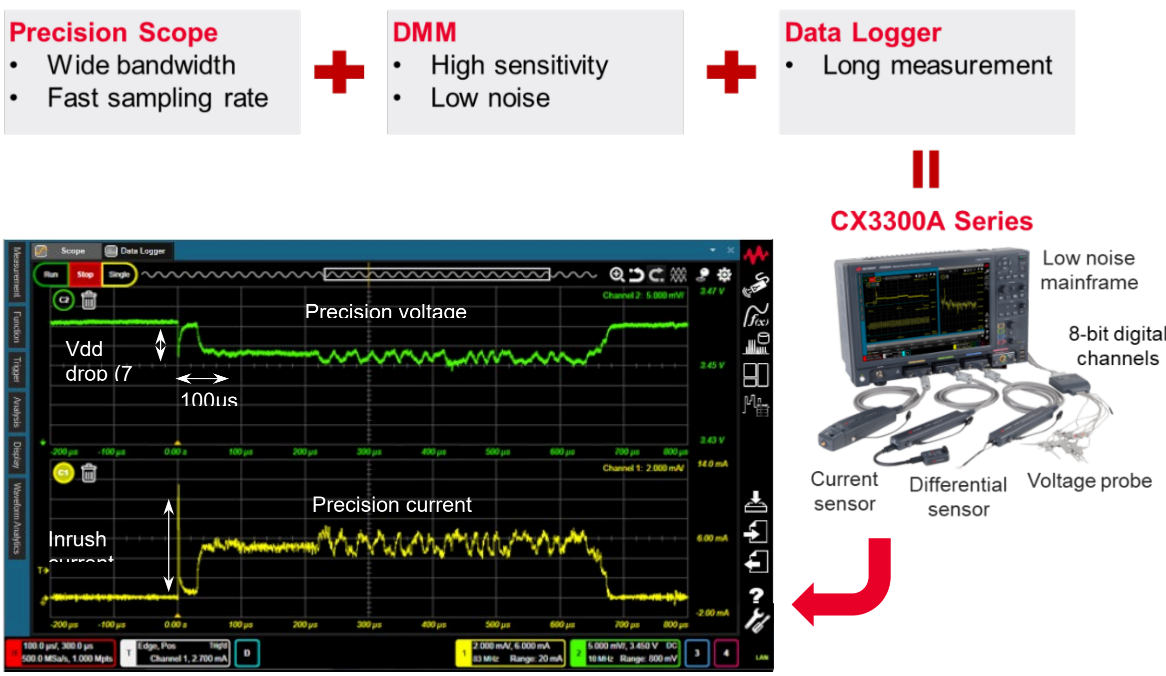


Figure 2. CX3300A visualizes precision dynamic current and voltage characteristics

Design Validation and Debugging

Figure 3 shows the typical IoT and mobile device operation and the measurement example using the CX3300A. The power rail current dynamically changes according to the device's operation. Capturing the current waveforms helps you with design validation and debugging that is not available by voltage measurement. The CX3300A enables you to capture the dynamic characteristics of the power rail precisely and quickly.

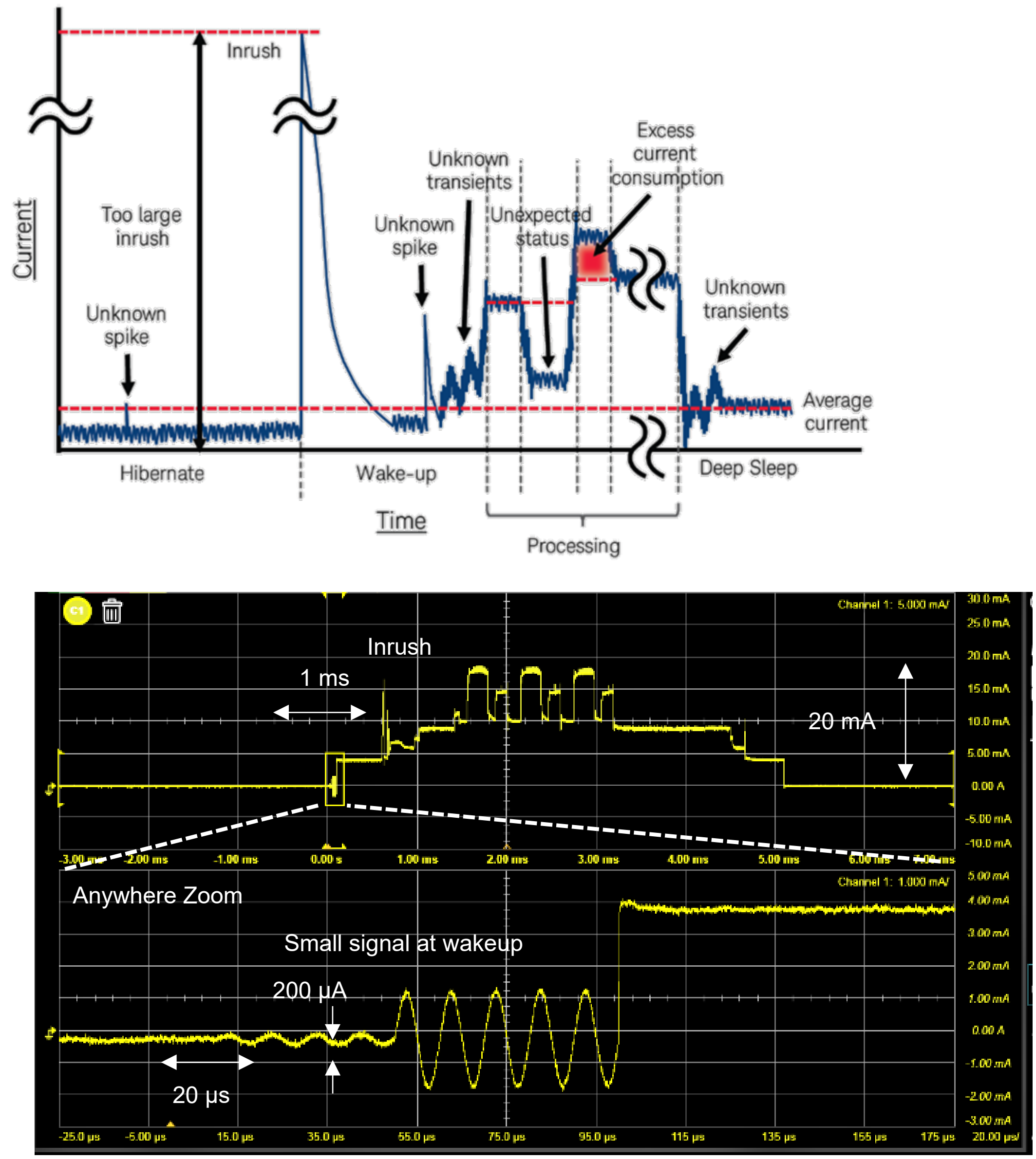
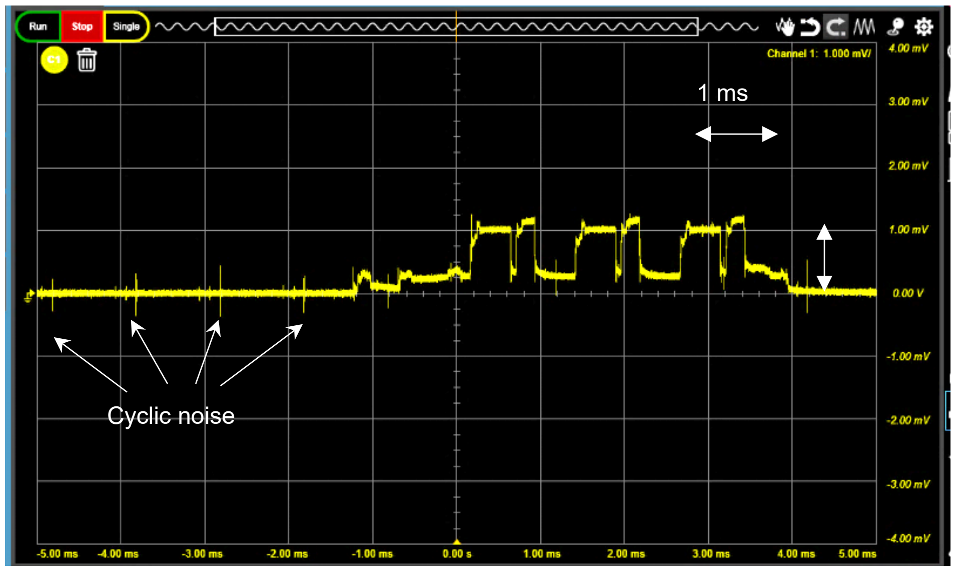


Figure 3. Precise dynamic current waveform provides valuable information to validate and optimize the circuit design.

Dynamic Current Measurements

A DMM or oscilloscope with a current probe or differential probe are commonly used to measure the current, but there are trade-offs with bandwidth, sampling rate, sensitivity, and noise. The comparison between the CX3300A and conventional measurement tools are shown in Figures 5 and 6. In some cases, multiple instruments are required to characterize the device comprehensively, or a single instrument is used for characterization. However, it is challenging to identify a potential design failure using a single instrument.

CX3300A



Conventional differential probe

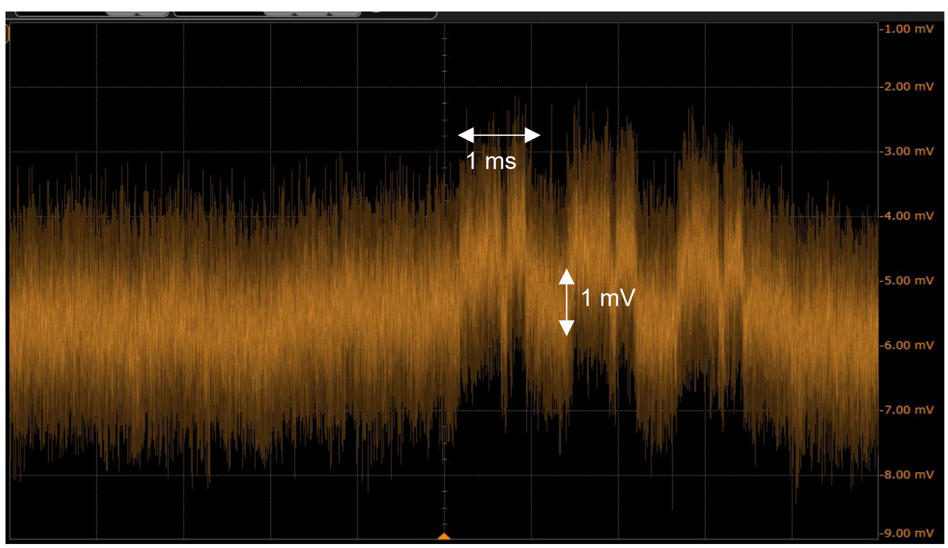
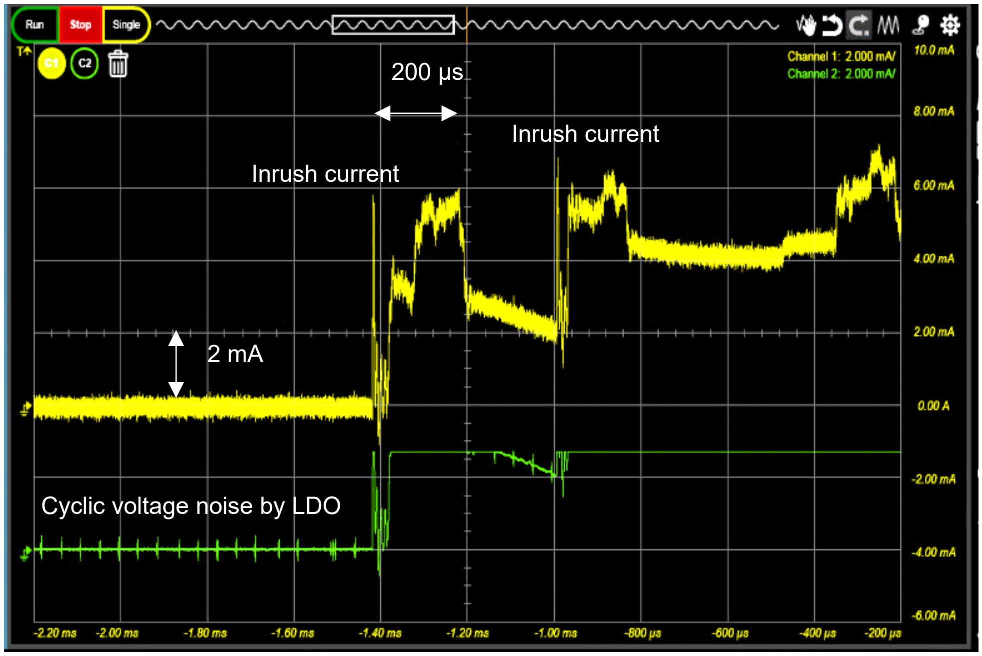


Figure 4. CX3300 captures very small differential voltage beyond a conventional differential probe

CX3300A



DMM

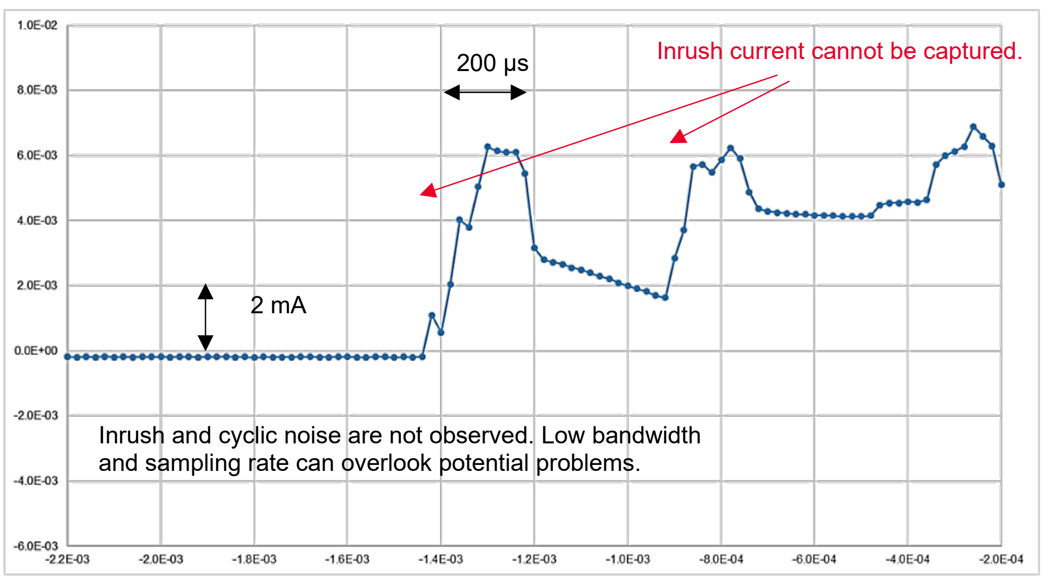
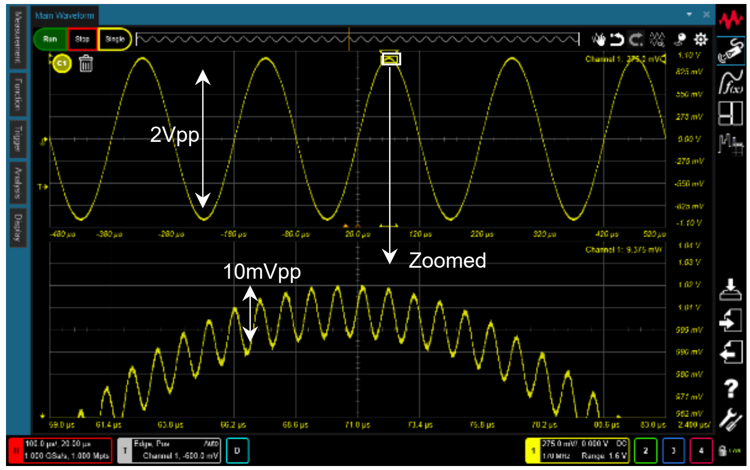


