2231A-30-3

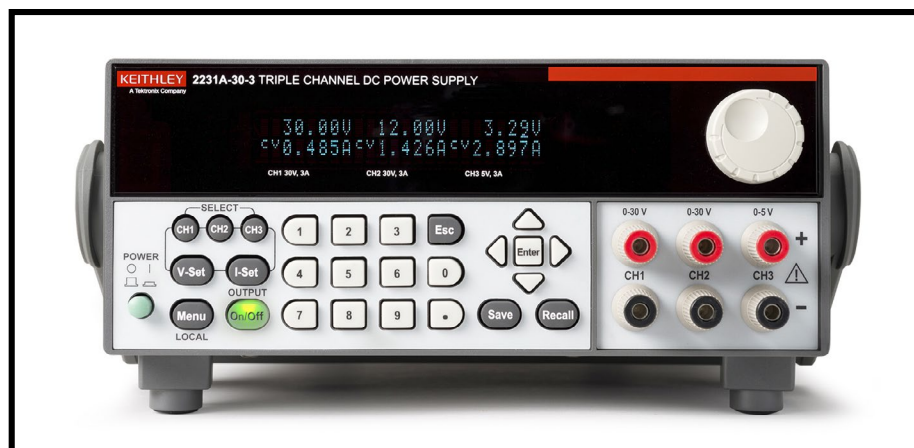# 195W Triple Channel DC Power Supply

- **Get three isolated, independent, and adjustable outputs in one instrument**

- **Output a total of 195W of power with two 30V@3A outputs and one 5V@3A output**

- **Set voltage outputs with 0.06% basic accuracy and current outputs with 0.2% basic accuracy**

- **Output DC power with less than 5mVp-p noise**

- **Display voltage and current measurements continuously from all three outputs**

- **Double output levels by connecting the two 30V channels in series or parallel**

- **Store frequently used configurations in any of 30 setup memory locations**

- **Turn off any output after a predetermined test time with each channel's output timer**

- **Control the supply from a PC with an optional USB adapter**

APPLICATIONS

- **Engineering and science student labs**

- **Service work**

- **Electronic design**

The Model 2231A-30-3 Triple Channel DC Power Supply can output a total of 195W of power, providing the power levels needed to energize a wide range of circuits and devices for benchtop work. Two channels can supply up to 30V at 3A each; the third channel can provide up to 5V at 3A. The Model 2231A-30-1 does not compromise on performance or convenience features, offering the versatility and ease of use you need, so it can be the only DC power supply on your bench.

Quality DC Power

The Model 2231A-30-3 is a linear-based design with less than 5mVp-p noise per output. Voltage and current settings have basic accuracies of 0.06% and 0.2% respectively. The load voltage and load current readback results provide the same levels of accuracy, so you can be confident you are sourcing accurate, low noise voltages and currents to your device-under-test (DUT).
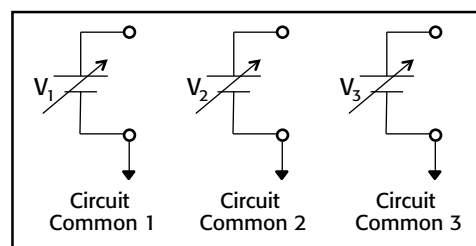
Three Fully Independent Outputs

Each output of the Model 2231A-30-3 is fully programmable and can be turned on and off independently from the other channels; it essentially provides three power supplies in one instrument. You can power up both the analog circuitry and the digital circuitry of a printed circuit board or a complete device, all with the same instrument.

All Outputs Are Isolated from Each Other and from Ground

Each output can power a circuit on a different ground reference. The low connection on each output is not connected to any of the other outputs. That means one supply can test three separate circuits on three different ground references or can power circuits that are transformer or optically isolated from each other. Furthermore, all outputs are not referenced to ground, so the Model 2231A-30-3 can power both floating circuits and grounded circuits.

Power Bipolar Circuits

Because the Model 2231A-30-3's outputs are isolated, one output can be turned effectively into a negative source by connecting its high terminal to the common reference point of a bipolar circuit. A second output can connect its low terminal to the same common reference point. The result is a positive output and a negative output. If the two 30V channels are used in this configuration, both outputs can be changed at the same time by using the Model 2231A-30-3's tracking function. That allows varying both channels at the same time while keeping their outputs at identical magnitudes.

The Model 2231A-30-3 has three fully independent, programmable outputs that are electrically isolated from each other. This allows them to power circuits that are on different grounds, such as optically isolated circuits.

195W Triple Channel DC Power Supply

DC POWER SUPPLIES

2231A-30-3

195W Triple Channel DC Power Supply

Ordering Information

2231A-30-3   **Triple Channel DC Power Supply**

Accessories Supplied

Documentation CD with User Manual
Certificate of Calibration
Power Cord

ACCESSORIES AVAILABLE

2231A-001	USB Adapter with USB Cable
RMU2U	Rack Mount Kit
386759800	RMU2U Rack Mount Cosmetic Filler Panel

SERVICES AVAILABLE

|	
2231A-30-3-EW	1 Year KeithleyCare® Gold Plan
2231A-30-3-5Y-EW	5 Year KeithleyCare Gold Plan
C/2231A-30-3-3Y-STD	KeithleyCare 3 Yr Std Calibration Plan
C/2231A-30-3-5Y-STD	KeithleyCare 5 Yr Std Calibration Plan

Supply 60V or 6A

When the application requires outputting more than 30V or 3A, the two 30V channels can be combined to double the output level. Wire the two outputs in series to deliver up to 60V or wire them in parallel to deliver up to 6A. For your convenience, the Model 2231A-30-3 display will read the total output, either voltage or current, to eliminate confusion. Also, the supply controls both outputs to deliver the required voltage or current. There's no need to set up each channel individually; the supply manages the channels for you, so combining channels is uncomplicated.

KEITHLEY   **2231A-30-3** TRIPLE CHANNEL DC POWER SUPPLY

15.000V   Para   5.000V
0.841A   2.071A

CH1 0-30V   CH2 0-30V   CH3 0-5.5V

Wire the two 30V channels in series or parallel to double the output voltage to 60V or the supplied current to 6A. The Model 2231A-30-3 has series and parallel modes that manage the channels and display the total output. This display shows the supply's parallel mode, including the output voltage and the total current from the channels wired in parallel.

Easily Test, Monitor, and Protect Your Circuits

- Adjust the outputs with the rotary knob or enter the output values precisely using the keypad with setting resolution of 10mV or 1mA.

- See the voltage and current readings on all channels at all times; the Model 2231A-30-3's display shows the readings from all three outputs simultaneously.

- Protect your DUT with an overvoltage protection setting for each output.

- Set timers to turn off an output after a programmed time to prevent excess stress on a circuit under development.

- Store and recall instrument setups for frequently used tests to begin testing quickly. You can store up to 30 unique test setups.
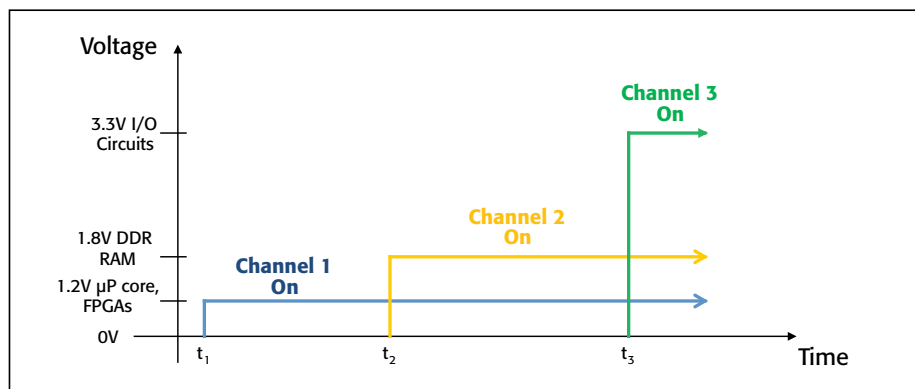
Safely power circuits up and down in the proper sequence using the three independently programmable output channels.

Control the Supply and Upload Data to a PC

Use the optional Model 2231A-001 USB Adapter to control the Model 2231A-30-1 via a PC's USB interface, then transfer readings from the outputs to combine with other test data for a more thorough analysis of DUT performance. The 2231A-001 USB Adapter provides the flexibility to use the supply under either manual or automated control.

2231A-30-3   195W Triple Channel DC Power Supply

Specifications

DC OUTPUT RATING

	Channel 1	Channel 2	Channel 3
Voltage	0–30 V	0–30 V	0–5 V
Current	0–3 A	0–3 A	0–3 A

MAXIMUM POWER: 195W

LOAD REGULATION:
  Voltage: ≤0.02% + 4mV
  Current: ≤0.2% + 3mA

LINE REGULATION:
  Voltage: ≤0.02% + 4mV
  Current: ≤0.2% + 3mA

RIPPLE AND NOISE (20Hz–20MHz):
  Voltage: ≤1mVrms/≤5mVp-p
  Current: ≤6mArms

SETTING RESOLUTION:
  Voltage: 10mV
  Current: 1mA

SETTING ACCURACY:
  Voltage: ≤0.06% + 20mV
  Current: ≤0.2% + 10mA

READBACK RESOLUTION:
  Voltage: 10mV
  Current: 1mA

READBACK ACCURACY:
  Voltage: ≤0.06% + 20mV
  Current: ≤0.2% + 10mA

ISOLATION VOLTAGE, OUTPUT TO CHASSIS: Any output can be isolated up to 240V (DC + peak AC with AC limited to a maximum of 3Vpk-pk and a maximum of 60Hz) relative to the earth ground terminal.

ISOLATION VOLTAGE, OUTPUT TO OUTPUT: Any output can be isolated up to 240V (DC + peak AC with AC limited to a maximum of 3Vpk-pk and a maximum of 60Hz) relative to any other output terminal.

TRACKING AND COMBINATION MODES:

  Tracking Mode: Maintains the ratio on the two 30V output channels that is present when the control is activated.

  Combination V1 + V2 Series Mode: Deliver up to 60V when CH1 and CH2 are wired in series. Meter reads back combined voltage.

  Combination I1 + 12 Parallel Mode: Deliver up to 6A when CH1 and CH2 are wired in parallel. Meter reads back combined current.

GENERAL

MEMORY: 30 setup memory locations.

OUTPUT TIMER RANGE: 0.1s to 99999.9s.

DISPLAY: Vacuum fluorescent display.

CONNECTIONS:
  Front: Power output jacks: 3 sets, safety-shrouded banana jacks.
  Rear: DB9 connector for remote control,

OVERTEMPERATURE PROTECTION: If the internal temperature of the supply exceeds 85°C, the supply will automatically turn off.

EMC COMPLIANCE: Conforms to European Union EMC Directive.

SAFETY COMPLIANCE: Conforms to European Union Low Voltage Directive.

POWER LINE RATINGS: 110VAC/230VAC ±10%.

POWER LINE FREQUENCY: 47Hz–63Hz.

MAXIMUM POWER CONSUMPTION: 750VA.

OPERATING ENVIRONMENT: 0° to 40°C, 5% to 80% relative humidity at up to 40°C.

STORAGE ENVIRONMENT: –20° to 70°C, 5% to 80% relative humidity up to 40°C, and 5% to 60% relative humidity from 40° to 70°C.

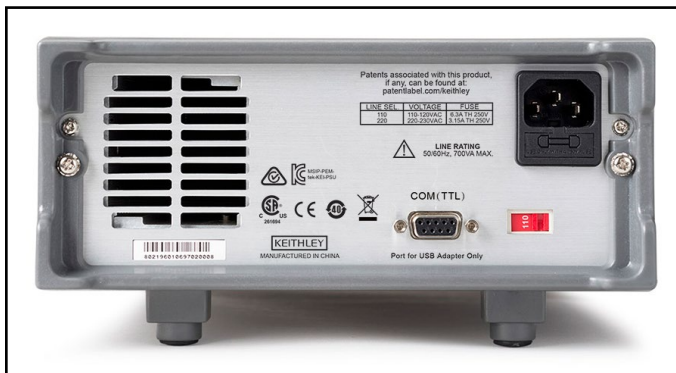**PHYSICAL CHARACTERISTICS**
  Height: 88.2 mm (3.5 in)
  Width: 214.5 mm (8.5 in)
  Depth: 354.6 mm (14 in)
  Net Weight: 7.10kg (15.7 lbs.).
  Shipping Weight: 9.40kg (20.7 lbs.).

WARRANTY: 3 years.

Model 2231A-30-3 rear panel showing the communication port, line power setting switch, and the power input connector with fuse holder.

KEITHLEY

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A Greater Measure of Confidence

For further information on how to purchase or to locate a sales partner please visit **www.keithley.com/buy**

Model 2231A-30-3 specifications

DC POWER SUPPLIES

# DMM6500 6½-Digit Bench/System Digital Multimeter

Datasheet

The DMM6500 is a modern bench/system DMM delivering more measurement functionality, best-in-class measurement insight, and a price that will not break your budget. The most recognizable feature of the DMM6500 is the large 5-inch (12.7 cm) capacitive touch screen display that makes it easy to observe, interact with, and explore measurements with "pinch and zoom" simplicity. Beyond its display technology, the DMM 6500 superior analog measurement performance delivers 25 PPM basic DCV accuracy for one year and 30 PPM for two years, potentially allowing you to extend your calibration cycles.

The DMM6500 is equipped with all the measurement functions you would expect in a bench multimeter, so there's no need to buy additional measurement capabilities. Its 15 measurement functions, including capacitance, temperature (RTD, thermistor, and thermocouple), diode test with variable current sources, and up to 1 MS/sec digitizing are now included.

The digitizing function can be used for voltage or current and is especially useful in capturing transient anomalies or to help profile power events such as the operating states of today's battery operated devices. Current and voltage can be digitized with a programmable 1 MS/sec 16-bit digitizer, making it possible to acquire waveforms without the need for a separate instrument.

Key Features

- 15 measurement functions including capacitance, temperature, and digitizing
- Expanded measurement ranges include 10 pA to 10 A and 1 mΩ to 100 MΩ
- Large 5-inch (12.7 cm) multi-touch capacitive touchscreen with graphical display
- Large internal memory; store up to 7 million readings
- Multiple language modes: SCPI, TSP® scripting, Keithley 2000 SCPI emulation, Keysight 34401A SCPI emulation
- Two-year specifications allow for longer calibration cycles
- Standard USB-TMC and LXI/Ethernet communication interfaces
- Optional user-installable communication interfaces including: GPIB, TSP-Link®, and RS-232
- Capture voltage or current transients with 1 MS/sec digitizer
- USB host port for storing readings, instrument configurations, and screen images
- Three-year warranty
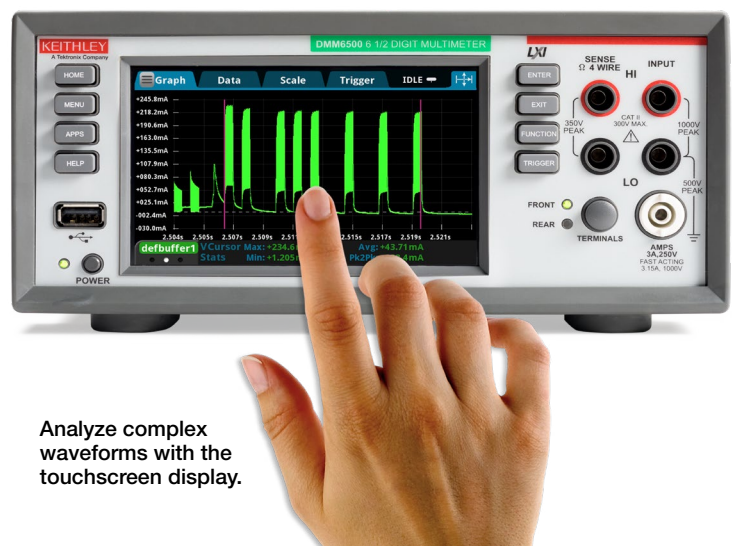
Analyze complex waveforms with the touchscreen display.

Tektronix

Capture and Analyze Voltage or Current Transitions

Power analysis is becoming more important in today's electronic designs. Designers must now consider more efficient components and complex system design typically requiring multiple power states. The DMM6500 has the tools you need to help design and troubleshoot these complex systems. Eight different current ranges allow measurements from 10 amps down to 10 pico-amps, giving you the dynamic range to measure your power states. In addition, a built-in 1 MS/sec digitizing function can help capture transient events, allowing you to see and analyze transitions as they occur.
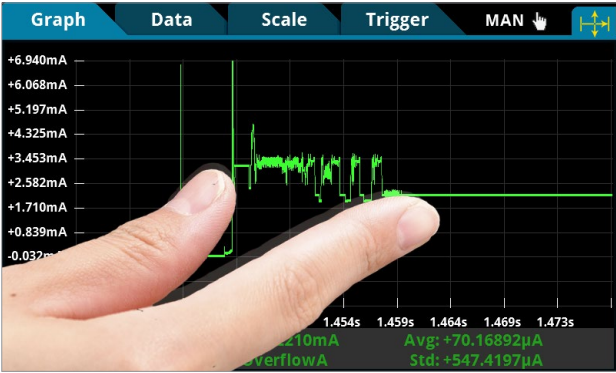
Pinch and zoom simplicity for in-depth waveform analysis.
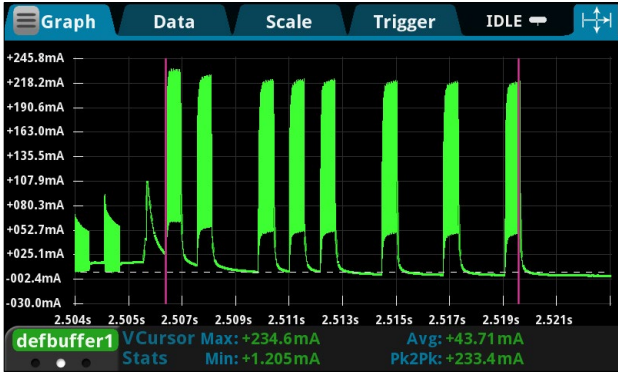
Visualize and analyze waveforms using adjustable cursors and statistics.

