# Keysight Technologies
# TS-8900 Automotive Electronics Functional Test System

Data Sheet


KEYSIGHT
TECHNOLOGIES

# A Functional Test System

– For automotive electronics manufacturing
– Suitable for medium to high pin count automotive electronic control unit (ECU) applications
– That uses industry standard PXI, GPIB and LXI instrumentations

TS-8900 is the latest addition to the widely established TS-Series of end-of-line test system for automotive electronics manufacturing. Designed to reduce your cost of test, the TS-8900 achieves this by providing a higher throughput and higher test coverage while reducing your equipment capital cost. It is ideal for medium to high channel count applications such as:

– Powertrain ECU
– Body and comfort ECU
– Safety ECU

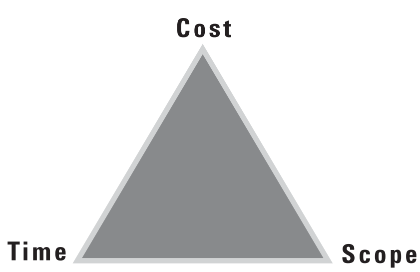
# TS-8900 Platform Overview

The Keysight Technolocies, Inc. TS-8900 provides a cost effective solution to automotive electronics manufacturers who are constantly under pressure to produce quality ECUs at a faster and lower cost than their competition without compromising test coverage.

The TS-8900 is a commercial off-the-shelf PXI-based platform designed specifically for automotive electronics functional test. This provides the benefits of enabling test development engineers to perform faster test development, execution and line integration.

With instruments engineered specifically for automotive applications to meet 3 critical components:

– time to deployment
– flexibility to accommodate a wide scope of ECUs and
– decreasing the total cost of test




The TS-8900 comprises a standard platform with test system of both hardware and software that is easily customized to suit your particular test strategy and range of ECUs.

With over 400 automotive applications-tuned libraries in our software, customers will be able to accelerate their platform test development and deployment up to 3x faster than building test systems from individual components.

The TS-8900 is scalable to meet manufacturers' needs that have requirements to deploy automotive end-of-line test systems that can start small and then scale up as their production capacity needs increase with time, thus keeping cost of tests low.

# TS-8900 Platform Characteristics

## Speed

The TS-8900 is designed specifically for automotive ECUs with medium to high pin count in mind. With high voltage, current and channel count support built in the load, stimulus and instruments of the system, customers are able to adopt new test methodologies like parallel testing cost effectively while increasing throughput. With over 400 automotive applications-tuned libraries in Keysight's TestExec SL 7.0, customers are able to develop & deploy their end-of-line test systems faster.

## Scalability

The TS-8900's modular design empowers customers to design & deploy systems that are scalable from, for example, a single device under test (DUT) functional test system to a four-DUT functional test system that is able to test four DUTs simultaneously. Customers thus have the flexibility of growing their functional test system capacities as the demand grows.

## Accuracy and repeatability

Equipment stability and signal paths used during the test measurement are compensated based on calibrated data (e.g. SENSE input feature). This provides customers accurate loads, stimulus and measurements resulting in repeatable tests. TS-8900 leverages the measurement speed, accuracy, and repeatability strengths of Keysight instruments, creating reliable and high performance automotive electronics functional test systems.

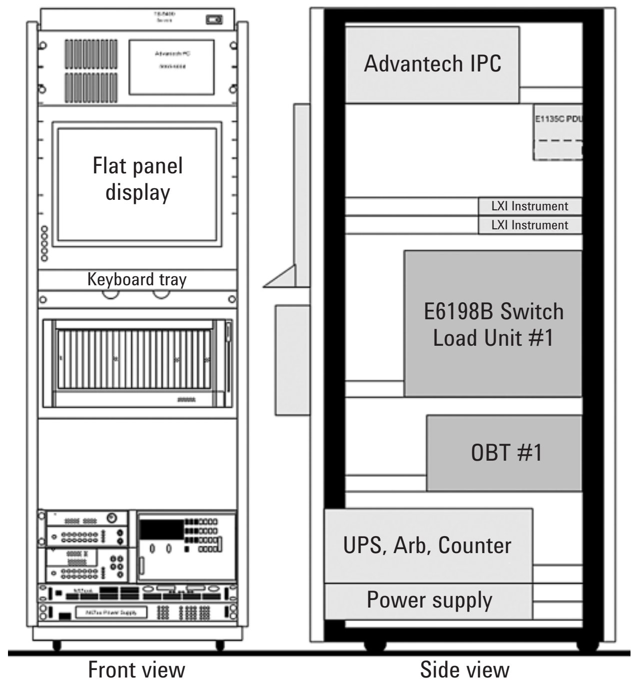
## Global standard and single vendor support

The TS-8900 provides a standard platform with Keysight global support to customers. This is achieved via TS-8900 compliance to various global safety standards and Keysight's global support infrastructure, thus lowering the total cost of test for customers where they can develop once and deploy everywhere.

# TS-8900 Platform Architecture

The TS-8900 comprises seven major sub-systems:

– System controller (software and I/O)
– Serial communication
– Power sources
– Measuring/Stimulus instrumentation (PXI, LXI, GPIB)
– DUT-Specific connections (loads, etc.)
– Signal/Load switching (DC/AC)
– Mass interconnect




## System Controller

The TS-8900 system controller comprises an industrial PC with 3.0 GHz Intel Core2Duo processor and 2 GB RAM with pre-installed Test Exec. 7.0 and Windows XP. With up to 3 PCI slots available, the TS-8900 provides customers with a scalable system controller that is able to able to support up to 1 PCI-based CAN module, a GPIB module and with 1 PCI slot to spare. The TS-5000 family application software comprises of 400 built-in libraries for automotive applications, empowering test engineers to develop test plans in shorter time frames.

Keysight TestExec SL is a test executive designed for high-volume, high throughput functional test application across multiple industries. This robust software empowers test developers with built-in functions that will ultimately reduce development time and improve throughput. These powerful functions encompass:

– A fully customizable operator user interface

– An open architecture for multiple-instrument integration

– A flexible test sequencing

– A set of easy-to-learn debugging tools and provisions for line integration in most manufacturing test environments.

TestExec SL boosts productivity, offers unique advantages for test automation and is unbeaten for ease of use. With its modular architecture, you can use the high-level tools and powerful features to accelerate program development and test integration with TestExec SL.

The Test Exec. 7.0 multithreading feature improves test time throughput via parallel execution of test measurements in the test plan. Figure 1 below reveals a test time reduction of up to 40% for a particular test plan using this feature in comparison to the test plan being executed in serial mode.

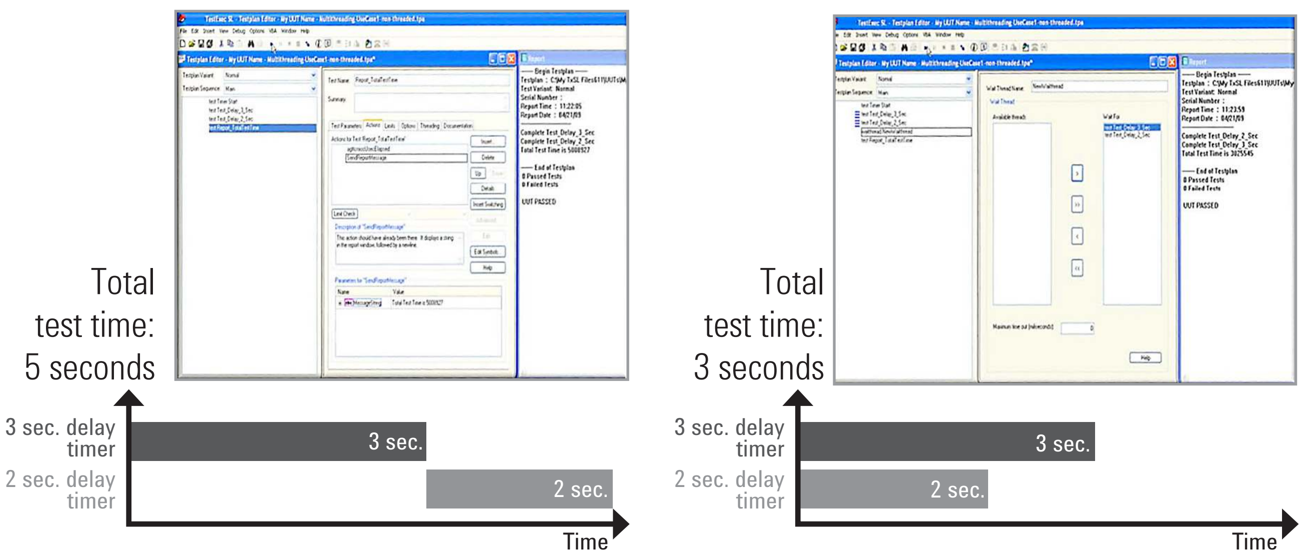



Figure 1. Parallel execution of test measurements with the multi-threading feature in TestExec 7.0 reduces test time by 40% in this illustration.

# TS-8900 Platform Architecture (continued)

## Power Sources

The TS-8900 provides customers with modular power supplies that support up 3300 W. Customers have the following modular power supply options to select:

– N5744A DC System Power Supply, 20 V, 38 A, 760 W

– N5745A DC System Power Supply, 30 V, 25 A, 750 W

– N5764A Power Supply, 20 V, 76 A, 1520 W

– N5765A Power Supply, 30 V, 50 A, 1500 W

– N8734A Power Supply, 20 V, 165 A, 3300 W

– N6702A Low-Profile MPS mainframe, 1200 W

The N5700 series provide users with an easy to integrate, cost-effective and high power density power supplies that starts from a 1U rack space. The N8734A provides up to 3.3 kW in a 2U rack package with flexible AC input voltage options. It supports USB, LAN (LXI C) and GPIB interfaces providing customers with more interface flexibilities.

## Measuring/Stimulus Instrumentation

The TS-8900 stimulus and measurement instruments are categorized in the following:

– PXI-interface instruments (M9186A, M9216A, M9185A)

– LXI-interface instruments (L4532A, L4534A, L4451A)

– GPIB-interface instruments (33521A, 33522A, 53220A)

## PXI-interface instruments

The PXI interface instruments for TS-8900 comprises the following :

– M9186A Isolated Single Channel Voltage/Current Source, 100 V

– M9216A High Voltage Acquisition module, 32-Channel, 250 kS/s, 16-bit, 100 V Input

– M9185A Isolated D/A Converter, 8/16 Channels, 16-bit, 16 V

– M9182A Digital Multimeter, 6½ digit, PXI

– M9183A Digital Multimeter, 6½ digit Enhanced Performance, PXI

– M9187A PXI Digital IO: 32 inputs, 32 outputs, 0.3 V to 50 V

With support for high voltage/current range, SENSE input and safety interlock features, the M9186A offers customers an elegant voltage/current source that does not require conditioning circuitry with accurate and repeatable results while protecting the DUT and instrument from damage due to high voltage spikes.

# TS-8900 Platform Architecture (continued)

The M9185A provides isolated 16-bit 8 / 16 channels of DC voltage channels with support of up to 16 V, providing the user with a direct input to the automotive DUT which for light vehicles will normally require up to 12 V.

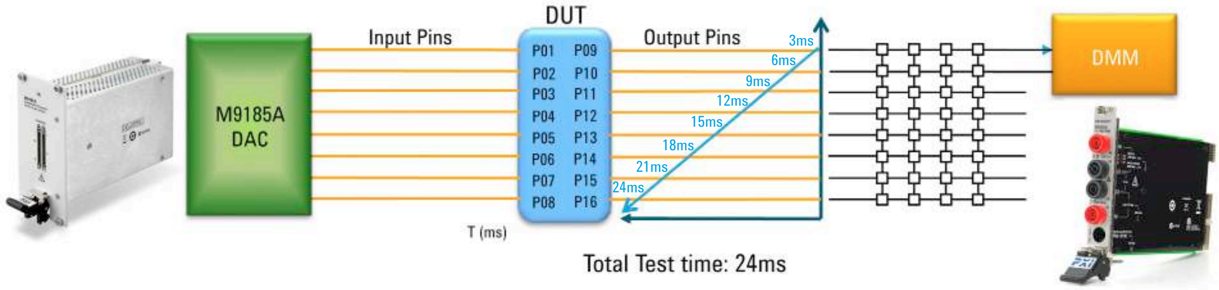
The M9216A provides users up to 32 voltage measurement channels with a 10 mV – 100 V auto measurement range in one single PXI card. This new high voltage acquisition module enables customers to improve their voltage measurements throughput by via new parallel test methodology compared to the current sequential measurement methodology using a digital multimeter (DMM) and switch matrix. With a sampling rate of 250 kSamples/s per channel, the M9216A supports measurement of higher frequency signals of up to 100 kHz.

## New test methodology: Parallel vs sequential voltage measurement

The M9216A empowers customers with improved throughput via parallel voltage measurements compared to the industry standard of sequential measurements. With reference to Figure 2 below, the M9216A enables significant voltage measurement improvements compared to sequential measurements using a digital multimeter and switch matrix configuration.

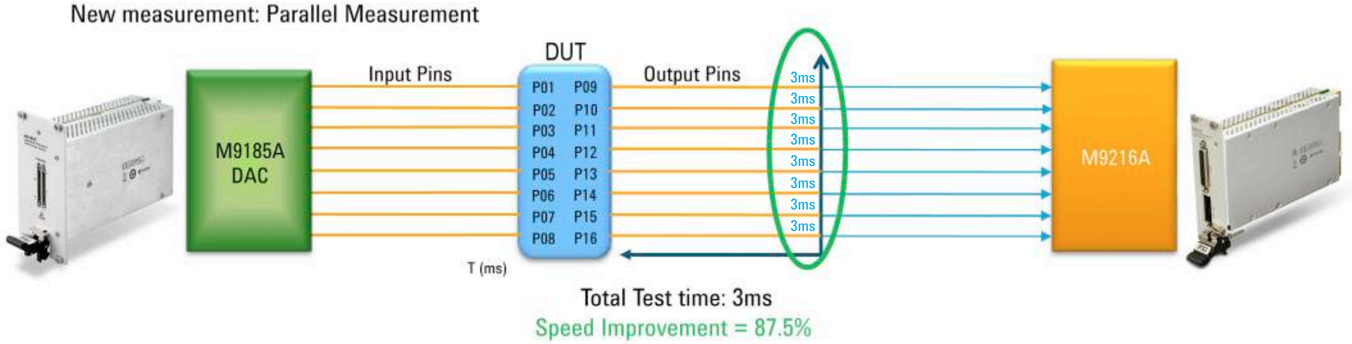
The M9182A and M9183A provides users with the highest transactional speeds in the market at 4500 readings/s and 20,000 readings/s respectively. The M9183A also supports advanced triggering, capacitance measurements and more temperature functions, providing users with flexibility to support a broad range of measurements.

### Subsystem voltage measurement – Sequential vs. Parallel Measurement




– Sequential measurement
– Path needs to be switched
– Total test time displayed is based on a sample test plan and only serves as an example. Actual test times vary by application.

New measurement: Parallel Measurement




– Parallel measurement
– Does not require an external switch matrix or multiplexer
– Total test time displayed is based on a sample test plan and only serves as an example. Actual test times vary by application.

Figure 2. The Keysight M9216A enables significant throughput improvement via parallel voltage measurement.

# TS-8900 Platform Architecture (continued)

## LXI-interface instruments

The Keysight L4532A and L4534A are high resolution, standalone LXI digitizers. They offer two or four channels of simultaneous sampling at up to 20 MSa/s, with 16 bits of resolution. Inputs are isolated and can measure up to ±250 V to handle your most demanding applications. Input channels with the ability to measure waveforms up to 250 V are beneficial when analyzing high voltage and transient signals as seen in many automotive applications. The L4532A and L4534A can make measurements that other products cannot. For example, since the ±250 V input range is combined with 16-bit analog to digital converters (ADCs), isolated front-end and low input offset allows a small voltage, such as a 250 mV, and a larger voltage, such as 250 V, to be measured at the same time.

The Keysight L4451A is a high performance 4-channel D/A converter that is LXI Class C compliant. With its small size and Ethernet connectivity, the D/A converter can be placed wherever your application needs it. The Keysight L4451A has four isolated analog channels that are useful to source bias voltages to your device under Test (DUT), to control your analog programmable power supplies, or use the outputs as set points for your control systems. You can use the standard waveforms provided or create your own with over 500,000 points. These points can be dynamically allocated among one or more channels and output as a point-to-point arb. Using this LXI instrument, you will obtain all the benefits of an Ethernet connection, instrument Web server, stan-dard software drivers and more. The L4451A has four independent, isolated channels that can output DC voltage up to ±16 V or DC current up to ±20 mA with 16 bits of resolution. The gain and offset can be adjusted on-the-fly.

## GPIB-interface instruments

The 33521A and 33522A provides you with the first 30 MHz Function/Arbitrary waveform generator in its class, 1– and 2– channel configurations, function pulses and point-by-point arbitrary waveforms in one instrument. Build many arbitrary waveforms without a PC with the embedded waveform builder. The 33521A and the 33522A provides the highest signal fidelity in their class, full bandwidth pulses and real point-by point arbitrary waveforms.

The 53220A represents a new generation of 350 MHz RF and Universal counter/timers with new performance and usability standards. The 53220A belongs to a family of first frequency counters with LXI-C compliance, the combination of high speed measurements and built-in analysis provide new functionality that has not previously been available in basic frequency counters/timers.

## Switch/Load Switching Unit (DC/AC)

The E6198B is a standard switch/load unit platform with standard Keysight global support that provides customers with an off-the-shelf switch/load box solution. Specifically designed for automotive ECUs with support for up to 30 A current input with fly-back protection and 48 channels (2 A per channel). The E6198B supports inductive and capacitive loads, with single load, dual load, or quad-load configuration providing customers with the flexibility to support various automotive ECUs for medium to high pin count applications. The E6198B is powered by a total of three power supplies ensuring optimal power supply for high pin count automotive ECUs with dedicated power supplies for each voltage line.

**Keysight Loadcards Specifications**

| Function | E6175A | E6176A | E6177A | E6177B | E6178A | N9377A | N9378A | N9379A |
|---|---|---|---|---|---|---|---|---|
| Number of channels (maximum) | 8 | 16 | 24 | 24 | 8 | 16, dual-load | 24, quad-load | 48, dual-load |
| Number of channels – unshared relays | 4 | 16 | 24 | 24 | 8 | 16 | 24 | 48 |
| Maximum current per channel | 7.5 A (15 A peak) | 7.5 A (15 A peak) | 2 A | 2 A | 30 A | 7.5 A (15 A peak) | 2 A | 2 A |
| Current measuring with sense resistor | Yes | Yes | No | Yes | No | Yes | No | No |
| Current measuring with current transducer | Yes | No | No | No | Yes | No | No | No |
| Flyback protection available (user installed) | Yes | Yes | No | No | Yes | Yes | No | No |
| Engineered for application | Inductive load | Common load | Low current | Low current | High current | High current dual-load | Low current quad-load | Low current dual-load |

# M9186A Product Specifications

## Voltage Source Accuracy

| Range | Conditions | Accuracy ± (% of output + offset) |
|---|---|---|
| ± 16 V | Up to 200 mA at no load. | 0.02 % + 3 mV |
| | Current Sense using the SENSE pin with respect to OUTPUT. | 200 mA range: 1.5 % + 500 µA<br>20 mA range: 0.5 % +50 µA<br>20 mA range: 0.5 % +50 µA<br>2 mA range: 0.5 % + 10 µA<br>200 µA range: 0.3 % + 5 µA |
| –10 to + 100 V | Up to 20 mA at no load. | 0.02 % + 40 mV |
| | Current Sense using the SENSE pin with respect to OUTPUT. | 0.75 % + 300 µA |

## Current Source Accuracy

| Range | Conditions | Accuracy ± (% of output + offset) |
|---|---|---|
| ± 200 mA | Over ± 16 V at no load. | 0.3 % + 500 µA |
| ± 20 mA | | 0.1 % + 50 µA |
| ± 2 mA | | 0.3 % + 5 µA |
| ± 200 µA | | 0.1 % + 0.5 µA |
| ± 20 mA | Over –10 to +100 Vdc at no load. | 0.3 % + 500 µA |

## General Specifications

| Description | Specification |
|---|---|
| Temperature Range<br>– Operating<br>– Storage | 0 ° to 55 °C<br>–40 °C to +70 °C |
| Relative Humidity | 80%, 0 °C to 40 °C (Non condensing) |
| Certifications and Compliance | Altitude : 10,000 ft (Operating)/15,000 ft (Non-operating) |
| – CE Mark Compliance<br>– Safety<br>– EMC Immunity<br>– EMC Emissions | 2006/95/EC; 2004/108/EC<br>Pollution Degree 2<br>EN/IEC 61326-1 Industrial Environment<br>EN/IEC 61326-1 Class A |
| Warm-Up Time | 30 minutes |
| PXI Power Requirements (typical) | 6 W at 5 V, 3 W at 3.3 V, 1 W at 12 V |

| Additional Information | |
|---|---|
| Recommended Calibration Interval | 1 Year |

| Physical Characteristics | |
|---|---|
| Dimensions | 3U, 2-Slot, PXI/cPCI module; 40.30 mm x 129.11 mm × 212.73 mm<br>(1.59 in. × 5.08 in. × 8.38 in.) |
| Weight | 0.56 kg (1.23 lb) |
| Front Panel Connector | Mini-Fit Jr (6 circuits) |
| | *NOTE – Front panel connector can accept wire gauges up to 16 AWG.* |