Figure 5. CX3300 captures small dynamic current and voltage signals that are not captured by a DMM

CX3300A Series Device Current Waveform Analyzer

High-resolution and high-speed 14-bit/16-bit Analog-to-Digital Converter (ADC) for precise measurement with a wide dynamic range

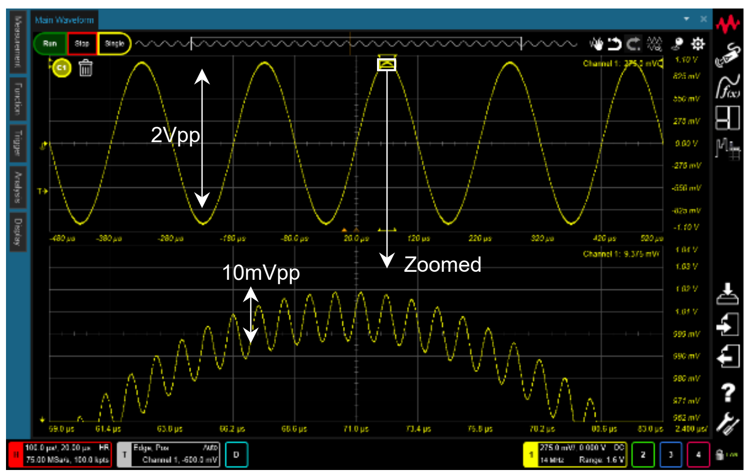
- Maximum 1GSa/s 14-bit ADC enables precision measurement of fast waveforms with a wide dynamic range beyond the conventional high-resolution oscilloscope
- Maximum 75MSa/s 16-bit high-resolution ADC for more precise measurement



14-bit high-speed ADC

Mainframe design to achieve wide bandwidth and low noise floor simultaneously

The instrument noise floor is a key challenge for precision measurement. Even if the ADC is high-resolution, the instrument noise floor can limit the measurement sensitivity and high-resolution. The CX3300A mainframe design achieves the wide bandwidth and low noise floor simultaneously and visualizes the precise dynamic current and voltage waveform measurement with the sensors.



16-bit high-resolution ADC

Figure 6. The CX3300A's low noise and high-resolution ADC can visualize 10 mVpp (1 MHz) on top of 2 Vpp (5 kHz) using the CX1151A passive probe interface

Intuitive graphical operation

User-friendly GUI allows you to easily start measurements and get accurate data on a 14.1-inch wide touch screen for critical analysis. It also provides common interface connectivity to meet the requirements with Windows 10 and solid-state drive (SSD).

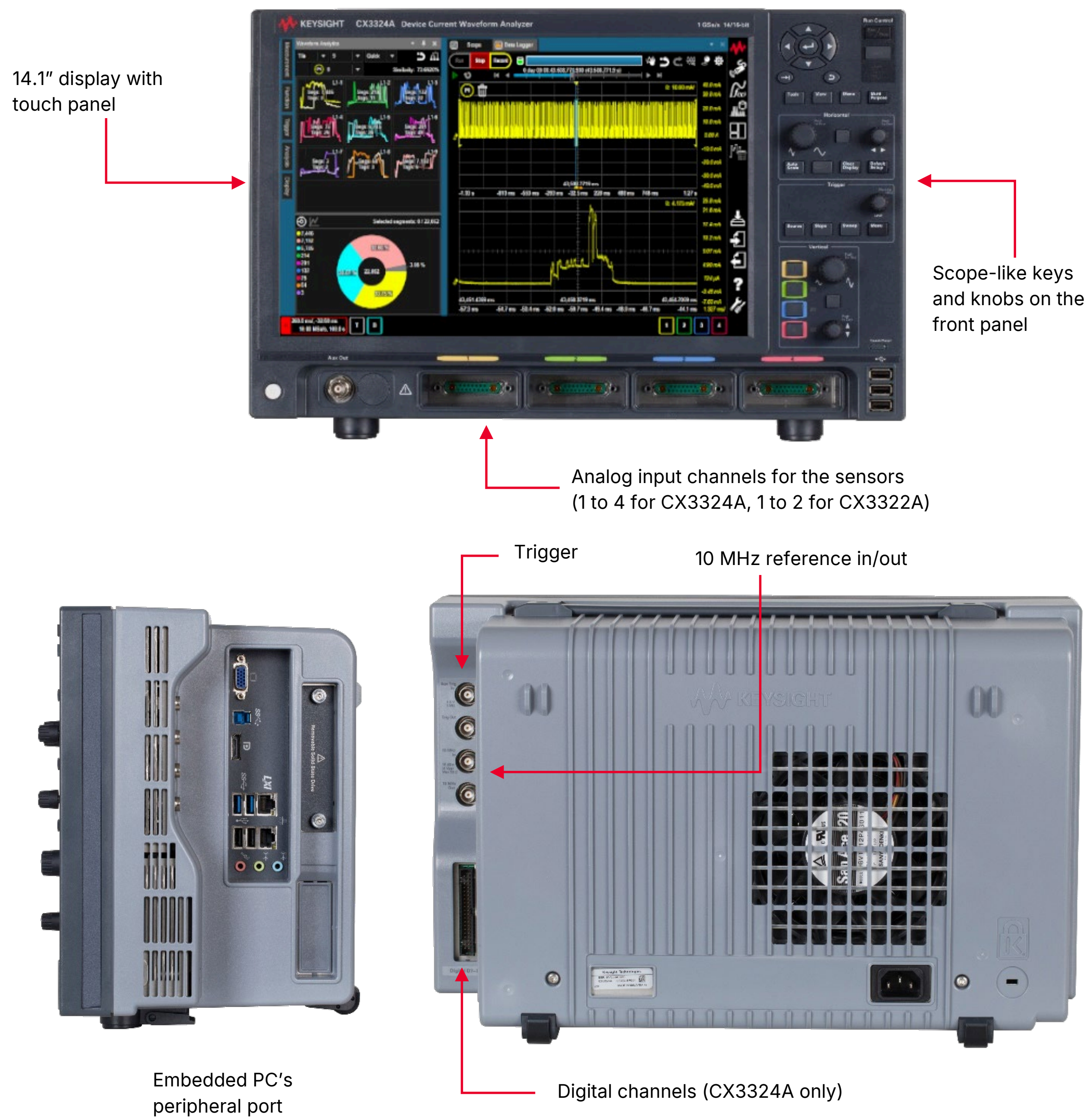


Figure 7. CX3324A front, side, and rear instrument views

Current and Voltage Sensor Options

The CX3300A series supports the following sensor options that cover a broad current and voltage measurement range. You can choose the appropriate sensor combinations according to your requirements of sensitivity, bandwidth, and connectivity.

Current measurement

- CX1101A Single-channel current sensor
- CX1102A Dual-channel current sensor
- CX1103A Low-side current sensor
- CX1104A Selectable shunt current sensor

Voltage and current measurement

- CX1105A Ultra-low noise differential sensor

Voltage measurement

- CX1151A Passive probe interface adapter

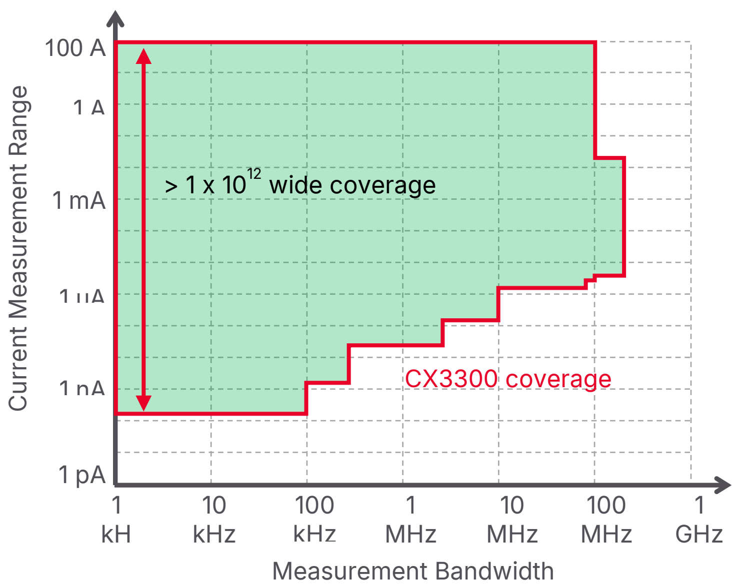


Figure 8. Various current sensors cover a wide current measurement area

CX1101A Single-Channel Current Sensor

The CX1101A is an essential current sensor used for various applications. The unique current sensing technology suppresses the higher frequency noise.

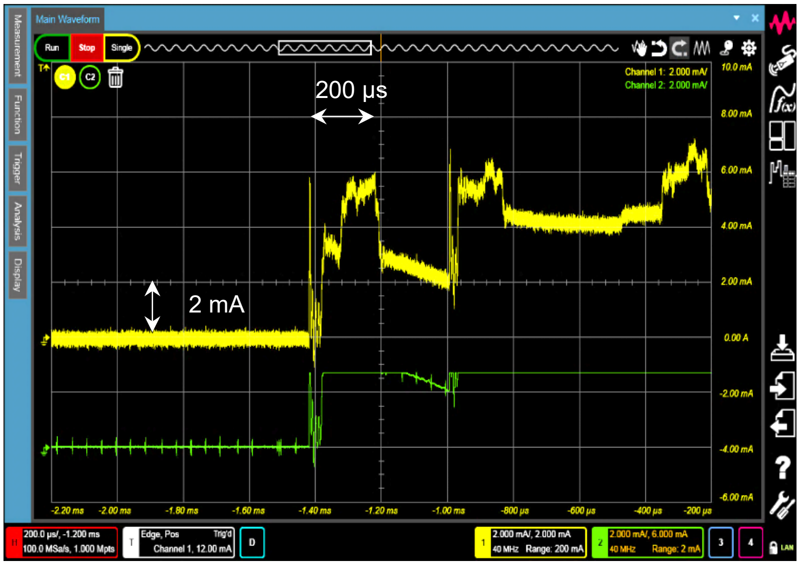
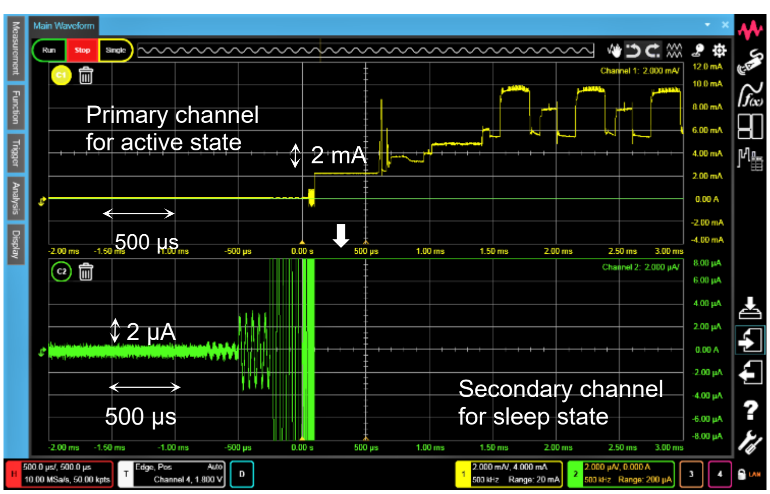


Figure 9. CX1101A measurement example

- 40 nA to 1 A (10 A with CX1206A)
- > 80 dB dynamic range
- 100 MHz maximum bandwidth

CX1102A Dual-Channel Current Sensor

The CX1102A dual-channel current sensor enables simultaneous measurements under two different measurement ranges. For example, the primary channel is set to a 20 mA range, while the secondary channel automatically sets to a 200 µA range. This setting enables the sub-µA measurement, which is the primary channel's range — and is 50 to 100 times larger than that of the secondary channel. This current sensor is very useful for low-power applications because it has an intermittent operation between sleep/standby and active states.

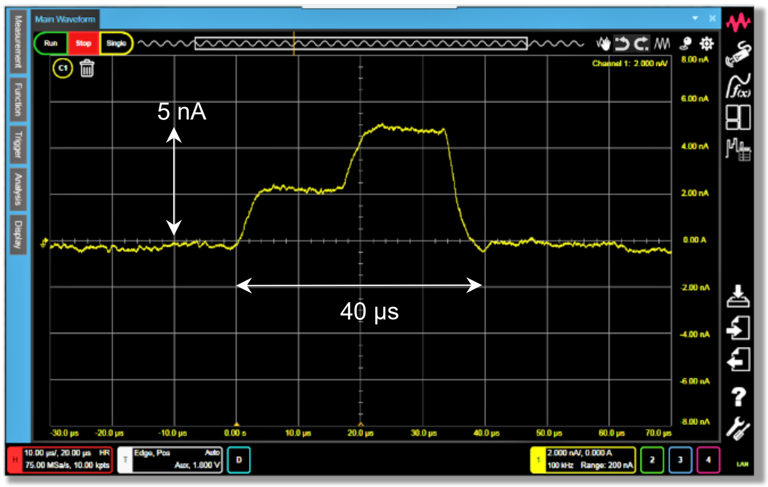


- 40 nA to 1 A
- > 100 dB dynamic range
- 100 MHz maximum bandwidth

Figure 10. CX1102A measurement example

CX1103A Low-Side Current Sensor

The CX1103A provides wide bandwidth and low current sensitivity that is useful to measure the current flowing into the circuit common ground. The CX1103A can cancel the DC offset current, and measures low-level dynamic sensor current signals on large DC current.