DMM6500 Measurement Capabilities
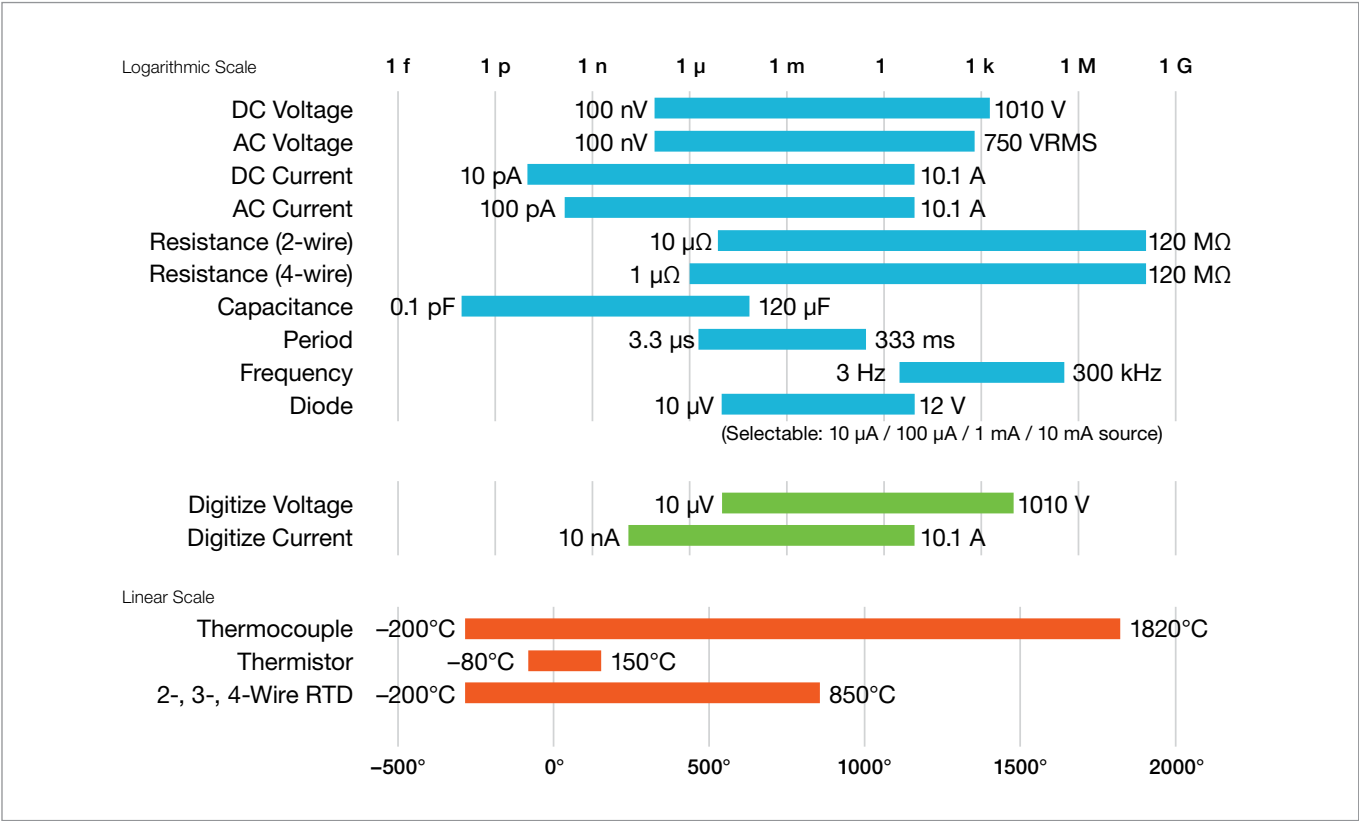
DMM6500 15 measurement functions and ranges.

DMM6500 Touchscreen Display Front Panel

Five-inch (12.7 cm) touchscreen displays more information simultaneously

One button access for easier navigation

Apps Key for quick access to customized programs

Online HELP is just a button press away

Store test results and screen images quickly via the USB 2.0 Host Port

Lower swipe screen speeds up access to often-used features such as function selection, statistics, and plotting

Front/rear input selector pushbutton with LED to easily identify position

DMM6500 Rear Panel

User-installable communication accessory. Provides connectivity options for GPIB, TSP-Link, or RS-232, and each with 6 programmable digital I/O ports

LAN/LXI Interface

BNC input/output triggers for external control and synchronization

User access to current protection fuse

Rear inputs including 10A current input

USB-TMC 2.0 Interface

User-installable scanner accessory for automated multi-channel measurements

Multi-channel/Scanning Applications

When characterizing or profiling your design it is often critical to make a series of measurements. In these applications the need for automated multi-channel measurements is advantageous. The DMM6500 is equipped with a scanner card slot allowing up to 10 channels of switching, giving you the capability to make automated multi-channel measurements. Plugging in the 2000-SCAN card gives users up to 10 channels of 2-pole measurements or 5 channels of 4-pole measurements. Functions can be programmed on a per-channel basis if supported by the switch topology.

2000-SCAN 10-Channel Multiplexer.
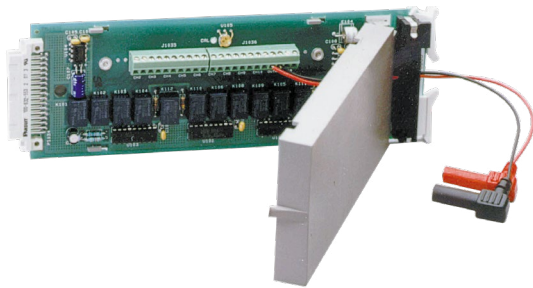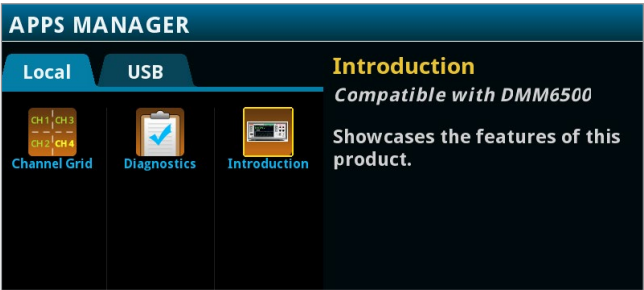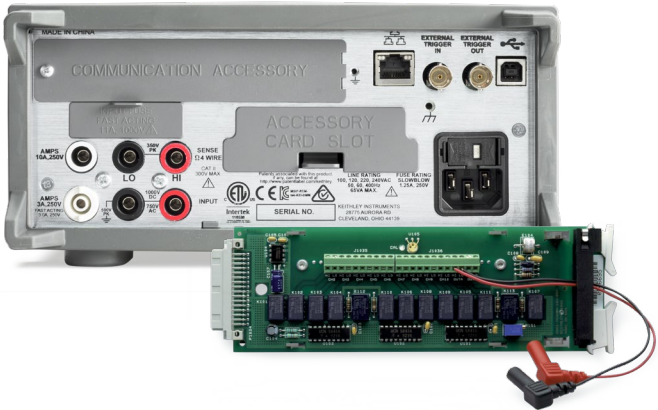
Application Programs

The DMM6500 is factory installed with application programs to help you get more out of your instrument. These application programs appear when the instrument is used in the TSP or native SCPI communication language mode. These examples highlight the unique ability of the DMM6500 to run specialized applications which customize the user interface. This can significantly change the way information is displayed or even automated in performing an application

Menu of application programs that can customize the display or perform special functions.

Temperature Measurement Applications

Temperature is one of the most measured signal types in the world, and the DMM6500 has many options to help you make this measurement. Besides RTD, thermistor, and thermocouple functions, you can equip your DMM with a nine-channel scanner card with built-in CJC for automated thermocouple temperature scanning. This feature is very useful when your design requires thermal profiling, especially when enclosed in a temperature chamber.

**2001-TCSCAN 9-Channel Thermocouple Multiplexer and DMM6500 rear panel.**

Ready to Use Instrument Drivers Simplify Programming

Prefer to create your own customized application software? Native National Instruments Labview®, IVI-C, and IVI-COM drivers are available for downloading to simplify the programming process. For the Labview® driver visit www.ni.com; for IVI drivers visit www.tek.com.

System Integration and Programming

Users have maximum programming flexibility with the DMM6500. In addition to traditional SCPI programming (default), the unit can also be configured for SCPI emulation for the Keithley 2000 or the Keysight 34401A. Additionally, Keithley's powerful Test Script Processor (TSP®) programming is another option that allows unique single- or multi-instrument testing applications where speed is critical.
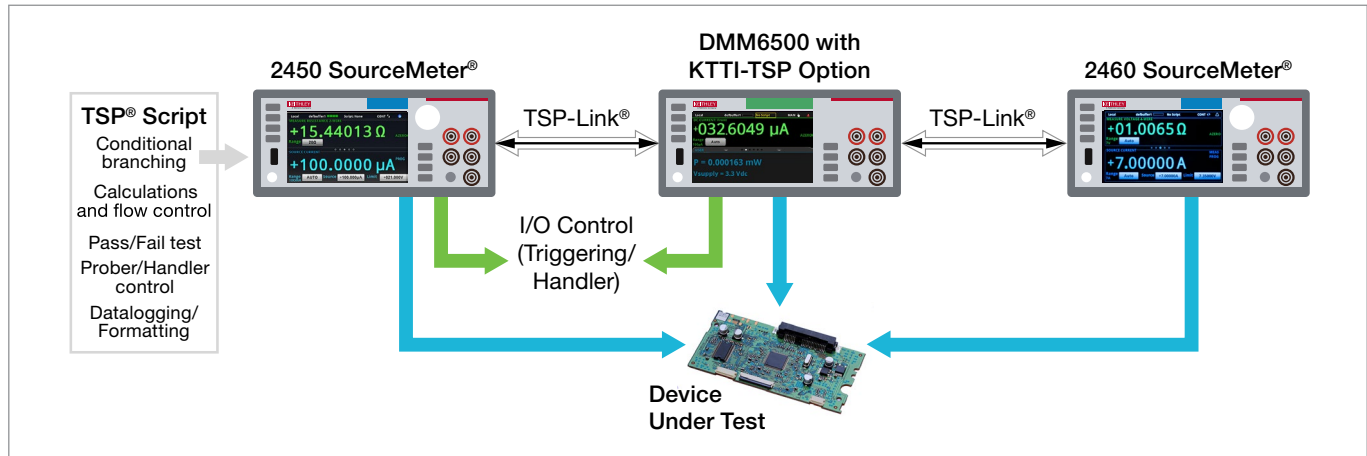
 TSP System using TSP-Link for instrument to instrument communication.

TSP® scripting allows running powerful test scripts directly on the instrument, without the need for an external PC controller. These test scripts are complete test programs based on an easy-to-use yet highly efficient and compact scripting language, LUA (www.lua.org). Scripts are a collection of instrument control commands and/or program statements. Program statements control script execution and provide facilities such as variables, functions, branching, and loop control. This allows you to create powerful measurement applications without an integrated development environment (IDE). Test scripts can contain any sequence of routines that are executable by conventional programming languages (including decision-making algorithms), so the instrument can manage every facet of the test without the need to communicate with a PC for decision making. This eliminates delays due to GPIB, Ethernet, or USB traffic congestion and greatly improves test times.

```
1  -- Define functions...
2  function meas4WRes(nplcVal)
3      --Set measure function to 4-wire Res
4      dmm.measure.func = dmm.FUNC_4W_RESISTANCE
5
6      --Enable autorange.
7      dmm.measure.autorange = dmm.ON
8
9      --Enable autozero.
10     dmm.measure.autozero.enable = dmm.ON
11
12     --Enable OCOMP
13     dmm.measure.offsetcompensation.enable = dmm.ON
14
15     --Set the number of power line cycles
16     dmm.measure.nplc = nplcVal
17
18     --Read the resistance value.
19     return dmm.measure.read()
20  end
21
22  -- Run main code...
23  -- Reset the Model DMM6500
24  reset()
25
26  -- Execute a 4W measurement
27  print(meas4WRes(1.0))
```

TSP Scripting example showing 4-wire resistance.

TSP technology also offers mainframe-less channel expansion. The KTTI-TSP is a user installable accessory card offering connectivity to TSP-Link® technology. This channel expansion bus allows connecting multiple DMM6500's or other TSP-enabled instruments together to form a tightly synchronized instrument system. Connection is provided with simple low cost Category 5 Ethernet cabling. The system is organized in a master-subordinate configuration, essentially allowing the connected instruments to act as one. Other Keithley TSP-enabled instruments include the 2450 and 2460 Graphical SourceMeter® SMU Instruments, Series 2600B SourceMeter® SMU Instruments, DMM7510, DAQ6510, and the Series 3700A Switch/Multimeter Measurement systems. TSP-Link technology supports up to 32 units, so it's easy to scale a system to fit the requirements of an application.

KickStart Instrument PC Control Software

KickStart allows you to configure, test, and collect data from multiple instruments, including DMMs, power supplies, SMU instruments, and dataloggers. You can control up to eight instruments at the same time and retrieve millions of readings from each instrument. This makes KickStart a great solution for your datalogging needs and for capturing lots of data from transient events with a digitizing DMM.

Getting insights quickly is important, so KickStart plots your data immediately and dedicates a large portion of the viewing area to the graph, while also allowing you to view and edit the most essential parameters of other instruments in your test setup. Kickstart also includes comparison tools to allow you to plot and overlay data from the run history of each test.

Key KickStart features:

- Automate data collection from up to eight instruments
- Replicate tests quickly using saved test configurations
- Use statistical summaries and built-in plotting and comparison tools to quickly discover measurement anomalies and trends
- Export data in ready-to-use formats for additional analysis or to share test updates with your colleagues
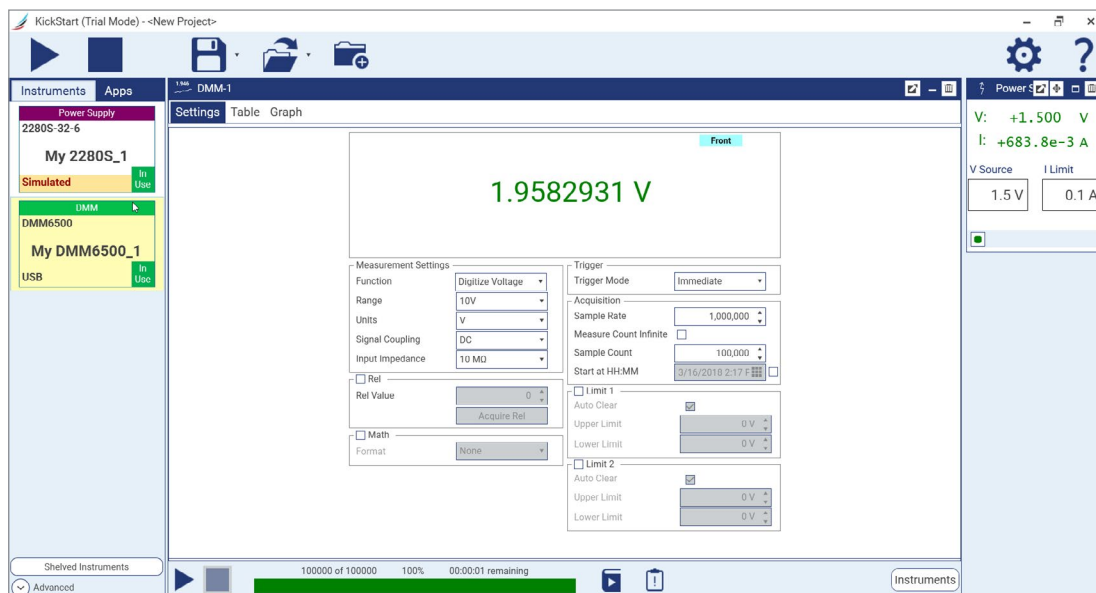
Kickstart allows you to perform and setup a test quickly and easily using a single point-and-click setup screen.
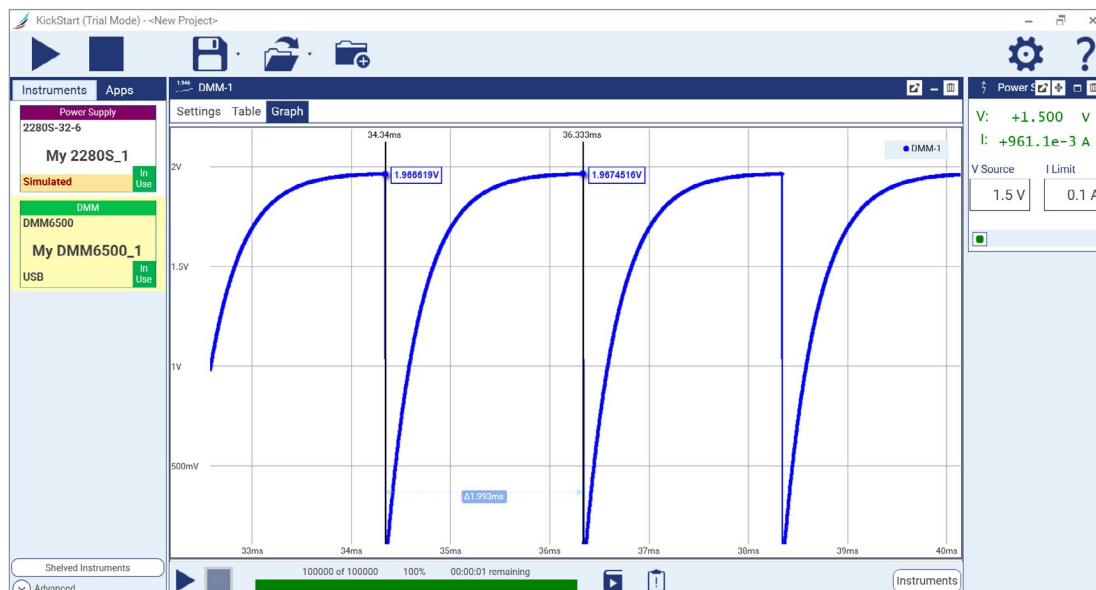
KickStart allows you to display data in both graphical and tabular formats. Mouse over the data in the graph to see exact values or use cursors to view detail on multiple data series at once.

Specification Conditions

This document contains specifications and supplemental information for the DMM6500 Multimeter System. Specifications are the standards against which the DMM6500 is tested. Upon leaving the factory, the DMM6500 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23°C, and are provided solely as useful information. Measurement accuracies are specified for DMM6500 front or rear input terminals and include conversion error for thermocouple, thermistor, and RTD measurements.

Measurement Conditions Include:

- After a 30-minute warmup period.
- 1 PLC or 5 PLC measurement rate; for NPLC settings less than 1 PLC, add appropriate noise error from "Measurement Noise" table.
- Autozero enabled.
- Calibration period: one year (recommended) or two years. Calibration period may vary depending on customer requirements.
- 24-hour accuracy specification is relative to calibrator accuracy.
- Communication accessory card slot cover or an optional KTTI interface card is properly installed onthe rear of the unit.