# M9186A Product Specifications (continued)

## General Specifications

| Configuration | |
|---|---|
| **Hardware** | |
| Model[1] | Description |
| M9186A | M9186A PXI isolated single channel voltage/current source |

| Related products | |
|---|---|
| **Software[2]** | |
| Model | Description |
| Keysight IO Libraries | Keysight IO Libraries Drivers, soft front panels and programming examples in LabVIEW, LabWindows/CVI, Visual Studio® C, C++ and C#, Visual Basic, and MATLAB |
| **Accessories** | |
| M9186A-CD1 | Software and product information on CD |

## Ordering

| Model | Description |
|---|---|
| M9186A | M9186A PXI isolated single channel voltage/current source, 100 V |

## Warranty and Calibration

| Advantage Services: Calibration and Warranty |
|---|
| Keysight Advantage Services is committed to your success throughout your equipment's lifetime. |

| Warranty Description | |
|---|---|
| **Standard warranty is 1 year** | |
| R-9MB-001-3C | 1 year return-to-Keysight warranty extended to 3 years |
| R-9MB-001-5C | 1 year return-to-Keysight warranty extended to 5 years |

1. For the M9186A to work properly, at least one PXI chassis and one PXI controller type must be available.
2. Keysight IO Libraries Suite 16.0 is required. The modular product won't work with Keysight IO Libraries Suite versions earlier than version 16.0

# M9216A Product Specifications

| Voltage input input (general) | |
|---|---|
| Number of Channels | 8 concurrent dual range channels |
| Resolution | 16 bit |
| Sampling rate | 250 kS/s |
| Analog bandwidth<br>(anti-aliasing filter) | 850 kHz |
| Dual range specifications<br>5 V<br>100 V | <br>1 mV to 5V<br>20 mV to 100 V |
| Input coupling | DC |
| Input impedance | 550 kΩ |
| Internal sample memory | 7500 samples for 5 V and 100 V range per channel |
| Trigger | Software and digital trigger<br>Pre and post trigger sample acquisition<br>Timed delay |

| Voltage input input accuracy (at 25 + 3° C) | |
|---|---|
| **5 V Range** | |
| Zero offset | 200 µV |
| Gain (% of reading) | 0.05% |
| Noise 3 sigma | 200 µV |
| **100 V Range** | |
| Zero offset | 1 mV |
| Gain (% of reading) | 0.05% |
| Noise 3 sigma | 2 mV |

| Multiplexer | |
|---|---|
| Input channels | 32 |
| Output channels | 8 channels to ADC |
| | 8 channels to auxiliary out |
| | 8 channels to auxiliary out 2 |
| Maximum input voltage | 100 V |
| Maximum input current | 0.5 A |
| Maximum common return pin voltage with respect to chassis ground | 45 V |

| Power | |
|---|---|
| Maximum current consumption from PXI<br>5 V<br>3.3 V | <br>0.8 A<br>0.5 A |
| Maximum input voltage | 100 V |
| Maximum input current | 0.5 A |
| Maximum common return pin voltage with respect to chassis ground | 45 V |
| Warm up time | 0.5 hour |

# M9216A Product Specifications (continued)

## General Specifications

| Environmental and physical | |
|---|---|
| Operating temperature | 0 to 55° C |
| Storage temperature | –20° C to 70° C |
| Relative humidity | 0% to 80% non condensing |
| Dimensions | 3U, 2-slot, PXI/cPCI module; 40.30 mm x 129.11 mm × 212.73 mm (1.59 in. × 5.08 in. × 8.38 in.) |
| Weight | 0.51 kg (1.12 lb) |
| Certifications and Compliance | Altitude : 10,000 ft (Operating)/ 15,000 ft (Non-operating) |
| CE Mark Compliance | 2006/95/EC; 2004/108/EC |
| Safety | Pollution Degree 2 |
| EMC Immunity | EN/IEC 61326-1 Industrial Environment |
| EMC Emissions | EN/IEC 61326-1 Class A |

| Additional information | |
|---|---|
| Recommended Calibration Interval | 1 Year |

| Configuration | |
|---|---|
| **Hardware** | |
| Model[1] | Description |
| M9216A | M9216A PXI 32-channel high voltage data acquisition |

| Related products | |
|---|---|
| **Software** | |
| Model[2] | Description |
| Keysight IO Libraries | Keysight IO Libraries Drivers, soft front panels and programming examples in LabVIEW, LabWindows/CVI, Visual Studio® C, C++ and C#, Visual Basic, and MATLAB |
| **Accessories** | |
| M9216A-CD1 | Software and product information on CD |

1. For the M9216A to work properly, at least one PXI chassis and one PXI controller type must be available.
2. Keysight IO Libraries Suite 16.0 is required. The modular product won’t work with Keysight IO Libraries Suite versions earlier than version 16.0

# M9185A Product Specifications

| DAC specifications | |
|---|---|
| Number of Channels | 8 or 16 channels |
| Resolution | 16-bit |
| Isolation | > 80 Vdc/ac peak (channel-to-chassis or channel to channel) |
| Synchronization | Software commands or external trigger. |
| Settling Time | 500 µs (typical) |

| DC Voltage | |
|---|---|
| Range | ± 16 V up to 10 mA |
| Resolution | 16-bit = 500 µV |
| Accuracy | ± (0.05% + 3.0 mV) |
| Ripple and Noise | < 80 mVpk-pk (typical) |

| DC Current | |
|---|---|
| Range | ± 20 mA |
| Resolution | 16-bit = 630 nA |
| Accuracy | ± (0.09% + 5.0 µA) |
| Ripple and Noise | < 2 µArms (typical) |

| I/O Trigger Characteristics | |
|---|---|
| **Trigger Input:** | |
| Input Level | TTL compatible (3.3 V logic, 5 V tolerant) |
| Slope | Rising or falling (selectable) |
| Pulse Width | > 100 nS |
| Input Impedance | > 10 kΩ typical, DC coupled |
| **Trigger Output:** | |
| Level | TTL compatible into 1 kΩ<br>(3.3 V logic) |
| Output Impedance | 50 Ω typical |

# M9185A Product Specifications (continued)

## General Specifications

| Environmental and physical | |
|---|---|
| Operating temperature | 0 to 55° C |
| Storage temperature | –40 °C to 70° C |
| Relative humidity | 80%, 0° C to 40° C (non condensing) |
| Altitude | 10,000 ft (Operating)/15,000 ft (Non-operating) |
| Dimensions | 8-channel: 40.30 mm x 128.40 mm × 215.00 mm<br>1.59 in × 5.06 in × 8.46 in<br>16-channel: 60.50 mm x 128.40 mm × 215.00 mm<br>2.38 in × 5.06 in × 8.46 in |
| Weight | 8-Channel; 0.47 kg (1.04 lb)<br>16-Channel; 0.60 kg (1.32 lb) |
| Output connector | Stacked VHDCI receptacle |
| CE mark compliance | 2006/95/EC; 2004/108/EC |
| Safety | Pollution degree 2 |
| EMC immunity | EN/IEC 61326-1 industrial environment |
| EMC emissions | EN/IEC 61326-1 Class A |
| Warm-up time | 30 minutes |

| Additional information | |
|---|---|
| Recommended calibration interval | 1 Year |

| Configuration | |
|---|---|
| Hardware | |
| M9185A [1] | M9185A PXI 8/16-channel D/A converter |

| Related products | |
|---|---|
| Software | |
| Keysight IO libraries [2] | Keysight IO Libraries Drivers, soft front panels and programming examples in LabVIEW, LabWindows/CVI, Visual Studio C, C++ and C#, Visual Basic, and MATLAB |
| Accessories | |
| M9185A-CD1 | Software and product information on CD |

1. For the M9185A to work properly, at least one PXI chassis and one PXI controller type must be available.
2. Keysight IO Libraries Suite 16.0 is required. The modular product won't work with Keysight IO Libraries Suite versions earlier than version 16.0.

# N5744A, N5745A, N5764A, and N5765A Performance Specifications

| | | | N5744A | N5745A | N5764A | N5765A |
|---|---|---|---|---|---|---|
| DC Output ratings[1] | Voltage | | 20 V | 30 V | 20 V | 30 V |
| | Current | | 38 A | 25 A | 76 A | 50 A |
| | Power | | 760 W | 750 W | 1520 W | 1500 W |
| Output Ripple and Noise | CV p-p[2] | | 60 mV | 60 mV | 60 mV | 60 mV |
| | CV rms[3] | | 8 mV | 8 mV | 8 mV | 8 mV |
| Load Effect (change from 10% to 90%) | Voltage | | 4 mV | 5 mV | 4 mV | 5 mV |
| | Current | | 12.6 mA | 10 mA | 20.2 mA | 15 mA |
| Source Effect | Voltage | | 4 mV | 5 mV | 4 mV | 5 mV |
| | Current | | 5.8 mA | 4.5 mA | 9.6 mA | 7 mA |
| Programming Accuracy[1] | Voltage | 0.05%+ | 10 mV | 15 mV | 10 mV | 15 mV |
| | Current | 0.1%+ | 38 mA | 25 mA | 76 mA | 50 mA |
| Measurement Accuracy | Voltage | 0.1%+ | 20 mV | 30 mV | 20 mV | 30 mV |
| | Current | 0.1%+ | 114 mA | 75 mA | 228 mA | 150 mA |
| Load Transient Recovery Time[4] | Time | | ≤1 ms | ≤1 ms | ≤1 ms | ≤1 ms |
| **Supplemental Characteristics** | Supplemental characteristics are not warranted but are descriptions of typical performance determined either by design or type testing | | | | | |
| Output Response Time | Up, full load | | 0.08 s | 0.08 s | 0.08 s | 0.08 s |
| | Down, full load | | 0.05 s | 0.08 s | 0.05 s | 0.08 s |
| | Down, no load | | 0.8 s | 0.9 s | 0.8 s | 0.9 s |
| Command Response Time[5] | — | | — | — | — | — |
| Remote Sense Compensation | Volts/load lead | | 1 V | 1.5 V | 1 V | 1.5 V |
| Over-voltage Protection | Range | | 1-24 V | 2-36 V | 1-24 V | 2-36 V |
| | Accuracy | | 0.20 V | 0.30 V | 0.20 V | 0.30 V |
| Output Ripple and Noise[6] | CC rms | | 76 mA | 63 mA | 152 mA | 125 mA |
| Programming Resolution Measurement Resolution | Voltage | | 2.4 mV | 3.6 mV | 2.4 mV | 3.6 mV |
| | Current | | 4.56 mA | 3 mA | 9.12 mA | 6 mA |
| Front Panel Display Accuracy (4 digits; ±1 count) | Voltage | | 0.10 V | 0.15 V | 0.1 V | 0.15 V |
| | Current | | 0.19 A | 0.13 A | 0.38 A | 0.25 A |

1. Minimum voltage is guaranteed to a maximum of 0.2% of the rated output voltage. Minimum current is guaranteed to a maximum of 0.4% of the rated output current.
2. Up to 20 MHz
3. From 5 Hz – 1 MHz
4. Time for output voltage to recover within 0.5% of its rated output for a load change from 10 to 90% of its rated output current. Voltage set point from 10% to 100% of rated output
5. Add this to the output reponse time to obtain the total programming time
6. From 5 Hz – 1 MHz, at 10% to 100% of output voltage at full load (for 6 V units from 33% to 100% of output voltage)

# N8734A Performance Specifications

| Performance Specifications | | | |
|---|---|---|---|
| DC output ratings | Voltage[1] | | 20 V |
| | Current[2] | | 165 A |
| | Power | | 3300 W |
| Output ripple and noise | CV $_{p\text{-}p}$ [3] | | 60 mV |
| Load effect | CV $_{rms}$ [4] | | 8 mV |
| | CV load regulation[5] | | 8 mV |
| Source effect | CC load regulation[6]<br>CV line regulation[7] | | 38 mA<br>4 mV |
| Programming accuracy | CC line regulation[7] | | 18.5 mA |
| | Voltage[1] | 0.05% + | 10 mV |
| Measurement accuracy | Current[2, 8] | 0.1% + | 330 mA |
| | Voltage | 0.1% + | 20 mV |
| Load transient recovery time | Current[8] | 0.1% + | 495 mA |
| | Time[9] | | <1 ms |
| **Supplemental Characteristics** | | | |
| Output response time | Up-prog response time[10] | | 80 ms |
| | Down-prog response time Full-load[10] | | 100 ms |
| | Down-prog response time No-load[11] | | 800 ms |
| Command response time<br>(add this to the output response time to obtain the total programming time) | | | 100 ms (typical) |
| Remote sense compensation | | | 2 V |
| Over-voltage protection | Range | | 1-24 V |
| Output ripple and noise | CC rms[12] | | 660 mA |
| Programming resolution<br>Measurement resolution | Voltage | | 2.4 mV |
| | Current | | 19.8 mA |
| Front panel display accuracy<br>(4 digits; ± 1 count) | Voltage | | 100 mV |
| | Current | | 825 mA |
| Temperature stability<br>(over 8 hours, after a 30 minute warm-up, with constant line, load, and temperature) | Voltage | | 10 mV |
| | Current | | 82.5 mA |
| Temperature coefficient<br>(after a 30 minute warm-up) | Voltage *from rated output voltage* | | 100 PPM/°C |
| | Current *from rated output current* | | 200 PPM/°C |

1. Minimum voltage is guaranteed to maximum 0.2% of rated output voltage.
2. Minimum current is guaranteed to maximum 0.4% of rated output current.
3. 20 MHz
4. 5 Hz - 1 MHz
5. From no-load to full-load, constant input voltage. Maximum drop in remote sense.
6. For load voltage change equal to the unit voltage rating, constant input voltage
7. Single-phase and 3-Phase 208 V models: 170~265 VAC, constant load.
   3-Phase 400 V models: 342~460 VAC, constant load.
8. The constant current programming readback and monitoring accuracy does not include the warm-up and load regulation thermal drift.
9. Time for output voltage to recover within 0.5% of its rated output for a load change 10 - 90% of rated output current, local sense.
10. From 10% to 90% or 90% to 10% of rated output voltage, with rated, resistive load.
11. From 90% to 10% of rated output voltage.
12. For 8 V - 15 V models the ripple is measured from 2 V to rated output voltage and rated output current. For other models, the ripple is measured at 10 - 100% of rated output voltage and rated output current.

# N8734A Performance Specifications (continued)

| **Supplemental Characteristics** (continued) | |
|---|---|
| **Analog programming and monitoring** | |
| $V_{out}$ voltage programming | 0-100%, 0-5 V or 0-10 V, user selectable. Accuracy and linearity: ±0.5% of rated $V_{out}$. |
| $I_{out}$ voltage programming [1] | 0-100%, 0-5 V or 0-10 V, user selectable. Accuracy and linearity: ±1% of rated $I_{out}$. |
| $V_{out}$ resistor programming | 0-100%, 0-5/10 Kohm full scale, user selectable. Accuracy and linearity: ±1% of rated $V_{out}$. |
| $I_{out}$ resistor programming [1] | 0-100%, 0-5/10 Kohm full scale, user selectable. Accuracy and linearity: ±1.5% of rated $I_{out}$. |
| On/Off control (rear panel) | Controlled by voltage: 0-0.6 V/2-15 V, or dry contact, user selectable logic. |
| Output current monitor [1] | 0-5 V or 0-10 V, user selectable, Accuracy: ±1%. |
| Output voltage monitor | 0-5 V or 0-10 V, user selectable, Accuracy: ±1%. |
| Power supply OK signal | TTL high (4-5 V) = OK; 0 V = Fail; 500 ohm series resistance. |
| CV/CC Indicator | 3.3 kW: CV = TTL high (4-5 V) (source current: 10 mA); CC = TTL low (0-0.6 V) (sink current = 10 mA)<br>5 kW: Open collector; CV mode: OFF, CC mode: ON, Max voltage = 30 V; Max sink current = 10 mA |
| Enable/disable | Dry contact. Open: off, Short: on. Max. voltage at terminal = 6 V |
| **Series and parallel capability** | |
| Parallel operation | Up to 4 identical units (same model number) can be connected in master/slave mode with single-wire current balancing |
| Series operation | Up to 2 identical units (same model number) can be connected using external protection diodes (see Output Terminal Isolation on page 17) |
| **Savable states** | |
| In volatile memory | 16 (in memory locations 0-15) |
| **Interface capabilities** | |
| GPIB | SCPI – 1993, IEEE 488.2 compliant interface |
| LXI Compliance | Class C (only applies to units with the LXI label on the front panel) |
| USB 2.0 | Requires Keysight I/O Library version M.01.01 and up, or 14.0 and up |
| 10/100 LAN | Requires Keysight I/O Library version L.01.01 and up, or 14.0 and up |
| **Environmental conditions** | |
| Environment | Indoor use, installation category II (AC input), pollution degree 2 |
| Operating temperature | 0° C to 40° C @ 100% load |
| Storage temperature | –20° C to 70° C |
| Operating humidity | 30% to 90% relative humidity (no condensation) |
| Storage humidity | 10% to 95% relative humidity (no condensation) |
| Altitude | Up to 3000 meters.<br>Above 2000 m, derate the output current by 2%/100 m and derate the maximum ambient temperature by 1° C/100 m. |
| Built-in Web server | Requires Internet Explorer 5+ or Netscape 6.2+ |

1. The constant current programming readback and monitoring accuracy does not include the warm-up and load regulation thermal drift.

# N8734A Performance Specifications (continued)

| Supplemental Characteristics (continued) | | |
|---|---|---|
| Dimensions | | Height: 88 mm (3.46 in); Width: 423 mm (16.65 in); Depth: 442.5 mm (17.42 in) (excluding connectors and handles) |
| Weight | | 3.3 kW: 13 kg (28.6 lbs.); 5 kW: 16 kg (35.2 lbs.) |
| Regulatory compliance | EMC | Complies with the European EMC directive 89/336/EEC for Class A test and measurement products.<br>Complies with the Australian standard and carries the C-Tick mark.<br>This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.<br>Electrostatic discharges >1 kV near the I/O connectors may cause the unit to reset and require operator intervention. |
| | Safety | Complies with the European Low Voltage Directive 73/23/EEC and carries the CE-marking.<br>Complies with the US and Canadian safety standards for test and measurement products.<br>Any LEDs used in this product are Class 1 LEDs as per IEC 825-1 |
| Acoustic noise declaration | | Statements provided to comply with requirements of the German Sound Emission Directive, from 18 January 1991.<br>Sound Pressure Lp <70 dB(A), *At Operator Position, *Normal Operation, *According to EN 27779 (Type Test).<br>Schalldruckpegel Lp <70 dB(A) *Am Arbeitsplatz, *Normaler Betrieb, *Nach EN 27779 (Typprüfung). |
| Output terminal isolation | 8 V to 60 V units | No output terminal may be more than ± 60 VDC from any other terminal or chassis ground. |
| | 80 V to 600 V units | No positive output terminal may be more than ± 600 VDC from any other terminal or chassis ground.<br>No negative output terminal may be more than ± 400 VDC from any other terminal or chassis ground. |

# N8734A Performance Specifications (continued)

| Supplemental Characteristics (continued) | | | |
|---|---|---|---|
| AC Input | Nominal input | 230 VAC single-phase option [13] | 190 - 240 VAC; 50/60 Hz |
| | | 208 VAC 3-phase option | 190 - 240 VAC; 50/60 Hz |
| | | 400 VAC 3-phase option | 380 - 415 VAC; 50/60 Hz |
| | Input current | 230 VAC single-phase option [13] | 23 - 24 A Max @ 100% load |
| | | 208 VAC 3-phase option | 3.3 kW models: 13.6 - 14.5 A Max @ 100% load<br>5 kW models: 21-22 A max @ 100% load |
| | | 400 VAC 3-phase option | 3.3 kW models: 6.8 - 7.2 A Max @ 100% load<br>5 kW models: 10.5 - 12 A Max @ 100% load |
| | Input range | 230 VAC single-phase option [13] | 170 - 265 VAC; 47 - 63 Hz |
| | | 208 VAC 3-phase option | 170 - 265 VAC; 47 - 63 Hz |
| | | 400 VAC 3-phase option | 342 - 460 VAC; 47 - 63 Hz |
| | Input VA | 3.3 kW models | 4000 VA |
| | | 5 kW models | 5800 VA |
| | Power factor | 230 VAC single-phase option [13] | 0.99 at nominal input and rated output power |
| | | 208 & 400 VAC 3-phase options | 3.3 kW models: 0.95 at nominal input and rated output power<br>5 kW models: 0.94 at nominal input and rated output power |
| | Efficiency | 3.3 kW models | 82% - 88% |
| | | 5 kW models | 83% - 88% |
| | Inrush current | 230 VAC single-phase option [13] | < 50 A |
| | | 208 VAC 3-phase option | < 50 A |
| | | 400 VAC 3-phase option | < 20 A |