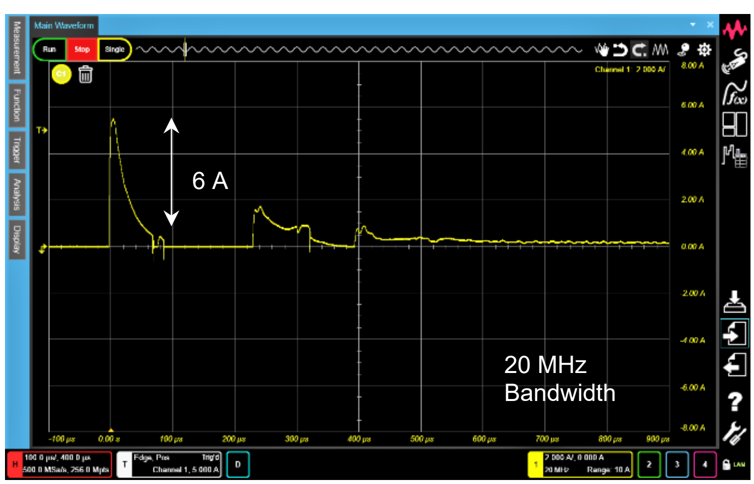


- 150 pA to 20 mA
- > 80 dB dynamic range
- 200 MHz maximum bandwidth

Figure 11. CX1103A measurement example

CX1104A Selectable Shunt Current Sensor

CX1104A enables accurate dynamic current measurements up to 15 A with a wide dynamic range down to 1 µA level sensitivity. It requires a resistive sensor head calibrated at Keysight.



- 1 µA to 15 A
- > 80 dB dynamic range
- 20 MHz maximum bandwidth

Figure 12. CX1104A measurement example

CX1105A Ultra-Low Noise Differential Sensor

The CX1105A ultra-low noise differential sensor measures a differential voltage across your shunt resistor on an evaluation test board. It performs a non-intrusive current measurement. The measurable voltage converts into current on the CX3300A's mainframe by entering the value of the shunt resistor. Figure 13 shows the measurement example of 1 mV peak waveform performs the low noise temperate testing in the chamber.

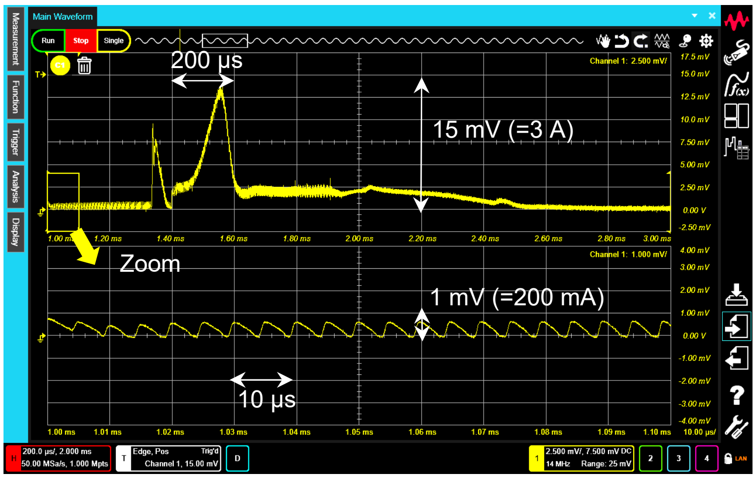
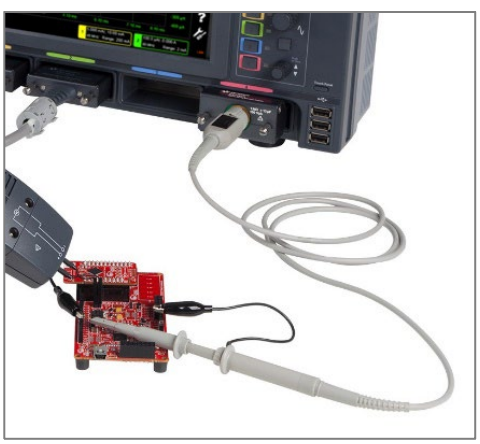


Figure 13. CX1105A measurement example

- Non-intrusive current measurement
- 1 µA to 100 A (depending on a shunt resistor)
- > 80 dB dynamic range
- 100 MHz maximum bandwidth

CX1151A Passive Probe Interface Adapter

The CX1151A is a passive prove interface adapter allows you to use a regular passive probe for voltage measurements to take full advantage of CX3300A's 16-bit high-resolution ADC and low noise.



- Max. 8V (Max 80V with 10:1 probe)
- > 80 dB dynamic range
- 300 MHz maximum bandwidth (with no passive probe)

Figure 14. CX1151A passive probe interface adapter

CX1152A Digital Channel for the CX3324A

The CX1152A digital channel helps you with digital triggering — up to 8 channels to measure current synchronized with digital signals such as the controller's I/O or data bus. Unlike conventional digital probes, each probe for the CX1152A has 10 MΩ input resistance, which enables you to make accurate low power measurements by minimizing the load current.

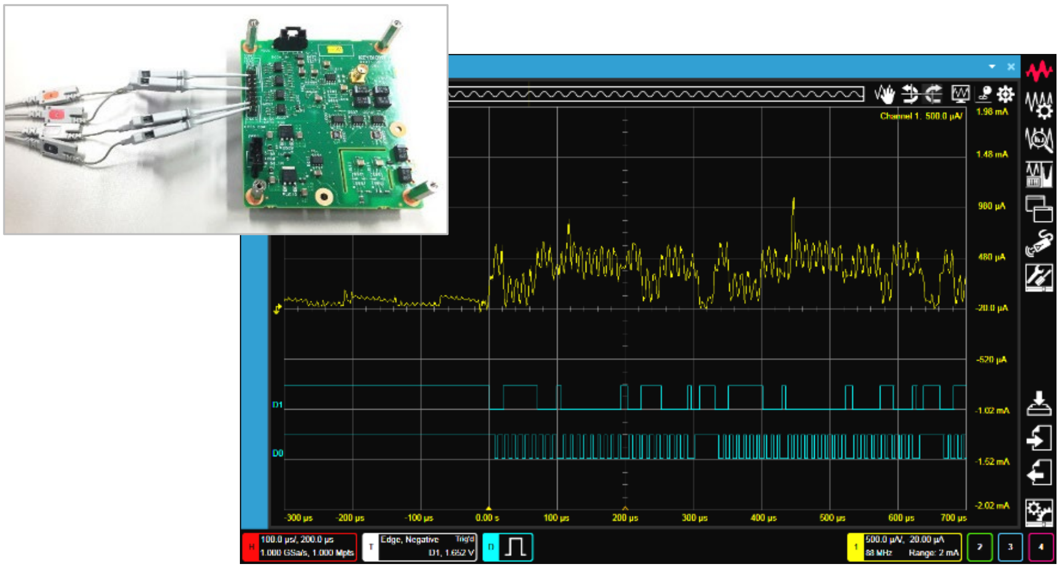


Figure 15. CX3324A has a digital channel to sync with the trigger by the digital bus

Analyzing a Long-Duration Measurement

Today's devices are designed to maximize the power efficiency and device operation time in the limited and lower supplied power. The sleep/dormant time is getting longer, and a series of device operation cycles require characterization is also getting longer. Because of the limitation of memory depth, R&D engineers need to compromise the measurement due to the trade-off of the sampling rate or measurement duration. There is a potential risk of reliability. The CX3300A supports the long-duration measurement with two operation modes, scope mode, and data logger mode.

In the scope mode, the CX3300A captures the waveform with a trigger similar to an oscilloscope. It automatically saves the data file at every trigger event to extract specific events in a long-duration device operation. Along with deep memory up to 256 Mpts and 14-bit/16-bit ADCs, the CX3300A measures the device operation precisely.

In the data logger mode, the CX3300A captures a continuous waveform without a trigger event. It is useful when capturing an entire waveform or when the waveform cannot be triggered. Our unique technology provides unprecedented measurement and analysis capabilities for a long-duration measurement. The technology records the fast waveform at a sampling rate up to 10MSa/s for a long-duration measurement, and up to 100 hours using internal/external storage (HDD/SSD) with remaining sensitivity.

In a long-duration measurement, the analysis of data is challenging because the data file is massive — the file size range in the hundreds of GB to TB file size. The CX3300A enables you to quickly playback the data from storage to help you find anomaly events with its powerful analysis features.

Capabilities	Scope Mode	Data Logger Mode (Option) [1]
Data storage	Embedded memory	Internal/external HDD/SSD
Maximum sampling rate	1GSa/s (14-bit) 75MSa/s (16-bit)	10MSa/s (14-bit) 7.5MSa/s (16-bit)
Maximum measurement duration	Memory size/sampling rate	100 hours
Maximum measurement point	256 Mpts	Sampling rate x 100 hours
Measurement window control	Trigger and memory size	Start trigger and stop time
Role of trigger	Measurement	Segmentation for analysis
Analysis features	Math function FFT (Fast Fourier Transform) Current profiler	Waveform analytics Waveform trend analyzer Math function FFT Current profiler

1. Recommend Windows 10, USB 3.0, and a storage device supporting USB 3.0 UASP (USB Attached SCSI Protocol) to take full advantage of the data logger mode

Waveform Analytics Accelerate Characterization, Validation, and Debugging

Anywhere Zoom

An easy-to-use zoom function allows you to view the waveform at any time. It instantly enables the magnifying lens function, which enables you to zoom in on any areas of interest. The zoom functionality includes vertical and horizontal scaling independent of the main waveform. As a result, you can fully utilize the CX3300A's high resolution 14/16 bit ADC and deep memory up to 256 Mpts.

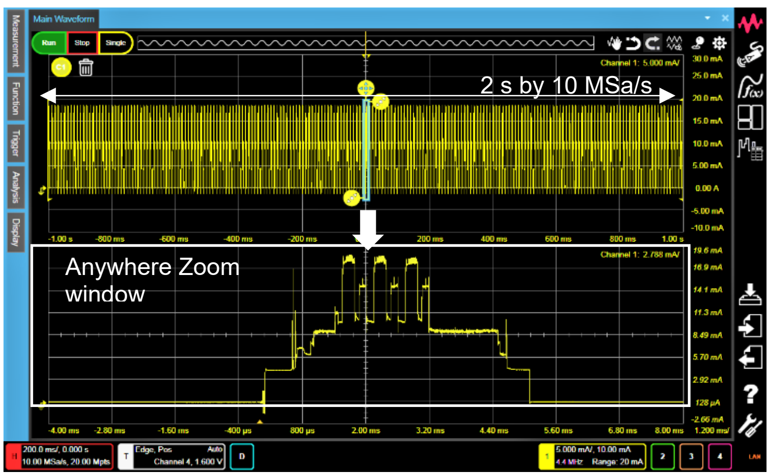


Figure 16. Anywhere zoom function

Automated Power and Current Profiler

Analysis of power or current profile is essential to determine current consumption at a specific event or status. However, this is a time-consuming task on an external PC using software such as Excel. The CX3300A supports the power and current profiler, which eliminates time-consuming power and current profile analysis. It can automatically adjust the time scale by the vertical level difference, instantly calculate key parameters such as average current, max/min current, accumulated charge. You can also adjust the segment manually according to your measurement profile.

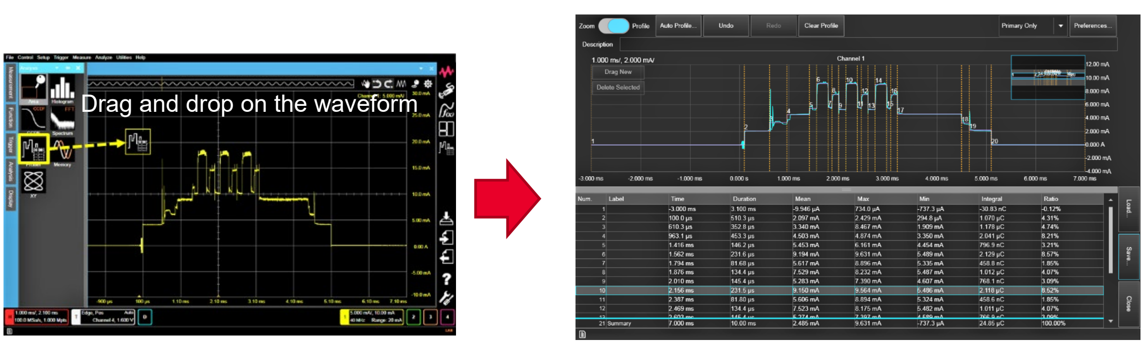


Figure 17. Automated power and current profiler results

Waveform Trend Analyzer for Analysis of the Trend in a Big Data

It is challenging to review the data from a long-duration measurement; there could be up to 100 hours of data. The CX3300A offers a new analytics approach using a waveform trend analyzer. It visualizes the statistical trend (minimum, maximum, average, and charge) of each segment for the entire waveform. It helps you to find the anomaly or inflection point of the waveform to analyze the specific region of the measurement data in details.

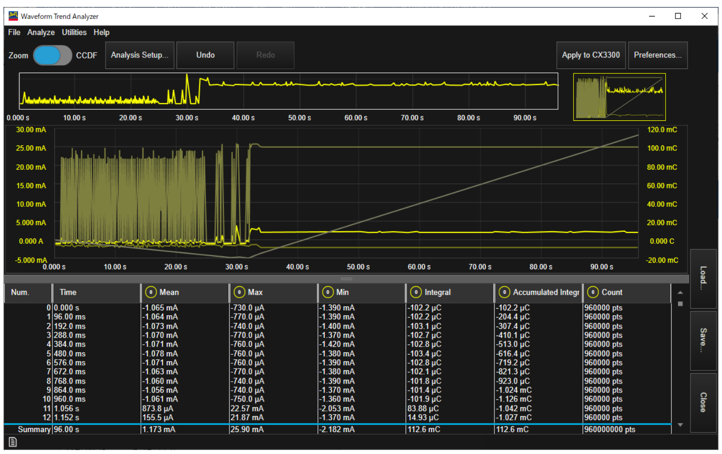


Figure 18. Waveform trend

Waveform Playback for Precise Analysis of the Waveform in the Database

The data logger mode measures a long-duration measurement of up to 100 hours. Even though the data and file size can be GB to TB, the CX3300A can quickly read the data from the storage, present the data within the embedded memory size, and playback at the speed that you feel like the real-time acquisition. The loaded data on the memory can be analyzed similarly to the scope mode.