Definitions:

- T_{CAL} — The temperature at which the instrument was calibrated (23°C for factory calibration).
- **Temperature coefficient** — Additional uncertainty added for each°C outside T_{CAL} ±5°C.
- **Power Line Cycle (PLC)** — 16.67 ms at 60 Hz and 20 ms at 50 Hz or 400 Hz line frequency. Frequency automatically sensed at power up.

DC Voltage

DC Voltage Accuracy ±(% of reading + % of range)

Range	Resolution	Input Impedance	24 Hours T_{CAL} ±1°C	90 Days T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Years T_{CAL} ±5°C	Temperature Coefficient
100 mV	100 nV	>10 GΩ or 10 MΩ ±1%	0.0015 + 0.0030	0.0025 + 0.0035	0.0030 + 0.0035	0.0035 + 0.0035	0.0001 + 0.0005
1 V	1 µV	>10 GΩ or 10 MΩ ±1%	0.0015 + 0.0006	0.0020 + 0.0006	0.0025 + 0.0006	0.0030 + 0.0006	0.0001 + 0.0001
10 V	10 µV	>10 GΩ or 10 MΩ ±1%	0.0010 + 0.0004	0.0020 + 0.0005	0.0025 + 0.0005	0.0030 + 0.0005	0.0001 + 0.0001
100 V	100 µV	10 MΩ ±1%	0.0015 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0050 + 0.0006	0.0006 + 0.0001
1000 V [1]	1 mV	10 MΩ ±1%	0.0020 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0050 + 0.0006	0.0006 + 0.0001

Measurement Noise Characteristics and Rejection Ratios

Measurement Rate in NPLCs	Digits	DCV RMS Noise Uncertainty (in % of range + fixed base) [2]	NMRR [3]	CMRR [3]
5 [4]	6.5	0	100 dB	140 dB
5		0	60 dB	140 dB
1 [4]		0	90 dB	140 dB
1		0	60 dB	140 dB
0.1 [4]		0.00015 + 1 µV	40 dB	120 dB
0.1	5.5	0.00015 + 4 µV	--	120 dB
0.01		0.00030 + 6 µV	--	80 dB
0.0005	4.5	0.00500 + 40 µV	--	80 dB

DC Voltage Characteristics

Overrange	20% on 100 mV, 1 V, 10 V, and 100 V. 1% on 1000 V
ADC Linearity (10 V range)	0.0001% of 10 V range
Input Impedance	**100 mV to 10 V Ranges:** Selectable: (>10 GΩ or 10 MΩ ±1%) in parallel with <400 pF. **100 V to 1000 V Ranges:** 10 MΩ ±1% in parallel with <400 pF
Input Bias Current	<50 pA at 23°C
Common Mode Current	<600 nA peak-peak at 50 Hz or 60 Hz
Earth Isolation	500 V_{peak} >10 GΩ and <300 pF any terminal to chassis
Common Mode Voltage	500 V_{peak} LO terminal to chassis maximum
Autozero Off Error	Add ±(0.0002% of range + 3 µV) within ±1°C and ≤10 minutes since last autozero Add ±(0.0010% of range + 10 µV) within ±5°C and ≤60 minutes since last autozero
Input Protection	Input HI 1100 V, Sense HI (SHI) and Sense LO (SLO) 350 V referenced to LO

Scanner Card Additional Uncertainties and Maximum Input Signal Levels

Scanner Card	Add the Following Uncertainty	Maximum Input Signal Level
2000-SCAN	1 µV	110 V
2001-TCSCAN	1 µV	110 V

Notes

1. For each additional volt over ±500 V, add 0.02 mV of uncertainty.
2. Noise values apply to terminals using a low-thermal short for 50 Hz and 60 Hz operation only. Measurements through a card may introduce additional noise.
3. NMRR for line frequency ±0.1%. For DC common mode and 1 kΩ unbalance on LO terminal, rejection of AC common mode signals is >80 dB for line frequency ±0.1%.
4. Line sync on.

Resistance

Resistance Accuracy ±(% of reading + % of range) [5]

Range	Resolution	Test Current (±5%)	Open Circuit Voltage (±5%)	24 Hours T_{CAL} ±1°C	90 Days T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Years T_{CAL} ±5°C	Temperature Coefficient
1 Ω [6]	1 µΩ	10 mA	12.5 V	0.0080 + 0.0200	0.0080 + 0.0200	0.0085 + 0.0200	0.0100 + 0.0200	0.0006 + 0.0010
10 Ω [6]	10 µΩ	10 mA	12.5 V	0.0020 + 0.0020	0.0080 + 0.0020	0.0085 + 0.0020	0.0100 + 0.0020	0.0006 + 0.0001
100 Ω	100 µΩ	1 mA	9.2 V	0.0020 + 0.0020	0.0075 + 0.0020	0.0085 + 0.0020	0.0100 + 0.0020	0.0006 + 0.0001
1 kΩ	1 mΩ	1 mA	9.2 V	0.0020 + 0.0006	0.0065 + 0.0006	0.0075 + 0.0006	0.0090 + 0.0006	0.0006 + 0.0001
10 kΩ	10 mΩ	100 µA	12.7 V	0.0020 + 0.0006	0.0065 + 0.0006	0.0075 + 0.0006	0.0090 + 0.0006	0.0006 + 0.0001
100 kΩ	100 mΩ	10 µA	12.5 V	0.0020 + 0.0006	0.0070 + 0.0010	0.0075 + 0.0010	0.0100 + 0.0010	0.0006 + 0.0001
1 MΩ	1 Ω	10 µA	12.5 V	0.0020 + 0.0006	0.0075 + 0.0006	0.0100 + 0.0006	0.0120 + 0.0006	0.0006 + 0.0001
10 MΩ [7]	10 Ω	0.7 µA ‖ 10 MΩ	7.1 V	0.0150 + 0.0006	0.0200 + 0.0010	0.0400 + 0.0010	0.0450 + 0.0010	0.0070 + 0.0001
100 MΩ [7]	100 Ω	0.7 µA ‖ 10 MΩ	7.1 V	0.0800 + 0.0030	0.2000 + 0.0030	0.2000 + 0.0030	0.2500 + 0.0030	0.0385 + 0.0001

Resistance Measurement Noise Characteristics [8]

Measurement Rate in NPLC	Digits	2-wire RMS Noise Uncertainty (in % of range + fixed base)	4-wire RMS Noise Uncertainty, Offset Compensation OFF (in % of range + fixed base) [9]	4-wire RMS noise uncertainty, offset compensation ON (in % of range + fixed base) [9]
5	6.5	0	0	0
1		0	0	0
0.1 [10]		0.00015 + 0.10 mΩ	0.00020 + 0.20 mΩ	0.00030 + 0.25 mΩ
0.1	5.5	0.00050 + 0.35 mΩ	0.00180 + 2.00 mΩ	0.00350 + 3.50 mΩ
0.01		0.00070 + 0.50 mΩ	0.00260 + 2.50 mΩ	0.00500 + 4.00 mΩ
0.0005	4.5	0.00650 + 3.50 mΩ	0.01000 + 7.00 mΩ	0.01500 + 10.00 mΩ

Resistance Characteristics

Overrange	20% on all ranges
Autozero Off Error	Add ±(0.0005% of range + 5 mΩ) within ±1°C and ≤10 minutes since last autozero Add ±(0.0020% of range + 10 mΩ) within ±5°C and ≤60 minutes since last autozero
Offset Compensation	Selectable on 1 Ω, 10 Ω, 100 Ω, 1 k Ω, and 10 kΩ ranges, 4-wire mode only
Maximum 4-wire Lead Resistance	5 Ω per lead for 1 Ω range 10% of range per lead for 10 Ω, 100 Ω, 1 kΩ, and 10 kΩ ranges 1 kΩ per lead for 100 kΩ, 1 MΩ, 10 MΩ, and 100 MΩ
Open Lead Detector	Selectable on all ranges, 4-wire mode only; default is off.
Input Protection	Input HI 1100 V, Sense HI (SHI) and Sense LO (SLO) 350 V referenced to LO

Scanner Card Additional Contact Resistance

Scanner Card	Contact Resistance
2000-SCAN	1 Ω at end of life
2001-TCSCAN	1 Ω at end of life

Notes

5. Specifications are for 2- and 4-wire resistance. For 2-wire, use relative offset and add 100 mΩ of additional uncertainty. For 4-wire, turn offset compensation on for ≤10 kΩ and off for >10 kΩ. The 1 Ω range is for 4-wire only.
6. Requires a 10-reading digital filter at 1 PLC or 2-reading digital filter at 5 PLC.
7. Specified for < 10% lead-resistance mismatch at HI and LO.
8. Applies for 1 Ω through 1 MΩ ranges. For 100 Ω range, multiply the listed values by five. Noise values apply to terminals using a low-thermal short for 50 Hz and 60 Hz operation only. Measurements through a card may introduce additional noise.
9. Open lead detection off.
10. Line sync on.

DC Current

DC Current Accuracy ±(% of reading + % of range)

Range	Resolution	Burden Voltage	24 Hours T_{CAL} ±1°C	90 Days T_{CAL} ±5°C	1 Year $T_{CA}L$ ±5°C	2 Years T_{CAL} ±5°C	Temperature Coefficient
10 µA	10 pA	<0.13 V	0.007 + 0.002	0.035 + 0.005	0.045 + 0.005	0.055 + 0.005	0.0030 + 0.0006
100 µA	100 pA	<0.14 V	0.010 + 0.020	0.035 + 0.005	0.045 + 0.005	0.055 + 0.005	0.0020 + 0.0005
1 mA	1 nA	<0.17 V	0.007 + 0.006	0.035 + 0.005	0.045 + 0.005	0.055 + 0.005	0.0020 + 0.0005
10 mA	10 nA	<0.17 V	0.006 + 0.003	0.018 + 0.005	0.020 + 0.005	0.025 + 0.005	0.0015 + 0.0005
100 mA	100 nA	<0.20 V [11]	0.010 + 0.030	0.015 + 0.005	0.020 + 0.005	0.025 + 0.005	0.0015 + 0.0005
1 A	1 µA	<0.55 V [11]	0.020 + 0.004	0.030 + 0.005	0.040 + 0.005	0.050 + 0.005	0.0030 + 0.0005
3 A	1 µA	<1.70 V [11]	0.030 + 0.004	0.040 + 0.004	0.050 + 0.004	0.060 + 0.004	0.0030 + 0.0005
10 A [12]	10 µA	<0.50 V	0.140 + 0.025	0.190 + 0.025	0.220 + 0.025	0.250 + 0.025	0.0060 + 0.0005

DC Current Characteristics

Overrange	20% on 10 µA, 100 µA, 1 mA, 10 mA, 100 mA, and 1 A ranges 1% on 3 A and 10 A ranges
Terminal Input Protection	Externally accessible 3 A, 250 V fast-acting fuse, 5 × 20 mm Keithley replacement part number FU-99-1 Externally accessible 11 A and 1000 V fuse Keithley replacement part number (11A) 159-0583-00
Autozero Off Error	Add ±0.004% of range within ±1°C and ≤10 minutes since last autozero Add ±0.015% of range within ±5°C and ≤60 minutes since last autozero

Nominal Shunt Resistance [13]

10 µA	100 µA	1 mA	10 mA	100 mA	1 A	3 A	10 A
10 kΩ	1 kΩ	100 Ω	10 Ω	1 Ω	100 mΩ	100 mΩ	5 mΩ

DC Current Measurement Noise Characteristics [14]

Measurement Rate in NPLC	Digits	Additional Noise Error (in % of range + fixed base)
5	6.5	0
1		0
0.1 [15]		0.0009 + 10.0 pA
0.1	5.5	0.0015 + 3.5 nA
0.01		0.0030 + 3.5 nA
0.0005	4.5	0.0200 + 5.0 nA

Notes

11. When using the rear terminals, add 0.1 V to the 100 mA range and 0.5 V to the 1 A and 3 A ranges.
12. For each additional ampere over ±6 A, add 2 mA of uncertainty. Operation for >1000 hours with a signal level of >7 A, add 0.05% of reading uncertainty for every 1000 hours.
13. Guaranteed by design.
14. Noise values apply to open terminals. Measurements through a card may introduce additional noise.
15. Line sync on.

Temperature

Thermocouple Accuracy ±°C [16]

Type	Resolution	Range	2 Year Accuracy T_{CAL} ±5°C; all uncertainties in °C			Temperature Coefficient in°C/°C
			Simulated or External CJC		Internal CJC (on module)	
			Front/Rear Terminals	2001-TCSCAN	2001-TCSCAN	
J	0.001°C	0° to 760°C	0.20	0.20	0.65	0.03
		−200° to <0°C	0.20	0.20	0.65	0.03
K	0.001°C	0° to 1372°C	0.20	0.20	0.70	0.03
		−200° to <0°C	0.30	0.30	0.70	0.03
N	0.001°C	0° to 1300°C	0.20	0.20	0.70	0.03
		−200° to <0°C	0.50	0.60	1.50	0.03
T	0.001°C	0° to 400°C	0.20	0.20	0.70	0.03
		−200° to <0°C	0.30	0.30	0.70	0.03
E	0.001°C	0° to 1000°C	0.20	0.20	0.70	0.03
		−200° to <0°C	0.20	0.30	0.70	0.03
R	0.010 °C	600° to 1768°C	0.40	0.50	1.30	0.03
		0° to <600°C	0.80	1.00	1.30	0.03
S	0.010 °C	600° to 1768°C	0.40	0.50	1.30	0.03
		0° to <600°C	0.80	1.00	1.30	0.03
B	0.010 °C	1100° to 1820°C	0.40	0.50	1.65	0.03
		350° to <1100°C	1.20	1.50	1.65	0.03

Resistance Temperature Detector (RTD) Accuracy ±°C

Types: 100 Ω platinum PT100, D100, F100, PT385, and PT3916 or user-configurable 0 Ω to 10 kΩ

Measurement Method	Resolution	Range	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient in°C/°C
2-wire [17]	0.01°C	−200° to 850°C	0.80	0.003
3-wire [18]	0.01°C	−200° to 600°C	0.35	0.003
		>600° to 850°C	0.37	0.003
4–wire	0.01°C	−200° to 600°C	0.06	0.003
		>600° to 850°C	0.12	0.003

Thermistor Accuracy ±°C

Types: 2.2 kΩ, 5 kΩ, and 10 kΩ

Measurement Method	Resolution	Range	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient in°C/°C
2-wire	0.01°C	80° to 150°C	0.08	0.002

For readings >70°C, add this additional uncertainty per Ω of lead, channel, and contact resistance

Thermistor Type	Common Model Number	70° to 100°C	>100° to 150°C
2.2 kΩ	44004	0.22°C per Ω	1.11°C per Ω
5 kΩ	44007	0.10°C per Ω	0.46°C per Ω
10 kΩ	44006	0.04°C per Ω	0.19°C per Ω

Notes

16. Accuracy excludes probe errors.
17. Specifications do not include errors that may arise from user's cable or terminal resistance.
18. 3-wire RTD accuracy is for <0.1 Ω lead-resistance mismatch for input HI and LO. Add 0.25°C per 0.1 Ω of HI-LO resistance mismatch.

Temperature Characteristics

Thermocouple Conversion	ITS-90
Thermocouple Reference Junction	External (CJC on 2001-TCSCAN or user-provided with 2000-SCAN) or simulated (fixed)
Open Thermocouple Detection	Selectable per channel (open >130 kΩ; default on
Earth Isolation	500 V_{PEAK} > 0 GΩ and <300 pF any terminal to chassis

AC Voltage

AC Voltage Accuracy ±(% of reading + % of range) [19]

Range	Resolution	Calibration Cycle	3 Hz to 5 Hz	5 Hz to 10 Hz	10 Hz to 20 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 300 kHz
100 mV	100 nV	24 hours	1.00 + 0.02	0.35 + 0.02	0.04 + 0.02	0.10 + 0.04	0.55 + 0.08	4.00 + 0.50
1 V	1 µV	90 days	1.00 + 0.03	0.35 + 0.03	0.05 + 0.03	0.11 + 0.05	0.60 + 0.08	4.00 + 0.50
10 V	10 µV	1 year	1.00 + 0.03	0.35 + 0.03	0.06 + 0.03	0.12 + 0.05	0.60 + 0.08	4.00 + 0.50
100 V	100 µV							
750 V	100 µV	2 years	1.00 + 0.03	0.35 + 0.03	0.07 + 0.03	0.13 + 0.05	0.60 + 0.08	4.00 + 0.50
Temperature Coefficient			0.100 + 0.003	0.035 + 0.003	0.005 + 0.003	0.011 + 0.005	0.060 + 0.08	0.200 + 0.020

AC Voltage Characteristics

Overrange (voltages in V_{RMS})	20% on 100 mV, 1 V, 10 V, and 100 V ranges. 0% for 750 V range
AC Measurement Method	AC-coupled digital sampling with anti-alias filter
Crest Factor (excludes sine wave)	Crest factors of up to 3:1 at full-scale input or 10:1 maximum, whichever is greater.
	Autorange selects optimum range for crest factor up to 10:1.
	Accuracy specifications apply to all crest factors and are limited to a product of (crest factor) × (fundamental frequency) ≤ 3 kHz.
Volt*Hertz Product	≤8 × 10^7 V*Hz [20]
Common Mode Rejection Ratio	>70 dB, for 1 kΩ unbalance in LO lead
Detector Bandwidth	Setting of 3 Hz, 30 Hz, or 300 Hz sets maximum measurement aperture of 200 ms, 20 ms, or 2 ms, respectively; only signals with frequency greater than the detector bandwidth are measured.
Input Impedance	1.1 MΩ ±2%, in parallel with <100 pF
Input Protection	1100 V_{peak}
Maximum DCV	400 V on any ACV range
ACV Frequency	Frequency reading automatically returned in reading buffer when in full buffer mode. Frequency readings are specified as in the frequency and period table.

Scanner Card Maximum Input Signal Levels

Module	Maximum input signal level
2000-SCAN	125 V_{RMS}/175 V_{peak}
2001-TCSCAN	125 V_{RMS}/175 V_{peak}

Notes
19. Specifications are for sine wave inputs >5% of range.
20. Guaranteed by design.