1. Available on 3.3 kW models only.

# M9182A and M9183A Technical Specifications and Characteristics

| M9182A and M9183A: Accuracy specifications ±(% of reading + % of range) [1,2] | | | | | |
|---|---|---|---|---|---|
| Function | Range[3] | Frequency | 24 hour 23° C ± 5° C | 90 day 23° C ± 5° C | 1 year 23° C ± 5° C |
| DC voltage | 200.0000 mV | | 0.0030 + 0.0005 | 0.0040 + 0.0008 | 0.0050 + 0.0010 |
| | 2.000000 V | | 0.0020 + 0.0002 | 0.0030 + 0.0002 | 0.0040 + 0.0003 |
| | 20.00000 V | | 0.0040 + 0.0006 | 0.0050 + 0.0007 | 0.0070 + 0.0008 |
| | 200.0000 V | | 0.0030 + 0.0001 | 0.0040 + 0.0001 | 0.0050 + 0.0003 |
| | 300.0000 V | | 0.0130 + 0.0002 | 0.0230 + 0.0003 | 0.0250 + 0.0003 |
| True RMS, AC voltage[4,5] (Fast RMS off) | 200.0000 mV[6] | 10 Hz - 20 Hz | 3.00 + 0.18 | 3.10 + 0.19 | 3.20 + 0.22 |
| | | 20 Hz - 47 Hz | 0.37 + 0.08 | 0.38 + 0.09 | 0.40 + 0.10 |
| | | 47 Hz - 10 kHz | 0.13 + 0.05 | 0.14 + 0.06 | 0.15 + 0.06 |
| | | 10 kHz - 50 kHz | 0.25 + 0.08 | 0.26 + 0.10 | 0.27 + 0.12 |
| | | 50 kHz - 100 kHz | 1.90 + 0.18 | 1.95 + 0.19 | 2.00 + 0.20 |
| | 2.000000 V | 10 Hz - 20 Hz | 3.00 + 0.10 | 3.10 + 0.11 | 3.20 + 0.13 |
| | | 20 Hz - 47 Hz | 0.37 + 0.07 | 0.38 + 0.08 | 0.40 + 0.09 |
| | | 47 Hz - 10 kHz | 0.05 + 0.05 | 0.06 + 0.06 | 0.07 + 0.06 |
| | | 10 kHz - 50 kHz | 0.32 + 0.06 | 0.33 + 0.66 | 0.35 + 0.08 |
| | | 50 kHz - 100 kHz | 1.90 + 0.08 | 2.00 + 0.09 | 2.10 + 0.10 |
| | 20.00000 V | 10 Hz - 20 Hz | 3.00 + 0.07 | 3.10 + 0.08 | 3.30 + 0.10 |
| | | 20 Hz - 47 Hz | 0.37 + 0.06 | 0.38 + 0.07 | 0.40 + 0.08 |
| | | 47 Hz - 10 kHz | 0.06 + 0.05 | 0.07 + 0.06 | 0.07 + 0.07 |
| | | 10 kHz - 50 kHz | 0.18 + 0.09 | 0.20 + 0.11 | 0.22 + 0.13 |
| | | 50 kHz - 100 kHz | 1.30 + 0.15 | 1.40 + 0.18 | 1.50 + 0.20 |
| | 200.0000 V & 300.0000 V | 10 Hz - 20 Hz | 3.00 + 0.07 | 3.10 + 0.08 | 3.30 + 0.08 |
| | | 20 Hz - 47 Hz | 0.43 + 0.06 | 0.44 + 0.07 | 0.45 + 0.08 |
| | | 47 Hz - 10 kHz | 0.07 + 0.05 | 0.08 + 0.07 | 0.09 + 0.08 |
| | | 10 kHz - 50 kHz | 0.28 + 0.07 | 0.30 + 0.08 | 0.32 + 0.10 |
| | | 50 kHz - 100 kHz | 1.30 + 0.09 | 1.60 + 0.12 | 2.40 + 0.13 |
| True RMS, AC voltage[4,5] (Fast RMS on) | 200.0000 mV[6] | 350 Hz - 800 Hz | 0.60 + 0.08 | 0.65 + 0.09 | 0.70 + 0.10 |
| | | 800 Hz - 10 kHz | 0.13 + 0.05 | 0.14 + 0.06 | 0.15 + 0.06 |
| | | 10 kHz - 50 kHz | 0.55 + 0.08 | 0.60 + 0.10 | 0.63 + 0.12 |
| | | 50 kHz - 100 kHz | 5.30 + 0.18 | 5.40 + 0.19 | 5.60 + 0.20 |
| | 2.000000 V | 350 Hz - 800 Hz | 0.93 + 0.07 | 0.96 + 0.08 | 1.00 + 0.09 |
| | | 800 Hz - 10 kHz | 0.07 + 0.05 | 0.08 + 0.06 | 0.08 + 0.06 |
| | | 10 kHz - 50 kHz | 0.62 + 0.06 | 0.65 + 0.66 | 0.70 + 0.08 |
| | | 50 kHz - 100 kHz | 5.10 + 0.08 | 5.20 + 0.09 | 5.30 + 0.10 |
| | 20.00000 V | 350 Hz - 800 Hz | 0.93 + 0.06 | 0.96 + 0.07 | 1.00 + 0.08 |
| | | 800 Hz - 10 kHz | 0.07 + 0.05 | 0.07 + 0.06 | 0.07 + 0.07 |
| | | 10 kHz - 50 kHz | 0.31 + 0.09 | 0.33 + 0.11 | 0.35 + 0.13 |
| | | 50 kHz - 100 kHz | 2.00 + 0.15 | 2.20 + 0.18 | 2.40 + 0.20 |
| | 200.0000 V & 300.0000 V | 350 Hz - 800 Hz | 1.00 + 0.06 | 1.10 + 0.07 | 1.10 + 0.08 |
| | | 800 Hz - 10 kHz | 0.07 + 0.05 | 0.07 + 0.07 | 0.08 + 0.08 |
| | | 10 kHz - 50 kHz | 0.34 + 0.07 | 0.45 + 0.08 | 0.50 + 0.10 |
| | | 50 kHz - 100 kHz | 2.50 + 0.09 | 2.80 + 0.12 | 3.20 + 0.13 |

1. Specifications are for 1 hour warm up, within 1 hour self-cal, aperture ≥ 0.5 sec, slow AC filter.
2. For temperatures outside the range of 23° C ± 5° C, but within 0° C to 50° C, add 0.1 × accuracy specification per ° C.
3. 20% over range on all ranges except 300 V range, 10% over range for 300 V range.
4. Minimum input specified: 5 mV or 1% of range, whichever is larger.
5. Signal is limited to $8 \times 10^6$ Volt Hz product. For example, at 32 kHz, the highest input is 250 V.
6. For inputs from 5 mV to 10 mV, add 100 µV to the specification.

# M9182A and M9183A Technical Specifications and Characteristics (continued)

| M9182A and M9183A: Accuracy specifications ±(% of reading + % of range)[1,2] | | | | | |
|---|---|---|---|---|---|
| Function | Range[3] | Frequency, test current or burden voltage | 24 hour 23° C ± 5° C | 90 day 23° C ± 5° C | 1 year 23° C ± 5° C |
| Resistance[4] | 20.00000 Ω (M9183A only) | 10 mA | 0.004 + 0.002 | 0.009 + 0.004 | 0.014 + 0.005 |
| | 200.0000 Ω | 1 mA | 0.004 + 0.002 | 0.010 + 0.002 | 0.013 + 0.003 |
| | 2.000000 kΩ | 1 mA | 0.003 + 0.002 | 0.008 + 0.002 | 0.012 + 0.002 |
| | 20.00000 kΩ | 100 μA | 0.003 + 0.002 | 0.008 + 0.002 | 0.012 + 0.002 |
| | 200.0000 kΩ | 10 μA | 0.006 + 0.002 | 0.010 + 0.002 | 0.016 + 0.003 |
| | 2.000000 MΩ | 1 μA | 0.018 + 0.002 | 0.030 + 0.003 | 0.040 + 0.004 |
| | 20.00000 MΩ | 100 nA | 0.120 + 0.002 | 0.130 + 0.003 | 0.200 + 0.003 |
| | 200.0000 MΩ (M9183A only) | 4 nA | 0.800 + 0.010 | 1.000 + 0.015 | 1.300 + 0.025 |
| DC current | 200.0000 nA (M9183A only) | < 100 μV | 0.130 + 0.020 | 0.160 + 0.023 | 0.170 + 0.030 |
| | 2.000000 μA (M9183A only) | < 100 μV | 0.050 + 0.004 | 0.080 + 0.003 | 0.210 + 0.008 |
| | 20.00000 μA (M9183A only) | < 100 μV | 0.050 + 0.002 | 0.080 + 0.003 | 0.130 + 0.004 |
| | 200.0000 μA (M9183A only) | < 2.5 mV | 0.052 + 0.100 | 0.070 + 0.150 | 0.100 + 0.200 |
| | 2.000000 mA | < 25 mV | 0.020 + 0.015 | 0.030 + 0.020 | 0.040 + 0.028 |
| | 20.00000 mA | < 250 mV | 0.020 + 0.002 | 0.035 + 0.003 | 0.045 + 0.003 |
| | 200.0000 mA | < 55 mV | 0.020 + 0.025 | 0.030 + 0.030 | 0.040 + 0.040 |
| | 2.000000 A | < 520 mV | 0.100 + 0.003 | 0.150 + 0.004 | 0.200 + 0.005 |
| True RMS, AC current [5] | 2.000000 mA [6] | 10 Hz - 20 Hz | 2.70 + 0.20 | 2.90 + 0.20 | 2.90 + 0.20 |
| | | 20 Hz - 47 Hz | 0.90 + 0.20 | 0.90 + 0.20 | 1.00 + 0.20 |
| | | 47 Hz - 1 kHz | 0.04 + 0.08 | 0.08 + 0.15 | 0.12 + 0.20 |
| | | 1 kHz - 10 kHz | 0.12 + 0.20 | 0.14 + 0.20 | 0.22 + 0.20 |
| | 20.00000 mA | 10 Hz - 20 Hz | 1.80 + 0.15 | 2.60 + 0.15 | 2.80 + 0.15 |
| | | 20 Hz - 47 Hz | 0.60 + 0.15 | 0.90 + 0.15 | 1.00 + 0.15 |
| | | 47 Hz - 1 kHz | 0.07 + 0.05 | 0.15 + 0.10 | 0.16 + 0.15 |
| | | 1 kHz - 10 kHz | 0.21 + 0.15 | 0.30 + 0.20 | 0.40 + 0.20 |
| | 200.0000 mA | 10 Hz - 20 Hz | 1.80 + 0.20 | 2.70 + 0.20 | 2.80 + 0.20 |
| | | 20 Hz - 47 Hz | 0.60 + 0.20 | 0.90 + 0.20 | 1.00 + 0.20 |
| | | 47 Hz - 1 kHz | 0.10 + 0.05 | 0.17 + 0.09 | 0.20 + 0.11 |
| | | 1 kHz - 10 kHz | 0.30 + 0.15 | 0.35 + 0.18 | 0.40 + 0.20 |
| | 2.000000 A | 10 Hz - 20 Hz | 1.80 + 0.20 | 2.50 + 0.23 | 2.70 + 0.25 |
| | | 20 Hz - 47 Hz | 0.66 + 0.30 | 0.80 + 0.30 | 0.90 + 0.30 |
| | | 47 Hz - 1 kHz | 0.30 + 0.19 | 0.33 + 0.19 | 0.35 + 0.20 |
| | | 1 kHz - 10 kHz | 0.40 + 0.20 | 0.45 + 0.23 | 0.50 + 0.25 |
| Frequency or period [7] | 200 mV to 300 V | 1 Hz - 130 Hz | 0.025 + 0.002 | 0.025 + 0.002 | 0.025 + 0.002 |
| | | 130 Hz - 640 Hz | 0.025 + 0.003 | 0.025 + 0.003 | 0.025 + 0.003 |
| | | 640 Hz - 2.5 kHz | 0.030 + 0.003 | 0.030 + 0.003 | 0.030 + 0.003 |
| | | 2.5 kHz - 40 kHz | 0.030 + 0.003 | 0.030 + 0.003 | 0.030 + 0.003 |
| | | 40 kHz - 200 kHz | 0.050 + 0.004 | 0.050 + 0.004 | 0.050 + 0.004 |
| | | 200 kHz - 300 kHz | 0.070 + 0.002 | 0.070 + 0.002 | 0.070 + 0.002 |

1. Specifications are for 1 hour warm up, within 1 hour self-cal, aperture ≥ 0.5 sec, slow AC filter.
2. For temperatures outside the range of 23° C ± 5° C, but within 0° C to 50° C, add 0.1 × accuracy specification per ° C.
3. 20% over range on all ranges except 300 V range, 10% over range for 300 V range.
4. Specifications are for 4-wire resistance measurements, or 2-wire using Math Null. Without Math Null, add 1 mΩ additional error to the specification.
5. Minimum input specified: 60 μA or 1.5% of range, whichever is larger.
6. For inputs from 60 to 120 μA, add 10 μA to the specification.
7. Minimum amplitude greater of: 100 mV, or 5 % of range for 1 Hz to 2.5 kHz, or 25 % of range for 2.5 kHz to 300 kHz.

# M9182A and M9183A Technical Specifications and Characteristics (continued)

| M9182A and M9183A: Accuracy specifications ±(% of reading + % of range) [1,2] | | | | | |
|---|---|---|---|---|---|
| Function | Range | Full scale reading or resolution | 24 hour 23 °C ± 5 °C | 90 day 23 °C ± 5 °C | 1 year 23 °C ± 5 °C |
| Duty cycle [3] [M9183A only] | 2 - 100 Hz | 0.02 % | 0.03 ± 0.03 | 0.03 ± 0.03 | 0.03 ± 0.03 |
| | 100 Hz - 1 kHz | 0.20 % | 0.03 ± 0.30 | 0.03 ± 0.30 | 0.03 ± 0.30 |
| | 1 - 10 kHz | 2.00 % | 0.03 ± 3.00 | 0.03 ± 3.00 | 0.03 ± 3.00 |
| Pulse width [4] [M9183A only] | 2 µs - 1 s | 1 µs | .01 ± 4 µs | 01 ± 4 µs | 01 ± 4 µs |
| Capacitance [5] | 1000.0 pF | 1199.9 pF | 1.00 + 0.10 | 1.00 + 0.10 | 1.00 + 0.10 |
| | 10.000 nF | 11.999 nF | 1.20 + 0.05 | 1.20 + 0.05 | 1.20 + 0.05 |
| [M9183A and M9182A] | 100.00 nF | 119.99 nF | 1.00 + 0.10 | 1.00 + 0.10 | 1.00 + 0.10 |
| | 1.0000 µF | 1.1999 µF | 1.00 + 0.10 | 1.00 + 0.10 | 1.00 + 0.10 |
| | 10.000 µF | 11.999 µF | 1.00 + 0.10 | 1.00 + 0.10 | 1.00 + 0.10 |
| | 100.00 µF | 119.99 µF | 1.00 + 0.10 | 1.00 + 0.10 | 1.00 + 0.10 |
| | 1.0000 mF | 1.1999 mF | 1.20 + 0.10 | 1.20 + 0.10 | 1.20 + 0.10 |
| | 10.000 mF | 11.999 mF | 2.00 + 0.10 | 2.00 + 0.10 | 2.00 + 0.10 |

## Definitions for specifications

Specification (spec): Represents warranted performance of a calibrated instrument that has been stored for a minimum of two hours within the operating temperature range of 0 to 55 °C, unless otherwise stated, and after a one hour warm-up period. The specifications include measurement uncertainty. Data represented in this document are specifications unless otherwise noted.

Typical (typ): Represents characteristic performance, which 80% of the instruments manufactured will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 25 °C).

Nominal (nom): The expected mean or average performance, or an attribute whose performance is by design, such as the 50 Ω connector. This data is not warranted and is measured at room temperature (approximately 25 °C).

Measured (meas): An attribute measured during the design phase for purposes of communicating expected performance, such as amplitude drift vs. time. This data is not warranted and is measured at room temperature (approximately 25 °C).

*Note: All graphs contain measured data from several units at room temperature unless otherwise noted.*

1. Specifications are for 1 hour warm up, within 1 hour self-cal, aperture ≥ 0.5 sec, slow AC filter.
2. For temperatures outside the range of 23° C ± 5° C, but within 0° C to 50° C, add 0.1 × accuracy specification per ° C.
3. Specifications are % of reading (0.03) ± adder.
4. Specifications are % of reading + time.
5. Specifications apply to input signals ≥ 5% of range, for values < 500 pF add 15% of range.

# M9182A and M9183A Technical Specifications and Characteristics (continued)

| M9182A and M9183A Sensitivity (nom) | | |
|---|---|---|
| **Function** | **Lowest Range** | **Sensitivity** |
| DCV | 200.0000 mV | 0.1 µV |
| ACV | 200.0000 mV | 0.1 µV |
| Resistance (M9183A) | 20.00000 Ω | 10 µΩ |
| Resistance (M9182A) | 200.0000 Ω | 100 µΩ |
| DCI (M9183A) | 200.0000 nA | 0.1 pA |
| DCI (M9182A) | 2.000000 mA | 10 nA |
| ACI | 2.000000 mA | 1 nA |
| Capacitance | 1000.0 pF | 0.1 pF |

| M9182A and M9183A temperature accuracy (spec) [1] | | | | | |
|---|---|---|---|---|---|
| **Temperature function** | **Type** | **R0 (Ω)** | **Sensitivity** | **Range/max temperature** | **1 year 23° C ± 5° C** |
| RTD temperature measurement [2,3] | pt385 | 100 Ω, 200 Ω | 0.01° C | –150 to 650° C | ± 0.06° C |
| | | 500 Ω, 1 kΩ | 0.01° C | –150 to 650° C | ± 0.03° C |
| | Cu (Copper) | Less than 12 Ω | 0.01° C | –100 to 200° C | ± 0.18° C at ≤ 20° C<br>± 0.05° C otherwise |
| | | Higher than 90 Ω | 0.01° C | –100 to 200° C | ± 0.10° C at ≤ 20° C<br>± 0.05° C otherwise |
| Thermocouple temperature measurement [4,5] | B | NA | 0.01° C | 2200° C | ± 0.38° C |
| | E | NA | 0.01° C | 1200° C | ± 0.035° C |
| | J | NA | 0.01° C | 2000° C | ± 0.06° C |
| | K | NA | 0.01° C | 3000° C | ± 0.07° C |
| | N | NA | 0.01° C | 3000° C | ± 0.10° C |
| | R | NA | 0.01° C | 2700° C | ± 0.25° C |
| | S | NA | 0.01° C | 3500° C | ± 0.35° C |
| | T | NA | 0.01° C | 550° C | ± 0.06° C |
| Thermistor [3] | 2.25 kΩ | NA | 0.01° C | –80 to 150° C | ± 0.1° C |
| | 5 kΩ | NA | 0.01° C | –80 to 150° C | ± 0.1° C |
| | 10 kΩ | NA | 0.01° C | –80 to 150° C | ± 0.1° C |

1. Specifications are for one hour warm up, within one hour self-cal, aperture ≥ 0.5 sec, slow AC filter.
2. 4-wire RTD measurement, R0 variable 10 Ω to 10 k Ω.
3. For total measurement accuracy, add temperature probe error.
4. For total measurement accuracy, add thermocouple error and cold junction compensation.
5. DMM linearization temperature range may be greater than that of the thermocouple device.

# M9182A and M9183A Technical Specifications and Characteristics (continued)

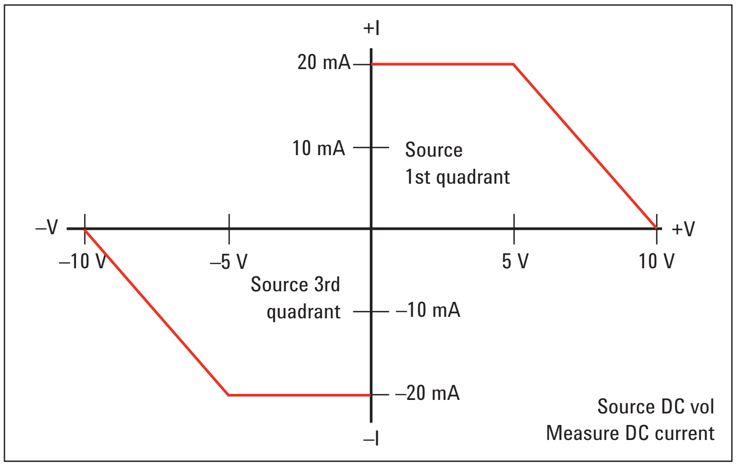
## Source-Measure [(spec) unless otherwise stated)]

| M9183A source DC voltage, measure DC voltage | | |
|---|---|---|
| Parameter | Extended resolution | Basic resolution |
| DC voltage source (output) range | –10.000 to +10.000 V | –10.000 to +10.000 V |
| DC current source/sink at 5 V output | 5 mA | 5 mA |
| DAC resolution (nom) | 18 bits | 12 bits |
| DC voltage source accuracy 1 year, (23° C ± 5° C) [1,2,3] | 0.015% ± 0.004% | 1.0% ± 0.4% |
| Settling time (typ) | 100 ms | 1 ms |
| Source resistance (nom) | 200 Ω | 200 Ω |

| M9183A source DC voltage, measure DC current | |
|---|---|
| DC voltage source (output) range | –10.000 to +10.000 V |
| DC current measurement range | 0 to ± 20 mA |
| Voltage resolution (nom) | 5 mV |
| Voltage source accuracy 1 Year, (23° C ± 5° C) [1,2,3] | 1.0% ± 0.35% |
| Settling time (typ) | 100 ms |
| DC current measurement accuracy | 0.1% + 0.005% |

| M9183A source DC voltage, measure DC voltage | |
|---|---|
| DC voltage measurement range | 0 to ± 2.0 V |

| Current output | Compliance voltage | Minimum Level | Source Accuracy 1 year, (23° C ± 5° C) [1,2,3] |
|---|---|---|---|
| < 1.25 µA | 4.2 V | 10 nA | 1% + 1% |
| < 12.5 µA | 4.2 V | 50 nA | 1% + 1% |
| < 125 µA | 4.2 V | 100 nA | 1% + 0.5% |
| < 1.25 mA | 4.2 V | 1 µA | 1% + 0.5% |
| < 12.5 mA | 1.2 V | 10 µA | 1% + 0.5% |




1. Specifications are for one hour warm up, within one hour self-cal, slow AC filter.
2. For temperatures outside the range of 23° C ± 5° C, but within 0° C to 50° C, add 0.1 × accuracy specification per ° C.
3. Repetitive reading at an aperture of 133 ms or higher.