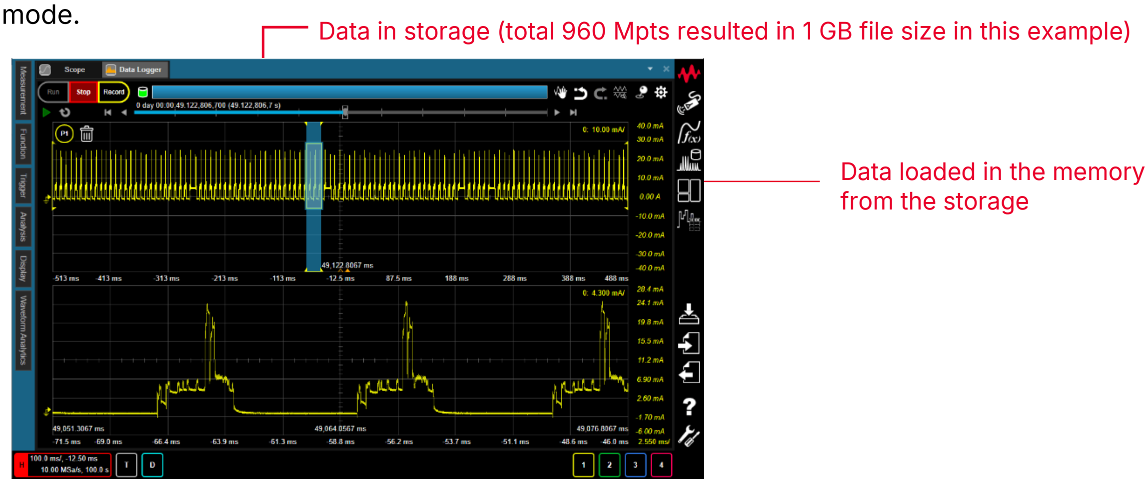


Figure 19. CX3300 can read and playback from the storage for deep analysis similar to the scope

Waveform Analytics Feature Enables you to Identify Anomalies Quickly

The CX3300A has a Waveform Analytics feature to help you identify the specific patterns and/or anomalies in the waveform database. It enables you to set the trigger condition and record the triggered waveform as the triggered segment. The Waveform Analytics group the triggered segments by the similarity. It enables you to identify an anomaly instantly without looking through the entire waveform. The selected segments are displayed and playback on the main window.

Waveform Analytics group the triggered segment by similarity with the number of occurrences. It is easy to find the unique anomaly.

Playback only the selected trigger pattern in the entire waveform for a quick deep dive analysis.

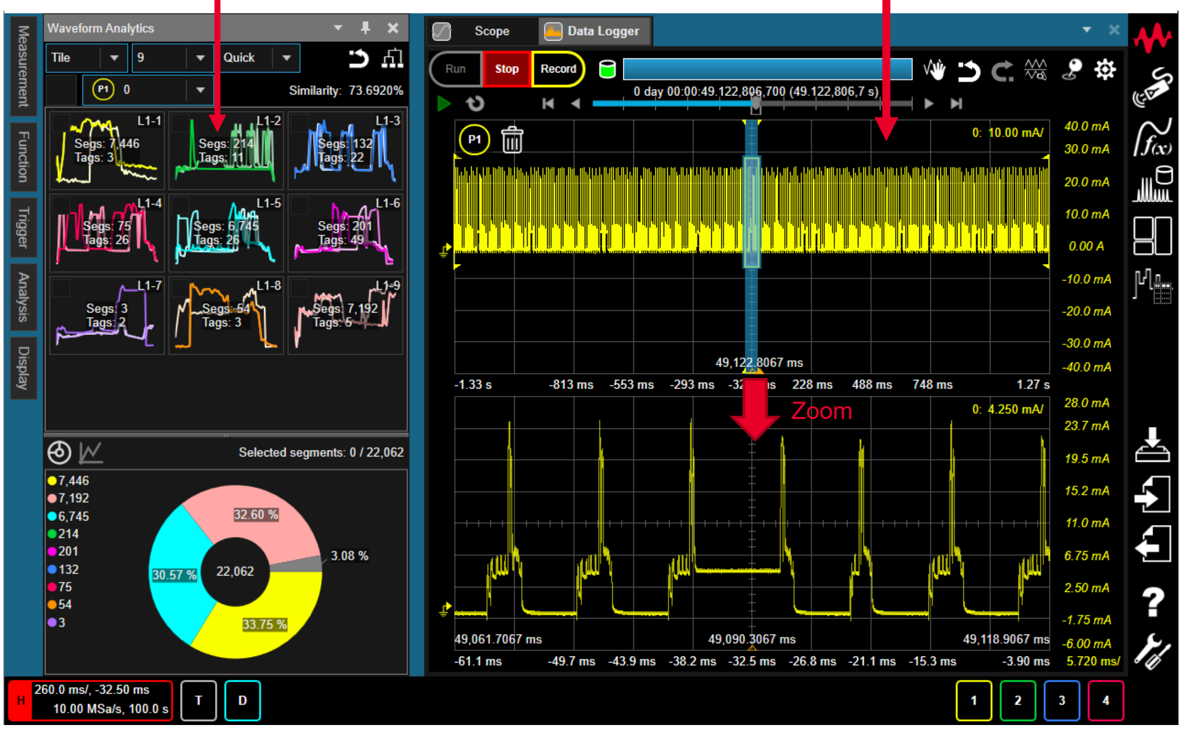
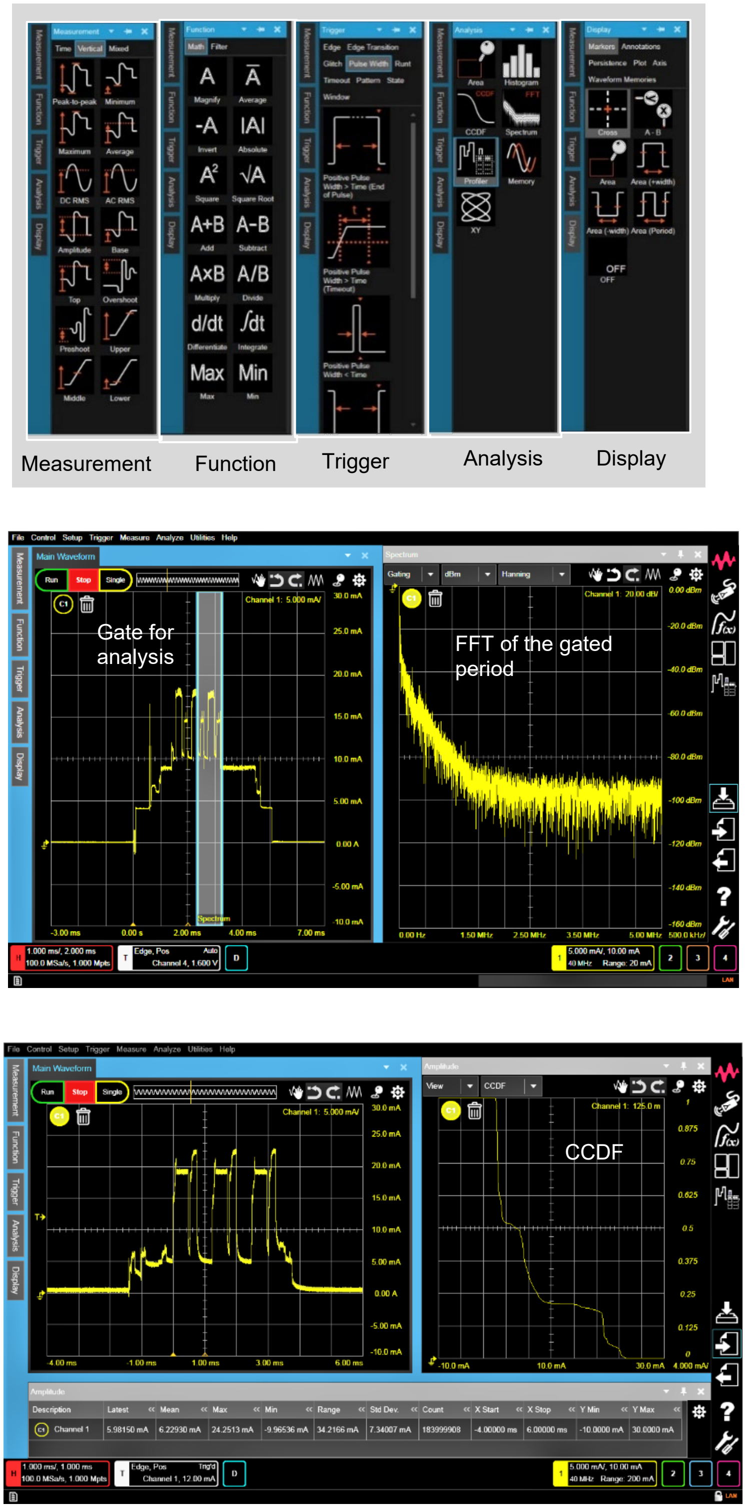


Figure 20. Waveform Analytics enables you to identify anomalies quickly

Other analysis capabilities



The CX3300 provides easy access to the built-in capabilities such as measurement, function, trigger, analysis, and display.

Frequency domain analysis (FFT) is available. You can focus on a specific period in the waveform by using the gating functions.

CX3300 features statistical analyses such as Complementary Cumulative Distribution Function (CCDF) or histogram on the mainframe. As a result, you can now focus on your measurement without transferring the data to your PC.

Figure 21. CX3300A supports many capabilities that are common in conventional scopes

Broad Range of Devices and Applications

Chipset and component device characterization

- MCU, SoC, FPGA, PLD, SoC, APU, MPU, GPU
- Low-power IC and sensor

Reference board design and validation of IoT and mobile devices

- Low-power IoT devices (*Bluetooth*® low energy, ZigBee, NB-IoT)
- Smartphone, tablet, and other mobile devices (WiFi, LTE)
- Wearable devices (watch, eyewear, wrist band)
- Energy harvesting (IC, sensor, actuator)

Mission-critical product assurance

- Medical/healthcare devices (pacemaker, vitals monitoring equipment, and more)
- Automotive (Electronic Control Units (ECU), sensors)

Semiconductor device characterization

- Non-Volatile Memory (NVM) devices

  An NVM device is a key component for IoT. The increasing demand for higher speed, lower latency, and reliability in NVM devices continues to evolve. For example, RRAM (resistive RAM), PCM (Phase-Change Memory), MRAM (Magnetoresistive RAM), and a variety of novel NVM devices. Characterizing these devices requires transient current measurements between read, write, and erase periods to evaluate how the resistance changes in the device. Minimizing the power consumption for these devices is essential. For example, the measured current must be 100 µA or less — while the pulse width for write and erase operations is as short as 100 ns or less.

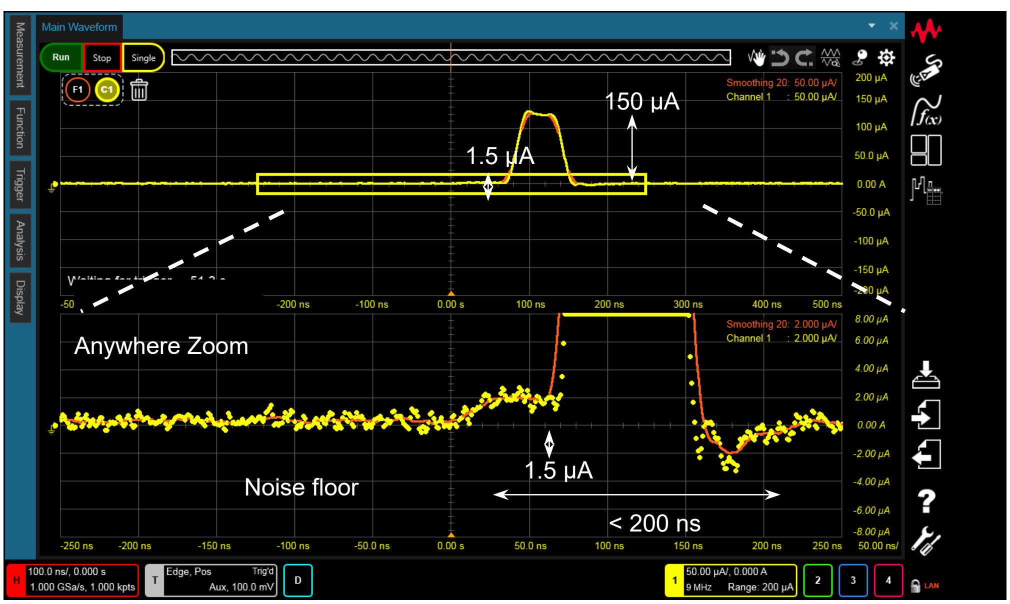


Figure 22. Pulsed measurement example using the pulse generator and CX3300A

Software Solutions

Current Waveform Analytics Software Enables you to Analyze the Power Rail Characteristics on your PC

CX3300APPC current waveform analytics software provides CX3300A scope mode and data logger mode capabilities. It enables the post-measurement analysis tasks without the instrument.

Easy Automated Testing by Benchvue Software

Keysight BenchVue software supports CX3300A series and allows you to control your CX3300A series from a PC. Connect multiple instruments to control with the CX3300A series — the powerful and intuitive test sequence capability quickly creates automated tests over the connected instruments. The measurement results are easily logged, plotted on a graph, and exported for further analyses.

Figure 23. BenchVue test sequence using a Keysight 33622A waveform generator and a CX3324A to make a simple pulse measurement

CX3300 Series Specifications and Characteristics

Specification Conditions

- Specifications are valid after a 30-minute warm-up and 23 ± 5 °C. Warranted specifications are denoted by **. All others are supplemental characteristics.
- Measurement accuracy is affected by RF electromagnetic fields with strengths higher than 3 V/m in the frequency range of 80 MHz to 2 GHz, or 1 V/m in the frequency range of 2 GHz to 27 GHz. The extent of this effect depends on instrument positioning and shielding.
- All sensor characteristics are defined by the 14-bit acquisition resolution of the CX3300 mainframe unless otherwise stated.
- Sensor maximum bandwidth is standalone bandwidth. The following equation can estimate the effective bandwidth when connected to the mainframe. 0.35/bandwidth calculates rise and fall times (10% to 90%).
- $$BW_{effective} = \frac{1}{\sqrt{\left(\frac{1}{BW_{sensor}}\right)^2 + \left(\frac{1}{BW_{mainframe}}\right)^2}}$$

CX3300A Mainframe

Comparison of CX3322A and CX3324A

		CX3322A	CX3324A
Number of analog channels		2	4
Number of digital channels		N/A	8 with CX1152A
Max. analog bandwidth [1]		50 MHz, 100 MHz, or 200 MHz	
Max. memory depth [1]		4 Mpts, 16 Mpts, 64 Mpts or 256 Mpts	
Measurement mode	Scope mode	Default	
	Data logger mode	Option [2]	

1. Maximum bandwidth and memory depth are selectable at ordering. Upgradable by license.
2. Data logger mode is optional, upgradable by license.

Vertical System – Performance Characteristics (Scope Mode and Data Logger Mode)

Vertical System - Analog Channels	Vertical Hardware Resolution			
	16-bit	**14-bit**		
Analog bandwidth (–3 dB)	14 MHz	50 MHz	100 MHz	200 MHz
RMS noise (±0.5 V fix, full BW)	46 µVrms	120 µVrms	170 µVrms	250 µVrms
Input coupling	DC			
Input impedance **	50 Ω: ±3.5%			
Input range	±0.65 V nominal, ±2 V peak			
DC measurement accuracy **	± (0.7% of reading + 0.7% of range) [1]			

1. ADC offset user calibration necessary

Horizontal System — Performance Characteristics (Scope Mode And Data Logger Mode)

Horizontal System	
Main time base range	1 ns/div to 10 ks/div
Resolution	1 ns
Reference position	Left, center, right
Time scale accuracy	10 ppm
Channel deskew	Range = -100 to +100 ns

Acquisition System - Performance Characteristics (Scope Mode)

Analog channel

Maximum real time sample rate [1]	14-bit	1 GSa/s for each channel
	16-bit	75 MSa/s for each channel
Memory depth [2]		4 Mpts, 16 Mpts, 64 Mpts or 256 Mpts
Sampling modes		Real time with average (normal)
		Real time with discard
		Real time with peak detect
Filters		sin (x) / x interpolation
		Averaging
		1MHz, 2 MHz, 5 MHz, 10 MHz, 20 MHz, 50 MHz, 100 MHz [3]
		Low-frequency noise suppression mode (16-bit high-resolution mode only)

1. All channels are set to the same resolution.
2. Memory depth selectable when ordering; upgradable by license.
3. Per-channel filters characterized by math functions.