AC Current

AC Current Accuracy ± (% of reading + % of range) [21]

Range	Resolution	Burden Voltage	Frequency	24 Hours T_{CAL} ±1°C	90 Days T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Years T_{CAL} ±5°C	Temperature Coefficient
100 µA	100 pA	<0.14 V	3 Hz – 1 kHz	0.10 + 0.07	0.10 + 0.07	0.10 + 0.07	0.10 + 0.07	0.015 + 0.010
			>1 kHz – 10 kHz [22]	0.15 + 0.07	0.15 + 0.07	0.15 + 0.07	0.15 + 0.07	0.030 + 0.010
1 mA	1 nA	<0.17 V	3 Hz – 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			>5 kHz – 10 kHz [22]	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
10 mA	10 nA	<0.17 V	3 Hz – 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10+ 0.04	0.015 + 0.006
			>5 kHz – 10 kHz [22]	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
100 mA	100 nA	<0.20 V [23]	3 Hz – 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			>5 kHz – 10 kHz [22]	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
1 A	1 µA	<0.75 V [23]	3 Hz – 5 kHz [24]	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			>5 kHz – 10 kHz [22]	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.030 + 0.006
3 A	1 µA	<1.70 V [23]	3 Hz – 5 kHz [24]	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.015 + 0.006
			>5 kHz – 10 kHz [22]	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.030 + 0.006
10 A	10 µA	<0.50 V	3 Hz – 1 kHz [24]	0.40 + 0.06	0.40 + 0.06	0.40 + 0.06	0.40 + 0.06	0.015 + 0.006
			>1 kHz – 5 kHz	1.00 + 0.07	1.00 + 0.07	1.00 + 0.07	1.00 + 0.07	0.030 + 0.012
			>5 kHz – 10 kHz [22]	1.00 + 0.07	1.00 + 0.07	1.00 + 0.07	1.00 + 0.07	0.030 + 0.012

AC Current Characteristics

Overrange	20% on 100 µA, 1 mA, 10 mA, 100 mA, and 1 A ranges 1% on 3 A and 10 A ranges
AC Measurement Type	AC-coupled True RMS; measures the AC component of the input Digital sampling with anti-alias filter
Input Protection	See DC current characteristics.
Crest Factor [25] (excludes sine wave)	10:1 maximum crest factor (1.75:1 at full-scale)
	Autorange selects optimum range for crest factor up to 10:1
	Accuracy specifications apply to all crest factors less than 5 and are limited to the product of (crest factor) × (fundamental frequency) ≤ 200 Hz.
ACI Frequency	Frequency readings are automatically returned in the reading buffer when in full buffer mode. Frequency values are typical.
Nominal Shunt Resistance [26]	100 µA: 1 kΩ, 1 mA: 100 Ω, 10 mA: 10 Ω, 100 mA: 1 Ω, 1 A: 100 mΩ, 3 A: 100 mΩ, 10 A: 5 mΩ

Notes

21. Specifications are for sine wave inputs >5% of range and >10 µA$_{RMS}$.
22. Typical performance for the indicated frequency ranges.
23. When using the rear terminals, add 0.1 V to the 100 mA range and 0.5 V to the 1 A and 3 A ranges.
24. For signals of <5 Hz, add 0.2% of reading uncertainty.
25. 100 µA range is specified only for crest factors <3.
26. Guaranteed by design.

Frequency and Period

Frequency and Period Accuracy ± (% of reading) [27]

Range	Resolution	Frequency	Period	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient in°C/°C
100 mV to 750 V (For signals >5% of range and >10 mV$_{RMS}$)	0.0001% of reading	3 Hz to 10 Hz	333 ms to 100 ms	0.100	0.0002
		>10 Hz to 100 Hz	<100 ms to 10 ms	0.030	0.0002
		>100 Hz to 1 kHz	<10 ms to 1 ms	0.010	0.0002
		>1 kHz to 300 kHz	<1 ms to 3.3 µs	0.009	0.0002
		Square Wave [28]		0.008	0.0002

Frequency and Period Characteristics

Measurement Method	Reciprocal-counting technique; measurement is AC-coupled using AC measurement functions.
Voltage Ranges	100 mV$_{RMS}$ full scale to 750 V$_{RMS}$; auto or manual ranging.
Gate Time	User definable from 2 ms to 273 ms (default 200 ms)

Continuity

Continuity Accuracy 2-Wire ±(% of reading + % of range) [29]

Range	Resolution	Test Current	Open Circuit Voltage (±5%)	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient
1 kΩ	100 mΩ	1 mA	9.2 V	0.010 + 0.010	0.0006 + 0.0001

Capacitance

Capacitance Accuracy ±(% of reading + % of range) [30]

Range	Resolution	Charge Current (±5%) [31]	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient
1 nF	0.1 pF	1 µA	0.80 + 0.50	0.05 + 0.05
10 nF	1 pF	10 µA	0.40 + 0.10	0.05 + 0.01
100 nF	10 pF	100 µA	0.40 + 0.10	0.05 + 0.01
1 µF	0.1 nF	100 µA	0.40 + 0.10	0.05 + 0.01
10 µF	1 nF	1 mA	0.40 + 0.10	0.05 + 0.01
100 µF	10 nF	1 mA	0.40 + 0.10	0.05 + 0.01

Capacitance Characteristics

Overrange	20% on all ranges.
Measurement Method	Constant current slope measurement.

Maximum Voltage and Voltage Clamp

For all devices: Clamped by hardware to <3 V.

Notes

27. Specifications apply for sine wave input; detector bandwidth of 3 Hz. For detector bandwidth 30 Hz, add 100 mHz uncertainty. For detector bandwidth 300 Hz, add 1 Hz uncertainty.
28. Used for square waves with amplitude > 10% of range and 10 Hz to 300 kHz.
29. Does not include the user's lead-resistance.
30. Accuracies are specified for cable, channel, and other stray connector capacitance properly zeroed with the REL function.
31. Discharge current limited to <10 mA.

Diode

Diode Voltage Accuracy ±(% of reading + additional uncertainty) [32]

Voltage Measure Range	Resolution	Maximum Voltage Measurement	Test Current (±5%)	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient
10 V	10 µV	12 V	10 µA	0.0045 + 60.0 µV	0.0008 + 10 µV
		10 V	100 µA	0.0045 + 80.0 µV	0.0008 + 10 µV
		7 V	1 mA	0.0045 + 170.0 µV	0.0010 + 10 µV
		7 V	10 mA	0.0045 + 1.1 mV	0.0010 + 10 µV

Digitize

Digitize DC Voltage Accuracy ±(% of reading + % of range) [33]

Range	Resolution	Input Impedance	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient
100 mV	10 µV	>10 GΩ or 10 MΩ ±1%	0.040 + 0.020	0.0025 + 0.0030
1 V	100 µV	>10 GΩ or 10 MΩ ±1%	0.030 + 0.010	0.0025 + 0.0010
10 V	1 mV	>10 GΩ or 10 MΩ ±1%	0.030 + 0.010	0.0025 + 0.0010
100 V	10 mV	10 MΩ ±1%	0.030 + 0.010	0.0025 + 0.0010
1000 V	100 mV	10 MΩ ±1%	0.030 + 0.010	0.0025 + 0.0010

Digitize DC Current Accuracy ±(% of reading + % of range) [33]

Range	Resolution	Burden Voltage	2 Year Accuracy T_{CAL} ±5°C	Temperature Coefficient
100 µA	10 nA	<0.14 V	0.07 + 0.05	0.0030 + 0.0035
1 mA	100 nA	<0.17 V	0.07 + 0.03	0.0030 + 0.0035
10 mA	1 µA	<0.17 V	0.05 + 0.03	0.0030 + 0.0035
100 mA	10 µA	<0.20 V [34]	0.05 + 0.03	0.0020 + 0.0035
1 A	100 µA	<0.55 V [34]	0.07 + 0.03	0.0040 + 0.0035
3 A	100 µA	<1.70 V [34]	0.09 + 0.04	0.0040 + 0.0035
10 A	1 mA	<0.50 V	0.25 + 0.08	0.0060 + 0.0100

Notes

32. Specifications do not include errors that may arise from user's cable or connection resistance.
33. DC accuracy specified with 1000 samples per second, 100-reading digital filter.
34. When using the rear terminals, add 0.1 V to the 100 mA range and 0.5 V to the 1 A and 3 A ranges.

Typical Digitize Signal Characteristics

1 dB full-scale of range

Function: Range	Spur-free Range SFDR (1 kHz / 10 kHz / 50 kHz)	THD + Noise SNDR (1 kHz / 10 kHz / 50 kHz)	Bandwidth (–3 dB, 5%)	Effective Number of Bits (1 kHz/10 kHz/50 kHz)
DCV: 100 mV	75 / 70 / 50	65 / 60 / 50	210 kHz	9 / 9 / 7
DCV: 1 V	95 / 90 / 75	80 / 80 / 75	210 kHz	12 / 12 / 11
DCV: 10 V	95 / 80 / 70	90 / 80 / 70	440 kHz	13 / 12 / 10
DCV: 100 V	50 / 35 / 25	50 / 40 / 30	17 kHz	10 / 8 / 7
DCV: 1000 V	50 / 35 / 25	50 / 40 / 30	17 kHz	13 / 11 / 10
DCI: 100 µA	80 / 65 / 45	70 / 65 / 45	430 kHz	12 / 10 / 8
DCI: 1 mA	80 / 65 / 45	70 / 65 / 45	570 kHz	12 / 10 / 8
DCI: 10 mA	80 / 65 / 45	70 / 65 / 45	230 kHz	12 / 10 / 8
DCI: 100 mA	80 / 65 / 45	70 / 65 / 45	340 kHz	12 / 10 / 8
DCI: 1 A	70 / 50 / 40	65 / 50 / 40	25 kHz	11 / 8 / 7
DCI: 3 A	70 / 50 / 40	65 / 50 / 40	25 kHz	11 / 8 / 7
DCI: 10 A	45 / 25 / 20	43 / 30 / 30	40 kHz	7 / 5 / 5

Digitizing Additional Characteristics

Maximum Resolution	16 bits
Measurement Input Coupling	DC coupled
Sampling Rate	Programmable 1 k through 1 MS/s
Minimum Record Time	1 µs
Maximum Record Length (Volatile)	Up to 7 million with standard buffer (includes channel and formatting information)

DC Voltage Ratio

DC Voltage Ratio Calculation [35]

Method	Measurement
Channel Ratio (through rear input scanner card)	$\text{Channel Ratio} = \dfrac{\text{Channel A}}{\text{Channel B}}$ Accuracy = (Accuracy of channel A measure range + Accuracy of channel B measure range) × Channel ratio
Channel Average (through rear input scanner card)	$\text{Channel Average} = \dfrac{\text{Channel A + Channel B}}{2}$ Accuracy = Accuracy of channel A measure range + Accuracy of paired channel B measure range
DCV Input Ratio (HI-LO/SHI–SLO) [36]	$\text{Ratio} = \dfrac{\text{HI signal}}{\text{SHI signal} - \text{SLO signal}}$ $\text{Accuracy} = \left(\dfrac{\text{HI range}}{\text{HI signal}} \times \text{DCV\% of range accuracy} + \dfrac{10 \text{ V}}{\text{SHI signal} - \text{SLO signal}} \times 0.0008\% \right) \times \text{Ratio}$

Notes

35. See DC Voltage Accuracy. SHI and SLO: 10 V range only. SHI and SLO (sense) terminals referenced to LO input. Maximum voltage referenced to LO 12 V.

36. Sense terminals on inputs are limited to 10 V range during ratio measurement. Add 0.0015% + 0.0005% per °C temperature coefficient to DCV percent of range accuracy when using the 100 V or 1000 V range on the input terminals.

System Specifications

Typical Reading Rates, DC Functions [37, 38]

60 Hz (50 Hz) Operation

NPLC	Functions: DCV (10 V) 2-wire Ω (≤10 kΩ), DCI (1 mA)		Functions: 4-wire Ω (≤1 kΩ) 4-wire and 3-wire RTD		Function: Thermistor or Thermocouple	
	Measurements (readings per second) [39]					
	Buffer	Computer	Buffer	Computer	Buffer	Computer
5	12 (10)	11 (9)	5 (4)	5 (4)	12 (10)	11 (9)
1	59 (48)	58 (48)	28 (23)	28 (23)	59 (49)	57 (48)
0.1	584 (490)	440 (380)	180 (160)	170 (150)	580 (480)	440 (380)
0.01	4900 (4100)	4800 (4100)	400 (390)	400 (390)	4800 (4100)	4700 (4000)
0.0005	20600 (20600)	19800 (19800)	460 (460)	460 (460)	21000 (21000)	20300 (20300)

Typical Reading Rates, AC Functions [37]

60 Hz (50 Hz) Operation

Function: ACV, ACI	Function: Frequency, Period	Measurements (readings per second)
Detector Bandwidth	Aperture	Buffer or Computer
3 Hz	200 ms	1
30 Hz	20 ms	10
300 Hz	2 ms	100

Scanning/Multiple Channels (with optional scan cards) [40]

Typical Scanning Measurement Rates	Measurements Into Buffer/Computer (channel per second)
Scanning DCV or 2-wire Ω	>90 with 2000-SCAN card, >90 with 2001-TCSCAN card
Scanning Thermocouple, Thermistor, or 2-wire RTD	>85 with 2000-SCAN card, >85 with 2001-TCSCAN card
Scanning 4-wire Ω and 3- or 4-wire RTD	>80 with 2000-SCAN card, >80 with 2001-TCSCAN card
Scanning ACV	>60 with 2000-SCAN card, >60 with 2001-TCSCAN card
Scanning Alternating DCV and 2-wire Ω	>85 with 2000-SCAN card, >85 with 2001-TCSCAN card

Notes

37. Reading speeds for autozero off, fixed range, autodelay off, offset compensation off, and open lead detector off where applicable.
38. Buffer measurements: For <0.1 PLC, multisample, and single buffer transfer binary reading only.
39. Computer measurements: For 5 PLC, 1 PLC, and 0.1 PLC single reading and single transfer to computer (USB).
40. Set-up conditions of the factory default setting with the following exceptions: 3.5 digits (0.0005 PLC), autorange off, autozero off, autodelay off, and open lead detection off.

Typical Function and Range Change Speed

Function	Function Change Time [42]	Range Change Time [43]	Autorange Time [42]
DCV, DCI, or 2-wire Ω [44]			<3.2 ms
4-wire Ω [45] or 3-wire RTD	<4 ms	<1.3 ms	<5.5 ms
Thermistor			—
Frequency or Period (2 ms aperture)	<1800 ms	<50 ms [46]	<50 ms [46]
ACV (300 Hz bandwidth)			
ACI (300 Hz bandwidth)	<100 ms	<4 ms	<5 ms
Capacitance	<4 ms	<3 ms	<30 ms
Digitize	<4 ms	<5 ms	—
Diode	<11 ms	—	—
Continuity	<11 ms	—	—
Thermocouple	<4 ms	—	—

Bus Transfer Speed [47]

	USB	LAN	GPIB	RS232 (Baud 115200)
Average for 1000 readings (binary)	441,000	268,000	201,000	10,000
Average for 1000 readings with relative timestamp (binary)	272,000	150,000	105,000	2,900
Average for 1000 readings with formatted elements [48]	46,000	29,000	17,000	290

Typical Digitize Voltage or Current [49]

Sampling rate	Measurements over USB to computer (readings per second)
10 kS/s	Up to 10,000
50 kS/s	Up to 50,000
100 kS/s	Up to 100,000
1 MS/s up to 7 s maximum duration	At least 90,000

Triggering

Trigger Sources Front panel trigger key, timer, command interface, LAN/LXI, Trigger In (BNC rear panel), Digital I/O (optional accessory card), and TSP-Link® (optional accessory card)

External Trigger Delay <1 µs when triggering from accessory card or rear BNC input

External Trigger Jitter <1 µs when triggering from accessory card or rear BNC input

External Trigger In/Trigger Out 0 V to 5 V logic signal input and output, TTL-compatible, programmable edge pulse
Minimum pulse width: 1 µs

External Trigger Out, Maximum Rate
Up to 90 kHz, measurement dependent

External Trigger In, Maximum Rate Up to 150 kHz, measurement dependent

Notes

41. Assume the signal is 10 kHz or above.
42. 3.5 digits, autozero off, 0.0005 PLC, excludes measurement time.
43. DCV = 10 V; 2-wire or 4-wire = 1 kΩ; DCI = 1 mA; ACI = 1 mA; ACV = 1 V; Capacitance = 10 µF.
44. 2-wire function for 100 Ω range and up. For the 10 Ω range, add 2.7 ms.
45. 4-wire function for 100 Ω range and up. For the 1 Ω and 10 Ω ranges, add 2.7 ms.
46. When ranging to 10 V and above, add 1.8 s.
47. SCPI programmed using 4-byte binary format.
48. Format elements: Reading, relative timestamp, channel, and unit.
49. SCPI programmed using 4-byte binary format.

Scanning (with optional scan cards)

Scan Count	1 to continuous
Scan Interval	0 s to 27.7 hours
Channel Delay	0 to 60 s
Measure Interval	0 s to 27.7 hours

Internal Memory

Maximum Reading Memory (volatile)	
	Up to 7 million readings with standard buffer (includes channel and formatting information).
Internal (non-volatile) Memory for Saved Scripts and Scan Configurations	
	6 MB, enables hundreds of scan configurations or TSP scripts to be saved in non-volatile memory.