# M9182A and M9183A Technical Specifications and Characteristics (continued)

## Triggering Characteristics

The M9182A and M9183A have advanced triggering capabilities that exceed those found on other digital multimeters. Advanced triggering allows you to capture the signal you need in a variety of applications.

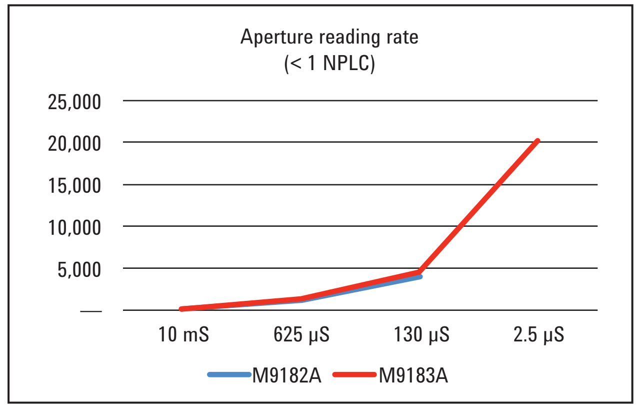
| External hardware trigger | |
|---|---|
| Trigger input voltage level range (at DIN 7 connector) | +3 to +15 V activates the trigger |
| Minimum trigger pulse width | Aperture + 50 μs |
| Trigger input impedance | 3 kΩ |
| Internal reading buffer | Circular, 80 readings |
| Edge | Selectable positive or negative edge |
| **PXI bus trigger inputs** | |
| Trigger input voltage level range (via PXI backplane) | CMOS level (see PXI standard) |
| Minimum trigger pulse width | 1/Aperture + 50 μs |
| Internal reading buffer | Circular, 80 readings |
| Edge | Selectable positive or negative edge |

| Trigger modes | | |
|---|---|---|
| Analog threshold trigger<br>(Pre-trigger or post-trigger) | Trigger point | Selectable threshold and positive or negative edge transition |
| | Buffer type | Circular |
| | Captures | 80 readings (pre-trigger + post trigger) |
| | Aperture range | 130 μs to 160 ms (M9182A)<br>2.5 μs to 160 ms (M9183A) |
| | Read interval range | 1/aperture to 65 ms |
| | Post-trigger readings | Selectable from 0 to 80 |
| | Pre-trigger readings | Selectable from 0 to 79 |
| Trigger delay<br>(Default values ensure 1st reading accuracy in most configurations) | Delay after trigger | 50 μs to 16 s |
| | Resolution | 1 μs to 65 ms, and 16 μs above 65 ms |

# M9182A and M9183A Technical Specifications and Characteristics (continued)

## Resolution vs. Aperture and Reading Rate for DCV, DCI, Ω

| Measurement aperture | Maximum readings per second | Resolution |
|---|---|---|
| 10 ms | 98 | 6½ digits (22 bits) |
| 625 µs | 1,200 | 5½ digits (18 bits) |
| 130 µs | 4,500 | 4½ digits (14 bits) |
| 2.5 µs | 20,000 | 4½ digits (14 bits) |

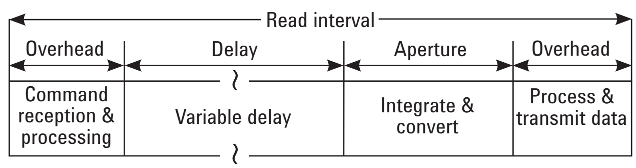



Read interval can be programmed in us increments for values up to 65 mS, and in 20 µs increments to 1 second

## Transaction Speed

Transactional I/O speed is a single reading measurement. This is important when you are taking many single measurements with the DMM. The M9183A delivers the highest transactional measurement speed in its class. These fast readings, up to 20,000 readings per second with a read interval rate of 50 µs, translate into higher test-system throughput and lower cost of test per unit tested.

Variable delay can be programmed to allow fully settled readings in any configuration.




Time frame of a single measurement
Minimum read interval = 50 µs (M9183A only)

## System Reading and Throughput Rates

| Switching ranges within a function | Aperture (A) | Range change time (ms) |
|---|---|---|
| DCV | A ≤ 20 ms | (A × 0.2) + 15 |
| | A > 20 ms | A + 15.6 |
| Resistance (2-wire or 4-wire) | A < 33 ms | (A × 0.05) + 15.5 |
| | A ≥ 33 ms | A + 13 |
| DCI (200 mA or 2 A to any other range) | A ≤ 40 ms | 4.2 |
| | A > 40 ms | 15.7 |
| DCI (all other ranges) | All apertures | 1 |
| Capacitance | All apertures | 12 |

| Switch between functions | Aperture (A) | Function change time (ms) |
|---|---|---|
| DCV | A < 16 ms | 15.6 |
| | A ≥ 16 ms | A + 25 |
| Resistance to DCI | A < 16.66 ms | 7.8 |
| | 16.66 ms ≤ A < 40 ms | A × 0.65 |
| | 40 ms < A < 66.66 ms | 7.8 |
| | A ≥ 66.66 ms | (A × 0.51) + 45 |
| DCV to capacitance | A < 33.33 ms | 23.4 |
| | A ≥ 33.33 ms | (A × 0.65) + 50 |
| Resistance to capacitance | A ≤ 33.33 ms | 23.4 |
| | 33.33 ms < A < 80 ms | (A × 2) + 35 |
| | 80 ms ≤ A < 160 ms | 23.4 |
| | A ≥ 160 ms | 160 |

# M9182A and M9183A Technical Specifications and Characteristics (continued)

| | |
|---|---|
| **DC voltage** | |
| Measurement method | Delta-sigma A/D conversion |
| Input resistance | 200 mV, 2.0 V ranges: > 10 GΩ with typical leakage of < 50 pA; |
| | 20 V, 200 V, 300 V ranges: 10.0 MΩ |
| Input isolation | 330 VDC, 250 VAC from Earth ground |
| Input overvoltage protection | 330 VDC all ranges |
| DCV noise rejection | Normal mode rejection at 50, 60, or 400 Hz ± 0.5%; > 95 dB (apertures ≥ 0.160 s); CMRR (1 kΩ lead imbalance) ≥ 120 dB |
| **True RMS AC voltage** | |
| Measurement method | AC coupled (10 Hz to 100 kHz) true RMS — measures the AC component only analog RMS DC converter |
| Crest factor | Maximum crest factor of 4 at full scale, 7 at 10% of range |
| Input impedance | 1 MΩ, in parallel with < 300 pF |
| Settling time | < 0.05 sec to within 0.15 of final value<br>Fast RMS: < 0.05 sec to within 0.1% of final value |
| Peak input | 8 x 106 volt Hz product (example: 250 V @ 32 kHz) |
| Input overvoltage protection | 330 VAC all ranges |
| ACV noise rejection | Common mode rejection at 50 Hz or 60 Hz; 1 kΩ imbalance in either lead > 60 dB |
| **Resistance** | |
| Measurement method | Selectable 2-wire or 4-wire. Current source referenced to LO output |
| Offset compensation (M9183A only) | All ranges, use with apertures > 5 ms |
| Maximum test voltage | 240 mV for 20 Ω and 200 Ω ranges; 2.4 V for 20 kΩ to 20 MΩ ranges;<br>1.0 V for 200 MΩ range (M9183A only) |
| Maximum lead resistance (4-wire) | 50 kΩ for 200 kΩ, 2.0 MΩ, and 20 MΩ ranges; 5 kΩ for 20 kΩ range<br>500 Ω for 200 Ω and 2 kΩ ranges |
| Input protection | 330 V on all ranges |
| **DC current** | |
| Shunt resistance | 10 Ω for 2 mA and 20 mA, 0.1 Ω for 200 mΩ and 2 A;<br>Virtual zero shunt for lower current ranges (M9183A only) |
| Input protection | Protected with 2.5 A, 250 V fast blow fuse |
| **True RMS AC current** | |
| Measurement method | AC coupled true RMS measurement (measures the AC component only.) analog RMS DC converter. |
| Shunt resistance | 10 Ω for 2 mA and 20 mA, 0.1 Ω for 200 mA and 2 A;<br>virtual zero shunt for lower current ranges (M9183A only) |
| Input protection | Protected with 2.5 A, 250 V fast blow fuse |

# M9182A and M9183A Technical Specifications and Characteristics (continued)

| | |
|---|---|
| **Frequency and period** | |
| Measurement method | Direct (conventional) counting |
| Input impedance | 1 MΩ with < 300 pF |
| Sensitivity (130 Hz) | .001 Hz |
| **Totalizer (M9183A only)** | |
| Active edge polarity | Positive or negative transition |
| Maximum count | 10,000,000,000 |
| Allowed rate | 1 to 30,000 events per second |
| Threshold | Set threshold DAC |
| Accuracy | ±2 counts |
| **Capacitance** | |
| Measurement method | Differential charge balance: variable currents used to stimulate dV/dt response. |
| Connection type | 2-wire |
| **Environmental and physical characteristics** | |
| Temperature range | Operating –10° to 55° C<br>Non-operating –40° to +85° C |
| Relative humidity | Operating to 80% at 40° C<br>Storage to 95% at 40° C |
| Connectors | V HI, 2-wire Ω IN, DCV OUT — Sheathed banana jack<br>V LO, 2-wire Ω IN, DCV OUT — Sheathed banana jack<br>I HI, 4-wire Ω IN — Sheathed banana jack<br>I LO, 4-wire Ω IN — Sheathed banana jack<br>Sync OUT — DIN 7, pin 2<br>External Trigger IN — DIN 7, pin 7<br>Trigger and Sync common — DIN 7, pin 4 |
| Safety | Complies with IEC 61010-1, Cat II 300 V, pollution degree 2 |
| EMC | Complies with EN61326-1 Industrial Environment |
| Warm-up time | 1 hour |

| **Physical characteristics** | |
|---|---|
| Dimensions | 3U/1-slot PXI/CompactPCI standard |
| Weight | 0.5 kg (1 lb.) |

| **Power dissipation:** | |
|---|---|
| +5 V | Total power |
| 300 mA | 1.5 W max |

# N6702A MPS Mainframes Technical Specifications

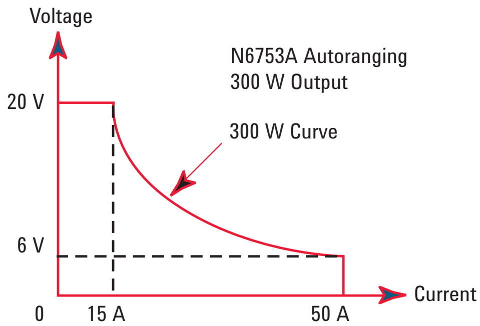
| Technical specifications | | | |
|---|---|---|---|
| Maximum total output power (= sum of total module output power) | N6700B | 400 W | when operating from 100 – 240 VAC input |
| | N6701A | 600 W | when operating from 100 – 240 VAC input |
| | N6702A | 1200 W | when operating from 200 – 240 VAC input |
| | | 600 W | when operating from 100 – 120 VAC input |
| Command processing time | From receipt of command to start of the output change | ≤ 1 ms | |
| Protection response characteristics | INH input<br>Fault on coupled outputs | 5 μs from receipt of inhibit to start of shutdown<br>< 10 μs (from receipt of fault to start of shutdown) | |
| Digital control characteristics | Maximum voltage ratings | 16.5 VDC/- 5 VDC between pins (pin 8 is internally connected to chassis ground). | |
| | Pins 1 and 2 as FLT output | Maximum low-level output voltage = 0.5 V @ 4 mA<br>Maximum low-level sink current = 4 mA<br>Typical high-level leakage current = 0.14 mA @ 16.5 VDC | |
| | Pins 1 - 7 as digital/trigger (pin 8 = common) outputs | Maximum low-level output voltage = 0.5 V @ 4 mA; 1 V @ 50 mA; 1.75 V @ 100 mA<br>Maximum low-level sink current = 100 mA<br>Typical high-level leakage current = 0.12 mA @ 16.5 VDC | |
| | Pins 1 - 7 as digital/trigger inputs and pin 3 as INH input (pin 8 = common) | Maximum low-level input voltage = 0.8 V<br>Minimum high-level input voltage = 2 V<br>Typical low-level current = 2 mA @ 0 V (internal 2.2 k pull-up<br>Typical high-level leakage current = 0.12 mA @ 16.5 VDC | |
| Interface capabilities | GPIB: | SCPI - 1993, IEEE 488.2 compliant interface | |
| | LXI compliance | Class C (applies to mainframes with firmware revision C.00.02 and up) | |
| | USB 2.0 | Requires Keysight IO Library version M.01.01 and up, or 14.0 and up | |
| | 10/100 LAN | Requires Keysight IO Library version L.01.01 and up, or 14.0 and up | |
| | Built-in web server | Requires Internet Explorer 5+ or Netscape 6.2+ | |
| Environmental conditions | Operating environment | Indoor use, installation category II (for AC input), pollution degree 2 | |
| | Temperature range | 0° C to 55° C (current is derated 1% per ° C above 40° C ambient temperature) | |
| | Relative humidity | Up to 95% | |
| | Altitude | Up to 2000 meters | |
| | Storage temperature | –30° C to 70° C | |
| | LED statement | Any LEDs used in this product are Class 1 LEDs as per IEC 825-1 | |

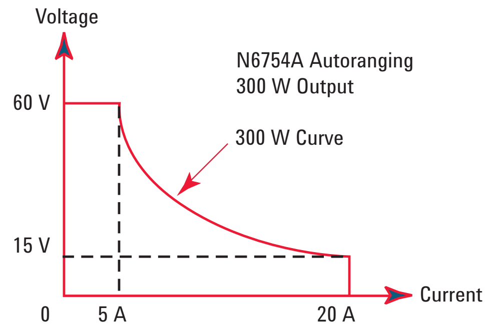
# N6702A MPS Mainframes Technical Specifications (continued)

| Technical specifications | | |
|---|---|---|
| Regulatory compliance | EMC | Complies with the European EMC directive 89/336/EEC for Class A test and measurement products.<br>Complies with the Australian standard and carries the C-Tick mark.<br>This ISM device complies with Canadian ICES-001.<br>Cet appareil ISM est conforme à la norme NMB-001 du Canada.<br>Electrostatic discharges greater than 1 kV near the I/O connectors may cause the unit to reset and require operator intervention. |
| | Safety | Complies with the European Low Voltage Directive 73/23/EEC and carries the CE-marking. This product also complies with the US and Canadian safety standards for test and measurement products. |
| Acoustic noise declaration | This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991. | Sound Pressure Lp < 70 dB(A),<br>*At Operator Position, *Normal Operation, *According to EN 27779 (Type Test).<br>Schalldruckpegel Lp <70 dB(A)<br>*Am Arbeitsplatz, *Normaler Betrieb, *Nach EN 27779 (Typprüfung). |
| Output terminal isolation | Maximum Rating | No output terminal may be more than 240 VDC from any other terminal or chassis ground. |
| AC input | Nominal input ratings | 100 VAC – 240 VAC; 50/60 Hz/400 Hz |
| | Input range | 86 VAC – 264 VAC |
| | Power consumption | 1000 VA typical (N6700B mainframes)<br>1500 VA typical (N6701A mainframes)<br>3000 VA typical (N6702A mainframes) |
| | Fuse | Internal fuse (not customer accessible) |
| Dimensions | Height | 44.45 mm; 1.75 in. |
| | Width | 432.5 mm; 17.03 in. |
| | Depth (including handles) | 585.6 mm; 23.06 in. (N6700B/N6701A mainframes)<br>633.9 mm; 24.96 in. (N6702A mainframes) |
| Weight | N6700B with 4 installed modules | Net: 12.73 kg; 28 lbs. |
| | N6701A with 4 installed modules | Net: 11.82 kg; 26 lbs. |
| | N6702A with 4 installed modules | Net: 14.09 kg; 31 lbs. |
| | Single-wide power module | Net: 1.23 kg; 2.71 lbs |
| | Double-wide power module | Net: 2.18 kg; 4.8 lbs |

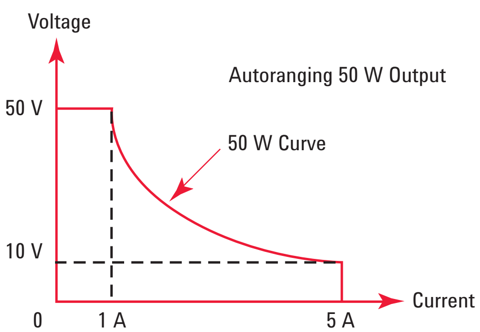
# N6702A MPS Mainframes Technical Specifications (continued)

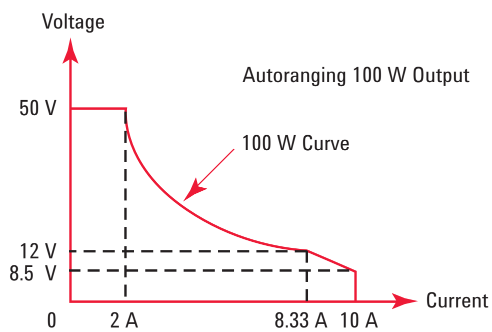
| Power Module Option Characteristics | | |
|---|---|---|
| Output relays (Option 760/761) | Type | Double-pole, double-throw |
| | Location | Output & sense terminals |
| Output lists (Option 054) | Maximum number of steps = 512 | |
| | Maximum dwell time in seconds = 262 | |
| | Maximum list repetitions = 256, or infinite | |
| Digitized measurements (Option 054) | Maximum measurement points = 4096 | |
| | Maximum sample rate = 50 kHz | |

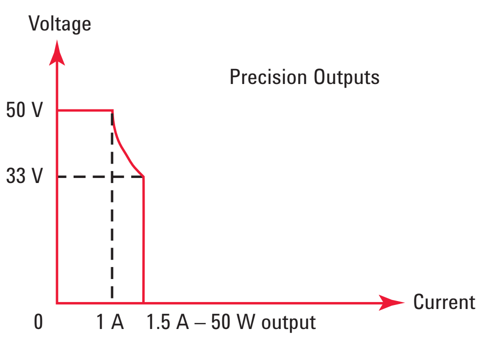



**Autoranging Characteristic**



# L4532A and L4534A Specifications (continued)

| **Specifications** | |
|---|---|
| **L4532A (2 channel) or L4534A (4 channel) digitizers with ADCs per channel** | |
| Max sample rate | 20 MSa/s |
| Sample resolution | 16 Bits |
| Input configuration | Isolated inputs (each channel independently isolated) |
| Isolation voltage (low to chassis) | ±40 V |
| Maximum input (Hi to Low) | ±250 Vpk[1] |
| Maximum input range | ±256 V |
| Input impedance | 1 MΩ \|\| 40 pF |
| Input coupling | DC or AC |
| AC cutoff freq (–3 dB) | < 10 Hz |
| Input ranges: | ±256 V, ±128 V, ±64 V, ±32 V, ±16 V, ±8 V, ±4 V, ±2 V, ±1 V, ±500 mV, ±250 mV |
| Over voltage protection | Yes |
| Maximum overvoltage transient | ±400 Vpk |
| Analog bandwidth (–3 dB) | 20 MHz typical |
| Noise filtering (2-pole Bessel) | 200 KHz, 2 MHz typical |
| Power requirements | |
| Line Voltage: | 100 to 240 VAC (universal) |
| Line frequency: | 50 Hz or 60 Hz |
| Power consumption: | 45 W (100 VA) |
| Safety conforms to | |
| IEC/EN 61010-1:2001( EU) | |
| CAN/CSA-C22.2 No. 61010-1-04 (Canada) | |
| UL 61010-1 (2nd Edition) (US) | |
| AS 61010.1:2003 (Australia/New Zealand) | |
| EMC conforms to | |
| IEC 61326-1:2005-12 (EU) | |
| EN 61326-1:2006 | |
| ICES-001:2004 (Canada) | |
| AS/NZS CISPR 11:2004 | |

1. CAT I IEC measurement Category I. Inputs may be connected only to circuits that are isolated from AC mains.
2. EXTernal can be used as an ARM source or a Trigger source, but not both at the same time.
3. OR can only be used if the EXTernal source is being used as a Trigger source.
4. Pulse width 1 µs (200 ns for records taking <2 µs to complete).
5. TTL output pulse can be configured for either rising or falling edge.
6. Latency between Level/window trigger detection and first (trigger) sample.