Acquisition System – Performance Characteristics (Data Logger Mode [1, 2])

Analog Channel

Maximum real time sample rate [3]	14-bit	10 MSa/s
	16-bit	7.5 MSa/s
Maximum record time [3]		100 hours for each channel
Sampling modes		Real time with average (normal)
		Real time with discard
Filters		Low-frequency noise suppression mode (16-bit high-resolution mode only)
Storage		Internal SSD and external SSD/HDD [4]
Embedded OS		Recommend Windows 10

1. Data logger mode is an option, selectable at ordering and upgradable by license.
2. Only analog channel data is stored in data logger mode.
3. All channels are set to the same resolution. Effective sampling rate depends on the number of measurement channels and storage data transfer performance.
4. Recommend USB 3.0 UASP (USB Attached SCSI Protocol) storage device.

Acquisition System Supplemental Characteristics (Data Logger Mode)

Maximum sampling rate[1]

Number Of Measurement Channels	Maximum Sampling Rate (ADC) [2]
1	10 MSa/s (14-bit), 7.5 MSa/s (16-bit)
2	5 MSa/s (14-bit/16-bit)
4	2 MSa/s (14-bit/16-bit)

1. Maximum sample rate is achievable when the signal noise floor is lower than 128LSB p-p; otherwise, data loss may occur.
2. Effective sampling rate depends on the storage data transfer performance. Recommend checking the maximum sampling rate with using the performance check tool furnished with the CX3300 series while using third-party external storage.

Maximum recording time limitation by free disk space

- Maximum recording time
  - Free disk space minus reserved disk space/(typical sample point size x sample rate x number of channels)
- Reserved disk space = 2 GB (gigabytes) [1]
- Typical sample point size = 1.7 bytes

1. Stores the additional information for waveform analytics.

Data file size created by a data logger mode measurement

- Data file size = Sample point size x recording time x sample rate x number of channels
- Sample point size = 1.5 to 2.5 bytes [1].

1. Depends on the signal noise floor.

Trigger System – Performance Characteristics (Scope Mode)

Trigger

Source	CX3322A	Channels 1, 2, aux, and line
	CX3324A	Channels 1, 2, 3, 4, aux, line, and digital channels
Sensitivity		Analog channel: 5% of sensor range
		Digital channel: See digital channel characteristics
		External trigger input: DC to 100 MHz (minimum input: 300 mVpp)
Trigger level range		Analog channel: ± sensor range [1]
		Digital channel: see digital channel characteristics
		External trigger Input: ±8 V (1 MΩ)
		External trigger output: 2.5 V (50 Ω, 100 ns pulse width)
Trigger coupling	Analog channel	DC: high frequency reject (50 kHz low pass filter)
	External trigger input	DC or AC: (10 Hz) low frequency reject (50 kHz high pass filter), high frequency reject (50 kHz low pass filter)
Sweep modes		Auto, triggered, single
Trigger holdoff range		100 ns to 10 s
Trigger actions		Specify an action to occur and the frequency of the action when a trigger condition occurs

1. Trigger level range for analog channels is the same as the sensor range connected to the mainframe. ± Sensor range = ± 4 div. at default setting.

Trigger Mode

Edge (analog and digital)	Rising, falling, either
Edge transition (analog)	Rising edge > time, rising edge < time, falling edge > time, falling edge < time
Glitch (analog and digital)	Positive glitch > time, positive glitch < time, positive glitch in range, Negative glitch > time, negative glitch < time, negative glitch in range
Pulse width (analog and digital)	Positive pulse width > time, positive pulse width > timeout, positive pulse width < time, negative pulse width > time, negative pulse width > timeout, negative pulse width < time
Runt (analog)	Positive runt, positive runt (time-qualified), negative runt, negative runt (time-qualified)
Timeout (analog and digital)	High too long, low too long, unchanged too long
Pattern/pulse range (analog and digital)	Pattern entered, pattern exited, pattern present > time, pattern present > timeout, pattern present < time, pattern present in range
State (analog and digital)	Rising edge (AND), rising edge (NAND), falling edge (AND), falling edge (NAND), either edge (AND), either edge (NAND)
Window (analog)	Entering range, exiting range, inside range > time, inside range > timeout, inside range < time, outside range > time, outside range > timeout, outside range < time

Trigger System - Performance Characteristics (Data Logger Mode) [1]

Trigger

Source	CX3322A	Channel 1, 2
	CX3324A	Channel 1, 2, 3, 4
Trigger level range		Analog channel: ± sensor range [1]
Trigger holdoff range		100 ns to 1 s
Trigger sequence		Single, dual, trigger to trigger

1. Trigger setting is not mandatory for measurement in data logger mode. The trigger in the data logger mode may be used to segment the triggered events for the waveform analytics in the analysis.

Trigger Mode

Edge (analog)	Rising, falling, either
Window (analog)	Entering range, exiting range

Digital Channel Characteristics (CX3324A Only) [1]

Vertical System

Input channels	8 channels
User-defined threshold range	±25 V, 10 mV step
Maximum input voltage	±40 V peak
Threshold accuracy	±(150 mV + 3% of threshold setting)
Input dynamic range	±25 V
Minimum input voltage swing	500 mV peak-to-peak
Input impedance	10 MΩ ±2% with approximately 8 pF in parallel
Channel-to-channel skew	4 ns
Resolution	1-bit

1. CX1152A digital channel interface is required.

Acquisition System - Performance Characteristics (Scope Mode)

Maximum real time sample rate	500 MSa/s
Maximum memory depth per channel [2]	128 Mpts
Minimum width glitch detect	7 ns

2. Memory depth depends on the analog channels.

Mainframe Platform Characteristics

Computer System and Peripherals

Operating system		Windows 10 IoT
PC system memory		8 GB RAM
CPU		3 GHz Intel i5 quad-core
Display		WXGA 14.1" capacitive multi-touch screen (1280 x 800 pixels)
PC ports [1]		USB2.0, USB3.0, 10/100/1000 LAN, LXI [2] LAN (web-enabled remote control)
Drives (SSD)		≥ 250 GB removable SSD
Display	Internal display	WXGA 14.1" capacitive multi-touch screen (1280 x 800 pixels)
	External display	VGA and DisplayPort (drivers support up to two simultaneous displays)
Peripherals		Optical USB mouse and compact keyboard provided. All models support any Windows compatible input device with a USB interface.

1. USB communication functionality can be affected by RF electromagnetic field having the strengths greater than 3 V/m in the frequency range of 80 MHz to 2 GHz or 1 V/m in the frequency range of 2 GHz to 27 GHz. The extent of this effect depends upon how the instrument is positioned and shielded.
2. LXI compliance: LXI 1.4 Core, LXI HiSLIP, LXI IPv6.

I/O Ports

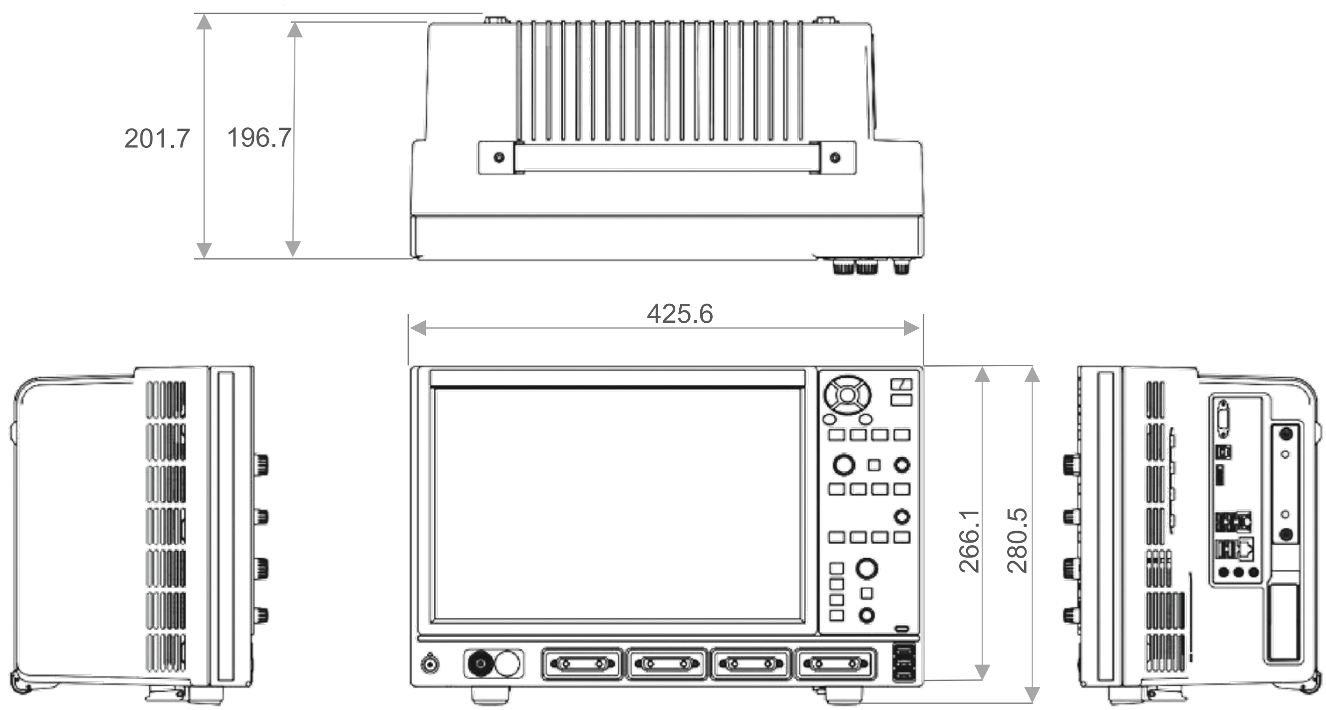
Aux output	±7 V max., ±200 mA max.: DC, pulse, square
Time base reference output	10 MHz, 8.33 dBm (Vpp = 1.65 V) into 50 Ω
Time base external reference input	10 MHz, 16 dBm (Vpp = 4 V) max. into 50 Ω

General Characteristics

Characteristics

Temperature	Operating	0 °C to 40 °C
	Storage	–20 °C to 60 °C
Humidity	Operating	Up to 80% relative humidity (non-condensing) at 40 °C
	Storage	Up to 90% relative humidity (non-condensing) at 60 °C
Altitude	Operating	Up to 2000 meters
	Storage	Up to 4600 meters
Power		100 V to 240 V ±10%, 50 Hz/60 Hz
	Max power dissipated	250 VA
Weight		Mainframe: 11 kg
Dimensions (feet retracted)		425.6 mm (W), 266.1 mm (H), 196.7 mm (D)
Safety		IEC 61010-1
Electromagnetic compatibility		IEC 61326-1

CX3300 Mainframe Schematic Diagram



Measurement and Analysis Features

Measurement, Math, and Analysis (Scope Mode and Data Logger Mode)

Measurements, Math, and Analysis

Waveform measurements	Amplitude	Peak-to-peak, minimum, maximum, average, DC RMS, AC RMS, amplitude, base, top, overshoot, preshoot, upper, middle, lower
	Time	Rise time, fall time, positive width, negative width, period, frequency, duty cycle, Tmin, Tmax
	Mixed	Slew rate, area
Math functions [1]	Operators	Add, subtract, multiply, divide, absolute value, average, delay, invert, magnify, max, min, differentiate, integrate, square, square root
		High pass filter, low pass filter, smoothing filter
Analysis	Markers	Crosshair, A-B, area
	Statistics analysis	Mean, min, max, standard development for waveform and waveform measurements
	Amplitude analysis	Histogram (hits, PDF, CDF, CCDF) and statistics with windowing
	Spectrum analysis (FFT)	Magnitude and phase with horizontal gating, up to 1 Mpts
	X-Y analysis	Up to 1 Mpts
	Waveform memory [2]	

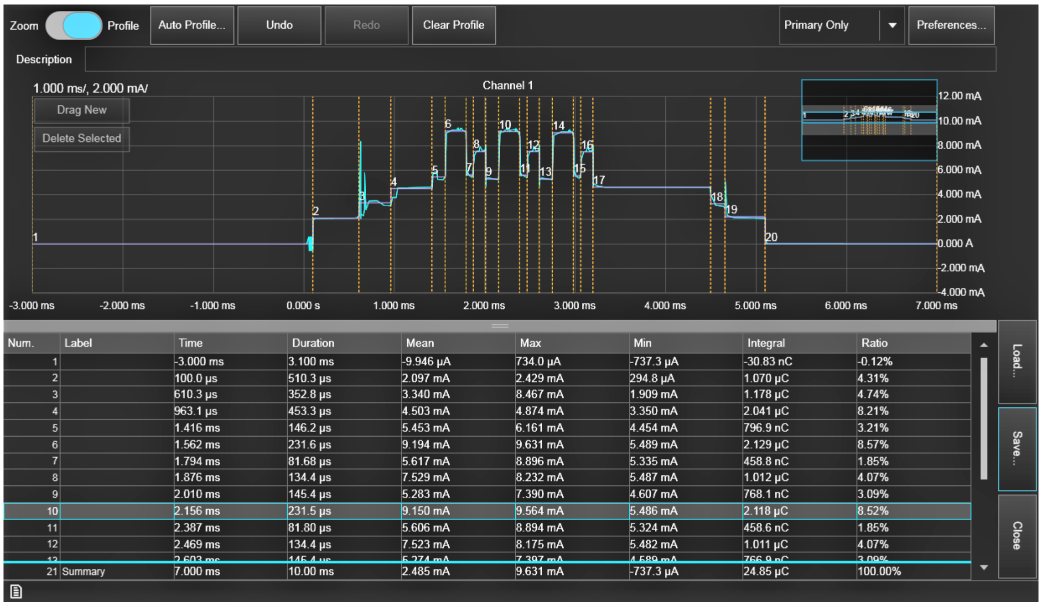
1. Operates on any combination of channels, memories, or other functions; up to 8 independent functions.
2. Use for measurements, math functions, and analyses; up to 8 independent memories.

Visualization

View		Waveform, histogram, spectrum, statistics, setup summary, sidebar
Display style	Waveform area	Single, dual, single plus anywhere zoom (vertical, and horizontal)
	Waveform style	Persistence, color grade
	Plot	Auto, dots, lines, area, gradation, diamonds
	Axis	Auto, linear, log, invert

Power and Current Profiler - Measurements and Analysis

The power and current profiler automatically adjust the time scale by the vertical level difference. It instantly calculates critical parameters such as average current, maximum/minimum current, and accumulated charge. The data displays in a table format. You can also adjust the segment manually according to your measurement profile. It eliminates time-consuming power and current profile analysis.