General Specifications

Line Power

Power Supply	100 V, 120 V, 220 V, and 240 V (±10%)
Power Line Frequency	50 Hz to 60 Hz and 400 Hz, automatically sensed at power-up
Maximum Power Consumption	50 VA
Typical Power Consumption	30 VA
Mains Input Fuse	250 V, 1.25 A slow-blow fuse: Keithley replacement part number FU-106-1.25

Environment and Regulatory

Operating Environment	Specified for 0° to 50°C, ≤80% relative humidity at 35°C, altitude up to 2000 meters
Storage Environment	−40° to 70°C
Vibration	MIL-PRF-28800F Class 3, random
Warm-up	30 minutes to rated accuracy
Safety	NRTL listed to UL61010-1, and CSA C22.2 No 61010-1; conforms with European Union Low Voltage Directive
EMC	Conforms to European Union EMC Directive

Mechanical

Display	12.7 cm (5 in.) capacitive touch, color TFT WVGA (800 × 480) with LED backlight
Rack Dimensions (W × H × D)	213.8 mm (8.42 in.) × 88.4 mm (3.48 in.) × 356.6 mm (14.04 in.)
Bench Dimensions (W × H × D)	224.0 mm (8.82 in.) × 107.2 mm (4.22 in) × 387.4 mm (15.25 in.)
Shipping Weight	4.54 kg (10.0 lb.) instrument only
Input Signal Connections	Front/rear safety banana jacks or scanner cards
Plug-in Scanner Slot	One slot on rear panel, see Optional Multi-Channel/Scanner Accessories.
Communication Slot	One slot on rear panel, see Optional Interfaces And Programmable Digital I/O.
Cooling	Forced air, fixed speed

Remote Interface – Standard

LAN/LXI Compliance	**RJ-45 Connector:** 10/100BT. **IP Configuration:** Static or DHCP (manual or automatic). **Web Interface:** Virtual front panel. **LXI Compliance:** LXI version 1.4 core 2016.
USB Device (rear panel, Type B)	2.0 full speed, USBTMC compliant
USB Host (front panel, Type A)	USB 2.0, support for flash drives, FAT32. **Capability:** Import/export instrument configuration files, reading buffers, screen captures, and scripts

Language

SCPI (default)	Default command set, Standard Commands for Programmable Instruments, SCPI-1999
TSP	Embedded Test Script Processor (TSP) accessible from any host interface; responds to high-speed test scripts comprised of remote commands and statements (for example, branching, looping, and math); able to execute test scripts stored in memory without host intervention
Emulation Modes	Keithley Model 2000 and 34401A

Math Functions

	REL, Minimum, Maximum, Average, Standard Deviation, peak-peak, dB, Limit Test, Percent, 1/x, and mX+b with user- defined units displayed

Miscellaneous

Real-time Clock	Lithium battery backup, CR2032 coin-type, factory replaceable, (3+ years of battery life); set and read year, month, day, hour, minute, and second. (Note: Seconds are not adjustable.)
Timestamp Resolution	15 ns with standard or full buffer style
Password Protection	30 characters
Alarms	Up to six: see Optional Interfaces and Programmable Digital I/O
Power Failure Recovery Mode	User selectable, resumes scanning once power is re-applied

Optional Interfaces and Programmable Digital I/O

KTTI-GPIB	GPIB IEEE-488.1 compliant; supports IEEE-488.2 common commands and status model topology
KTTI-RS232	RS232, 9-pin d-sub female connector; standard baud rates from 300 to 115,200 bps are supported
KTTI-TSP	RJ-45 (quantity 2); TSP-Link® expansion interface allows TSP-enabled instruments to trigger and communicate with each other
Digital I/O	For KTTI-RS232, KTTI-GPIB, and KTTI-TSP
	Connector: 9 pin d-sub female
	5 V Power Supply Pin: Limited to 500 mA > 4 V (solid-state fuse protected)
	Lines: Six input / output, user-defined for control, alarms (limits), or triggering
	Input Signal Levels: 0.7 V (maximum logic low), 3.7 V (minimum logic high)
	Input Voltage Limits: −0.25 V (absolute minimum), 5.25 V (absolute maximum)
	Maximum Source Current: 2.0 mA at > 2.7 V (per pin)
	Maximum Sink Current: −50 mA at 0.7 V (per pin, solid state fused)

Ordering Information

DMM6500	6½-Digit Bench/System Digital Multimeter

Supplied Accessories

1757	Pair, General Purpose Test Lead Set, 1000 V Cat II
USB-B-1	USB Cable, Type A to Type B, 1 m (3.3 ft.)
	Traceable Calibration Certificate
	Three-Year Warranty

Instruction Manuals/Documentation (available at www.tek.com/DMM6500)

DMM6500 Quick Start Guide
DMM6500 User's Manual
DMM6500 Reference Manual

Software and Drivers (available at tek.com)

IVI/VISA Drivers for Microsoft® Visual Basic®, Visual C/C++®
National Instruments (NI®) LabView™, NMI LabWindows™/CVI (available at ni.com)
Keithley Test Script Builder available at https://www.tek.com/keithley-test-script-builder
KickStart available at www.tek.com/kickstart

Power Cord Options

AO	North America power plug (120 V, 60 Hz)
A1	Universal Euro power plug (220 V, 50 Hz)
A2	United Kingdom power plug {240 V, 50 Hz)
A3	Australia power plug (240 V, 50 Hz)
A4	Chile, Italy (220 V, 50 Hz)
A5	Switzerland power plug (220 V, 50 Hz)
A6	Japan power plug (100 V, 50/60 Hz)
A7	Denmark
A8	Israel
A9	Argentina
A10	China power plug (50 Hz)
A11	India power plug (50 Hz)
A12	Brazil power plug (60 Hz)
A99	No power cord

Optional Multi-Channel/Scanner Accessories

2000-SCAN Card	10 channel 2-pole or 5 channel 4-pole multiplexer
2001-TCSCAN Card	9 channel 2-pole or 4-channel 4-pole multiplexer with CJC sensor
	Limited compatibility with 2001-SCAN and 2000-SCAN-20. See the DMM6500 Firmware Release Notes for additional information.

Optional Interfaces and Programmable Digital I/O

KTTI-RS232	RS-232 Communication and Digital I/O Accessory, user-installable
KTTI-GPIB	GPIB Communication and Digital I/O Accessory, user-installable
KTTI-TSP	TSP-Link Communication and Digital I/O Accessory, user-installable

Available Accessories

Test Leads and Probes

1752	Premium Safety Test Lead Kit
1754	2-Wire Universal 10-Piece Test Lead Kit
1756	General Purpose Test Lead Kit
5804	Kelvin (4-Wire) Universal 10-Piece Test Lead Kit
5805	Kelvin (4-Wire) Spring-Loaded Probes
5806	Kelvin Clip Lead Set
5808	Low Cost Single-pin Kelvin Probe Set
8606	High Performance Modular Probe Kit
8610	Low Thermal Shorting Plug

Replacement Fuses

FU-106-1.25	Main Input Fuse, 3 A
FU-99-1	Current Input Fuse, 3 A, 250 V Fast Acting 5×20mm
159-0583-00	Current Input Fuse, 11 A, 1000 V

Cables, Connectors, Adapters

CA-18-1	Shielded Dual Banana Cable, 1.2 m (4 ft.)

Communication Interfaces & Cables

KPCI-488LPA	IEEE-488 Interface for PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter
7007-1	Shielded GPIB Cable, 1 m (3.2 ft)
7007-2	Shielded GPIB Cable, 2 m (6.5ft)
CA-180-3A	CAT5 Crossover Cable for TSP-Link / Ethernet
USB-B-1	USB Cable, Type A to Type B, 1 m (3.3 ft)

Triggering and Control

2450-TLINK	DB-9 to Trigger Link Connector Adapter
8501-1	Trigger Link Cable, DIN-to-DIN, 1 m (3.2 ft.)
8501-2	Trigger Link Cable, DIN-to-DIN, 2 m (6.5 ft.)
8503	DIN-to-BNC Trigger Cable

Rack Mount Kits

4299-8	Single Fixed Rack Mount Kit
4299-9	Dual Fixed Rack Mount Kit
4299-10	Dual Fixed Rack Mount Kit. Mount One DMM6500 and One Series 26xxB Instrument
4299-11	Dual Fixed Rack Mount Kit. Mount One DMM6500 and One Instrument from Series 2400, Series 2000, etc.

Available Services

Extended Warranties

Instruments

DMM6500-EW	3 year factory warranty extended to 4 years from date of shipment
DMM6500-5Y-EW	3 year factory warranty extended to 5 years from date of shipment

Calibration Contracts

C/DMM6500-3Y-DATA	KeithleyCare 3 Year Calibration w/Data Plan
C/DMM6500-3Y-STD	KeithleyCare 3 Year Std Calibration Plan
C/DMM6500-5Y-DATA	KeithleyCare 5 Year Calibration w/Data Plan
C/DMM6500-5Y-STD	KeithleyCare 5 Year Std Calibration Plan
C/NEW DATA	Calibration data for new units
C/NEW DATA ISO	ISO-17025 Calibration data for new units

Contact Information

Australia* 1 800 709 465

Austria 00800 2255 4835

Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777

Belgium* 00800 2255 4835

Brazil +55 (11) 3759 7627

Canada 1 800 833 9200

Central East Europe/Baltics +41 52 675 3777

Central Europe/Greece +41 52 675 3777

Denmark +45 80 88 1401

Finland +41 52 675 3777

France* 00800 2255 4835

Germany* 00800 2255 4835

Hong Kong 400 820 5835

India 000 800 650 1835

Indonesia 007 803 601 5249

Italy 00800 2255 4835

Japan 81 (3) 6714 3086

Luxembourg +41 52 675 3777

Malaysia 1 800 22 55835

Mexico, Central/South America and Caribbean 52 (55) 56 04 50 90

Middle East, Asia, and North Africa +41 52 675 3777

The Netherlands* 00800 2255 4835

New Zealand 0800 800 238

Norway 800 16098

People's Republic of China 400 820 5835

Philippines 1 800 1601 0077

Poland +41 52 675 3777

Portugal 80 08 12370

Republic of Korea +82 2 6917 5000

Russia/CIS +7 (495) 6647564

Singapore 800 6011 473

South Africa +41 52 675 3777

Spain* 00800 2255 4835

Sweden* 00800 2255 4835

Switzerland* 00800 2255 4835

Taiwan 886 (2) 2656 6688

Thailand 1 800 011 931

United Kingdom/Ireland* 00800 2255 4835

USA 1 800 833 9200

Vietnam 12060128

* European toll-free number.
If not accessible, call: +41 52 675 3777

Rev. 090617

KEITHLEY
A Tektronix Company

Find more valuable resources at TEK.COM

KickStart

KEITHLEY
A Tektronix Company

Accelerate the path to the measurements you want with KickStart Software. KickStart simplifies what you need to know about the instrument so that in just minutes you can take the instrument out of the box and get real data on your device. By plotting data immediately and offering quick statistical summaries of the data in the reading table, KickStart allows you to gather insights faster and make the decisions you need to move on to the next stage of device development. KickStart saves you time by facilitating quick replication of tests and comparison of results using convenient export features. With KickStart, you can focus on interpreting the test results so that your team can meet their innovation goals.

Key Features

KickStart Software for the PC enables quick test setup and data visualization when using multiple instruments.

- Save time by automating data collection of millions of readings.
- Set up a multi-instrument test with the ability to independently control up to eight instruments.
- Supports power supplies, source measure unit (SMU) instruments, DMMs, and dataloggers.
- Replicate tests quickly using saved test configurations.
- Use built-in plotting and comparison tools to quickly discover measurement anomalies and trends.
- Export data in ready-to-use formats for reports and additional analysis.

Applications

- Device characterization: Characterize materials and discrete components and verify design of electronic modules.
- Datalogging: Reliably log data to the PC; useful for testing device compliance to regulatory or industrial standards.

Tektronix®

Minimized Time to Results

Connect your instrument to your PC and have KickStart discover your instrument in seconds. KickStart supports instruments connected using GPIB, LAN, and USB interfaces. With a simple drag of the mouse, launch an app to control and collect data from an instrument. KickStart can collect millions of readings from each instrument, which makes it a great solution for your long-term datalogging needs and for capturing a lot of data from transient events with a digitizing DMM. KickStart presents the data in tabular and graphical formats. In the table, KickStart presents a statistical summary of the data in each column. You can hide non-essential data, and the statistics automatically update to reflect only data visible in the table. This can be quite useful for applications in which you want to monitor devices after they have reached thermal stabilization.

KickStart provides a test solution even when your tests involve the control of multiple instruments. One of the largest enhancements for KickStart Version 2.0 is the control of multiple instruments through a single interface. You can launch and run up to eight apps at the same time. You can see results from multiple instruments in a single easy-to-view format.

View data in the reading table in an easy to read format. Hide rows or columns to show only relevant data

| | Min | 0.00000 | 1.028138e+6 | 1.003069e+3 | 205.2340 |
	Max	20.2058	1.031195e+6	1.003075e+3	205.2395
	Mean	10.1031	1.029230e+6	1.003070e+3	205.2352
	StdDev	5.95789	468.1030	888.3387e-6	797.2339e-6

KickStart calculates basic statistics for each column of data visible in the table.
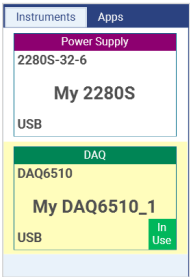
KickStart quickly discovers all connected instruments and allows you to create tests and view data even when instruments are not connected to the PC.

Faster Insights into Data

KickStart plots your data immediately so that you can quickly discover anomalies or trends and make the needed decisions to get you to the next phase of development of your material, device, or module. Getting insights quickly is most important, so a large portion of the viewing area is dedicated to the graph. There are built-in tools to compare and overlay data from previous test runs. You can mark or highlight points of interest in the graph and use cursors to view detail on multiple data series at once.
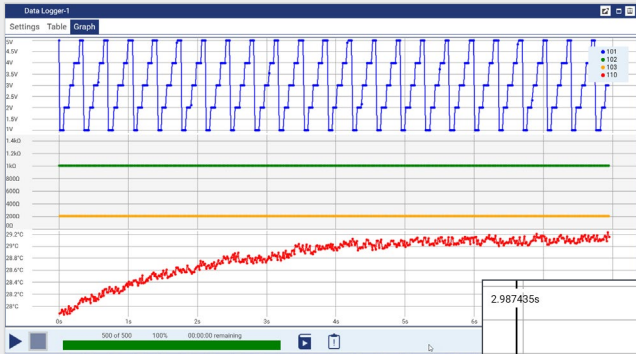
Data always gets prime focus in KickStart. Use the graph to discover measurement trends or anomalies.
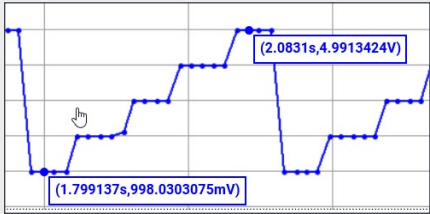
Use markers to highlight points of interest on the graph.
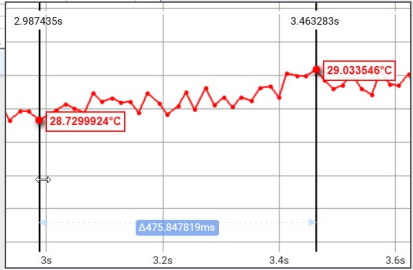
Use cursors to get information on multiple data series or to calculate differences on the horizontal scale.

Peace of Mind.
Confidence. Reliability.

Proving that your device or module complies with industrial and regulatory standards is an important part of ensuring that your device or electronic module will meet your customer's requirements. Safe archival of test data is essential in compliance testing. KickStart streams data from the instrument to PC storage media, so, even in the event of power outage, your data is preserved.
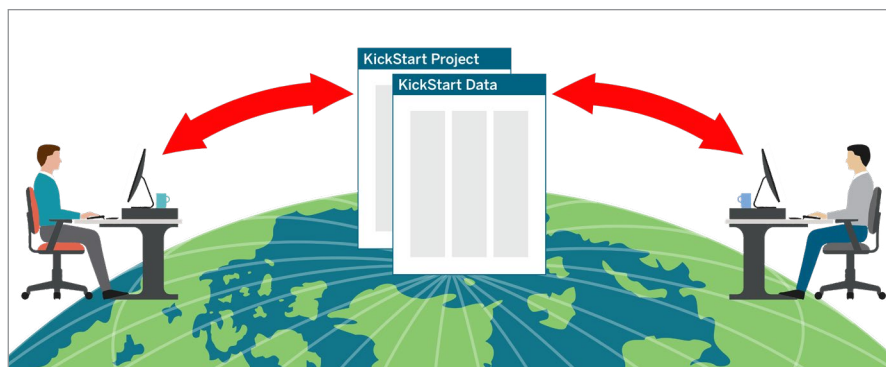

Save tests and share data for easy collaboration between multiple development sites.

Additionally, you can save any test project that you create to re-use later or to share with others. This allows you to replicate tests easily at other locations, which is essential when you work on a global development team.

KickStart even allows you to prepare your tests using simulated instruments so that you are ready to test once the actual instrument arrives. You can quickly swap the actual instrument in your test configuration later. The use of simulated instruments also allows offline viewing of the data and test setup.

Available KickStart Apps
Base KickStart Apps

KICKSTARTFL-BASE includes four apps to control your SourceMeter® SMU Instrument, DMM, data logger, or power supply.
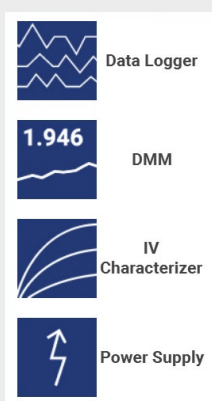

Premium Apps

KICKSTARTFL-HRMA is an optional app for KickStart Software that allows you to make insulation resistivity measurements with the 6517B Electrometer/ High Resistance Meter and the 8009 Resistivity Test Fixture.

Power Supply App

This app simplifies supplying power to your device or system.

- Quickly set up automated tests using bias or list sweep mode.
- Interactively control bias conditions while monitoring measurements on another instrument.
- Use along with the Precision Multimeter App for application such as power consumption analysis or monitoring load current stability.
- Supports Keithley 2280S-32-6 and 22380S-60-3 Precision Measurement DC Power Supplies.
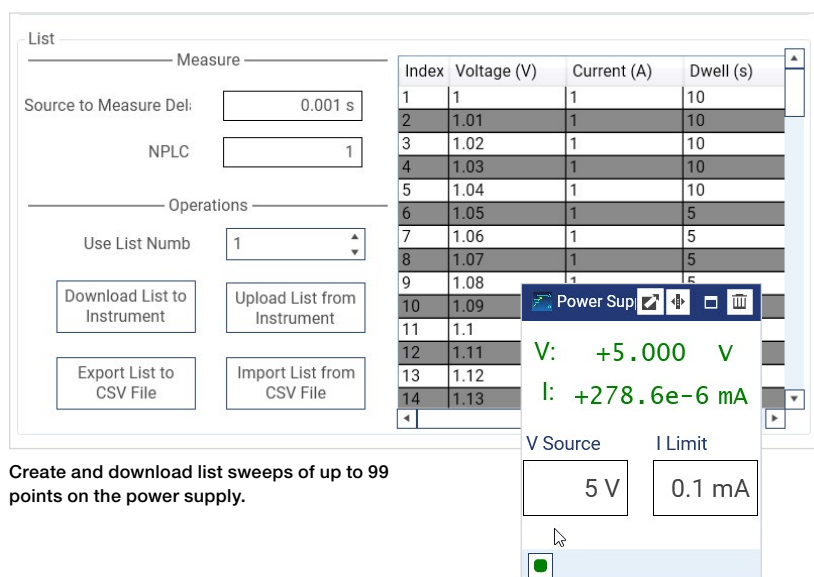
Create and download list sweeps of up to 99 points on the power supply.