**Arm and Trigger**

Each Arm event gates 1 or more trigger events. Each Trigger event causes acquisition of data into a single record at the configured sample rate. The number of data records is configurable from 1 to 1024.

| Source | ARM | Trigger | Description |
|---|---|---|---|
| IMMediate | ● | ● | Trigger or ARM at INIT time |
| EXTernal[2] | ● | ● | BNC TTL input edge (selectable rising/falling edge |
| Software | ● | ● | Instrument commands |
| Timer | ● | | 0.0 s to 3600.0 s with 50 ns resolution |
| Channel/Edge | | ● | Selectable level, rising/falling, hysteresis |
| Channel/Window | | ● | Selectable high and low levels, leaving/entering, hysteresis |
| OR[3] | | ● | Logical OR of channel trigger source and External |

| **Sampling** | |
|---|---|
| Programmable sample rates: | 1 KSa/s, 2 KSa/s, 5 KSa/s, 10 KSa/s, 20 KSa/s, 50 KSa/s, 100 KSa/s, 200 KSa/s, 500 KSa/s, 1 MSa/s, 2 MSa/s, 5 MSa/s, 10 MSa/s, 20 MSa/s |
| External event output: | |
| Event types: | Trigger, end-of-record, end-of-acquisition |
| Output signal: [4,5] | TTL (rising edge) |
| Impedance: | 25 ohm or 50 ohm |
| Trigger modes: | |
| Pre trigger | 0 to record length – 4 |
| Post trigger | Record length-pretrigger |
| Timestamp triggered event | Elapsed time since INIT, or CONTinuous running timestamp |
| Timestamp resolution | 12.5 ns |
| Trigger delay | 0 – 3600 s with 50 ns resolution |
| Trigger holdoff | 0 – 10 s with 50 ns resolution |
| Trigger latency [6] | 12.5 ns |
| Trigger reactive | |
| Ext input trigger latency | 40 ns to 51 ns |
| Ext output trigger latency | 4 ns to 21 ns |

# L4532A and L4534A Specifications (continued)

| **Accuracy** [1] | | | | | |
|---|---|---|---|---|---|
| **DC Accuracy – Total specification (% of reading + % of range)**[4] | | | | | |
| | 23° C ± 5° C | | $T_{autozero}$ ±3° C [5] | Temp coefficient outside 18-28° C | |
| **Range** | **±% of reading** | **±% of range** | **±% of range** | **±% of reading/C** | **±% of range/C** |
| 250 mV | 0.10 | 0.30 | 0.11 | 0.010 | 0.015 |
| 500 mV | 0.10 | 0.20 | 0.06 | 0.010 | 0.010 |
| 1 V, 2 V | 0.10 | 0.12 | 0.04 | 0.010 | 0.010 |
| 4 V, 64 V | 0.10 | 0.30 | 0.05 | 0.010 | 0.015 |
| 8 V, 128 V | 0.10 | 0.20 | 0.04 | 0.010 | 0.010 |
| 16 V, 32 V, 256 V | 0.10 | 0.12 | 0.04 | 0.010 | 0.010 |

| | |
|---|---|
| Integral nonlinearity | ±5 LSB |
| Differential nonlinearity | ±1 LSB typical, no missing codes |
| Input bias current | < 10 nA typical |

| **Dynamic Characteristics** [4] **(Measured using a 65536 point FFT)** | | | | | |
|---|---|---|---|---|---|
| Input range 980 kHz input (–1 dBFS) | | | | | |
| | SFDR - dBc | THD - dBc | SNR - dB | SINAD - dB | ENOB [2] |
| 250 mV | 71 | 79 | 67 | 66.7 | 10.8 |
| 500 mV | 77 | 83 | 70 | 69.8 | 11.3 |
| 1 V | 81 | 85 | 73 | 72.7 | 11.8 |
| 2 V | 85 | 82 | 75 | 74.2 | 12.0 |
| 4 V | 70 | 80 | 64 | 63.9 | 10.3 |
| 8 V | 70 | 83 | 65 | 64.9 | 10.5 |
| 16 V | 70 | 81 | 65 | 64.9 | 10.5 |
| Input range 10 MHz input (-1 dBFS) | | | | | |
| 250 mV | 71 | 71 | 66 | 64.8 | 10.5 |
| 500 mV | 71 | 73 | 68 | 66.8 | 10.8 |
| 1 V | 69 | 68 | 72 | 66.5 | 10.8 |
| 2 V | 63 | 62 | 72 | 61.6 | 9.9 |

| | |
|---|---|
| AC flatness (DC-4 MHz) | ±0.28 dB relative to 1 kHz |
| 250 mV | ±0.20 dB relative to 1 kHz |
| 500 mV, 1 V, 2 V, 4 V, 8 V, 16 V, 32 V | ±0.2 dB ±0.01 dB/° C |
| 64 V, 128 V, 256 V | relative to 1 kHz |
| Crosstalk (Ch to Ch) $R_s$ = 50 Ohm | <–90 dB @ 1 MHz |

1. 100,000 reading average @ 1 MSa/s
2. For 1 V range and greater, typical offset with constant temperature is 0.01% of range.
3. ENOB = (SINAD - 1.76)/6.02
4. External timebase measurements made with 1 Vpp sinewave with <2 ps RMS jitter.

## L4532A and L4534A Specifications (continued)

| Timing and synchronization | |
|---|---|
| Internal timebase accuracy | ±50 ppm |
| Internal timebase output (Clock out BNC) | |
| Frequency | 10 MHz |
| Level | >1 Vpp |
| External timebase reference (Clock in BNC) | |
| Lock range | 10 MHz ±5000 pp (10 MHz ±50 kHz) |
| Clock lock skew (typical) | ±10 ns (typical) |
| Level | 1 Vpp sinewave min <2 psec rms jitter |
| Input resistance nominal | 100 kΩ nominal |
| **Waveform memory** | |
| Data memory | |
| Standard [1] | 32 MSa/ch |
| Extended [1] | 128 MSa/ch |
| Random access to readings Multiple record mode | Capture multiple records from multiple triggers |
| **Waveform measurements** | |
| Voltage | peak-to-peak, minimum, maximum, average, RMS, amplitude, base, top, overshoot, preshoot, upper, middle, lower |
| Time | rise, fall, period, frequency, positive width, negative width, duty cycle |
| **Utilities** | |
| Calibration | |
| Calibration cycle | 1 year |
| Internal calibration source | 0 to ±16 V typical |
| Electronic calibration | Requires an external 6.5 digit DMM and PC |
| Self test | Power on self test, Complete test performed via *TST? command |

| Hardware | |
|---|---|
| 1U Full rack LXI | 425.7 mm W x 44.5 H x 367.9 mm D |
| Weight | |
| L4532A (2 Ch) | 3.3 kg |
| L4534A (4 Ch) | 3.63 kg |
| Front panel | Power switch & display |
| Back panel (Connectors) | |
| Power input | |
| Input channels | BNC |
| Cal Src Out | BNC |
| 10 MHz In | BNC |
| 10 MHz Out | BNC |
| Trig In/Out | BNC |
| I/O interface | LAN (Gbit), USB 2.0 |
| **Software** | |
| Web interface: | Internet Explorer, IE (version 6 & 7), Mozilla Firefox and Netscape. Requires Java-enabled browser (Java 1.6 or greater) |
| Programming language: | ASCII commands, IEEE 488.2 compliant |
| Computer interfaces: | |
| LAN: Standard LAN 10/100/1000BaseTx | (VXI-11[2] compliant), Sockets (service at port 5025), Telnet (service at port 5024)) |
| USB: Standard USB 2.0 | (USBTMC[3] compliant) |
| Programming via direct native command set: | |
| VISA IO control (LAN or USB) | Keysight IO Libraries Suite 15.0 or greater recommended |
| LAN sockets control (LAN only) | <Sockets programming> |
| Programming via software driver IVI-COM, IVI-C Driver for Window 2000/XP/Vista, G driver for LabVIEW | |
| Compatible with programming tools and environments: Keysight VEE Pro, Microsoft Visual Studio.NET, C/C++, Visual Basic 6, National Instruments Test Stand, Measurement Studio, LabWindows/CVI, LabVIEW | |

1. Nominal values. Specific sample max is 33,554,432 and 134,205,440 samples.
2 VXI-11 allows transfer of IEEE 488.1 and IEEE 488.2 messages over a TCP/IP network. Supported by Keysight IO Library Suite (included)
3. USB Test and Measurement Class (TMC) that communicates over USB, complying with IEEE 488.1 and IEEE 488.2 standards. Supported by Keysight IO Library Suite (included)

# L4532A and L4534A Specifications (continued)

| Minimum system requirements (I/O libraries & drivers) | | |
|---|---|---|
| Operating system | Windows XP SP2 (or later)<br>Windows 2000 Professional SP4 (or later) | Windows Vista 32-bit (Home, Basic, Premium, Business, Ultimate, Enterprise) |
| Processor | 450 MHz Pentium II or higher required.<br>800 MHz recommended | 1 GHz 32-bit (x86) |
| Available memory | 128 MB minimum,<br>(256 MB or greater recommended) | 512 MB minimum<br>(1 GB recommended) |
| Available disk space | 280 MB minimum,<br>1 GB recommended for Microsoft.NET framework 2.0,<br>65 MB for Keysight IO Libraries Suite | |
| Video | Super VGA (800 x 600), 256 colors or more | Support for Direct X 9 graphics with 128 MB graphics memory recommended (Super VGA graphics is supported) |
| Browser | Microsoft Internet Explorer 5.01 or greater | Microsoft Internet Explorer 7 or greater |

| Environmental | |
|---|---|
| Operational environment: | Pollution degree 2, indoors |
| Operating temperature: | 0 to 55° C |
| Storage temperature: | –40 to+70° C |
| Warm-up period: | <60 min to rated specs |
| Relative humidity @ 40° C: | 20 to 95% non-condensing |
| Vibration: | Keysight’s ETM limits |

| Data storage/transfer | |
|---|---|
| Pre trigger data: | Up to full record length<br>-4 samples |
| Record Length: | 8 samples to 32 MSa/128 MSa |
| Post trigger data: | 4 samples to 128 MSamples |
| Maximum number of triggers: | Number of records (triggers) configurable to 1024 records |
| Resolution: | One sampling interval |
| Timestamp rollover | >1.5 years |
| Maximum data transfer rate from memory | |
| USB 2.0 | 8 MB/s |
| Gbit LAN | 15.0 MB/s |

| Ordering information | |
|---|---|
| L4532A | 2 channel 20 MSa/s digitizer |
| Opt 001 | Standard memory (32 MS/ch) |
| Opt 002 | Extended memory (128 MS/ch) |
| L4534A | 4 channel 20 MSa/s digitizer |
| Opt 001 | Standard memory (32 MS/ch) |
| Opt 002 | Extended memory (128 MS/ch) |
| **Includes Product Reference CD (Products doc and examples), IO Libraries CD, and Power Cord.** | |
| Accessories | |
| Opt 908 | Rack mount kit L4532-67001 |
| Option 0B0 | Deletes printed manual set |
| Option ABA | (Full documentation included on CD ROM)<br>English printed manual set |

For additional information please visit:
http://www.Keysight.com/find/L4534A

| Related Keysight literature |
|---|
| *Keysight VEE Pro*, Data sheet, Literature No. 5989-7427EN |
| *Keysight E2094N IO Libraries Suit*e, Data sheet, Literature No. 5989-1439EN |

# L4451A Specifications and Characteristics

| **Output specifications** | |
|---|---|
| Maximum update rate: | 200 kHz point-to-point |
| Monotonic : | to 16-bits |
| Isolation: | > 80 VDC/AC peak (chan-to-chassis or chan-to-chan) |
| Synchronization: | Software commands or external trigger |
| Internal/external CLK accuracy: | 100 ppm |
| AC accuracy: | Not specified |
| **DC voltage** | |
| Amplitude: | ±16 V up to 10 mA |
| Resolution: | 16-bit = 500 µV |
| Amplitude Accuracy (DC): | ±(0.05% + 3.0 mV |
| Ripple and noise: | < 2 mVrms, 20 Hz to 250 kHz into 10 kΩ load |
| Settling time: | 40 µs (-full scale to +full scale step, single channel, to rated accuracy) |
| Output impedance: | < 1 Ω with the load sensed |
| **DC current** | |
| Range: | ±20 mA |
| Resolution: | 16-bit = 630 nA |
| Accuracy: | ±(% value + amps) (temperature within ±5° C of Tcal or *Cal?) 90-day: ±(0.09% + 5.0 µA) |
| Ripple and noise: | < 2 µArms, 20 Hz to 250 kHz into 250 Ω |
| Compliance voltage: | ±12 V |
| Max open circuit voltage: | < ±22 V |

| **Phase-locking I/O trigger characteristics** | | |
|---|---|---|
| Trigger input | Input level: | TTL compatible (3.3 V logic, 5 V tolerant) |
| | Slope: | Rising or falling, selectable |
| | Pulse width: | > 100 ns |
| | Input impedance: | > 10 kΩ, DC coupled |
| Trigger output | Level: | TTL compatible into 1 kΩ (3.3 V logic) |
| | Output impedance: | 50 Ω typical |
| Clock input | Input level: | TTL compatible (3.3 V logic, 5 V tolerant) |
| | Input impedance: | > 10 kΩ, DC |
| | Maximum rate: | 10 MHz |
| Clock output | Level: | TTL compatible Into 1 kΩ (3.3 V logic) |
| | Output impedance: | 50 Ω typical |
| | Maximum rate: | 10 MHz |
| | Accuracy: | ±100 ppm |

## L4451A Specifications and Characteristics (continued)

| | |
|---|---|
| **Memory** | |
| Type | Volatile |
| Size | 500 K for waveforms |
| States | 5 instrument states with user label in non-volatile memory |
| **General specifications** | |
| Power supply | Universal 100 V to 240 V ±10% |
| Power line frequency | 50 Hz to 60 Hz ±10% automatically sensed |
| Power consumption | 15 VA |
| Operating Environment | Full accuracy for 0° C to 55° C<br>Full accuracy to 80% R.H. at 40° C |
| Storage environment | -40° C to 70° C |
| Dimensions (H x W x L) | 40.9 x 212.3 x 379.3 mm (1.61 x 8.36 x 14.93 in) |
| Weight | 3.7 kg, 8.2 lbs |
| Safety conforms to | CSA, UL/IEC/EN 61010-1 |
| EMC conforms to | IEC/EN 61326-1, CISPR 11 |
| Warranty | 1 year |
| **Software** | |
| Keysight connectivity software included | Keysight I/O Libraries Suite 14 or greater (E2094N) |
| **Minimum system requirements** | |
| PC hardware | Intel Pentium 100 MHz, 64 Mbyte RAM, 210 Mbyte disk space<br>Display 800x600, 256 colors, CD-ROM drive |
| Operating system[1] | Windows 98 SE/NT/2000/XP |
| **Computer interfaces** | |
| | Standard LAN 10BaseT/100BaseTx<br>Optional IEEE 488.2 GPIB |
| **Software driver support for programming languages** | |
| Software drivers | IVI-C and IVI-COM for Windows NT/2000/XP<br>LabVIEW |
| **Compatible with programming tools and environments** | |
| Keysight | VEE Pro<br>T&M Toolkit<br>(reqs Visual Studio.NET) |
| National Instruments | TestStand<br>Measurement Studio<br>LabWindows/CVI<br>LabVIEW<br>Switch Executive |
| Microsoft | Visual Studio.NET<br>C/C++<br>Visual Basic 6 |

1. Load I/O Libraries Version M for Windows NT support or version 14.0 for Windows 98 SE support

# 33521A Specifications

Unless otherwise stated, all specifications apply with a 50 Ω resistive load.

| | | |
|---|---|---|
| **Instrument characteristics** | | |
| **Models & options** | | |
| 33521A | 1-channel | |
| 33522A | 2-channel | |
| Option 002 | Increases arbitrary waveform memory to 16 MSa/channel | |
| Option 010 | OCXO timebase for ultra-high stability | |
| Option 400 | GPIB interface | |
| **Waveforms** | | |
| Standard | Sine, square, ramp, pulse, triangle, Gaussian noise, PRBS (Pseudorandom Binary Sequence), DC | |
| Built-in arbitrary | Cardiac, exponential fall, exponential rise, Gaussian pulse, Haversine, Lorentz, D-Lorentz, negative ramp, sinc | |
| User-defined arbitrary | Up to 1 MSa (16 MSa with Option 002) with multi-segment sequencing | |
| **Operating modes & modulation types** | | |
| Operating modes | Continuous, modulate, frequency sweep, burst, output gate | |
| Modulation types | AM, FM, PM, FSK, BPSK, PWM, Sum (carrier + modulation) | |
| **Waveform characteristics** | | |
| **Sine** | | |
| Frequency range | 1 μHz to 30 MHz, 1-μHz resolution | |
| Amplitude flatness (spec)[1, 2]<br>(relative to 1 kHz) | < 100 kHz:<br>100 kHz to 5 MHz:<br>5 to 20 MHz:<br>20 to 30 MHz: | ± 0.10 dB<br>± 0.15 dB<br>± 0.30 dB<br>± 0.40 dB |
| Harmonic distortion (typical) [2, 3] | < 20 kHz:<br>20 to 100 kHz:<br>100 kHz to 1 MHz:<br>1 to 20 MHz:<br>20 to 30 MHz: | < –70 dBc<br>< –65 dBc<br>< –50 dBc<br>< –40 dBc<br>< –35 dBc |
| THD (typical) | 20 Hz to 20 kHz: | < 0.04% |
| Non-harmonic spurious (typical) [2, 3] | Standard: < –75 dBc, increasing +20 dB/decade above 2 MHz<br>Option 010: < –75 dBc, increasing +20 dB/decade above 10 MHz<br>(or < –100 dBm, whichever is greater, below 500 MHz) | |
| Phase noise (SSB) (typical)<br>1 kHz offset:<br>10 kHz offset:<br>100 kHz offset: | Standard<br>–105<br>–115<br>–125 | Option 010<br>–110 dBc/Hz<br>–125 dBc/Hz<br>–135 dBc/Hz |

1. Add 1/10th of the output amplitude and offset accuracy specification per ° C for operation at temperatures beyond 23°C ± 5° C.
2. Auto range ON.
3. DC Offset set to zero.