Data Logger Mode Features

The followings are recommended to take full advantage of the data logger mode analysis capabilities: Windows 10, USB 3.0, and a storage device supporting USB 3.0 UASP (USB Attached SCSI Protocol).

Recording view

When the waveform is recording in the data logger mode, the recording view displays in the main display window. Measurement data streams into the database on a storage device and displays for you to preview. Use the waveform playback to analyze the data. Note: Recording view has the limitations of bandwidth and data refresh cycle.

Waveform playback

Waveform playback is the main display window in the data logger mode except for waveform recording. Waveform playback allows the measurement setup for data logger mode measurement and the post-measurement analysis. It can playback the waveform by reading the data set on the embedded memory from storage. The waveform navigates by time as well as by trigger point. Measurements, math, and analysis capabilities are available in the waveform memory as well as the scope mode.

Triggered segmentation

The trigger setting is not mandatory to measure in data logger mode. However, the triggering capability can be used to tag the specific triggered events in the waveform during the measurement. The trigger information is helpful to identify the specific point in the long-duration measurement for analysis. The triggered segments are tagged with similarity cluster information in the database for waveform analytics. Using triggered segmentation feature can affect the effective sampling rate because of data processing bandwidth.

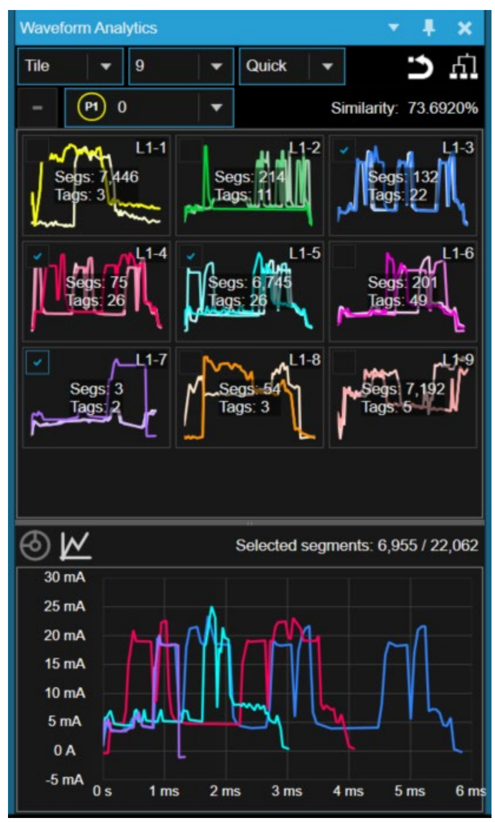
Triggered segmentation is in progress during the measurement. Use the following recommended settings to prevent data loss caused by overloading:

Recommended Settings of Triggered Segmentation

Number of segments	<5,000,000 segments /100s
Segment density	<1 segment/20us (number of measurement channel is 1 or 2) <1 segment/50us (number of measurement channel is 3 or 4)
Number of tags	20 to 500 (typical application such as BLE, similarity = 90% to 99%)
	10 to 50 (Multi-tone signal, similarity = 70% to 95%)
	1 to 2 (perfectly repetitive signal such as power line, similarity = 99% to 99.7%)
	Not applicable (random/white noise)

Waveform analytics

Waveform Analytics enables you to classify the triggered segments up to 12 clusters. You can quickly identify the specific waveform pattern or anomaly with visual readings. This feature can be used in waveform playback to accelerate the analysis.

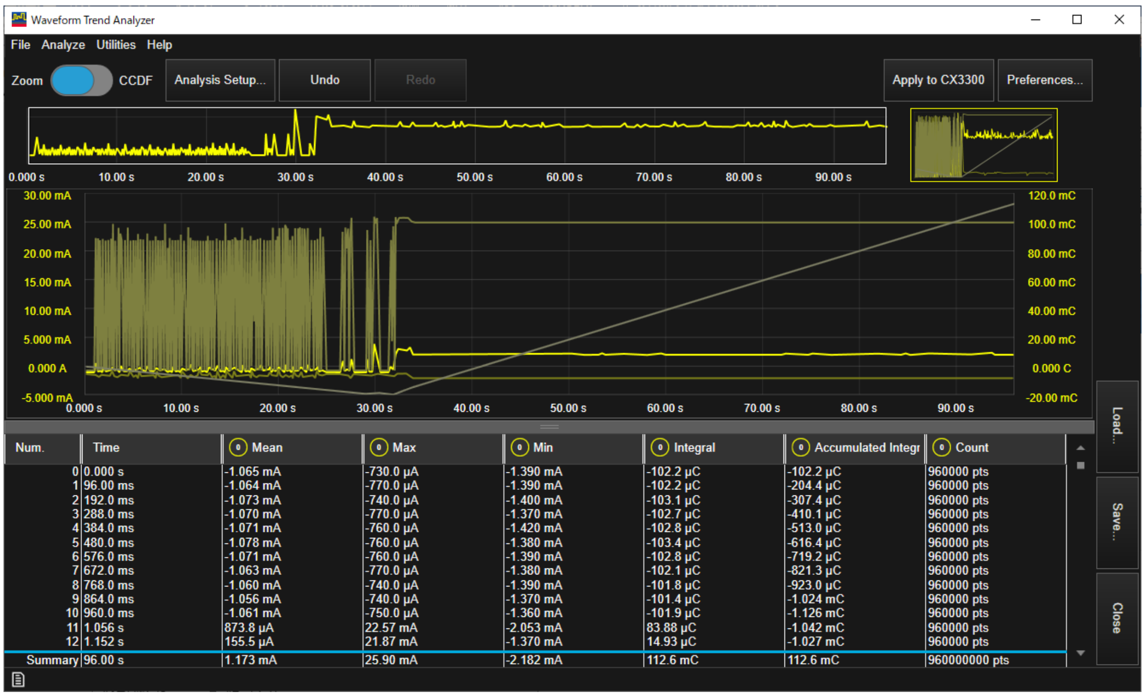


Retriggering

Retriggering allows you to change the trigger condition to perform the triggered segmentation on the existing waveform database offline without performing the measurement. It takes the same time as when measuring because it replays the entire waveform with a different trigger setting.

Waveform trend analyzer

The waveform trend analyzer provides an analytics approach for long-duration measurement data. It visualizes the trend of statistical parameters (min, max, average, and charge) of each segment for the entire waveform via a trend chart and list. It supports a CCDF chart (histogram, PDF, CDF, CCDF). The waveform trend analyzer allows you to estimate the area to view and load for an in-depth analysis.



Data File Functions (Scope Mode and Data Logger Mode)

File Type			Save	Load
Scope mode	Composite (including all setup and result)		Yes [1]	Yes
	Waveform	Waveform	Yes [1]	Yes
		HDF5	Yes [1]	Yes
		CSV, TSV	Yes [1]	
	Setup		Yes	Yes
	Report	Report	Yes	
		CSV, TSV, text	Yes	
	Screen capture	JPG, BMP, PNG	Yes	
Data logger mode [2]	Waveform Database	Waveform database [3]	Yes	Yes
		CSV, TSV	Yes	
	Composite		Yes [1]	
	Waveform	Waveform	Yes [1]	
		HDF5	Yes [1]	
		CSV, TSV	Yes [1]	
	Setup		Yes	
	Report	Report	Yes	
		CSV, TSV, Text	Yes	
	Screen capture	JPG, BMP, PNG	Yes	
Power and current profiler	Composite			Yes
	Waveform	Waveform		Yes
		HDF5		Yes
	Profiler	Profiler	Yes	Yes
Waveform trend analyzer	Waveform database	Waveform database		Yes
		CSV, TSV	Yes	

1. Autosave function enables you to save the file per measurement.
2. Store long-duration measurement data in the waveform database. Data size in the memory depth (max. 256 Mpts) displays on the screen. Only the waveform database stores the entire waveform measurement data of the data logger mode.
3. Data logger measurement automatically creates the database. Waveform data can be extracted with a specified duration and saved as a new database.

CX3300APPC Current Waveform Analytics Software

CX3300APPC current waveform analytics software provides the same analysis capabilities as the CX3300 series firmware except for the measurement execution. A software license is required, and a trial version is available at www.keysight.com.

Recommended System Requirements

Computer system and peripherals	Operating system	Windows 10 64-bit or Windows 11 64-bit
	Processor	Greater than or equal to 3 GHz
	Memory	Greater than or equal to 8 GB
	Disk space	Greater than or equal to 20 GB
	Graphics card	DirectX 11 or later
	Display resolution	Greater than or equal to 1280 x 800 (WXGA)

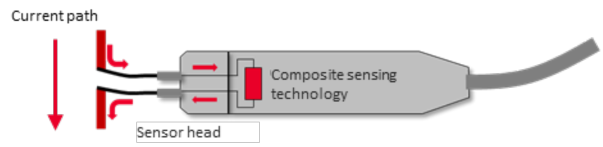
Minimum System Requirements

Computer system and peripherals	Operating system	Windows 10 64-bit or Windows 11 64-bit
	Processor	1 GHz
	Memory	4 GB
	Disk space	10 GB
	Graphics card	DirectX 11
	Display resolution	1280 x 800 (WXGA)

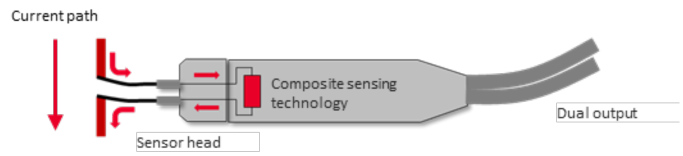
CX3300A Current and Voltage Sensors

Overview

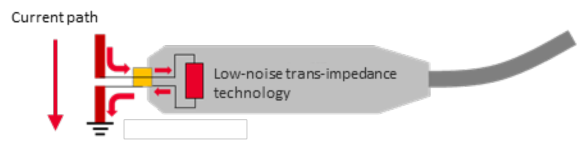
CX1101A
Single-channel
current sensor



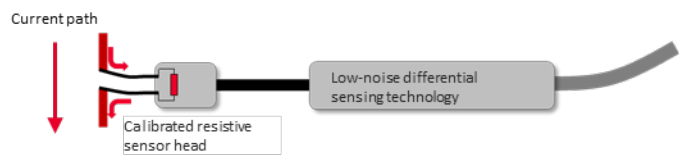
CX1102A
Dual-channel
current sensor



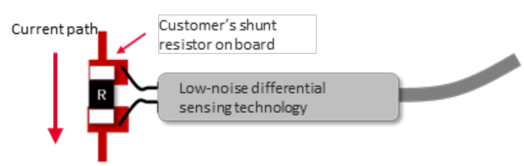
CX1103A



CX1104A
Selectable shunt
current sensor



CX1105A
Ultra-low noise
differential sensor



CX1151A
Passive probe
adapter

Product Description	CX1101A Single-Channel Current Sensor	CX1102A Dual-Channel Current Sensor	CX1103A Low-Side Current Sensor	CX1104A Selectable Shunt Current Sensor	CX1105A Ultra-Low Noise Differential Sensor	CX1151A Passive Probe Interface Adapter
Measurement	**Current**	**Current**	**Current**	**Current**	**Current / Voltage**	**Voltage**
Maximum standalone bandwidth	100 MHz	100 MHz	200 MHz	20 MHz	100 MHz	300 MHz
Effective bandwidth [1]	< 90 MHz	< 90 MHz	< 140 MHz	< 20 MHz	< 90 MHz	< 165 MHz
Maximum measurable current or voltage	1 A (10 A)	1 A	20 mA	15 A	100 A (realistic max.)	8 V (1:1 probe)
RMS noise [1]	40 nA [2]	40 nA [2]	150 pA [2]	22 µA [2]	20 µV [2]	90 µV [3]
Dynamic range	Over 80 dB	Over 100 dB	Over 80 dB	Over 80 dB	Over 80 dB	Over 80 dB
Typical insertion resistance	410 mΩ (50 Ω)	410 mΩ (50 Ω)	4 Ω (50 Ω)	5.5 mΩ to 1 Ω [4]	N/A [5]	N/A
Maximum common mode voltage	±40 V	±12 V	±0.5 V	±40 V	±40 V or ±6 V	±8V (1:1 probe)
Required number of channels	1	2	1	1	1	1
Measurement side (High/Low)	High or low	High or low	Low	High or low	High or low	High

1. With 200 MHz mainframe bandwidth.
2. At 20 MHz noise bandwidth (NBW).
3. At 200 MHz NBW.
4. 6 selectable shunts
5. Customer’s shunt.

CX1101A Single-Channel Current Sensor Characteristics

CX1101A Current Measurement Characteristics Overview [1]

Range	R_{IN} [2]	Noise (rms) at 20 MHz NBW	Maximum Bandwidth (-3 dB)
10 A	15 mΩ (typical)	10 mA	3 MHz [3]
1 A	410 mΩ (typical) 550 mΩ (max)	2 mA	100 MHz
200 mA		0.2 mA	100 MHz
20 mA		20 µA	100 MHz
2 mA		3 µA	100 MHz
200 µA	50 Ω (typical) 77 Ω (max)	500 nA [5]	500 kHz [5]
		400 nA [4]	25 kHz
20 µA		150 nA [5]	500 kHz [5]
		40 nA [4]	25 kHz

1. CX1206A is used for 10A range and CX1203A is used for all other ranges.
2. CX1203A slide switch set to "0 Ω".
3. Bandwidth at -4 dB.
4. Sensor built-in low pass filter is set to "on."
5. CX1101A's firmware version must be 2.0 or later to enable these ranges.

CX1101A DC Measurement Accuracy [1]

Range	Standalone	With Mainframe	
	23 ± 5 °C	23 ± 5 °C	$T_{USERCAL}$ ± 3 °C, 24 hrs. [2]
10 A	± (5% + 5%)	± (5.7% + 5.9%)	N/A
1 A	± (2% + 2%)**	± (2.7% + 2.9%) **	± (1.8% + 0.4%)
200 mA	± (2% + 2%)**	± (2.7% + 2.9%) **	± (0.7% + 0.4%)
20 mA	± (2% + 2%)**	± (2.7% + 2.9%) **	± (0.6% + 0.3%)
2 mA	± (2% + N/A)**	± (2.7% + N/A) **	± (0.7% + 1.1%)
200 µA	± (2% + 2%)**	± (2.7% + 2.9%) **	± (0.7% + 0.3%)
20 µA	± (2% + N/A)**	± (2.7% + N/A) **	± (0.7% + 1.1%)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at V_{CM} = 0 V (zero common-mode input voltage at either $+I_{IN}$ or $-I_{IN}$). Add 0.7% typical to offset error for V_{CM} up to 40 V. The reading is defined as the measured value. DC measurement condition at 20 ms averaging.
2. After executing the user calibration with the mainframe.