View and set the most essential parameters on the power supply in KickStart's minimized view.

Precision Multimeter App

This app affords you a simple way to log data using your Keithley DMM.

- Automate long-term datalogging.
- Plot and inspect waveforms from the digitizer built into the DMM.
- Trigger digitizer on digital events or programmed analog levels.
- Supports Keithley DMM7510 7½-Digit and DMM6500 6½-Digit DMMs and DAQ6510 Data Acquisition and Logging Multimeter System.
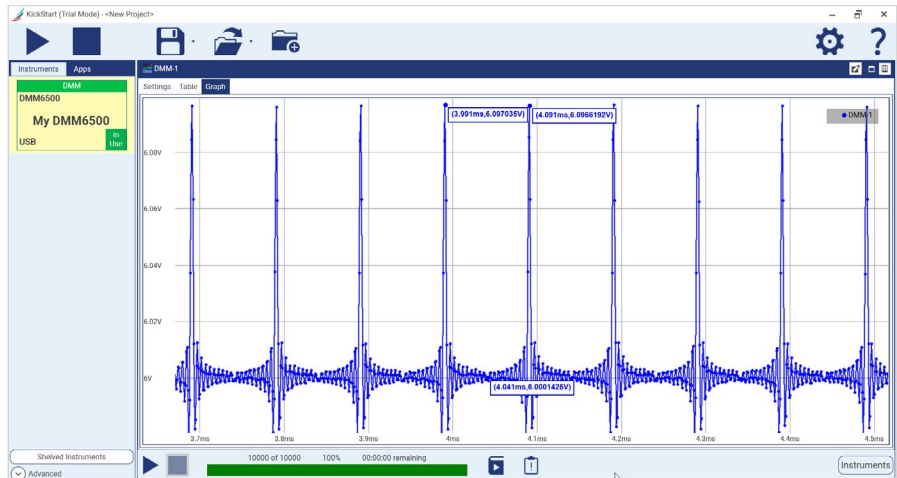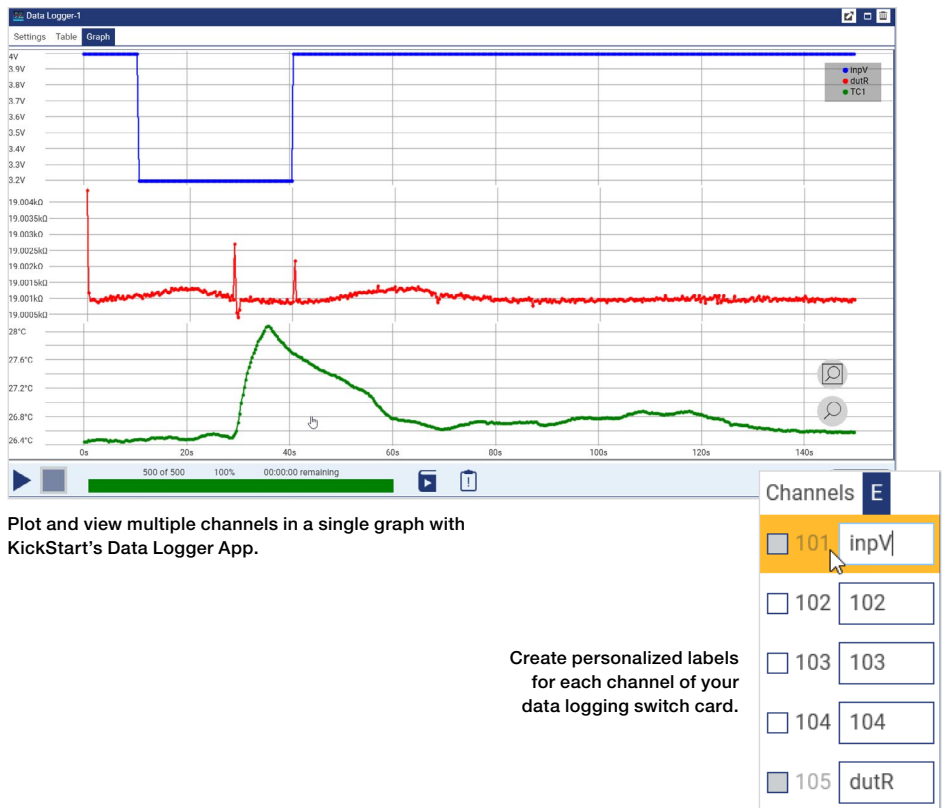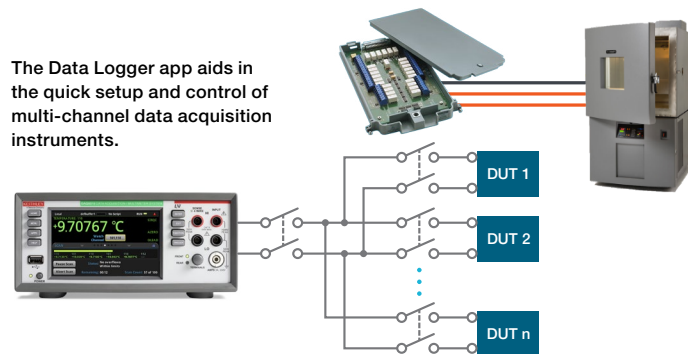

Capture waveforms with the DMM6500 Digitizing DMM using KickStart's Precision Multimeter App.

Data Logger App

Use the KickStart Data Logger App to set up and control your multi-channel data acquisition instrument. This app is designed to help you configure all your channels very quickly and even validate your connections during test configuration. It allows you to set up multiple channels with the same configuration but give each channel a meaningful label so that you can quickly scan your results and grab the information you need. Configure pass/fail limits for each channel in order to set alarm conditions and obtain quick visual verification of test results.

- Stream millions of readings to PC storage media for safe data archival.
- View multiple measurement functions in a single data window using stacked graphs.
- Plot measurement data versus another channel or versus time.
- Export data in ready-to-use formats for reports and additional analysis even while the test is running.
- Supports Keithley DAQ6510, DMM6500 (with scan card), 2700, 2701, and 2750.

The Data Logger app aids in the quick setup and control of multi-channel data acquisition instruments.


Plot and view multiple channels in a single graph with KickStart's Data Logger App.

Create personalized labels for each channel of your data logging switch card.

I-V Characterizer App

Use the I-V Characterizer App to perform current vs. voltage (I-V) test on a variety of materials, two-terminal and multi-terminal semiconductor devices, solar cells, and much more. You can configure each SMU for a variety of bias and sweep sourcing operations, including linear, log, list, and dual sweeps.

- Configure and control up to four SourceMeter SMU instruments with independent sweeps or multi-level sweeps.

- Differentiate SMU instrument channels and their measurement data using labels that are relevant to your device or module.

- Use built-in comparison tools to compare and overlay multiple test runs in a single graph.

- Create tests by mixing any of these SMU instruments: Series 2400, Series 2600B, and 6430 SourceMeter SMU Instruments.
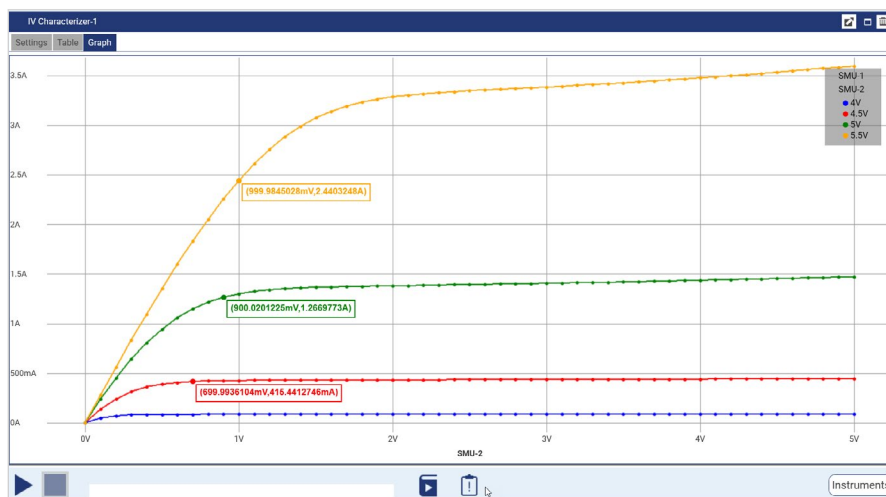
Create current vs. voltage characteristics for 2-terminal, 3-terminal, and 4-terminal devices.
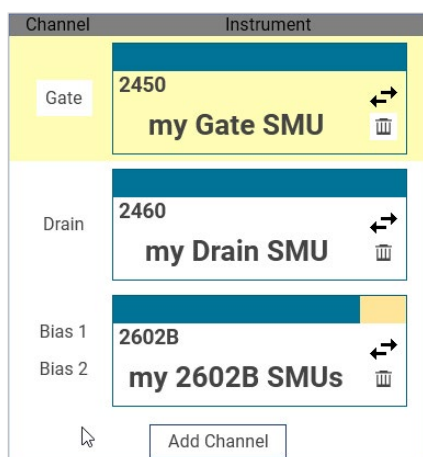
Characterize devices using up to four of Keithley's SourceMeter SMU instruments.
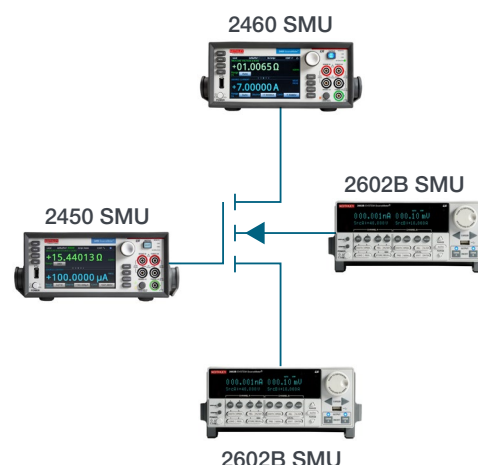
Download the latest version of KickStart today from www.tek.com/keithley-kickstart.

KickStart allows you to create tests and view, manipulate and export data without a license. To communicate with and control an instrument, KickStart requires a license. KickStart installs with a one-time 90-day trial license. Visit tek.com to get a quote for KICKSTARTFL-BASE, a floating license that unlocks all the base KickStart apps, A floating license allows selected users to manage transfer of individual license files to different PCs. License management is done through the Tektronix Asset Management System (TekAMS).

For more info on TekAMS, visit https://www.tek.com/products/product-license. Each valid license entitles you to unlimited support by Tektronix' worldwide technical support centers and field applications engineers.
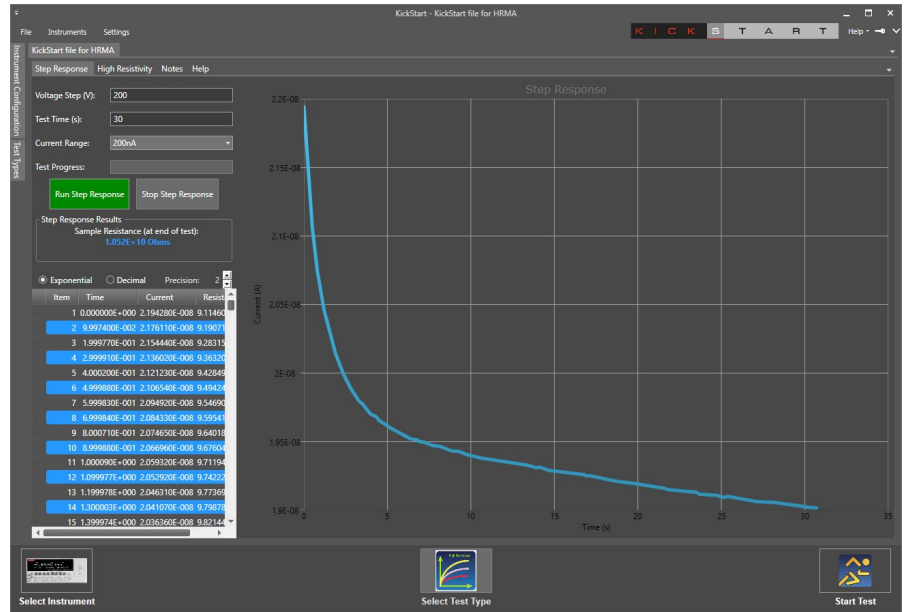
Recommended System Requirements

- CPU: Dual-core processor 2 GHz or better

- Memory: 8GB RAM

- Disk Drive: 8GB of free space

- Windows 10, 8, 7 64-bit

- PC disk space required: 1 GB

- Instrument communication interfaces: USB, GPIB, LAN

- Display resolution: Minimum 1920×1080 recommended

Optional High Resistivity Measurement Premium Application (KICKSTARTFL-HRMA)

KickStart's High Resistivity Measurement Application allows for reliable insulator resistivity measurement according to ASTM D257 standard. This app is designed for use with Keithley's 6517B Electrometer/High Resistance Meter. The 6517B along with the 8009 Resistivity Test Fixture is a laboratory standard for volume and surface resistivity measurements on insulating materials.

The KickStart High Resistance Measurement Option makes it easier for you to:

- Perform a Step Response Test to identify electrification time appropriate to the material's time constant.

- Observe resistivity dependence on temperature and relative humidity of environment using optional probes 6517-TP and 6517-RH.

- Use the alternating polarity measurement technique to eliminate inherent background currents for the most accurate resistivity measurements.

Licensing Information

The KickStart High Resistivity Measurement Application requires the KICKSTARTFL-HRMA floating license. A floating license allows selected users to manage transfer of individual license to different PCs. This app requires installation of KickStart version 1.9.8. It is not yet compatible with KickStart 2.0. Please visit http://www.tek.com/keithley-kickstart to download KickStart version 1.9.8 and request a 30-day trial of the KICKSTARTFL-HRMA license.

Use the Step Response Test to identify appropriate electrification time.
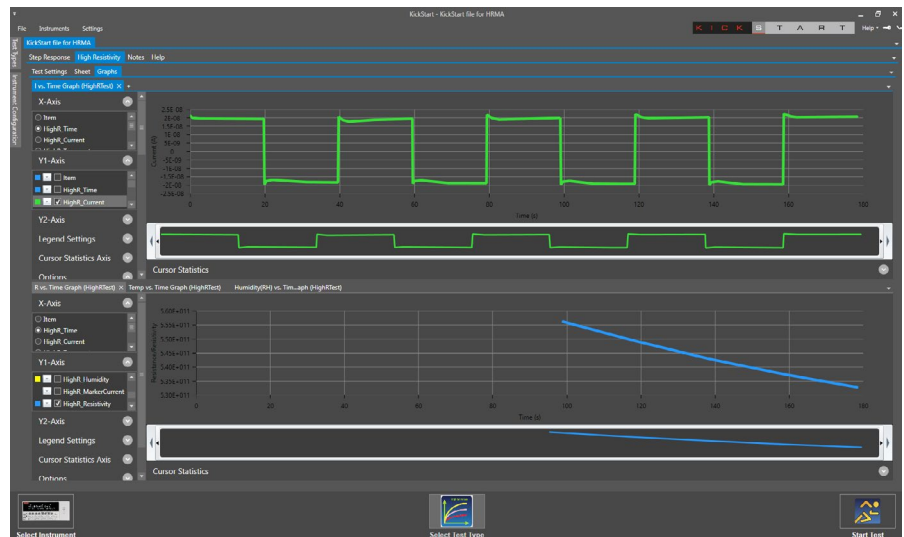
Hi-R test using the alternating polarity technique to improve accuracy in insulation resistance measurements.

System Requirements for KICKSTARTFL-HRMA

- Windows 10, 8, 7 32-bit or 64-bit
- Processor: 1 GHz or faster (2 GHz or greater recommended)
- RAM: 1 GB (32-bit) or 2 GB (64-bit) (4GB or greater recommended)
- Disk drive space required: 600 MB
- Instrument communication interfaces: GPIB (for 6517B)
- Display resolution: Minimum 1024×768

Learn More about KickStart

Visit www.tek.com/keithley-kickstart for the latest information about KickStart.

For questions, please visit Tektronix Technical Forums at http://forum.tek.com or contact your local Tektronix sales office noted on the back of this datasheet.

Contact Information

Australia* 1 800 709 465

Austria 00800 2255 4835

Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777

Belgium* 00800 2255 4835

Brazil +55 (11) 3759 7627

Canada 1 800 833 9200

Central East Europe/Baltics +41 52 675 3777

Central Europe/Greece +41 52 675 3777

Denmark +45 80 88 1401

Finland +41 52 675 3777

France* 00800 2255 4835

Germany* 00800 2255 4835

Hong Kong 400 820 5835

India 000 800 650 1835

Indonesia 007 803 601 5249

Italy 00800 2255 4835

Japan 81 (3) 6714 3086

Luxembourg +41 52 675 3777

Malaysia 1 800 22 55835

Mexico, Central/South America and Caribbean 52 (55) 56 04 50 90

Middle East, Asia, and North Africa +41 52 675 3777

The Netherlands* 00800 2255 4835

New Zealand 0800 800 238

Norway 800 16098

People's Republic of China 400 820 5835

Philippines 1 800 1601 0077

Poland +41 52 675 3777

Portugal 80 08 12370

Republic of Korea +82 2 6917 5000

Russia/CIS +7 (495) 6647564

Singapore 800 6011 473

South Africa +41 52 675 3777

Spain* 00800 2255 4835

Sweden* 00800 2255 4835

Switzerland* 00800 2255 4835

Taiwan 886 (2) 2656 6688

Thailand 1 800 011 931

United Kingdom/Ireland* 00800 2255 4835

USA 1 800 833 9200

Vietnam 12060128

* European toll-free number.
If not accessible, call: +41 52 675 3777

Rev. 090617

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Tektronix®

Digital Storage Oscilloscope
TBS2000B Series Datasheet
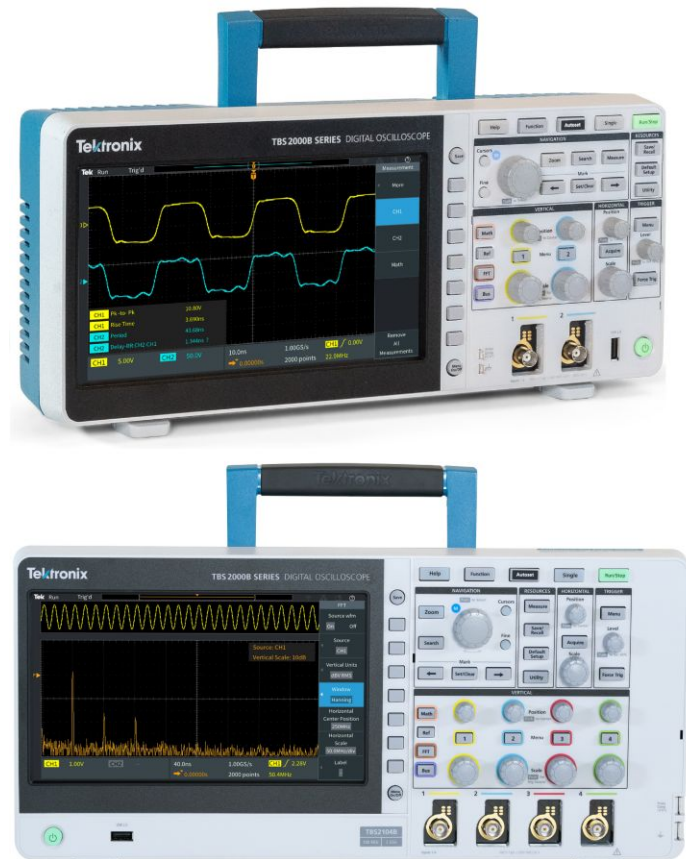
The TBS2000B Series of Oscilloscopes with a 9-inch WVGA display, 5 million point record length and 2 GS/s sample rate, capture and display significantly more signal to help you debug and validate the designs faster. Easily and confidently analyze your signals with new on-waveform cursor readouts and 32 automated measurements, each with informative tips. The TekVPI® probe interface supports traditional passive BNC probes, but also enables wide application coverage with the latest active voltage probes and current probes.