# 33521A Specifications (continued)

| Waveform characteristics (continued) | |
|---|---|
| **Square & pulse** | |
| Frequency range | 1 μHz to 30 MHz, 1 μHz resolution |
| Rise and fall times (nominal) | Square: 8.4 ns, fixed<br>Pulse: 8.4 ns to 1 μs, independently variable, 100-ps or 3-digit resolution |
| Overshoot (typical) | < 2% |
| Duty cycle | 0.01% to 99.99% [1] |
| Pulse width | 16 ns minimum, 100-ps resolution |
| Jitter (cycle-to-cycle, typical) | < 40 ps rms |
| Built-in arbitrary | Cardiac, exponential fall, exponential rise, Gaussian pulse,<br>Haversine, Lorentz, D-Lorentz, negative ramp, sinc |
| **Ramp & triangle** | |
| Frequency range | 1 μHz to 200 kHz, 1 μHz resolution |
| Ramp symmetry | 0.0% to 100.0%, 0.1% resolution<br>(0% is negative ramp, 100% is positive ramp, 50% is Triangle) |
| Nonlinearity (typical) | < 0.05% from 5% to 95% of the signal amplitude |
| **Gaussian noise** | |
| Bandwidth (typical) | 1 mHz to 30 MHz, variable |
| Crest factor (nominal) | 4.6 |
| Repetition period | > 50 years |
| **Pseudorandom binary sequence (PRBS)** | |
| Bit rate | 1 mbps to 50 Mbps, 1 mbps resolution |
| Sequence length | $2^{m-1}$, m=7, 9, 11, 15, 20, 23 |
| Rise and fall times (nominal) | 8.4 ns to 1 μs, variable, 100-ps or 3-digit resolution |

| Arbitrary waveform characteristics | | |
|---|---|---|
| **General** | | |
| Waveform length | 8 Sa to 1 MSa (16 MSa with Option 002) in increments of 1 sample | |
| Sample rate | 1 μSa/s to 250 MSa/s, 1 μSa/s resolution | |
| Voltage resolution | 16 bits | |
| Bandwidth (–3 dB, nominal) | Filter Off:<br>“Normal” Filter On:<br>“Step” Filter On: | 40 MHz<br>0.27 x (Sample Rate)<br>0.13 x (Sample Rate) |
| Rise and fall time | 0.35 / Bandwidth (10 ns min) with "Normal" or "Step" filter On | |
| Settling time (typical) | < 200 ns to 0.5% of final value | |
| Jitter (typical) | Filter Off:<br>“Normal” or “Step” filter On: | < 40 ps rms<br>< 5 ps |

1. Subject to pulse width limits.

# 33521A Specifications (continued)

| | |
|---|---|
| **Arbitrary waveform characteristics (continued)** | |
| Waveform sequencing | |
| Operation | Individual arbitrary waveforms (segments) can be combined into user-defined lists (sequences) to form longer, more complex waveforms. Each sequence step specifies whether to repeat the associated segment a certain number of times, to repeat it indefinitely, to repeat it until a Trigger event occurs, or to stop and wait for a Trigger event. Additionally, the behavior of the Sync output can be specified in each step.<br>To improve throughput, up to 32 sequences totalling up to 1,024 segments can be pre-loaded into volatile memory. |
| Segment length | 8 Sa to 1 MSa (16 MSa with Option 002) in increments of 1 sample |
| Sequence length | 1 to 512 steps |
| Segment repeat count | 1 to $1x10^6$, or infinite |
| **Output characteristics** | |
| Isolation | |
| Outputs | Connector shells for channel output(s), Sync, and Mod In are connected together but isolated from the instrument's chassis. Maximum allowable voltage on isolated connector shells is ±42 Vpk |
| Signal output | |
| Output impedance (nom) | 50 Ω |
| On, off, inverted | User-selectable for each channel |
| Voltage limit | User-definable $V_{MAX}$ and $V_{MIN}$ limits |
| Overload protection | Output turns off automatically when an overload is applied<br>Instrument will tolerate a short-circuit to ground indefinitely |
| Built-in arbitrary | Cardiac, exponential fall, exponential rise, Gaussian pulse, Haversine, Lorentz, D-Lorentz, negative ramp, sinc |
| Amplitude | |
| Range | 1 mVpp to 10 Vpp into 50 Ω<br>2 mVpp to 20 Vpp into open circuit |
| Resolution | 4 digits |
| Units | Vpp, Vrms, or dBm, selectable |
| Accuracy [1, 2] (spec) | ±1% of setting ±1 mVpp at 1 kHz |
| DC offset | |
| Range [5] | ±(5 VDC - Peak AC) into 50 Ω<br>±(10 VDC - Peak AC) into open circuit |
| Resolution | 4 digits |
| Units | VDC |
| Accuracy [1, 2] (spec) | ±1% of Offset setting ±0.25% of Amplitude setting ±2mV |
| **Frequency accuracy** | |
| Standard freqeuncy reference (spec) | |
| 1 year, 23° C ± 5° C | ±1 ppm of setting ± 15 pHz |
| 1 year, 0° C to 55° C | ±2 ppm of setting ± 15 pHz |
| High-stability frequency reference (spec): Option 010 | |
| 1 year, 0° C to 55° C | ±0.1 ppm of setting ± 15 pHz |

1. Add 1/10th of the output amplitude and offset accuracy specification per ° C for operation at temperatures beyond 23° C ± 5° C.
2. Auto range ON.

## 33521A Specifications (continued)

| **Modulation types and operating modes** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Carrier | AM | FM | PM | FSK | BPSK | PWM | Sum | Burst | Sweep |
| Sine and Square | ● | ● | ● | ● | ● | | ● | ● | ● |
| Pulse | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Triangle and Ramp | ● | ● | ● | ● | ● | | ● | ● | ● |
| Gaussian Noise | ● | | | | | | ● | ●[a] | |
| PRBS | ● | ● | ● | | | | ● | ● | |
| Single ARB | ● | | ●[b] | | ●[b] | | ● | ● | |
| Sequenced ARB | ● | | | | | | ● | | |

| **Modulating signals** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Carrier | Sine | Square | Triangle / Ramp | Noise | PRBS | ARB | External |
| Sine | ● | ● | ● | ● | ● | ● | ● |
| Square and Pulse | ● | ● | ● | ● | ● | ● | ● |
| Triangle and Ramp | ● | ● | ● | ● | ● | ● | ● |
| Gaussian Noise | ● | ● | ● | | ● | ● | ● |
| PRBS | ● | ● | ● | ● | | ● | ● |
| ARB | ● | ● | ● | ● | ● | | ● |

| **Modulation characteristics** | |
|---|---|
| **Amplitude modulation (AM)** | |
| Source | Internal or external, or either channel with 33522A |
| Type | Full-carrier or double-sideband suppressed-carrier |
| Depth [1] | 0% to 120%, 0.01% resolution |
| **Frequency modulation (FM)2** | |
| Source | Internal or external, or either channel with 33522A |
| Deviation | 1 μHz to 15 MHz, 1 μHz resolution |
| **Phase modulation(PM)** | |
| Source | Internal or external, or either channel with 33522A |
| Deviation | 0° to 360°, 0.1° resolution |
| **Frequency shift key modulation (FSK)2** | |
| Source | Internal timer or ext trig connector |
| Mark & space | Any frequency within the carrier signal's range |
| Rate | 0 Hz to 1 MHz |
| **Binary phase shift key modulation (BPSK)** | |
| Source | Internal timer or ext trig connector |
| Phase shift | 0° to 360°, 0.1° resolution |
| Rate | 0 Hz to 1 MHz |
| **Pulse width modulation (PWM)** | |
| Source | Internal or external, or either channel with 33522A |
| Deviation[3] | 0% to 100% of pulse width, 0.01% resolution |
| **Additive modulation (Sum)** | |
| Source | Internal or external, or either channel with 33522A |
| Ratio[4] | 0% to 100% of carrier amplitude, 0.01% resolution |

1. Add 1/10th of the output amplitude and offset accuracy specification per ° C for operation at temperatures beyond 23° C ± 5° C.
2. All frequency changes are phase-continuous.
3. Subject to pulse width limits.
4. Subject to maximum output voltage limits.

# 33521A Specifications (continued)

| Burst[1] | |
|---|---|
| Type | Counted or gated |
| Count | 1 to 1x108 cycles, or infinite |
| Gated | Produces complete cycles while Ext Trig is asserted |
| Start/stop phase[2] | -360° to 360°, 0.1° resolution |
| Trigger source | Internal Timer or Ext Trig connector |
| Marker | Adjustable to any cycle; indicated by the trailing edge of the Sync pulse |
| **Sweep[3]** | |
| Type | Linear, Logarithmic, List (up to 128 user-defined frequencies) |
| Operation | Linear and Logarithmic sweeps are characterized by a Sweep time (during which the frequency changes smoothly from Start to Stop), a Hold time (during which the frequency stays at the Stop frequency), and a Return time (during which the frequency changes smoothly from Stop to Start). Returns are always linear. |
| Direction | Up (Start freq < Stop freq) or Down (Start freq > Stop freq) |
| Start and stop frequencies | Any frequency within the waveform's range |
| Sweep time | Linear: 1 ms to 3600 s, 1 ms resolution; 3601 s to 250,000 s, 1 s resolution<br>Logarithmic: 1 ms to 500 s |
| Hold time | 0 s to 3600 s, 1 ms resolution |
| Return time | 0 s to 3600 s, 1 ms resolution |
| Trigger source[4] | Immediate (continuous), external, single, bus, or timer |
| Marker | Adjustable to any frequency between Start and Stop for Linear and Logarithmic types or any frequency in the list for List type; indicated by the trailing edge of the sync pulse |
| **Internal timer for FSK, BPSK, BURST, and SWEEP** | |
| Range | 1 µs to 8000s, 6-digit or 4 ns resolution |
| **2-channel characteristics (33522A only)** | |
| Operating modes | Independent, coupled parameter(s), combined (Ch 1 + Ch 2), Equal (Ch 2 = Ch 1), or differential (Ch 2 = -Ch 1) |
| Parameter coupling | None, frequency (ratio or difference) and/or amplitude and DC offset |
| Relative phase | 0° to 360°, 0.1° resolution |
| Skew (typical) | < 200 ps (when performing identical operations) |
| Crosstalk (typical) | < –85 dB |

1. Counted Burst operation is not allowed for Gaussian Noise.
2. limited to arbitrary waveforms that are < 1 million points; phase resolution limited by number of points in arbitrary waveforms < 3,600 points.
3. All frequency changes are phase-continuous.
4. External trigger only for sweep time > 8000 sec.

# 33521A Specifications (continued)

| | |
|---|---|
| **Sync/marker output** | |
| Connector | Front-panel BNC, isolated from chassis |
| Functions | Sync, sweep marker, burst marker, or arbitrary waveform marker |
| Assignment | Channel 1 or channel 2 |
| Polarity | Normal or inverted |
| Voltage level (nominal) | 3 Vpp into open circuit, 1.5 Vpp into 50 Ω |
| Output impedance (nominal) | 50 Ω |
| Minimum pulse width (nominal) | 16 ns |
| **External trigger/gate** | |
| Connector | Rear-panel BNC, chassis-referenced |
| Function | Input or output |
| Assignment | Channel 1, channel 2, or both (as input)<br>Channel 1 or channel 2 (as output) |
| Polarity | Positive or negative slope |
| Voltage level (nominal) | 0 V to 0.4 V for low, > 2.3 V for high, 3.5 V maximum (as input)<br>3 Vpp (nom) into open circuit, 1.5 Vpp (nom) into 50 Ω (as output) |
| Impedance (nominal) | 10 k Ω, DC-coupled (as input)<br>50 Ω (as output) |
| Minimum pulse width (nominal) | 16 ns |
| Input rate | DC to 1 MHz |
| Minimum pulse width | 100 ns (as input) |
| Duty cycle (nominal) | 50% (as output) |
| Trigger delay | 0 s to 1000 s, 4 ns resolution; applies to all trigger events |
| Input latency (typical) | < 135 ns with Trigger Delay set to zero |
| Input jitter (typical) | < 2.5 ns, rms |
| Fanout | <= 4 total Keysight 33521A and 33522A |
| **Modulation input** | |
| Connector | Rear-panel BNC, isolated |
| Assignment | Channel 1, Channel 2, or both |
| Voltage level | ±5 V full-scale |
| Input impedance (nominal) | 5 k Ω |
| Bandwidth (-3 dB, typical) | 0 Hz to 100 kHz |
| **Frequency reference input** | |
| Connector | Rear-panel BNC, isolated from chassis and all other connectors |
| Reference selection | Internal, external, or auto |
| Frequency range | Standard: 10 MHz ± 20 Hz<br>Option 010: 10 MHz ± 1 Hz |
| Lock time (typical) | < 2 s |
| Voltage level | 200 mVpp to 5 Vpp |
| Input Impedance (nominal) | 1 k Ω \|\| 20 pF, AC-coupled |

# 33521A Specifications (continued)

| **Frequency reference output** | |
|---|---|
| Connector | Rear-panel BNC, chasis-referenced |
| Frequency (nominal) | 10 MHz |
| Output impedance (nominal) | 50 Ω, AC-coupled |
| Level (nominal) | 0 dBm,  632 mVpp into 50 Ω |
| **Real-time clock/calendar** | |
| Set and read | Year, month, day, hour, minute, second |
| Battery | CR-2032 coin-type, replacable, > 5-year life (typical) |

**Programming times (measurement)**

Configuration change speed

| | LAN (socket) | LAN (VXI-11) | USB 2.0 | GPIB |
|---|---|---|---|---|
| Change function | 5 ms | 6 ms | 5 ms | 5 ms |
| Change frequency | 2 ms | 3 ms | 2 ms | 3 ms |
| Change amplitude | 20 ms | 20 ms | 19 ms | 22 ms |
| Select user arb (16 k) | 9 ms | 11 ms | 9 ms | 9 ms |

Arbitrary waveform download speed to volatile

| (binary transfer) | LAN (socket) | LAN (VXI-11) | USB 2.0 | GPIB |
|---|---|---|---|---|
| 4 k sample | 6 ms | 18 ms | 8 ms | 39 ms |
| 1 M sample | 1.3 s | 2.6 s | 13 s | 9.1 s |

**Memory**

Aribtrary waveform and instrument state memory

| | |
|---|---|
| Volatile | $1x10^6$ samples per channel or 16x106 samples per channel (Option 002)<br>512 sequence steps per channel |
| Non-volatile | File sytem file space is limited to 64 MB<br>(~32 MSa of arbitrary waveform records) |
| Instrument state | |
| Store / Recall | User defined instrument states |
| Power Off | Power Off state automatically saved |
| Power On | Factory default settings or last power off settings |
| USB File System | |
| Front-panel port | USB 2.0 high-speed mass storage (MSC) class device |
| Capability | Read or write instrument configuration settings, instrument states<br>and user arbitrary waveform and sequence files. |
| Speed | 10 MB/s (nominal) |

# 33521A Specifications (continued)

| General characteristics | |
|---|---|
| **Computer interfaces** | |
| LXI- C (rev1.3) | 10/100Base-T Ethernet (Sockets & VXI-11 protocol)<br>USB2.0 (USB-TMC488 protocol)<br>GPIB/IEEE-488.1, IEEE-488.2 |
| Web user interface | Remote operation and monitoring |
| Programming language | SCPI-1999, IEEE-488.2<br>Keysight 33210A / 33220A compatibile |
| Graphical display | 4.3" Color TFT WQVGA (480x272) with LED backlight |
| **Mechanical** | |
| Size | 261.1mm W x 103.8mm H x 303.2mm D (with bumpers installed)<br>212.8mm W x 88.3mm H x 272.3mm D (with bumpers removed)<br>2U x ½ rack width |
| Weight (nom) | 3.3 kg (7.2 lbs) |
| **Environmental** | |
| Storage temperature | -40˚C to 70˚C |
| Warm-up time | 1 hour |
| Operating environment | EN61010, polution degree 2; indoor locations |
| Operating temperature | 0˚C to 55˚C |
| Operating humidity | 5% to 80% RH, non-condensing |
| Operating altitude | up to 3000 meters |
| **Regulatory** | |
| Safety | Complies with European Low Voltage Directive and carries the CE-marking.<br>Conforms to UL 61010-1, CSA C22.2 61010-1, and IEC 61010-1:2001 |
| EMC | Complies with European EMC Directive for test and measurement products.<br>- IEC/EN 61326-1<br>- CISPR Pub 11 Group 1, class A<br>- AS/NZS CISPR 11<br>- ICES/NMB-001<br>*Complies with Australian standard and carries C-Tick mark*<br>*This ISM device complies with Canadian ICES-001.*<br>*Cet appareil ISM est conforme a la norme NMB-001 du Canada* |
| Acoustic Noise (nom) | *SPL 35 dB(A)* |
| **Line power** | |
| Voltage | 100 V - 240 V 50/60 Hz -5%, +10%<br>100 V - 120 V 400 Hz ±10% |
| Power consumption (typ) | < 45 W, < 130 VA |
| **Warranty** | |
| | 1 year standard, 3 years optional |

# 53210A, 53220A, 53230A Specifications

| Input channel characteristics (nominal) | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Channels** | | | |
| Standard (DC - 350 MHz) | Ch 1 | Ch 1 & Ch 2 | |
| Optional (6 or 15 GHz) | Ch 2 | Ch 3 | |
| **Standard inputs (nominal)** | | | |
| **Frequency range** | | | |
| DC coupled | DC (1 mHz) to 350 MHz (2.8 ns to 1000 sec) | | |
| AC coupled, 50 Ω[1] or 1 MΩ | 10 Hz - 350 MHz | | |
| **Input** | | | |
| Connector | Front panel BNC(f). Option 201 adds parallel rear panel BNC(f) inputs[2] | | |
| Input impedance (typical) | Selectable 1 MΩ ± 1.5% or 50 Ω ± 1.5% \| \| <25 pF | | |
| Input coupling | Selectable DC or AC | | |
| Input filter | Selectable 100 kHz cut-off frequency low pass<br>10 Hz (AC coupling) cut-off frequency high pass filter | | |
| **Amplitude range** | | | |
| Input range | ±5 V (±50 V) full scale ranges | | |
| Sensitivity[3,4] (typical) | DC - 100 MHz: 20 mVpk<br>> 100 MHz: 40 mVpk | | |
| Noise[3] | 500 µVrms (max), 350 µVrms (typical) | | |
| **Input event thresholds** | | | |
| Threshold levels | ±5 V (±50 V) in 2.5 mV (25 mV) steps | | |
| Noise reject[4] | Selectable On/ Off | | |
| Slope | Selectable Positive or Negative | | |
| Auto-scale | Acquires signal for current measurement channel,<br>selects range (5 V or 50 V), sets auto-level 50% | | |
| Auto-level | Selectable On or Off<br>On: Sets auto-level (% of Vpp) operation<br>Occurs once for each INIT or after a timeout. Measures signal Vpp and sets Trigger level to 50%<br>Off: Selectable user set level (Volts) | | |
| Minimum signal frequency for auto level | User selectable (Slow (50 Hz), Fast (10 kHz)) | | |
| Minimum signal for auto level | 300 mVpp | | |
| **Maximum input** | | | |
| 50 Ω damage level | 1 W | | |
| 50 Ω protection threshold | Will not activate below 7.5 Vpk<br>50 Ω internal termination auto-protects<br>by switching to 1 M Ω | | |
| 1 M Ω damage level | DC - 5 kHz: 350 Vpk (AC + DC)<br>5 kHz - 100 kHz: Derate linearly to 10 Vpk (AC + DC)<br>>100 kHz: 10 Vpk (AC + DC) | | |

1. AC coupling occurs after 50 Ω termination.
2. When ordered with optional rear terminals, the standard/baseband channel inputs are active on both the front and rear of the universal counter though the specifications provided only apply to the rear terminals. Performance for the front terminals with rear terminals installed is not specified.
3. Multiply value(s) by 10 for the 50 V range.
4. Stated specification assumes Noise Reject OFF. Noise Reject ON doubles the sensitivity minimum voltage levels.

# 53210A, 53220A, 53230A Specifications (continued)

| Input channel characteristics (nominal)<br>Optional microwave inputs (nominal) | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Frequency range** | | | |
| Option 106 | 100 MHz - 6 GHz | | |
| Option 115 | 300 MHz - 15 GHz | | |
| **Input** | | | |
| Connector | Front panel precision Type-N(f)<br>Option 203 moves the input connector to a rear panel SMA(f) | | |
| Input impedance (typical) | 50 Ω ± 1.5% (SWR < 2.5) | | |
| Input coupling | AC | | |
| **Continuous wave amplitude range** | | | |
| Option 106 | Autoranged to +19 dBm max. (2 Vrms) | | |
| Option 115 | Autoranged to +13 dBm max. (1.0 Vrms) | | |
| Sensitivity (typical)[1] | 6 GHz (Opt 106): –27 dBm (10 mVrms)<br>15 GHz (Opt 115):<br>0.3 – 2 GHz: -23 dBm<br>2 – 13 GHz: -26 dBm<br>13 – 15 GHz: -21 dBm | | |
| **Input event thresholds** | | | |
| Level range | Auto-ranged for optimum sensitivity and bandwidth | | |
| AM tolerance<br>(CW only with > –20 dBm)[2] | 50% modulation depth | | |
| **Maximum input** | | | |
| Damage level | > +27 dBm (5 Vrms) | | |

1. Assumes sine wave.
2. Assumes AM Rate > 10/gate. For Option 106, use a tolerance of 15% modulation depth for frequencies less than 900 MHz.