CX1101A Additional Characteristics

Additional Characteristics		
Input common-mode impedance [1]		750 MΩ // 31 pF (nominal)
Measurable over range		10% of range
Burden voltage		R_{IN} x measured current
Maximum input voltage (common mode) [2]	Peak voltage (DC + AC) limit	±40 V
	AC voltage limit	±5 V above 1 MHz
Absolute maximum input current [4]	10 A range	11 A
	2 mA to 1 A ranges	1.5 A[3]
	20µ and 200 µA ranges	A

1. Measured with a CX1201A. Both inputs have the same input impedance. When using a CX1203A sensor head, the minus terminal is internally connected to the circuit common through a 10 MΩ resistor.
2. For all current measurement ranges.
3. 125mA when using CX1203A with 50 Ω setting.
4. See CX1100 User's Guide (CX1100-90000) for more information.

CX1101A General Information [1]

General Information	
Cable length	Sensor cable: 1.5 m, GND lead: 16 cm
Dimension [2]	46.8 mm (W), 31.9 mm (H), 205.3 mm (D)
Weight	400 g
Accessories included	1 each coaxial termination adapter sensor head (CX1203A)
	1 each coaxial cable, SMA plug to open, 100 mm (8121-2773) [3]
	1 each coaxial cable, SMA plug to MHF plug, 100 mm (8121-2774) [3]
	1 each MHF pulling tool (8710-2791) [3]
	5 each coaxial cable, MHF plug, shorted, 21 mm (8121-2780) [3]
	5 each RF connector, MHF jack straight SMT (1250-3656) [3]
	1 each SMA(P) to BNC(J) 50 Ω coaxial adapter (1250-3975)
	1 each GND lead (C1101-61711)

1. Refer to mainframe's "Environmental and General" for additional information.
2. Includes CX1203A sensor head; does not include cable and adapter.
3. Included in CX1203A sensor head.

CX1102A Dual-Channel Current Sensor Characteristics

CX1102A Current Measurement Characteristics Overview [1]

Range		R_{IN} [2]	Noise (rms) at 20 MHz NBW		Maximum Bandwidth (-3 dB)
Primary Channel	**Secondary Channel**	**Secondary Channel**	**Primary Channel**	**Secondary Channel**	
1 A	20 mA	410 mΩ (typical) 550 mΩ (max.)	2 mA	20 µA	100 MHz
200 mA	2 mA		0.2 mA	3 µA	
20 mA	200 µA	50 Ω (typical) 77 Ω (max.)	20 µA	500 nA	500 kHz
			8 µA [3]	400 nA [3]	90 kHz [3]
2 mA	20 µA		2 µA	200 nA	500 kHz
			1 µA [3]	40 nA [3]	25 kHz [3]

1. CX1203A sensor head is used to measure the characteristics.
2. CX1203A slide switch set to 0 Ω.
3. Sensor built-in low pass filter set to "on."

CX1102A DC Measurement Accuracy [1]

Range		Standalone	With Mainframe	
Primary/secondary	**Range**	**23 ± 5 ºC**	**23 ± 5 ºC**	**$T_{USERCAL}$ ±3 ºC, 24 hrs.** [2]
Primary	1 A	± (2% + 2%) **	± (2.7% + 2.9%) **	± (1.8% + 0.4%)
	200 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
	20 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.3%)
	2 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.7% + 0.3%)
Secondary	20 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
	2 mA	± (2% + N/A) **	± (2.7% + N/A) **	± (0.6% + 0.9%)
	200 µA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
	20 µA	± (2% + N/A) **	± (2.7% + N/A) **	± (0.7% + 0.9%)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common mode input voltage at either +IIN or -IIN). Add 0.9% typical to offset error for VCM up to 12 V. The reading is defined as the measured value. DC measurement condition at 20 ms averaging.
2. After executing the user calibration with the mainframe.

CX1102A Additional Characteristics

Additional Characteristics			
Input common-mode impedance [1]			750 MΩ // 18 pF (nominal)
Measurable over range			10% of range
Burden voltage			R_{IN} x measured current
Maximum input voltage (common mode) [2]	Peak voltage (DC + AC) limit		±12 V
Absolute maximum input current [4]	Primary	200 mA and 1 A ranges	1.5 A[3]
	Secondary	2 mA and 20 m A ranges	
	Primary	2 mA and 20 m A ranges	50 mA
	Secondary	2 mA and 20 m A ranges	

1. Measured with a CX1201A.
2. For all current measurement ranges.
3. 125 mA when using CX1203A with 50 Ω setting.
4. See "CX1100 User's Guide" (CX1100-90000) for more information

CX1102A General Information [1]

General Information	
Cable length	Sensor cable: 1.5 m, GND lead: 16 cm
Dimension [2]	46.8 mm (W), 31.9 mm (H), 215.3 mm (D)
Weight	600 g
Accessories included	1 each coaxial termination adapter sensor head (CX1203A)
	1 each coaxial cable, SMA plug to open, 100 mm (8121-2773) [3]
	1 each coaxial cable, SMA plug to MHF plug, 100 mm (8121-2774) [3]
	1 each MHF pulling tool (8710-2791) [3]
	5 each coaxial cable, MHF plug, shorted, 21 mm (8121-2780) [3]
	5 each RF connector, MHF jack straight SMT (1250-3656) [3]
	1 each SMA(P) to BNC(J) 50 Ω coaxial adapter (1250-3975)
	1 each GND lead (C1101-61711)

1. Refer to mainframe's "Environmental and General" for additional information.
2. Includes CX1203A sensor head. Does not include cable and adapter.
3. Included in CX1203A sensor head.

CX1103A Low-Side Current Sensor Characteristics

CX1103A Current Measurement Characteristics Overview

Range	R_{IN}	Noise (rms) at 20 MHz NBW	Maximum Bandwidth (-3 dB)
20 mA	50 Ω typical, 55 Ω max. (50 Ω input “on”) 4 Ω typical, 6 Ω max. (50 Ω input “off”)	5 µA	200 MHz
2 mA		1.5 µA	75 MHz
200 µA		150 nA	9 MHz
20 µA		25 nA	2.5 MHz
2 µA		1.5 nA	250 kHz
200 nA		150 pA	100 kHz

CX1103A DC Measurement Accuracy [1]

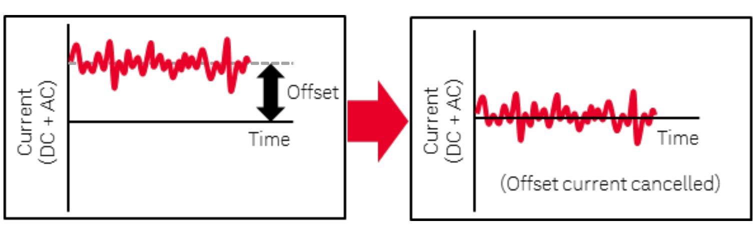
Range	Standalone	With Mainframe	
	23 ± 5 °C	23 ± 5 °C	$T_{USERCAL}$ ± 3 °C, 24 hrs. [2]
20 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.3%)
2 mA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
200 µA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
20 µA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (0.6% + 0.4%)
2 µA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (1.3% + 0.4%)
200 nA	± (2% + 2%) **	± (2.7% + 2.9%) **	± (1.3% + 0.3%)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common-mode input voltage at either +IIN or -IIN). The “reading” is defined as the measured value. DC measurement condition at 20 ms averaging.
2. After executing the user calibration with the mainframe.

CX1103A DC Offset Cancel

The CX1103A can cancel DC offset current and extract the necessary dynamic current. This feature is useful to measure low-level dynamic sensor current signals on large DC current.

Range	DC Offset Range and Resolution
20 mA	±20 mA, 0.8 µA resolution
2 mA	
200 µA	±200 µA, 8 nA resolution
20 µA	
2 µA	±2 µA, 80 pA resolution
200 nA	



CX1103A Additional Characteristics

Additional Characteristics

Measurable over range		10% of range
Burden voltage		R_{IN} x measured current
Maximum input voltage (common mode) [1]	Input 50 Ω off	±0.5 V
	Input 50 Ω on	±1.0 V
Absolute maximum input current [2]		125 mA

1. For all current measurement ranges.
2. See "CX1100 User's Guide" (CX1100-90000) for more information.

CX1103A General Information [1]

General Information

Cable length	Sensor cable: 1.5 m, GND lead: 16 cm
Dimension	45.8 mm (W), 28.1 mm (H), 163.1 mm (D)
Weight	300 g
Accessories included	1 each SMA(P) to BNC(J) 50 Ω coaxial adapter (1250-3975)
	1 each GND lead (C1101-61711)

1. Refer to mainframe's "Environmental and General" for additional information.

CX1104A Selectable Shunt Current Sensor Characteristics

CX1104A Current Measurement Characteristics Overview [1]

Resistive Sensor Head	Range (Upper/Lower)	Typical R_{IN} [2]	Noise (rms) at 20 MHz NBW	Noise (rms) at 2.5 kHz NBW [3]	Maximum Bandwidth (−3 dB)
CX1211A	15 A	5.5 mΩ	48 mA	1.6 mA	20 MHz
	10 A		8.8 mA	160 µA	
CX1212A	10 A	8.0 mΩ	24 mA	800 µA	
	5 A		4.4 mA	80 µA	
CX1213A	5 A	23 mΩ	6 mA	200 µA	
	1.25 A		1.1 mA	20 µA	
CX1214A	3 A	53 mΩ	2.4 mA	80 µA	
	500 mA		440 µA	8 µA	
CX1215A	2 A	103 mΩ	1.2 mA	40 µA	
	250 mA		220 µA	4.0 µA	
CX1216A	250 mA	1.0 Ω	120 µA	4 µA	
	25 mA		22 µA	400 nA	

1. CX1104A measures the current using the CX1210A series calibrated resistive sensor head. Refer to the CX1210A series resistive sensor head section for additional details.
2. RIN includes both current sensing resistance and parasitic resistance in the sensor head; the sensing resistance is calibrated.
3. High-resolution mode (16-bit) is enabled.

CX1104A DC Current Measurement Accuracy [1,2]

Range		Standalone	With Mainframe	
Primary/Secondary	Range	23 ± 5 °C	23 ± 5 °C	TUSERCAL ± 3 °C, 24 hrs. [3,4]
CX1211A	15 A	± (3.3 % + 1.0 %) **	± (4.0 % + 7.1 %) **	± (4.0 % + 2.0 %)
	10 A	± (3.5 % + 0.2 %) **	± (4.2 % + 1.1 %) **	± (4.2 % + 0.3 %)
CX1212A	10 A	± (3.3 % + 0.8 %) **	± (4.0 % + 5.3 %) **	± (4.0 % + 1.5 %)
	5 A	± (3.5 % + 0.2 %) **	± (4.2 % + 1.1 %) **	± (4.2 % + 0.3 %)
CX1213A	5 A	± (1.9 % + 0.4 %) **	± (2.6 % + 2.7 %) **	± (2.6 % + 0.8 %)
	1.25 A	± (2.1 % + 0.2 %) **	± (2.8 % + 1.1 %) **	± (2.8 % + 0.3 %)
CX1214A	3 A	± (1.0 % + 0.3 %) **	± (1.7 % + 1.8 %) **	± (1.7 % + 0.5 %)
	500 mA	± (1.3 % + 0.2 %) **	± (2.0 % + 1.1 %) **	± (2.0 % + 0.3 %)
CX1215A	2 A	± (1.6 % + 0.2 %) **	± (2.3 % + 1.3 %) **	± (2.3 % + 0.4 %)
	250 mA	± (1.8 % + 0.2 %) **	± (2.5 % + 1.1 %) **	± (2.5 % + 0.3 %)
CX1216A	250 mA	± (1.5 % + 0.2 %) **	± (2.2 % + 1.1 %) **	± (2.2 % + 0.3 %)
	25 mA	± (1.7 % + 0.2 %) **	± (2.4 % + 1.1 %) **	± (2.4 % + 0.3 %)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common-mode input voltage at either +IIN or -IIN). Reading is defined as a measured value. DC measurement condition at 20 ms averaging.
2. Current measurement accuracy is a combination of the voltage measurement accuracy and the accuracy of CX1104A and CX1210A series resistive sensor head. Calculation for the current measurement accuracy in the table is:
3. Gain error% = CX1104A gain error + CX1210A series resistor value accuracy
4. Offset error%= (DC voltage measurement range [V] x offset error%) / CX1210A series nominal sensor resistor value
5. After executing the user calibration with the mainframe. High-resolution mode is enabled.
6. Gain error is only characterized under the temperature range 23 ± 5 °C.

CX1104A DC Voltage Measurement Accuracy [1,2]

Range	Standalone	With Mainframe	
	23 ± 5 °C	23 ± 5 °C	TUSERCAL ± 3 °C, 24 hrs. [3]
250 mV (Upper range)	± (0.58 % + 0.15 %) **	± (1.28 % + 1.05%) **	± (NA + 0.3 %)
25 mV (Lower range)	± (0.84 % + 0.15 %) **	± (1.54 % + 1.05 %) **	± (NA + 0.3 %)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common-mode input voltage at either +IIN or -IIN). Reading is defined as a measured value. DC measurement condition at 20 ms averaging.
2. CX1104A alone is a voltage sensor and has a voltage measurement accuracy specification tabulated above.
3. After executing the user calibration with the mainframe. High-resolution mode is enabled.

CX1104A Additional Characteristics

Additional Characteristics		
Input common-mode impedance		20 MΩ // 32 pF (Nominal)
Maximum input voltage (common mode)	DC peak	±40 V
	DC to 0.4 Hz	Linear change
	0.4 Hz to 100 MHz	±6 V
Common mode rejection ratio (CMRR)	1 kHz	110 dB
	1 MHz	50 dB

1. See “CX1100 User’s Guide” (CX1100-900000) for additional information.
2. Time to settle to within 10% of range full scale when driven by square pulse input having an amplitude of Vmax_ND (± 280 mV for upper range; ± 75 mV for lower range).

CX1104A General Information [1]

General Information	
Cable length	Sensor cable: 1.5 m, GND lead: 16 cm, USB cable: 15 cm
Dimension [2]	30.0 mm (W), 20.5 mm (H), 205.2 mm (D)
Weight	300 g
Accessories included	1 each USB type-C cable (C1104-61701)
	1 each banana adapter (C1210-60001)
	1 each ground lead (C1101-61711)

1. Refer to mainframe’s “Environmental and General” for additional information.
2. Does not include cable and adapter.

CX1105A Ultra-Low Noise Differential Sensor Characteristics

CX1105A Current Measurement Characteristics Overview [1]

Range	Noise (rms) at 20 MHz NBW	Noise (rms) at 2.5 kHz NBW[1]	Maximum Bandwidth (-3 dB)
2.5 V	1100 µV	200 µV	100 MHz
1 V	1100 µV	200 µV	
250 mV	45 µV	3.0 µV	
100 mV	24 µV	1.3 µV	
25 mV	20 µV	400 nV	

1. High-resolution mode (16-bit) is enabled.

CX1105A DC Measurement Accuracy [1]

Range[2]	Standalone	With Mainframe	
	23 ± 5 ºC	**23 ± 5 ºC**	**$T_{USERCAL}$ ± 3 ºC, 24 hrs.** [3]
2.5 V	± (0.8 % + 1.0 %) **	± (1.5 % + 2.2 %) **	± (1.5 % + 0.6 %)
1 V	± (0.8 % + 2.1 %) **	± (1.5 % + 3.3 %) **	± (1.5 % + 0.8 %)
250 mV, 100 mV, and 25 mV	± (0.7 % + 0.2 %) **	± (1.4 % + 1.1 %) **	± (1.4 % + 0.3 %)

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common-mode input voltage at either +IIN or -IIN). Reading is defined as the measured value. DC measurement condition at 20 ms averaging.
2. 25 V and 1 V range at VCM (common-mode input voltage at either input of +Vin or -Vin); add 0.2% to offset error at VCM up to 40 V.
3. After executing the user calibration with the mainframe. High-resolution mode is enabled.