Key performance specifications

- 2 and 4 analog channel models

- 200 MHz, 100 MHz, and 70 MHz bandwidth models up to 2 GS/s sampling rate

- 5 M record length on all channels

- 5 year warranty

Key features

- 9-inch WVGA color display with 15 horizontal grids shows 50% more signal

- TekVPI probe interface supports active, differential, and current probes with automatic scaling and units

- New front-end design enables more accurate measurements

- 32 automated measurements, and FFT function for quick waveform analysis

- Search and Mark features for easy identification of events that occur in the acquired waveform

- HelpEverywhere provides helpful on-screen tips for new users

- Built-in Scope Intro handbook provides operating instructions and oscilloscope fundamentals

- The instrument user interface and the front panel overlay is translated into 10 languages

Connectivity

- USB 2.0 host port on the front panel for quick and easy data storage

- USB 2.0 device port on rear panel for easy connection to a PC

- 10/100BASE-T Ethernet port for remote control over LAN

- Wi-Fi interface provides wireless communications capability support [1]

Education

- Courseware function presents lab exercise guidance on the display

- Fully compatible with TekSmartLab lab management software for education

- Autoset, Cursors and Automated measurements can be disabled to help educators to teach basic concepts to students

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[1]   A Wi-Fi adapter is available in some countries from Tektronix distributors as an accessory, model TEK-USB-WIFI. See Ordering Information for details.

Designed to make your work easier

The TBS2000B Series is designed for easy operation and quick hands-on learning. Dedicated controls provide quick access to important settings, so you can evaluate signals faster. With the TBS2000B you get 10 vertical divisions and 15 horizontal divisions, so you can see more of your signal. The large display also offers more room for measurement results and menu information.

The Zoom function lets you quickly pan through the record and zoom in to see signal details. The new on screen cursors overlay the cursor measurements on the screen making them intuitive to read and understand.
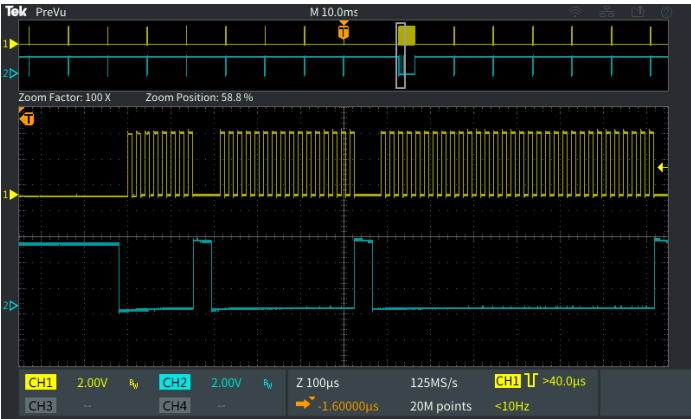
In Zoom mode, an overview of the entire record is shown in the upper part of the display and the lower part displays the detailed Zoomed view.
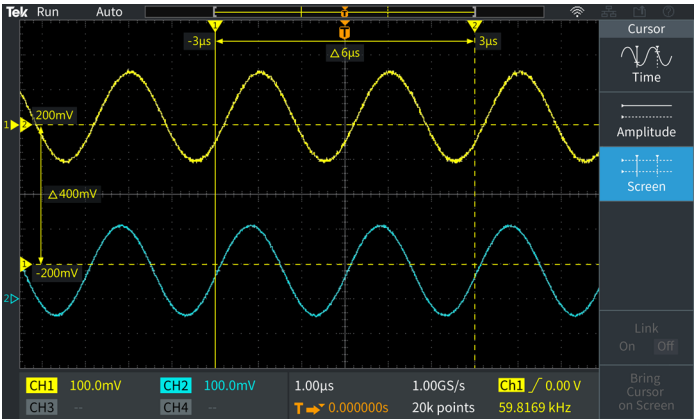
The cursor readouts are presented on the waveform display. Cursors can be used to measure time and amplitude.
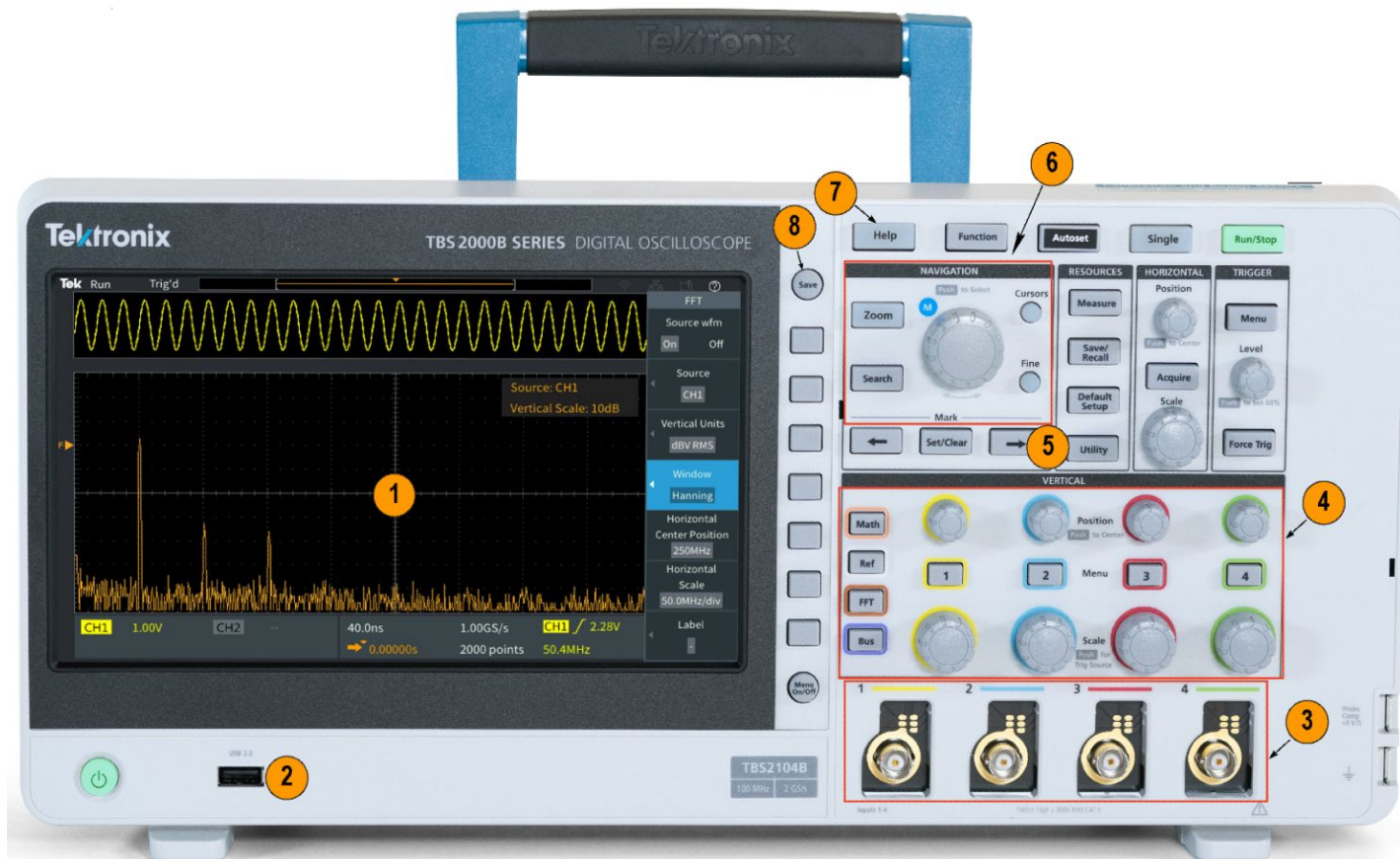
TBS2000B front panel

Image reference	Description
1	Large 9" Display
2	USB port for save / recall
3	TekVPI Probe Interface, for use with passive and active probes
4	Dedicated control knobs per channel

Image reference	Description
5	Search for event for interest
6	Multi purpose knob for navigation, zoom and cursors
7	Help everywhere
8	One-button save

TBS2000B rear panel

Image reference	Description
1	Aux Out signal
2	Ethernet for remote connectivity
3	USB port for WiFI connectivity
4	USB TMC for remote connectivity

Versatile triggering and acquisition modes – The trigger system is designed for troubleshooting today's mixed signal designs. Beyond a basic edge trigger, it also includes pulse width and runt triggering, which are especially useful for troubleshooting digital sections of your designs. Pulse width triggering is perfect for hunting narrow glitches or timeout conditions. Runt trigger is designed to capture signals that are shorter in amplitude than expected.

The Instrument offers several acquisition modes. The default acquisition mode is Sample Mode which works well for most applications. The Peak Detect Mode is useful for hunting spikes, and Average Mode can help reduce noise on repetitive signals.

Quickly search for events of interest – The search button enables you to quickly setup a search criteria based on trigger settings. All occurrences of the event of interest with the acquisition are highlighted with search marks. Easily navigate to each instance of occurrence with dedicated navigation buttons for closer inspection and analysis.
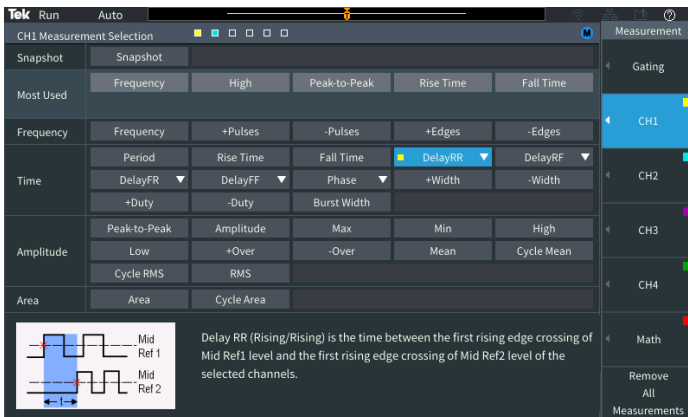

Search and mark

Search through events of interest and mark then through the entire acquisition.

Automated measurements are easier than ever – A comprehensive set of automated measurements enable fast and convenient testing of a wide variety of signal conditions for different applications.

Measurements are all listed and selected on a single screen.

The measurements are grouped into four categories: Frequency, time, amplitude, and area. All the measurements are displayed on a single measurement selection screen making it easy to choose from 32 automated measurements, no more hunting through various menus. Measurements are color coded by the source, and are presented on a transparent background, so waveforms are not obscured by the readouts. The HelpEverywhere system provides help texts with graphics to explain how a measurement is performed, making it easier for new users to know which measurement to use and to interpret the results.
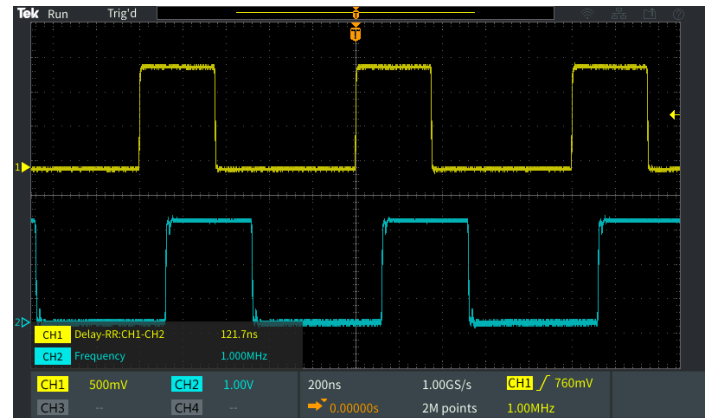
Measurements are transparent so waveforms are not obscured.

FFT function – You can understand the frequency content of your signals with the FFT function by pressing the dedicated front-panel FFT button. Display only the FFT, or turn on the source waveform display to see both the frequency and the time domain waveform. A transparent readout shows important settings without blocking the FFT display.
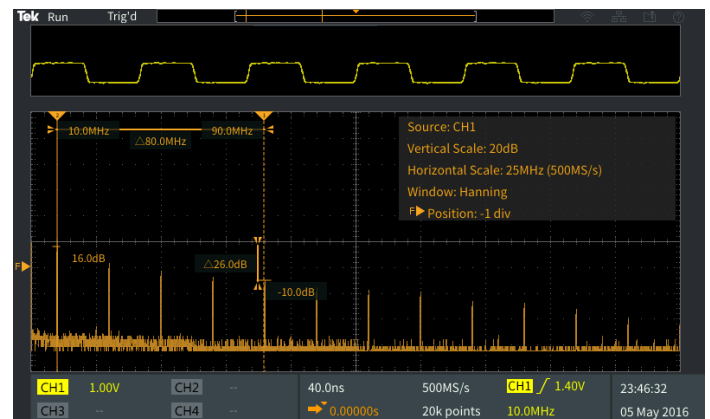
The time domain source waveform can be displayed above the FFT frequency spectrum.

TekVPI® Interface and active probe support

The TekVPI probe interface sets the standard for ease of use in probing. With this interface the TBS2000B Series Oscilloscope supports a wide range of the latest voltage and current probes, providing coverage for many applications. These probes are powered by and communicate with the TBS2000B through the VPI interface. Scale factors and status information, such as error conditions, are sent to the instrument for processing and display. This saves you from having to manually set scale factors, calculate offsets, or the need to degauss your current probes.

The new front end design with higher 2GS/s sample rate offers lower noise and higher effective bits enabling more accurate measurements.

TekVPI probes communicate scale settings, ranges, and status to the TBS2000B.

First in its class with wireless communications

On the rear of the instrument, you will find several communications ports. The USB device port or LAN port can be used to control the instrument using the fully-documented command set.

Wi-Fi adapters are configured through integrated setup menus and support seamless wireless communications

The TBS2000B is the first oscilloscope in its class to support wireless communication. Plug a compatible Wi-Fi dongle into the USB host port and setup the interface for Wi-Fi from the front panel.

Built-in tips for faster setup

HelpEverywhere is a unique feature on theTBS2000B. It shows instant help information as you navigate through key menus. The tips include measurement information, application tips, and general guidance in the form of text and graphics. You can selectively turn tips on and off from the HelpEverywhere menu.
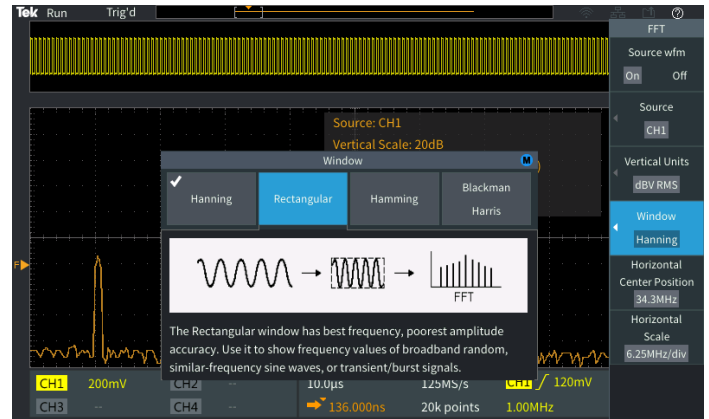
HelpEverywhere tips explain important settings.