# 53210A, 53220A, 53230A Measurement Characteristics

| **Measurement range** (nominal) | **53210A** | **53220A** | **53230A** |
|---|---|---|---|
| **Frequency, period (average) measurements** | | | |
| **Common** | | | |
| Channels | Ch 1 or optional Ch 2 | Ch 1, Ch 2 or optional Ch 3 | |
| Digits/s | 10 digits/s | 12 digits/s | 12 digits/s |
| Maximum display Resolution[1] | 12 digits | 15 digits | 15 digits |
| Measurement technique | Reciprocal | Reciprocal and resolution enhanced | Reciprocal, resolution-enhanced or continuous (gap-free) |
| Signal type | Continuous Wave (CW) | | CW and pulse/burst (Option 150) |
| Level & slope | Automatically preset or user selectable | | |
| Gate | Internal or external | | |
| Gate time[2] | 1 ms to 1000 s in 10 µs steps | 100 µs to 1000 s in 10 µs steps | 1 µs to 1000 s in 1 µs steps |
| Advanced gating[3] | N/A | Start delay (time or events) and stop hold-off (time or events) | |
| FM tolerance | ± 50% | | |
| **Frequency, period** | | | |
| Range[4] | DC (1 mHz) to 350 MHz (2.8 ns to 1000 s) | | |
| Microwave input (optional) | Option 106 - 100 MHz to 6 GHz (166 ps to 10 ns)<br>Option 115 - 300 MHz to 15 GHz (66 ps to 3.3 ns) | | |
| **Frequency ratio**[5] | | | |
| Range | $10^{15}$ Displayable range | | |
| **Timestamp/modulation domain** | | | |
| Sample rate[6] | N/A | N/A | 1 MSa/s, 800 kSa/s, 100 kSa/s, 10 kSa/s |
| #Edges/timestamp | N/A | N/A | Auto-acquired per acquisition |
| Acquisition length | N/A | N/A | up to 1 MSa or 100,000 s (max) |
| **Time interval (single-shot) measurements**[7] | | | |
| **Common** | | | |
| Channels | N/A | Ch 1 or 2 | |
| Single-shot time resolution | N/A | 100 ps | 20 ps |
| Gating | N/A | Internal or external gate<br>Start delay (time or events) and stop hold-off (time or events) | |
| Slope | N/A | Independent start, stop slopes | |
| Level | N/A | Independent start, stop slopes | |
| Channel-to-channel time skew (typical) | N/A | 100 ps | 50 ps |

1. Maximum display resolution for frequency and period. Totalize display resolution is 15 digits, time interval based measurements are 12 digits.
2. Continuous, gap-free measurements limits the gate time setting to 10 µs to 1000 s in 10 µs steps.
3. Refer to the gate characteristics section for more details on advanced gate capabilities.
4. For totalize, time interval and frequency measurements, you may get measurement readings beyond the range stated, but the accuracy of those readings is not specified.
5. Measurements on each input channel are performed simultaneously using one gate interval. The actual measurement gate interval on each channel will be synchrounous with edges of each input signal.
6. Maximum sample rate. Actual sample rate will be limited by the input signal edge rate for signals slower than the selected sample rate. Maximum timestamp rate offers minimal FM tolerance. If high FM tolerance is required, use lower timestamp rates.
7. Specifications apply if measurement channels are in 5 V range, DC coupled, 50 Ω terminated and at fixed level for: time interval

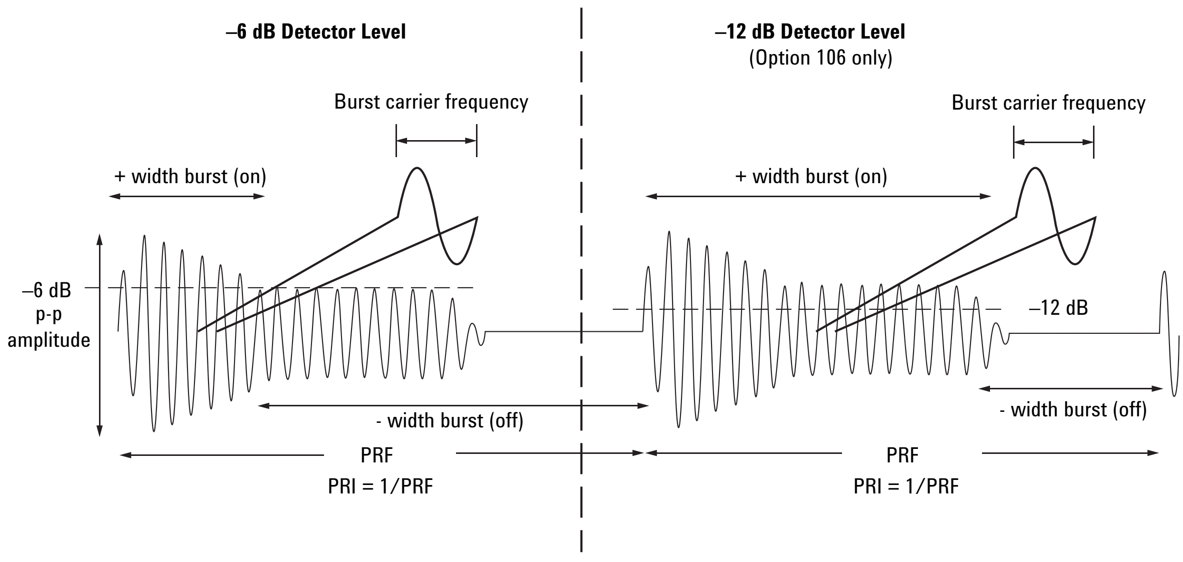
# 53210A, 53220A, 53230A  Measurement Characteristics (continued)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Time interval A to B, B to A** | | | |
| Range[1] | N/A | –1 ns to 100,000 s (nom)<br>–0.5 ns to 100,000 s (min) | |
| **Time interval A or B** | | | |
| Range | N/A | 2 ns to 100,000 s (min) | |
| Minimum width | N/A | 2 ns | |
| Minimum edge repetition rate | N/A | 6 ns | |
| Level & slope | N/A | Auto-level or user selectable | |
| **Single-period, pulse-width, rise time, fall time** | | | |
| Range | N/A | 0 s to 1000 s | |
| Minimum width | N/A | 2 ns | |
| Minimum edge repetition Rate | N/A | 6 ns | |
| Level & slope | N/A | Auto-level or user selectable | |
| **Duty** | | | |
| Range | N/A | .000001 to .999999 or 0.0001% to 99.9999% | |
| Minumim width | N/A | 2 ns | |
| Level & slope | N/A | Auto-level or user selectable | |
| **Phase A to B, B to A** | | | |
| Range[2] | N/A | -180.000º to 360.000º | |
| **Totalize measurements** | | | |
| Channels | N/A | Ch 1 or Ch 2 | |
| Range[1] | N/A | 0 to $10^{15}$ events | |
| Rate | N/A | 0 - 350 MHz | |
| Gating | N/A | Continuous, timed, or external gate input<br>Gate accuracy is 20 ns | |
| **Level measurements** | | | |
| Voltage level - standard input channels | ±5.1 Vpk with 2.5 mV resolution or ±51 Vpk with 25 mV resolution | | |
| Microwave power level (microwave channel option) | 0 to 4 relative signal power | | |

1. For totalize, time interval and frequency measurements, you may get measurement readings beyond the range stated, but the accuracy of those readings is not specified.
2. Assumes two frequencies are identical, only shifted in phase.

# 53210A, 53220A, 53230A Measurement Characteristics (continued)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Pulse/burst frequency and pulse envelope detector (Option 150)**[1] | | | |
| Pulse/burst measurements | N/A | N/A | Carrier frequency, carrier period, pulse repetition interval (PRI), pulse repetition frequency (PRF), positive and negative width |
| Pulse/burst width for carrier frequency measurements[2] | N/A | N/A | > 200 ns<br>Narrow: < 17 µs<br>Wide: >13 µs |
| Minimum pulse/burst width for envelope measurements | N/A | N/A | > 50 ns |
| Acquisition | N/A | N/A | Auto, Manual[3] |
| PRF, PRI range | N/A | N/A | 1 Hz – 10 MHz |
| Pulse detector response time (typical)[4] | N/A | N/A | 15 ns rise, fall |
| Pulse width accuracy | N/A | N/A | 20 ns + (2*carrier period) |
| Power ratio (typical) | N/A | N/A | > 15 dB |
| Power ranged and sensitivity (sinusoidal) (typical)[5] | N/A | N/A | +13 dBm (1 Vrms) to –13 dBm (50 mVrms) |




1. Option 150 microwave pulse/burst measurement descriptions.
2. Applies when burst width * Carrier Freq > 80.
3. Manual control of gate width and gate delay are allowed only for wide pulsed mode.
4. For pulsed signals > –7 dBm (100 mVrms) while gated on.
5. For option 115, use –10 dBm (71 mVrms) for lower sensitivity limit.

# 53210A, 53220A, 53230A Gate, Trigger and Timebase Characteristics

| **Gate characteristics** (nominal) | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Gate** | | | |
| Source | Time, external | Time, external or advanced | |
| Gate time (step size)[1] | 1 ms - 1000 s (10 µs) | 100 µs - 1000 s (10 µs) | 1 µs - 1000 s (1 µs) |
| **Advanced: gate start** | | | |
| Source | N/A | Internal or external, Ch 1/Ch 2 (unused standard channel input) | |
| Slope | N/A | Positive or negative | |
| Delay time[1] | N/A | 0 s to 10 s in 10 ns steps | |
| Delay events (edges) | N/A | 0 to $10^8$ for signals up to 100 MHz | |
| **Advanced: gate stop hold-off** | | | |
| Source | N/A | Internal or external, Ch 1/Ch 2 (unused standard channel input) | |
| Slope | N/A | Positive or negative | |
| Hold-off time[1] | N/A | Hold-off Time settable from 60 ns to 1000 s | |
| Hold-off events (edges) | N/A | 0 to $10^8$ (minimum width (positive or negative) >60 ns) | |
| **External gate input characteristics (typical)** | | | |
| Connector | Rear panel BNC(f) Selectable as external gate input or gate output signal | | |
| Impedance | 1 kΩ when selected as external gate input | | |
| Level | TTL compatible | | |
| Slope | Selectable positive or negative | | |
| Gate to gate timing | 3 µs gate end to next gate start | | |
| Damage level | <-5 V, >+10 V | | |
| **Gate output characteristics (typical)** | | | |
| Connector | Rear panel BNC(f) Selectable as external gate input or gate output signal | | |
| Impedance | 50 Ω when selected for gate output | | |
| Level | TTL compatible | | |
| Slope | Selectable positive or negative | | |
| Damage level | <-5 V, >+10 V | | |

1. Continuous, gap-free measurements limits the Gate Time setting to 10 µs to 1000 s in 10 µs steps.

# 53210A, 53220A, 53230A Gate, Trigger and Timebase Characteristics

| Trigger characteristics (nominal) | 53210A | 53220A | 53230A |
|---|---|---|---|
| General | | | |
| Trigger source | Internal, external, bus, manual | | |
| Trigger count | 1 to 1,000,000 | | |
| Trigger delay | 0 s to 3600 s in 1 μs steps | | |
| Samples/trigger | 1 to 1,000,000 | | |
| External trigger input (typical) | | | |
| Connector | Rear panel BNC(f) | | |
| Impedance | 1 kΩ | | |
| Level | TTL compatible | | |
| Slope | Selectable positive or negative | | |
| Pulse width | > 40 ns min. | | |
| Latency | Frequency, period: 1 μs + 3 periods<br>time interval, totalize: 100 ns | | |
| External trigger rate | 300/s max | 1 k/s max | 10 k/s max |
| Damage level | <-5 V, >+10 V | | |
| **Timebase characteristics** (nominal) | | | |
| Timebase reference | Internal, external, or auto | | |
| Timebase adjustment method | Closed-box electronic adjustment | | |
| Timebase adjustment Resolution | $10^{-10}$ ($10^{-11}$ for Option 010 U-OCXO timebase) | | |
| External timebase input (typical) | | | |
| Impedance | 1 kΩ AC coupled | | |
| Level (typ) | 100 mVrms to 2.5 Vrms | | |
| Lock frequencies | 10 MHz, 5 MHz, 1 MHz | | |
| Lock range | ±1 ppm (±0.1 ppm for Option 010 U-OCXO timebase) | | |
| Damage level | 7 Vrms | | |
| Timebase output (typical) | | | |
| Impedance | 50 Ω ± 5% at 10 MHz | | |
| Level | 0.5 Vrms into a 50 Ω load<br>1.0 Vrms into a 1 kΩ load | | |
| Signal | 10 MHz sine wave | | |
| Damage level | 7 Vrms | | |

1. Continuous, gap-free measurements limits the Gate Time setting to 10 μs to 1000 s in 10 μs steps.

# 53210A, 53220A, 53230A Math, Graphing and Memory Characteristics (nominal)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Math operations** | | | |
| Smoothing (averaging) [1] | Selectable 10 (slow), 100 (medium), 1,000 (fast) reading moving average<br>Selectable filter reset .1% /1000 ppm (fast), .03%/300 ppm (medium), .01%/100 ppm (slow) change from average | | |
| Scaling | mX-b or m(1/X)-b<br>User settable m and b (offset) values | | |
| Δ-change | (X-b)/b scaled to %, ppm, or ppb<br>User settable b (reference) value | | |
| Null | (X-b)<br>User settable b (reference) value | | |
| Statistics [1] | Mean, standard deviation, Max, Min, Peak-to-Peak, count | Mean, standard deviation, Allan deviation[2], Max, Min, Peak-to-Peak, count | |
| Limit test [2] | Displays PASS/ FAIL message based on user defined Hi/ Lo limit values. | | |
| Operation | Individual and simultaneous operation of smoothing, scaling, statistics, and limit test | | |
| **Graphical display selections** | | | |
| Digits | Numeric result with input level shown | | |
| Trend | Strip chart (measurements vs. readings over time)<br>Selectable screen time | | |
| Histogram | Cumulative histogram of measurements; manual reset<br>HI/LO limit lines shown<br>Selectable bin and block size | | |
| Limit test | Measurement result, tuning bar-graph, and PASS/FAIL message | | |
| Markers | Available to read values from trend & histogram displays | | |
| **Memory** | | | |
| Data log | Guided setup of # of readings/counts;<br>automatically saves acquisition results to non-volatile memory | | |
| Instrument state | Save & recall user-definable instrument setups | | |
| Power-off | Automatically saved | | |
| Power-on | Selectable power-on to reset (Factory), power-off state or user state | | |
| Volatile reading memory | 1 M readings (16 MBytes) | | |
| Non-volatile internal memory | 75 Mbytes (up to 5 M readings) | | |
| USB file system | Front-panel connector for USB memory device | | |
| Capability | Store/recall user preferences and instrument states, reading memory, and bit map displays | | |

1. These Math operations do not apply for Continuous Totalize or Timestamp measurements.
2. Limit Test only displays on instrument front panel. No hardware output signal is available.

# 53210A, 53220A, 53230A Speed Characteristics[1] (meas)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| Measurement/IO timeout (nominal) | no timeout or 10 ms to 2000 s, in 1 ms steps | | |
| Auto-level speed | Slow mode (50 Hz): 350 ms (typical)<br>Fast mode (10 kHz): 10 ms (typical) | | |
| Configure-change speed | Frequency, Period, Range, Level: 50 ms (typical) | | |
| **Single measurement throughput[2]: readings/s**<br>(time to take single measurement and transfer from volatile reading memory over I/O bus) | | | |
| Typical (Avg. using READ?): | | | |
| LAN (VXI-11) | 110 | 120 | |
| LAN (sockets) | 200 | 200 | |
| USB | 200 | 200 | |
| GPIB | 210 | 220 | |
| **Optimized (Avg. using *TRG;DATA:REM? 1, WAIT):** | | | |
| LAN (VXI-11) | 160 | 180 | |
| LAN (sockets) | 330 | 350 | |
| USB | 320 | 350 | |
| GPIB | 360 | 420 | |
| **Block reading throughput[2]: readings/s (Example uses: 50,000 readings)**<br>(time to take blocks of measurements and transfer from volatile reading memory over I/O bus) | | | |
| Typical (Avg. using READ?): | | | |
| LAN (VXI-11) | 300 | 990 | 8700 |
| LAN (sockets) | 300 | 990 | 9700 |
| USB | 300 | 990 | 9800 |
| GPIB | 300 | 990 | 4600 |
| **Optimized (Avg. using *TRG;DATA:REM? 1, WAIT):** | | | |
| LAN (VXI-11) | 300 | 990 | 34700 |
| LAN (sockets) | 300 | 990 | 55800 |
| USB | 300 | 990 | 56500 |
| GPIB | 300 | 990 | 16300 |

1. Operating speeds are for a direct connection to a >2.5 GHz dual core CPU running Windows XP Pro SP3 or better with 4 GB RAM and a 10/100/1000 LAN interface.
2. Throughput data based on gate time. Typical reading throughput assumes ASCII format, Auto level OFF with READ? SCPI command. For improved reading throughput you should also consider setting (FORM:DATA REAL,64), (DISP OFF), and set fastest gate time available.

# 53210A, 53220A, 53230A Speed Characteristics[1] (measurement) (continued)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Maximum measurement speed to internal non-volatile memory[2]: (readings/s)** | | | |
| Timestamp | N/A | N/A | 1,000,000 |
| Frequency, period, totalize | 300 | 1000 | 75,000 |
| Frequency ratio | | | 44,000 |
| Time interval, rise/fall, width, burst width | N/A | | 90,000 |
| Duty cycle | N/A | | 48,000 |
| Phase | N/A | | 37,000 |
| PRI, PRF | N/A | N/A | 75,000 |
| **Transfer from memory to PC via:** | | | |
| LAN (sockets) | 600,000 readings/sec | | |
| LAN (VXI-11) | 150,000 readings/sec | | |
| USB | 800,000 readings/sec | | |
| GPIB | 22,000 readings/sec | | |

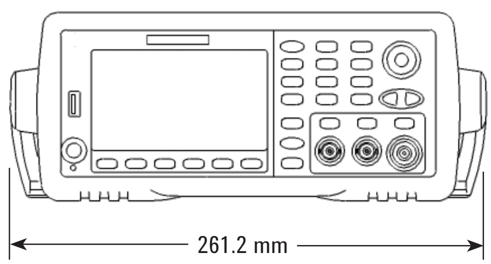
1. Operating speeds are for a direct connection to a > 2.5 GHz dual core CPU running Windows® XP Pro SP3 or better with 4 GB RAM and a 10/100/1000 LAN interface.
2. Maximum 53230A rates represent > = 20 MHz input signals with min gate times, no delays or holdoffs. Measurement rates for the 53210A & 53220A are limited by min gate time. Actual meas rates are limited by the repetition rate of the input being measured.

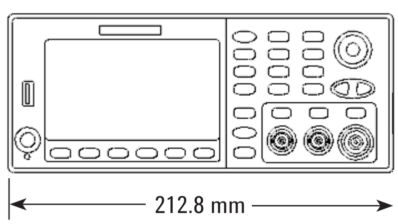
## 53210A, 53220A, 53230A General Characteristics (nominal)

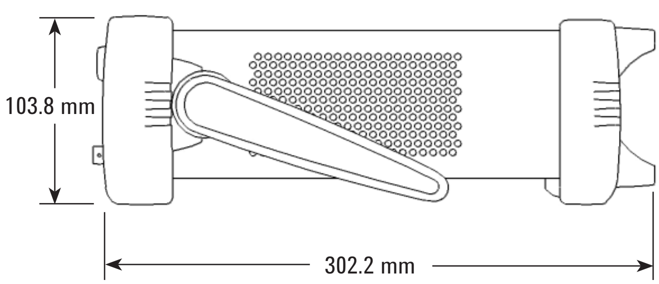
| | 53210A | 53220A | 53230A |
|---|---|---|---|
| Warm-up time | 45-minutes | | |
| Display | 4.3" Color TFT WQVGA (480 x 272), LED backlight | | |
| User interface and help languages | English, German, French, Japanese, Simplified Chinese, Korean | | |
| USB flash drive | FAT, FAT32 | | |
| **Programming language** | | | |
| SCPI | 532xx Series and 53131A/53132A/53181A Series compatibility mode | | |
| **Programming interface** | | | |
| LXI-C 1.3 | 10/ 100/ 1000 LAN (LAN Sockets and VXI-11 protocol) | | |
| USB 2.0 device port | USB 2.0 (USB-TMC488 protocol) | | |
| GPIB interface (Option 400) | GPIB (IEEE-488.1, IEEE-488.2 protocol) | | |
| Web user interface | LXI Class C Compatible | | |
| **Mechanical** | | | |
| Bench dimensions | 261.1 mm W x 103.8 mm H x 303.2 mm D | | |
| Rack mount dimensions | 212.8 mm W x 88.3 mm H x 272.3 mm D (2U x ½ width) | | |
| Weight | 3.9 kg (8.6 lbs) fully optioned<br>3.1 kg (6.9 lbs) without Option 300 (battery option) | | |
| **Environmental** | | | |
| Storage temperature | –30° C to +70° C | | |
| Operating environment | EN61010, pollution degree 2; indoor locations | | |
| Operating temperature | 0° C to +55° C | | |
| Operating humidity | 5% to 80% RH, non-condensing | | |
| Operating altitude | Up to 3000 meters or 10,000 ft | | |
| **Regulatory** | | | |
| Safety | Complies with European Low Voltage Directive and carries the CE-marking<br>Conforms to UL 61010-1, CSA C22.2 61010-1, IEC 61010-1:2001, CAT I | | |
| EMC | Complies with European EMC Directive for test and measurement products.<br>IEC/EN 61326-1<br>CISPR Pub 11 Group 1, class A<br>AS/NZS CISPR 11<br>ICES/NMB-001<br>Complies with Australian standard and carries C-Tick Mark<br>This ISM device complies with Canadian ICES-001<br>Cet appareil ISM est conforme a la norme NMB-001 du Canada | | |
| Acoustic noise (nominal) | SPL 35 dB(A) | | |
| **Line power** | | | |
| Voltage | 100V - 240V ± 10%, 50-60 Hz ±5%<br>100 V - 120 V, 400 Hz ±10% | | |
| Power consumption | 90 VA max when powered on or charging battery;<br>6 VA max when powered off/standby | | |

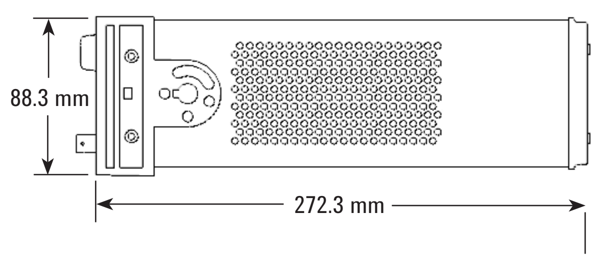
# 53210A, 53220A, 53230A General Characteristics (nominal) (continued)

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| **Battery (Option 300)** | | | |
| Technology | Internal lithium ion battery with integrated smart battery monitor & charger | | |
| Operating temperature limits | 0 to 55° C. Battery will only charge under 35° C. Instrument running on battery power above 50° C will turn off to minimize battery capacity degradation. | | |
| Storage temperature limits | –10° C to 60° C. Extended exposure to temperatures above 45° C could degrade battery performance and life | | |
| Operating time (typ) | 3 hours when operated below +35° C | | |
| Standby time - OCXO powered (typ) | 24 hours | | |
| Recharge time (typical)[1] | 4 hours to 100% capacity; 2 hours to 90% capacity | | |
| **Accessories included** | | | |
| CD | User's guide, SCPI/programmers reference, programming examples, drivers (IVI-COM, LabView), IO library instructions | | |
| Cables | Power line cord, 2 m USB 2.0 | | |
| **Warranty** | | | |
| Standard | 1 year | | |




Dimensions apply to all three models: 53210A, 53220A, 53230A.