CX1105A Input Impedance

Range	Input Impedance at 23 ± 5 ºC	
	Common	**Differential**
2.5 V and 1 V	2 MΩ//9.5 pF	3.9 MΩ//4.8 pF
250 mV, 100 mV and 25 mV	21 MΩ//24 pF (+IN) 21 MΩ//27 pF (-IN)	42 MΩ//16 pF

CX1105A Input Voltage

Range	Maximum Input Voltage (Differential Mode)	Maximum Input Voltage (Common Mode)		
		DC Peak	**DC to 3 Hz**	**3 Hz to 100 MHz**
2.5 V and 1 V	±40 V	±40 V	Linear change	±5 V
250 mV, 100 mV, 25 mV	+4 V/−1.8 V	±6 V	Linear change	±0.5 V

CX1105A Additional Characteristics

Additional Characteristics	
CMRR at 1 MHz	60 dB
Input coupling	DC, AC (550 Hz)

CX1105A General Information [1]

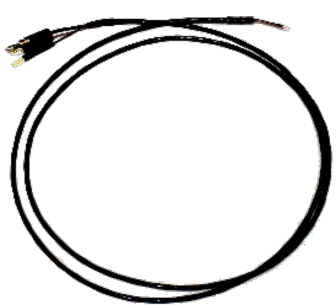
General Information

Cable length	Sensor cable: 1.5 m, GND lead: 16 cm
Dimension [2]	30.0 mm (W), 20.5 mm (H), 203.4 mm (D)
Weight	300 g
Accessories included	1 each test lead (5959-9334, quantity of 5 leads)
	1 each twisted pair cable soldering model (100 mm, C1105-61702)
	1 each twisted pair cable socket model (100 mm, C1105-61701)
	1 each test adapter (C1105-66602)
	1 each adjustment tool (8710-2831)
	1 each tool grabber clip (1400-3652)
	1 each grabber mini (1400-1422, quantity of 2)
	1 each ground lead (C1101-61711)

1. Refer to mainframe's "Environmental and General" for additional information.
2. Does not include cable and adapter.

CX1105A Optional Accessories

- 1 m shielded twisted pair for temperature test from -50 ℃ to +150 ℃.



CX1151A Passive Probe Interface Adapter Characteristics

CX1151A Characteristics Overview [1]

Range	Noise (rms)[1]	DC Offset Range and Resolution	Maximum Bandwidth (-3 dB)[2]
8 V	5 mV	±16 V, 16-bit resolution	300 MHz
4 V	2.8 mV		
1.6 V	1.8 mV		
400 mV	250 µV	±0.8 V, 16-bit resolution	
200 mV	140 µV		
80 mV	90 µV		

1. Full bandwidth measured with mainframe (Option B20: 200 MHz bandwidth)
2. Maximum bandwidth of CX1151A standalone. The following equation estimates the effective bandwidth when connected to mainframe and passive probe:

$$BW_{effective} = \frac{1}{\sqrt{\left(\frac{1}{BW_{adaptor}}\right)^2 + \left(\frac{1}{BW_{probe}}\right)^2 + \left(\frac{1}{BW_{mainframe}}\right)^2}}$$

CX1151A DC Measurement Accuracy [1]

Range	Standalone	With Mainframe		
	23 ± 5 °C	23 ± 5 °C	$T_{USERCAL}$ ± 3 °C, 24 hrs.[2] (14-bit ADC)	$T_{USERCAL}$ ± 3 °C, 24 hrs.[2] (16-bit ADC)
8 V	± (0.6% + 0.8%) **	± (1.3% + 1.7%) **	± (0.4% + 0.6%)	± (0.3% + 0.4%)
4 V	± (0.6% + 0.8%) **	± (1.3% + 1.7%) **	± (0.8% + 0.6%)	± (0.5% + 0.4%)
1.6 V	± (0.6% + 0.8%) **	± (1.3% + 1.7%) **	± (0.8% + 0.6%)	± (0.5% + 0.4%)
400 mV	± (0.6% + 0.8%) **	± (1.3% + 1.7%) **	± (0.4% + 0.6%)	± (0.3% + 0.4%)
200 mV	± (0.6% + 0.8%) **	± (1.3% + 1.7%) **	± (0.8% + 0.6%)	± (0.5% + 0.4%)
80 mV	± (0.9% + 1.2%) **	± (1.6% + 2.1%) **	± (0.8% + 0.6%)	± (0.5% + 0.4%)

1. Accuracy is defined as gain [% of readings] + offset [% of range]. Reading" is defined as the measured value. DC measurement condition at 20 ms averaging.
2. After executing the user calibration with the mainframe.

CX1151A DC Measurement Accuracy with 10:1 Passive Probe[1,2]

Range	$T_{USERCAL}$ ± 3 °C, 24 hrs.[3] (14-bit ADC)	$T_{USERCAL}$ ± 3 °C, 24 hrs.[3] (16-bit ADC)
80 V	± (2.1% + 0.6%)	± (1.1% + 0.4%)
40 V	± (1.5% + 0.6%)	± (0.8% + 0.4%)
16 V	± (0.7% + 0.6%)	± (0.4% + 0.4%)
4 V	± (1.7% + 0.6%)	± (0.9% + 0.4%)
2 V	± (1.2% + 0.6%)	± (0.7% + 0.4%)
800 mV	± (0.4% + 0.6%)	± (0.3% + 0.4%)

1. Accuracy is defined as gain [% of readings] + offset [% of range]. Reading" is defined as the measured value. DC measurement condition at 20 ms averaging.
2. N2843A passive probe is used.
3. After executing the user calibration with the mainframe.

CX1151A Additional Characteristics

Additional Characteristics	
Input impedance	1 MΩ ±0.1%, 13 pF
Input coupling	DC, AC (3.5 Hz)
Maximum input voltage	±100 V peak (DC + AC)

CX1151A General Information [1]

General Information

Dimension	58.6 mm (W), 30.2 mm (H), 87.5 mm (D)	
Weight	130 g	
Recommended passive probe [1]	10:1	N2843A
Supported passive probe	1:1	10070D, N2870A
	10:1	10073D, 10074D, N2862B, N2863B, N2871A, 2872A, N2873A, N2890A, N2894A, N2853A, N2843A, 2842A, N2841A, N2840A
	20:1	N2875A
	100:1	10076C

1. N2843A is used to measure the characteristics shown above.
2. Mainframe detects the supported probe's ratio.

CX3300A Sensors Heads

CX1200A Series Sensor Heads for CX1101A And CX1102A [1]

CX1201A sensor head; coaxial through

CX1201A has two SMA connectors for connecting ammeter + and – terminals to a source instrument and DUT. Maximum current: 1 A. Input: SMA jack connectors.

CX1202A sensor head; coaxial through with V monitor

CX1202A has two SMA connectors for connecting ammeter + and – terminals to a source instrument and DUT. Also has an SMA connector for monitoring voltage. Maximum current: 1 A. Input: SMA jack connectors.

CX1203A sensor head; coaxial termination

CX1203A has an SMA connector for connecting ammeter + and – terminals to DUT. Also has a built-in series resistor, 50 Ω. Maximum current: 1 A with 0 Ω, 70 mA with 50 Ω series resistor. Input: SMA jack connector (center: +, outer: –).

CX1204A sensor head; twisted pair adapter

CX1204A is a sensor head with extension cables (shielded, twisted pair, 100 mm, or 300 mm) for soldering the DUT. Maximum current: 1 A.

CX1205A sensor head; test lead adapter

CX1205A has two minijack terminals for connecting ammeter + and – terminals to DUT. Maximum current: 1 A. Input: Minijack terminals.

CX1206A sensor head; test lead adapter (for CX1101A only)

CX1206A expands the maximum measurement current of CX1101A up to 10 A. It has two banana jack terminals for connecting ammeter + and – terminals to DUT. Maximum current: 10 A. Input: Banana jack terminals.

1. See "CX1100 User's Guide" (CX1100-90000) for more information.

CX1210A series sensor heads for CX1104A

CX1211A resistive sensor head (15 A, 5.5 mΩ)

CX1212A resistive sensor head (10 A, 8 mΩ)

CX1213A resistive sensor head (5 A, 23 mΩ)

CX1214A resistive sensor head (3 A, 53 mΩ)

CX1215A resistive sensor head (2 A, 103 mΩ)

CX1216A resistive sensor head (0.25 A, 1 Ω)

CX1210A Series Maximum Current

Resistive Sensor Head	Maximum Current (DC/RMS)	Maximum Current (Peak Current)	Typical R_{IN}
CX1211A	15 A **	15 A **	5.5 mΩ
CX1212A	10 A **	15 A **	8 mΩ
CX1213A	5 A **	10 A **	23 mΩ
CX1214A	3 A **	5 A **	53 mΩ
CX1215A	2 A **	2.5 A **	103 mΩ
CX1216A	0.25 A **	0.25 A **	1 Ω

CX1210A Series Resistor Accuracy [1]

Resistive Sensor Head	Nominal Sense Resistor Value	Standalone Accuracy at 23 ± 5 °C		
		Accuracy Within I_{SPEC}	I_{SPEC}	Full-Scale Accuracy
CX1211A	2.5 mΩ	± 2.7 % **	10 A [2]	± 3.3 %
CX1212A	5 mΩ	± 2.7 % **	10 A [2]	± 2.9 %
CX1213A	20 mΩ	± 1.3 % **	1.5 A	± 1.4 %
CX1214A	50 mΩ	± 0.5 % **	1.5 A	± 0.5 %
CX1215A	100 mΩ	± 1.0 %**	1.0 A	± 1.0 %
CX1216A	1 Ω	± 0.9 % **	0.25 A	± 0.9 %

1. Accuracy is defined as gain [% of readings] + offset [% of range] at VCM = 0 V (zero common-mode input voltage at either +IIN or -IIN). The reading is defined as a measured value. DC measurement condition at 20 ms averaging.
2. Specified by pulsed measurement: pulse width = 1 ms, duty = 0.1 %

CX1210A Series General Information [1]

General Information

Dimension	30.0 mm (W), 14.0 mm/21.5 mm (H), 48.7 mm (D)
Weight	20 g
Furnished accessories	1 each wire set (red and black, C1104-68001, quantity of 5)

1. Refer to mainframe's "Environmental and General" for additional information.

CX1152A Digital Channel Interface (For CX3324A Only)

General Information [1]

General Information

Cable length	Digital channel cable: 1.15 m, probe lead: 28.5 cm
Dimension [2]	68.1 mm (W), 18.5 mm (H), 103.0 mm (D)
Weight	130 g
Furnished accessories	5 probe ground leads (5959-9334)
	10 grabbers (5090-4832)
	1 each BNC-probe tip adapter (C1152-60001)

1. Refer to "CX3300A mainframe - digital channel characteristics" for characteristics.
2. Doesn't include pod leads and cables.

Ordering Information

Mainframe

Category		Model Number	Description
CX3322A	Mainframe	CX3322A	Device current waveform analyzer, 1 GSa/s, 14/16-bit, 2 Channel
	Bandwidth option	CX3322A-B05	Bandwidth – 50 MHz
		CX3322A-B10	Bandwidth – 100 MHz
		CX3322A-B20	Bandwidth – 200 MHz
	Memory size	CX3322A-004	Memory – 4 Mpts/ch
		CX3322A-016	Memory – 16 Mpts/ch
		CX3322A-064	Memory – 64 Mpts/ch
		CX3322A-256	Memory – 256 Mpts/ch
	Data logger mode	CX3322A-STG	Data logger mode option
	Calibration	CX3322A-A6J	ANZI Z540-1-1994 calibration
		CX3322A-UK6	Commercial calibration certificate with test data
	Peripherals	CX3300A-KBD	Mini keyboard and optical mouse
CX3324A	Mainframe	CX3324A	Device current waveform analyzer, 1 GSa/s, 14/16-bit, 4 Channel
	Bandwidth option	CX3324A-B05	Bandwidth – 50 MHz
		CX3324A-B10	Bandwidth – 100 MHz
		CX3324A-B20	Bandwidth – 200 MHz
	Memory size	CX3324A-004	Memory – 4 Mpts/ch
		CX3324A-016	Memory – 16 Mpts/ch
		CX3324A-064	Memory – 64 Mpts/ch
		CX3324A-256	Memory – 256 Mpts/ch
	Data logger mode	CX3324A-STG	Data logger mode option
	Calibration	CX3324A-A6J	ANZI Z540-1-1994 calibration
		CX3324A-UK6	Commercial calibration certificate with test data
	Peripherals	CX3300A-KBD	Mini keyboard and optical mouse

Sensor and Accessories

Category		Model Number	Description
Current sensor	CX1101A	CX1101A	Current sensor, single channel, ±40 V, 100 MHz, 40 nA – 1 A
		CX1101A-A6J	ANZI Z540-1-1994 calibration
		CX1101A-UK6	Commercial calibration certificate with test data
	CX1102A	CX1102A	Current sensor, dual channel, ±12 V, 100 MHz, 40 nA - 1 A
		CX1102A-A6J	ANZI Z540-1-1994 calibration
		CX1102A-UK6	Commercial calibration certificate with test data
	CX1103A	CX1103A	Current sensor, low-side, 200 MHz, 150 pA - 20 mA
		CX1103A-A6J	ANZI Z540-1-1994 calibration
		CX1103A-UK6	Commercial calibration certificate with test data
	CX1104A	CX1104A	Current sensor, selectable resistive sensor head, ±40 V, 20 MHz
		CX1104A-A6J	ANZI Z540-1-1994 calibration
		CX1104A-UK6	Commercial calibration certificate with test data
Current and voltage sensor	CX1105A	CX1105A	Differential sensor, single channel, 100 MHz
		CX1105A-A6J	ANZI Z540-1-1994 calibration
		CX1105A-UK6	Commercial calibration certificate with test data
Voltage sensor	CX1151A	CX1151A [1]	Passive probe interface adapter
		CX1151A-A6J	ANZI Z540-1-1994 calibration
		CX1151A-UK6	Commercial calibration certificate with test data
Digital channel		CX1152A	Digital channel, 10 input, ±25 V, 8-channels
Accessories		CX1903A	Rackmount kit for CX3300 series
		CX1905B	Attachment for 3D probe positioner

Current Waveform Analytics Software

Category	Model Number	Description
PC software	CX3300APPC	Current waveform analytics software

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