On-screen scope fundamentals

Scope Intro handbook is embedded into the TBS2000B help system. Pressing the front panel Function button gives you access to information on oscilloscope basic operations, as well as an overview of the TBS2000B and TekSmartLab Lab Management System for education.
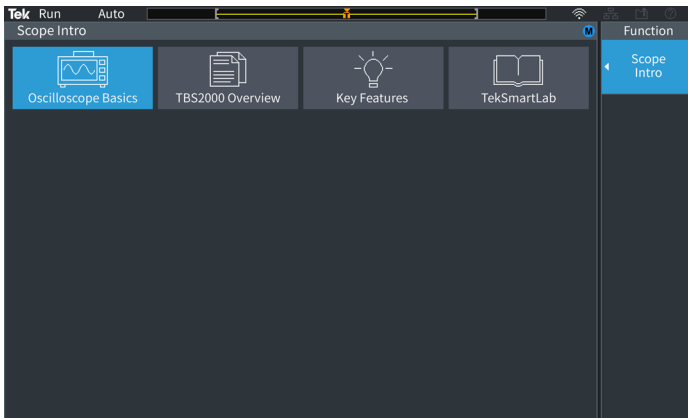
Scope Intro covers basic oscilloscope and TBS2000B usage

Innovative new education solutions

The TBS2000B offers new ways to enable educators to devote more time to teaching circuit concepts instead of lab setup and management.
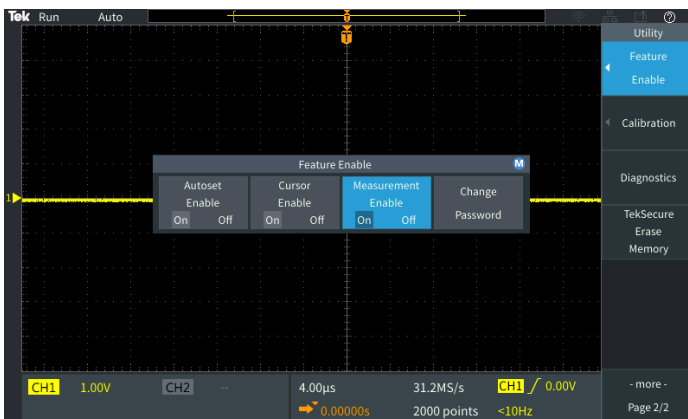
With menus

Educators can disable Autoset, Cursors and automated measurements on the instruments so that they can teach the students on the basic concepts and help them understand how to use the instrument horizontal and vertical controls to get the waveform display, use the graticule to measure time and voltage and manually plot / calculate the signal characteristics.
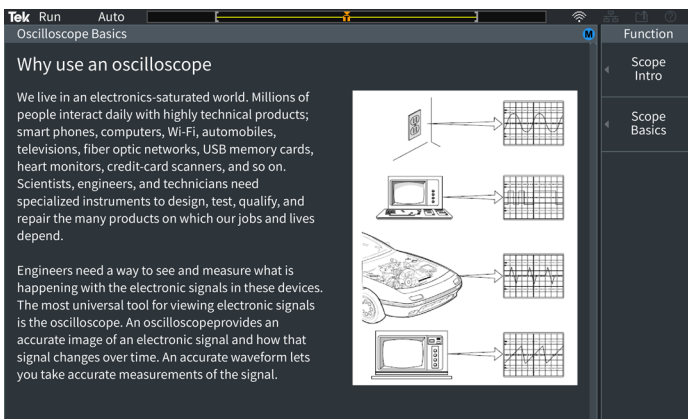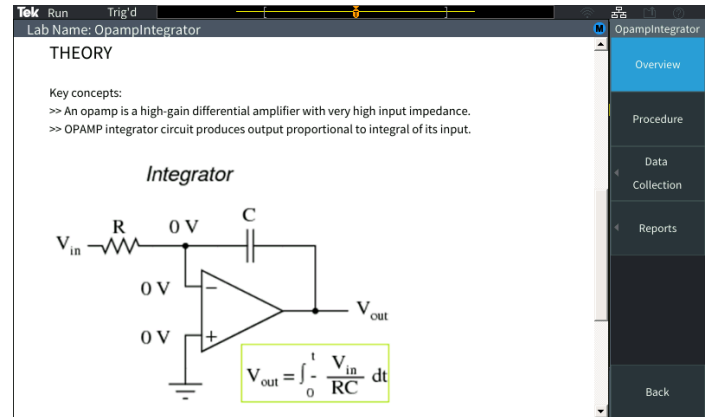

The Courseware function allows students to see lab information on the instrument display.

The integrated Courseware function allows professors to load lab exercises on the instrument to give students guidance at each station and provides a structured framework into which students can capture data to incorporate into their reports. Over 100 sample lab exercises are available for download from the Tektronix Courseware Resource Center.

The TBS2000B can be easily integrated into the TekSmartLab System. Together they enable educators to preset a lab full of instruments with a few mouse-clicks and allow lab instructors to track every student's progress from one central workstation.

TekBench

TekBench™ is PC software that controls Tektronix oscilloscopes and arbitrary function generators. It offers intuitive instrument control, automated measurement data logging, automated frequency response measurements, and easy waveform exporting with required format to eliminate extra time and effort. It allow users to focus on their experiment rather than learning the instrument

TekBench

Performance you can count on

Tektronix has industry-leading service and support, and every TBS2000B Series Oscilloscope is backed with a standard 5-year warranty.

Specifications

All specifications are guaranteed unless noted otherwise. All specifications apply to all models unless noted otherwise.

Model overview

Models	TBS2072B	TBS2074B	TBS2102B	TBS2104B	TBS2202B	TBS2204B
Analog Channels	2	4	2	4	2	4
Bandwidth	70 MHz	70 MHz	100 MHz	100 MHz	200 MHz	200 MHz
Sample rate	2 GS/s	2 GS/s	2 GS/s	2 GS/s	2 GS/s	2 GS/s
Record length	5 M points	5 M points	5 M points	5 M points	5 M points	5 M points

Vertical system analog channels

Hardware bandwidth limits	20 MHz
Input coupling	DC, AC, or GND
Input impedance	1 MΩ ± 1 %, 13 pF ± 1.5 pF
Input sensitivity range	2mV/div 10 V/div
Vertical resolution	8 bits
Maximum input voltage, 1 MΩ	300 V RMS with peaks ≤ ±450 V

Acquisition modes

Sample	Acquire sampled values.
Peak Detect	Captures glitches as narrow as 3.5 ns at all sweep speeds.
Average	From 2 to 512 waveforms included in average.
Hi-Res	Averages multiple sample of one acquisition interval into one waveform point.
Roll	Scrolls waveforms right to left across the screen at sweep speeds slower than or equal to 40 ms/div (400 ms/div at 20M record length).

Waveform math

Arithmetic:	Add
	Subtract
	Multiply
	FFT

DC balance	± (1 mV +0.1 div)
DC gain accuracy	± 2% 10 V/div through 5 mV/div±
	3% typical 2 mV/div

Vertical system analog channels

DC voltage measurement accuracy average mode

Average of 16 waveforms	±((DC Gain Accuracy) X |reading - (offset - position)| + Offset Accuracy + 0.11 div + 1 mV)
Delta Volts between any two averages of ≥16 waveforms acquired with the same oscilloscope setup and ambient conditions	±(DC Gain Accuracy X |reading| + 0.08 div + 1.4 mV)

Vertical position range   ± 5 divisions

Vertical offset ranges

Volts/Div setting	Offset range, 1 MΩ
2 mV/Div to 63 mV/Div	± 1 V
64 mV/div to 999 mV/div	± 10 V
1 V/div to 10 V/div	± 100 V

Analog bandwidth, DC coupled

200 MHz models:	DC to >200 MHz
100 MHz models:	DC to ≥100 MHz
70 MHz models:	DC to ≥70 MHz

Common mode rejection ratio (CMRR), typical   100:1 at 60 Hz, reducing to 10:1 with 50 MHz sine wave with equal Volts/div and coupling settings on each channel.

Channel-to-channel isolation

TBS2072B, TBS2074B	TBS2102B, TBS2104B	TBS2202B, TBS2204B
≥100:1 at ≤70 MHz	≥100:1 at ≤100 MHz	≥100:1 at ≤200 MHz

Horizontal system analog channels

Maximum duration of time captured at highest sample rate (all channels)   5 ms

Time base range   TBS220x: 1 ns/div to 100 sec/div

TBS207x, TBS210x: 2 ns/div to 100 sec/div

Time-base delay time range   -15 divisions to 5000 s

Deskew range   ±100 ns

Time base accuracy   ±25 ppm over any ≥1 ms interval

Trigger system

Trigger modes	Auto, Normal, and Single
Trigger holdoff range	20 ns to 8 s
Trigger types	
Edge	Positive or negative slope on any channel. Coupling includes DC, HF reject, LF reject, and noise reject.
Pulse width	Trigger on width of positive or negative pulses that are >, <, =, or ≠ a specified period of time.
Runt	Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again.
Trigger coupling analog channels	DC, Noise Reject, High Freq Reject, Low Freq Reject.

Sensitivity, edge–type trigger, DC coupled

Trigger Source	Sensitivity
70 MHz models	0.4 division
100 MHz models	0.5 division
200 MHz models	0.7 division

Trigger level ranges	Input channels: ± 4.90 divisions from center screen

Data storage

Nonvolatile memory retention time, typical	No time limit for Front Panel Settings, saved waveforms, setups, and calibration constants.
Real-Time clock	A programmable clock providing time in years, months, days, hours, minutes, and seconds.

Waveform measurements

Cursors	Time, amplitude and screen.
Automated measurements	32, of which up to six can be displayed on-screen at any one time. Measurements include: Period, Frequency, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width, Burst Width, Phase, Positive Overshoot, Negative Overshoot, Peak to Peak, Amplitude, High, Low, Max, Min, Mean, Cycle Mean, RMS, Cycle RMS, Positive Pulse Count, Negative Pulse Count, Rising Edge Count, Falling Edge Count, Area, Cycle Area, Delay FR, Delay FF, Delay FR, and Delay RR.
Gating	Isolate the specific occurrence within an acquisition to take measurements on, using either the screen, between waveform cursors or full record length.

Waveform math

Arithmetic	Add, subtract, and multiply waveforms.
FFT	Spectral magnitude. Set FFT Vertical Scale to Linear RMS or dBV RMS, and FFT Window to Rectangular, Hamming, Hanning, or Blackman-Harris.

Remote control software

web page	Built-in web page enables remote control of horizontal and vertical scale, trigger settings, and measurements. Allows waveform and image save to USB flash drive.

Display system

Display type	9 inch (228 mm) wide format liquid crystal TFT color display.
Display resolution	800 horizontal by 480 vertical displayed pixels (WVGA).
Waveform styles	Vectors, Variable Persistence, and Infinite Persistence.
Graticules	Grid, None.
Format	YT and XY.

Input output ports

USB 2.0 high-speed host port	Supports USB mass storage devices, Wi-Fi dongle, One port available on rear panel and one on front panel.
USB 2.0 high-speed device port	
Device port	Rear-panel connector allows for communication/control of oscilloscope through USBTMC or GPIB with a TEK-USB-488.
Compatible USB-WIFI dongles	NETGEAR WNA1000M, WNA3100M, D-LINK DWA-131, TP-LINK TL-WN823N
LAN port (Ethernet)	RJ-45 connector, supports 10/100BASE-T.
Probe compensator	
Amplitude	5 V
Frequency	1 kHz
Kensington-style lock	Rear-panel security slot connects to standard Kensington-style lock.

Power source

Power source voltage	100 to 240 V_{AC} RMS ±10%
Power source frequency	47 Hz to 63 Hz (100 to 240 V)
	360 Hz to 440 Hz (100 to 132 V)
Power consumption	40 W maximum

Physical characteristics

Dimensions

TBS2xx2:	Height: 174.9 mm (6.89 in)
	Width: 372.4 mm (14.66 in)
	Depth: 117.7 mm (4.64 in)
TBS2xx4:	Height: 201.5mm (7.93 in)
	Width: 412.8 mm (16.25 in)
	Depth: 128.1 mm (5.58 in)

Weight

TBS2xx2:	2.62 kg (5.8 lbs.), standalone instrument.
	5.1 kg (11.2 lbs.), when packaged for domestic shipment.
TBS2xx4:	4.08 kg (9.0 lbs.), stand-alone instrument.
	6.89 kg (15.2 lbs.), when packaged for domestic shipment.

Cooling clearance

50 mm (2 in) required on left side and rear of instrument.

EMC, environment, and safety

Temperature

Operating:	0 °C to +50 °C (+32 ºF to 122 ºF)
Nonoperating:	-40 °C to +71 °C (-40 ºF to 160 ºF)

Humidity

Operating:	5% to 95% relative humidity (% RH) at up to +30° C
	5% to 60% RH above +30° C up to +50° C
	non-condensing
Nonoperating:	5% to 95% RH (Relative Humidity) at up to +30° C
	5% to 60% RH above +30° C up to +60° C
	non-condensing

Altitude

Operating:	Up to 3,000 meters (9,842 feet).
Non-Operating:	Up to 12,000 meters (39,370 feet).
	Altitude is limited by possible damage to LCD at higher altitudes. This damage is independent of operation.

Regulatory

Electromagnetic compatibility	EC Council Directive 2014/30/EU
Safety	UL61010-1, UL61010-2-030, CAN/CSA-C22.2 No. 61010.1, CAN/CSA-C22.2 No. 61010-2:030; complies with the Low Voltage Directive 2014/35/EU for Product Safety

Ordering information

Models

Product	Supported instruments
TBS2072B	70 MHz bandwidth, 2 GS/s sample rate, 2-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.
TBS2074B	70 MHz bandwidth, 2 GS/s sample rate, 4-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.
TBS2102B	100 MHz bandwidth, 2 GS/s sample rate, 2-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.
TBS2104B	100 MHz bandwidth, 2 GS/s sample rate, 4-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.
TBS2202B	200 MHz bandwidth, 2 GS/s sample rate, 2-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.
TBS2204B	200 MHz bandwidth, 2 GS/s sample rate, 4-channel digital storage oscilloscope, 5 Mpts record length, 5 year warranty. Certificate of Calibration Standard.

Bandwidth upgrade options

Options	Supported instruments
SUP2-BW7T102	Upgrade 70 MHz to 100 MHz on 2-channel models of TBS2000B Series oscilloscopes
SUP2-BW7T104	Upgrade 70 MHz to 100 MHz on 4-channel models of TBS2000B Series oscilloscopes
SUP2-BW7T202	Upgrade 70 MHz to 200 MHz on 2-channel models of TBS2000B Series oscilloscopes
SUP2-BW7T204	Upgrade 70 MHz to 200 MHz on 4-channel models of TBS2000B Series oscilloscopes
SUP2-BW10T202	Upgrade 100 MHz to 200 MHz on 2-channel models of TBS2000B Series oscilloscopes
SUP2-BW10T204	Upgrade 100 MHz to 200 MHz on 4-channel models of TBS2000B Series oscilloscopes

Standard accessories

Probes

TPP0200	200 MHz, 10x passive probe (one per analog channel) 200 MHz models
TPP0100	100 MHz, 10x passive probe (one per analog channel) for 70 MHz and 100 MHz models

Accessories

071-3635-xx	Compliance and Safety Instructions
077-1149-xx	Programmer manual, available in http://www.tek.com
-	Power cord
-	Calibration certificate documenting traceability to National Metrology Institute(s) and ISO9001 quality system registration

Warranty   Five-year warranty covering all parts and labor, excluding probes.

Recommended accessories

Probes   Tektronix offers over 100 different probes to meet your application needs. For a comprehensive listing of available probes, please visit www.tektronix.com/probes.

P5100A	2.5 kV, 500 MHz, 100X high-voltage passive probe
TDP0500	500 MHz TekVPI $^®$ differential voltage probe with ±42 V differential input voltage
THDP0200	±1.5 kV 200 MHz high-voltage differential probe
THDP0100	±6 kV 100 MHz high-voltage differential probe
TAP1500	1.5 GHz TekVPI $^®$ active voltage probe
TCP0020	50 MHz TekVPI $^®$ 20 Ampere AC/DC current probe
TCP0030A	120 MHz TekVPI $^®$ 30 Ampere AC/DC current probe
TCP0150	20 MHz TekVPI $^®$ 150 Ampere AC/DC current probe
TCP2020	50 MHz BNC 20 Ampere AC/DC current probe
P5202A	100 MHz, 640 V High Voltage differential probe
P5205A	100 MHz, 1.3 kV High Voltage differential probe
P5210A	50 MHz, 5.6 kV High Voltage differential probe

Accessories

ACD2000	Soft transit case for TBS2000B 2-channel instrument
ACD4000B	Soft transit case, for TBS2000B 4-channel instrument
TPA-BNC	TekVPI $^®$ to TekProbe $^®$ BNC adapter
TEK-DPG	TekVPI $^®$ Deskew pulse generator signal source
067-1686-XX	Power measurement deskew and calibration fixture
TEK-USB-488	GPIB-to-USB adapter
TEK-USB-WIFI	USB Wi-Fi [2] dongle for TBS2000B Series Oscilloscope only

[2]   Certified to comply with CE, FCC and IC regulations. Available in Australia, Canada, China, EU Region, New Zealand, and United States. For other compatible Wi-Fi adapters, see Compatible USB-WIFI dongles under Input output ports specifications.

Instrument options

Instrument Options

2-WIFI	USB Wi-Fi dongle for TBS2000B Series Oscilloscope only

Power plug options

Opt. A0	North America power plug (115 V, 60 Hz)
Opt. A1	Universal Euro power plug (220 V, 50 Hz)
Opt. A2	United Kingdom power plug (240 V, 50 Hz)
Opt. A3	Australia power plug (240 V, 50 Hz)
Opt. A4	North America power plug (240 V, 50 Hz)
Opt. A5	Switzerland power plug (220 V, 50 Hz)
Opt. A6	Japan power plug (100 V, 50/60 Hz)
Opt. A10	China power plug (50 Hz)
Opt. A11	India power plug (50 Hz)
Opt. A12	Brazil power plug (60 Hz)
Opt. A99	No power cord
Opt E1	Universal EURO, United Kingdom and Switzerland

Language options

Opt. L0	English manual
Opt. L1	French manual
Opt. L2	Italian manual
Opt. L3	German manual
Opt. L4	Spanish manual
Opt. L5	Japanese manual
Opt. L7	Simplified Chinese manual
Opt. L8	Traditional Chinese manual
Opt. L9	Korean manual
Opt. L10	Russian manual
Opt. L99	No manual

Language options include translated front-panel overlay for the selected language(s).

Service options

Opt. C3	Calibration Service 3 years. Includes traceable calibration or functional verification applicable, for recommended calibrations. Coverage includes the initial calibration plus 2 years calibration coverage.
Opt. C5	Calibration Service 5 years. Includes traceable calibration or functional verification applicable, for recommended calibrations. Coverage includes the initial calibration plus 4 years calibration coverage.
Opt. D1	Calibration Data Report.
Opt. D3	Calibration Data Report 3 years (with Option C3).
Opt. D5	Calibration Data Report 5 years (with Option C5).
Opt. T3	Three Year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support.
Opt. T5	Five Year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support.

Probes and accessories are not covered by the oscilloscope warranty and Service Offerings. Refer to the datasheet of each probe and accessory model for its unique warranty and calibration terms.

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

ASEAN / Australasia (65) 6356 3900
Belgium 00800 2255 4835*
Central East Europe and the Baltics +41 52 675 3777
Finland +41 52 675 3777
Hong Kong 400 820 5835
Japan 81 (3) 6714 3086
Middle East, Asia, and North Africa +41 52 675 3777
People's Republic of China 400 820 5835
Republic of Korea +822 6917 5084, 822 6917 5080
Spain 00800 2255 4835*
Taiwan 886 (2) 2656 6688

Austria 00800 2255 4835*
Brazil +55 (11) 3759 7627
Central Europe & Greece +41 52 675 3777
France 00800 2255 4835*
India 000 800 650 1835
Luxembourg +41 52 675 3777
The Netherlands 00800 2255 4835*
Poland +41 52 675 3777
Russia & CIS +7 (495) 6647564
Sweden 00800 2255 4835*
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Canada 1 800 833 9200
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28 Jan 2020   3GW-61509-0

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