1. Assumes calibrated battery.

# 53210A, 53220A, 53230A Timebase

Timebase Uncertainty = ( Aging + Temperature + Calibration Uncertainty )

| Timebase | Standard TCXO | Option 010 Ultra-High Stability OCXO |
|---|---|---|
| **Aging[1] (spec)** | | |
| 24-hour, $T_{CAL}$ ±1° C | | ± 0.3 ppb (typical) |
| 30-day, $T_{CAL}$ ±5° C | ± 0.2 ppm (typical) | ± 10 ppb |
| 1-year, $T_{CAL}$ ±5° C | ± 1 ppm | ± 50 ppb |
| **Temperature (typical)** | | |
| 0 °C to 55° C relative to 25° C | ± 1 ppm | ± 5 ppb |
| $T_{CAL}$ ± 5° C | ± 0.5 ppm | ± 0.5 ppb |
| **Calibration uncertainty** | | |
| Initial factory calibration[2] (typical) | ± 0.5 ppm | ± 50 ppb |
| Supplemental characteristics (typical) | | |
| 5-min. warm-up error[3] | ± 1 ppm | ± 10 ppb |
| 72-hour retrace error[4] | < 50 ppb | < 2 ppb |
| Allan deviation t = 1s | 1 ppb | 0.01 ppb |

Front/rear view of 53230A

1. All Timebase Aging Errors apply only after an initial 30-days of continuous powered operation and for a constant altitude ±100 m. After the first 1-year of operation, use ½ x (30-day and 1-year) aging rates shown.
2. Only use the Factory Calibration error values for the period before your first re-calibration. Factory Calibration uncertainty includes the instrument settability error, the factory calibration source uncertainty, and additional timebase uncertainty due to factory calibration before the required initial 30-days of powered operation. Settability defines the resolution increments you can reach is in steps of 0.1 ppb (0.01 ppb on Option 010).
3. Warm-up error applies when the instrument is powered on in a stable operating environment. When moved between different operating environments add the Temperature error during the initial 30-minutes of powered operation
4. Retrace error may occur whenever the instrument line-power is removed or whenever the instrument is battery operated and the battery fully discharges. Retrace error is the residual timebase shift that remains 72-hours after powering-on an instrument that has experienced a full power-cycle of the timebase. Additional frequency shift errors may occur for instrument exposure to severe impact shocks > 50 g.

# 53210A, 53220A, 53230A Accuracy Specifications

## Definitions

Random Uncertainty
The RSS of all random or Type-A measurement errors expressed as the total RMS or 1-σ measurement uncertainty. Random uncertainty will reduce as $1/\sqrt{N}$ when averaging N measurement results for up to a maximum of approximately 13-digits or 100 fs.

Systematic Uncertainty
The 95% confidence residual constant or Type-B measurement uncertainty relative to an external calibration reference. Generally, systematic uncertainties can be minimized or removed for a fixed instrument setup by performing relative measurements to eliminate the systematic components.

Timebase Uncertainty
The 95% confidence systematic uncertainty contribution from the selected timebase reference. Use the appropriate uncertainty for the installed timebase or when using an external frequency reference substitute the specified uncertainty for your external frequency reference.

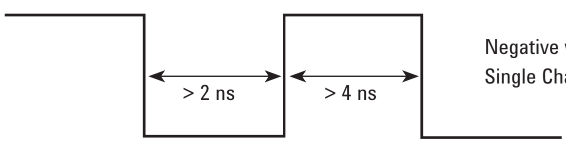
Basic accuracy[1] = ± [(k * Random Uncertainty) + Systematic Uncertainty + Timebase Uncertainty]

| Measurement Function | 1-☐ Random Uncertainty | Systematic Uncertainty | Timebase Uncertainty[2] |
|---|---|---|---|
| Frequency [3]<br>Period (parts error) | $\frac{1.4 * (T_{SS}^2 + T_E^2)^{½}}{R_E * \text{gate}}$ | If $R_E \ge 2$: 10 ps / gate (max), 2 ps / gate (typ)[4]<br>If $R_E < 2$ or REC mode ($R_E = 1$): 200 ps / gate | • |
| Option 106 & 115:<br>Frequency [3]<br>Period (parts error) | $\frac{1.4 * (T_{SS}^2 + T_E^2)^{½}}{R_E * \text{gate}}$ | If $R_E \ge 2$: 10 ps / gate (max), 2 ps / gate (typ)[4]<br>If $R_E < 2$ : 100 ps / gate | • |
| Frequency Ratio A/B (typ) [5]<br>(parts error) | 1.4* Random Uncertainty<br>of the *worst case* Freq input | Uncertainty of Frequency A plus Uncertainty<br>of Frequency B | |
| Single Period<br>(parts error)[17] | $\frac{1.4 * (T_{SS}^2 + T_E^2)^{½}}{\text{Period Measurement}}$ | $\frac{T_{accuracy}}{\text{Period Measurement}}$ | • |
| Time Interval (TI)[17], Width [17], or<br>Rise/Fall Time [7, 17] (parts error) | $\frac{1.4 * (T_{SS}^2 + T_E^2)^{½}}{\lvert\text{TI Measurement}\rvert}$ | $\frac{\text{Linearity}^{6} + \text{Offset}^{8}}{\lvert\text{TI Measurement}\rvert}$<br>Linearity = $T_{accuracy}$<br>Offset (typ) = $T_{LTE}$ + skew + $T_{accuracy}$ | • |
| Duty [5, 9, 10, 17]<br>(fraction of cycle error) | $2 * (T_{SS}^2 + T_E^2)^{½} *$ Frequency | $(T_{LTE} + 2 * T_{accuracy})$*Frequency | |
| Phase [5, 9, 17] (Degrees error) | $2 * (T_{SS}^2 + T_E^2)^{½} *$ Frequency *<br>360° | $(T_{LTE}$+skew+$2 * T_{accuracy})$*Frequency*360° | |
| Totalize[11] (counts error) | ± 1 count[11] | | |
| Volts pk to pk [12] (typ)<br>5 V range | | DC - 1 kHz: 0.15% of reading + 0.15% of range<br>1 kHz - 1 MHz: 2% of reading + 1% of range<br>1 MHz - 200 Hz: 5% of reading + 1% of range<br>+ 0.3 * (Freq/250 MHz) * reading | |
| **Optional Microwave Channel Opt 150 - Pulse/Burst Measurements[3, 13]** | | | |
| PRF, PRI (parts error) [14] | If $R_E > 1$: 200 ps / ($R_E$ * gate)<br>If $R_E = 1$: 500 ps / gate | $\frac{200\ \text{ps}}{R_E * \text{gate}}$ | • |
| Pulse/burst Carrier Frequency [15]<br>(Narrow Mode) (parts error) | $\frac{100\ \text{ps}}{\text{Burst Width}}$ | $\frac{200\ \text{ps}}{\text{Burst Width}}$ | • |
| Pulse/burst Carrier Frequency [16]<br>(Wide Mode) (parts error) | $\frac{40\ \text{ps}}{R_E * \text{Burst Width}}$ | $\frac{100\ \text{ps}}{R_E * \text{Burst Width}}$ | • |

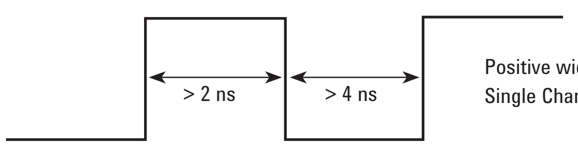
# 53210A, 53220A, 53230A Accuracy Specifications (continued)

1. Apply the appropriate errors detailed for each measuring function.
2. Use Timebase Uncertainty in Basic Accuracy calculations only for Measurement Functions that show the ● symbol in the Timebase Uncertainty column.
3. Assumes Gaussian noise distribution and non-synchronous gate, non-gaussian noise will effect Systematic Error. Note all optional microwave channel specifications (continuous wave and pulse/burst) assume sine signal.
4. Typical is achieved with an average of 100 readings with 100 samples per trigger. Worst case is trigger and sample count set to 1.
5. Improved frequency ratio, duty and phase specifications are possible by making independent measurements.
6. Minimum Pulse Width for using stated linearity is 5 ns; Pulse Widths of 2-5 ns use linearity=400 ps.
7. Residual instrument Rise/ Fall Time 10%-90% 2.0 ns (typ). Applies to fixed level triggering. Threshold can still be set based on % of auto-level detected peaks, but since these peak levels may contain unknown variations, accurate measurements need to be based on absolute threshold levels.
8. Input signal slew rates and settling time have effects on offset. Offset is calibrated with rise times < 100 ps.
9. Constant Duty or Phase are required during the measurement interval. Duty and Phase are calculated based on two automated sequential measurements - period and width or TI A to B, respectively.
10. Duty is represented as a ratio (not as a percent).
11. Additional count errors need to be added for gated totalize error, latency or jitter. If gated, add gate accuracy term (See Totalize measurements in the Measurement Characteristics section).
12. Volts pk error apply for signal levels between full range and 1/10th range. Spec applies to sine wave only. 50 V range reading accuracy is 2% at DC-1 KHz, 5% 1 KHz -1 MHz band. Accuracy above 200 MHz is not specified on both ranges.
13. Specifications apply to signals from ±13 dBm, operable to ±19 dBm.
14. Use the $R_E$ equation, but use the input PRF for $F_{IN}$. Assume sharp envelope transition.
15. Applies when Burst Width * Carrier Freq > 80.
16. Specifications based on gate and width for automated detection. If in manual mode, delay and width selected will impact accuracy specification. For approximate accuracy for manual gate, use the $R_E$ calculation, but $F_{IN}$ is now $10^6$ and use gate as burst width. For input signals where PRI < 250 µs, double the 1-σ Random Uncertainty specification, unless a Trigger Count of 1 and a large Sample Count acquisition method are used.
17. Specifications apply if measurement channels are in 5 V range, DC coupled, 50Ω terminated and at fixed level. The following minimum pulse width requirements apply:

Single-Period: < 250 MHz, 50% Duty
Phase, Dual Channel Time Interval: < 160 MHz, 50% Duty




Negative width, Negative duty,
Single Channel Time Interval Fall to Rise




Positive width, Positive duty,
Single Channel Time Interval Rise to Fall

# Definition of Measurement Error Sources and Terms used in Calculations

| | 53210A | 53220A | 53230A |
|---|---|---|---|
| $R_E$ | 1 | use $R_E$ equation | use $R_E$ equation |
| $T_{SS}$ | 100 ps | 100 ps | 20 ps |
| Skew | | 100 ps | 50 ps |
| $T_{accuracy}$ | | 200 ps | 100 ps |

**Confidence Level (k)**

For 99% Confidence use k= 2.5 in accuracy calculations.
For 95% Confidence use k= 2.0 in accuracy calculations.

# E6198B Load Cards and Pin Cards Specifications

| Keysight Loadcards Specifications | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Function | E6175A | E6176A | E6177A | E6177B | E6178A | N9377A | N9378A | N9379A |
| Number of channels (maximum) | 8 | 16 | 24 | 24 | 8 | 16, dual-load | 24, quad-load | 48, dual-load |
| Number of channels - unshared relays | 4 | 16 | 24 | 24 | 8 | 16 | 24 | 48 |
| Maximum current per channel | 7.5 A (15 A peak) | 7.5 A (15 A peak) | 3 A | 3 A | 30 A | 7.5 A (15 A peak) | 2 A | 2 A |
| Current measuring with sense resistor | Yes | Yes | No | Yes | No | Yes | No | No |
| Current measuring with current transducer | Yes | No | No | No | Yes | No | No | No |
| Flyback protection available (user installed) | Yes | Yes | No | No | Yes | Yes | No | No |
| Engineered for application | Inductive load | Common load | Low current | Low current | High current | High current dual-load | Low current quad-load | Low current quad-load |

# E8782A and E8783A Specifications

| General specifications | | |
|---|---|---|
| Parameter | Specification | |
| Power requirement | Voltage: +5 Vdc | |
| Capacitance – DUT pin to UUT common | Open channel: 100 pF<br>Closed channel: 300 pF | |
| Channels | E8782A | E8783A |
| | 40 measurement<br>24 instrument | 64 measurement |
| Resistance | DUT pin to auxiliary input: 1 ohm (maximum)<br>DUT pin to analog bus connector: 1 ohm* (maximum)<br>** with 100 ohm protection resistor bypassed* | |
| Pin channel voltage | 200 volts | |
| Number of concurrent analog channels | 4 | |
| Operating temperature | 0 to 40° C | |
| Operating humidity | 80% relative humidity, 0 to 40° C | |
| Maximum current consumption | 3 A at 5 V | |
| **Relay characteristics** | | |
| Parameter | Specification | |
| Type | Dry reed | |
| Switching speed | Close: 500 ms<br>Open: 400 ms | |
| Switching characteristics | 1.0 A carry<br>0.5 A while switching<br>7.5 volt-amps maximum instantaneous switching | |
| Other relay parameters | 300 VDC standoff voltage<br>200 VDC switching voltage | |

## TS-8900 Ordering Information

| Part No | Description |
| --- | --- |
| U8971A-ATO | TS-8900 HIGH PERFORMANCE FUNCTIONAL TEST SYSTEM WITH EXPRESSCONNECT INTERFACE |
| U8970A-OC-BASE | U8970A Base Option Class |
| U8970A-C01 | M/S Cabinet 1.6M Vertical |
| U8970A-C02 | M/S Cabinet 2M Vertical |
| U8970A-E01 | M/S KIT-MASS INTERCONNECT EXPRESSCONNECT |
| U8970A-HB1 | LXI HUB FOR LXI INSTRUMENTATION |
| U8970A-OC-ACCUM | Accumulator card option class |
| U8970A-601 | ExpressConnect Accumulator Card for TS8900 |
| U8970A-OC-SLUCRD | SLU CARDS AND WIRING OPTION CLASS |
| U8970A-201 | SWITCH/LOAD UNIT E6198B |
| U8970A-210 | PIN CARD MATRIX E8782A - 40X4 WITH 24 INSTR ROWS |
| U8970A-610 | E8782A CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-211 | PIN CARD MATRIX E8783A - 40X4 WITH 24 INSTR ROWS |
| U8970A-612 | E8783A CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-613 | E8783A CABLE - EXPRESSCONNECT PIN MATRIX AUX |
| U8970A-270 | E8794A CABLE - CUSTOM CARD TO MATRIX AUX |
| U8970A-233 | LOAD CARD E6177B - 24 CHANNEL |
| U8970A-234 | LOAD CARD E6175A - 8 CHANNEL |
| U8970A-230 | LOAD CARD E6178B - 8 CHANNEL 30A |
| U8970A-231 | LOAD CARD N9377A - DUAL FOR 16 CHANNEL |
| U8970A-232 | LOAD CARD N9379A - HIGH DENSITY FOR 48 CHANNEL |
| U8970A-624 | E6177B CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-623 | E6175A CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-614 | E6178B CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-615 | N9377A CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-616 | N9379A CABLE - EXPRESSCONNECT FOR TS8900 |
| U8970A-OC-COMBO | COMBO MATERIAL OPTION CLASS |
| U8970A-CB1 | BALLAST COMBO MATERIAL FOR POWER SUPPLIES |
| U8970A-CH0 | NO HALF RACK INSTRUMENTS |
| U8970A-CH1 | ONE HALF RACK INSTRUMENT |
| U8970A-CH2 | TWO HALF RACK INSTRUMENTS |
| U8970A-CL1 | SLU SLOT FILLER |
| U8970A-CF1 | FILLER 2 U FOR MISSING INSTRUMENT |
| U8970A-CF2 | FILLER 3 U FOR MISSING INSTRUMENT |
| U8970A-OC-ACCY | ACCESSORIES |
| U8970A-KM1 | FIXED KEYBOARD AND MOUSE PAD TRAY |
| U8970A-UP1 | APC Smart-UPS 3000VA USB & Serial RM 2U 230V |
| U8970A-OC-SPLCFG | SPECIAL CONFIGURATION OPTION CLASS |
| U8970A-S01 | CUSTOM CONFIGURATION REQUIRING STATEMENT OF WORK |
| U8970A-S02 | SPECIAL INSTRUCTIONS TO CHANGE MATERIAL. REQUIRES SOW |

# TS-8900 Ordering Information (continued)

| Part No | Description |
|---|---|
| U8970A-OC-APPSW | TS-5400 APPLICATION SOFTWARE OPTION CLASS |
| U8970A-SW1 | TS-5000 FAMILY APPLICATION SOFTWARE 7.0V |
| U8970A-OC-GPIBLXI | GPIB/LXI INSTRUMENTS OPTION CLASS |
| U8970A-115 | GPIB/LXI ARB 33521A - 30 MHZ 1-CHANNEL |
| U8970A-116 | GPIB/LXI ARB 33522A, 30 MHZ 2-CHANNELS |
| U8970A-120 | GPIB/LXI COUNTER 53220A, 350MHZ 12 DIGITS/S 100PS |
| U8970A-125 | LXI DIGITIZER L4532A, 20 MS/S 16-BIT 2-CHANNELS |
| U8970A-130 | LXI DIGITIZER L4534A, 20 MS/S 16-BIT 4-CHANNELS |
| U8970A-131 | LXI DAC L4451A, 4-CHANNELS WITH WAVEFORM MEMORY |
| U8970A-617 | LXI DAC L4451A CABLE - EXPRESSCONNECT 4-CHANNELS |
| U8970A-OC-PXIMOD | PXI INSTRUMENTS OPTION CLASS |
| U8970A-300 | PXIE CHASSIS M9018A - 18-SLOT 3U 8GB/S |
| U8970A-305 | PCIE CABLE INTERFACE M9021A - GEN 2 X8 |
| U8970A-330 | PXI SED M9216A - 32-CHANNEL 250KS/S 16-BIT 100V INPUT |
| U8970A-618 | PXI SED M9216A CABLE - EXPRESSCONNECT 32-CHANNELS |
| U8970A-619 | PXI SED M9216A CABLE - EXPRESSCONNECT AUX 32-CHANNELS |
| U8970A-335 | PXI Isolated DAC M9185A - 8Channel |
| U8970A-336 | PXI Isolated DAC M9185A - 16Channel |
| U8970A-620 | PXI ISOLATED DAC M9185A CABLE - EXPRESSCONNECT 8-CHANNELS |
| U8970A-340 | PXI ISOLATED V/I SOURCE M9186A - 3W 100V SINGLE CHANNEL |
| U8970A-621 | PXI ISOLATED V/I SOURCE M9186A CABLE - EXPRESSCONNECT |
| U8970A-350 | PXI DIO M9187A - 64-BIT 0.3-50V |
| U8970A-622 | PXI DIO M9187A CABLE - EXPRESSCONNECT 64-BIT 0.3-50V |
| U8970A-310 | PXI DMM M9182A - 6.5 Digit |
| U8970A-311 | PXI DMM M9183A - 7.5 Digit |
| U8970A-OC-PWRSUP | POWER SUPPLY OPTION CLASS |
| U8970A-503 | DC POWER SUPPLY N5764A - 20V, 76A, 1520W, INCLUDING CABLE |
| U8970A-501 | DC POWER SUPPLY N5744A - 20V, 38A, 760W INCLUDING CABLE |
| U8970A-502 | DC POWER SUPPLY N5745A - 30V, 25A, 750W INCLUDING CABLE |
| U8970A-504 | DC POWER SUPPLY N5765A - 30V, 50A, 1500W INCLUDING CABLE |
| U8970A-505 | DC POWER SUPPLY N8734A - 20V, 165A, 3300W INCLUDING CABLE |
| U8970A-506 | DC POWER SUPPLY N8735A - 30V, 110A, 3300W INCLUDING CABLE |
| E2233B-ATO | Modular Power Supply - 1200W Max |
| E2233B-OC-COMBO | N6702A Combination Materials |
| E2233B-OC-CABLES | N7602A Power Supply Cables |
| E2233B-OC-MODULE | E2233B DC Power Modules |
| E2233B-004 | N6776A DC Power Module, 100V, 3A, 300W |
| E2233B-003 | N6775A DC Power Module, 60V, 5A, 300W |
| E2233B-002 | N6774A DC Power Module, 35V, 8.55A, 300W |
| E2233B-001 | N6773A DC Power Module, 20V, 15A, 300W |
| E2233B-CORE | CORE MATERIAL for N6702A |

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