Series 2281S

Battery Simulator and Precision DC Power Supply

- Simulate a battery's output during the charge and discharge cycles
- Create, edit, import, and export battery models
- Build a library of battery models automatically based on measurement results using battery test mode
- Display the real-time change of the SOC, V_{oc}, and V_t for the simulated battery
- Compute battery capacity in Amp-Hour and Equivalent Series Resistance (ESR)
- Program the battery SOC, Voc, capacity, and resistance
- Provide two modes of simulation–dynamic and static
- Monitor charge/discharge current and voltage
- Output up to 120W of low noise, linear regulated power
- Monitor load currents from 100nA to 6A with high accuracy
- Measure voltage and current with 6½-digit resolution
- Sink current up to 1A and source current up to 6A
- Built-in graphing simplifies analyzing trends or displaying voltage or current waveforms
- High resolution TFT display and soft-key/icon-based user interface simplify power supply operation
- Digital I/O for direct communication with other devices and instruments
- GPIB, USB, and LAN interfaces
- Emulation of front panel display and controls via your web browser simplifies automated control and monitoring

The Series 2281S Battery Simulator and Precision DC Power Supply innovatively integrates battery simulation with the functions of a high-precision power supply and battery testing. It's able to analyze the DC consumption of a device under test, test a battery, and generate a battery model based on battery charging process and simulate a battery based on the battery model. The 2281S-20-6 can output up power to 20V and 6A and sink current up to 1A.

The 2281S uses linear regulation to ensure low-output noise and superior load current measurement sensitivity. A high resolution color thin film transistor (TFT) screen displays a wide range of information on measurements. Soft-key buttons and a navigation wheel combine with the TFT display to provide an easy-to-navigate user interface that accelerates instrument setup and operation. In addition, built-in plotting functions allow monitoring trends such as drift. These features provide the flexibility required for both benchtop and automated test system applications. In addition, the 2281S provides a list mode, triggers, and other speed optimization functions to minimize test time in automated testing applications.

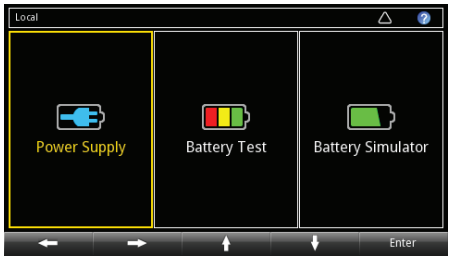


Figure 1. Series 2281S startup screen.

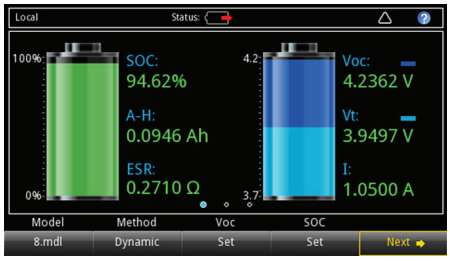


Figure 2. Battery simulator home screen.

Battery simulation based on a battery model

In the battery simulator function of the 2281S, real battery output performance can be simulated based on a selected battery model. State of charge (SOC) and voltage open circuit (V_{oc}) can be set to any state to test the device under specific circumstance. There are two modes from which to choose:

- Static: During the static simulation, V_{oc} and SOC stay the same.
- Dynamic: During the dynamic simulation, V_{oc} and SOC change according to charging and discharging as with a real battery.

Capacity can also be reduced to accelerate the charging and discharging process for better test efficiency.

Series 2281S

Battery Simulator and Precision DC Power Supply

Ordering Information

2281S-20-6 Precision DC Supply and Battery Simulator, 20V, 6A

Accessories Supplied

- Quick Start Guide
- KickStart Quick Start Guide
- User Documentation CD
- LAN Crossover Cable
- Power Cord
- Rear Panel Mating Connector with Cover

ACCESSORIES AVAILABLE

2280-001	Rear Panel Mating Connector and Cover
2280-TEST-LEAD	Power Supply Test Lead Kit, 1000VA, 20A Rating
2450-TLINK	Trigger Link Cable to connect 2281S Digital I/O to Trigger Link I/O on other Keithley instruments
4299-8	Single Fixed Rack-Mount Kit
4299-9	Dual Fixed Rack-Mount Kit
4299-10	Dual Fixed Rack-Mount Kit for one 2U Graphical Display Instrument and one Series 26xx Instrument
4299-11	Dual Fixed Rack-Mount Kit for one 2U Graphical Display Instrument and one Series 24xx, Series 2000, or 2U Agilent Instrument
CA-180-3A	LAN crossover cable
7007-05	Double Shielded Premium IEEE-488 Interface Cables, 0.5m (1.6 ft)
7007-1	Double Shielded Premium IEEE-488 Interface Cables, 1m (3.2 ft)
7007-2	Double Shielded Premium IEEE-488 Interface Cables, 2m (6.5 ft)
7007-3	Double Shielded Premium IEEE-488 Interface Cables, 3m (10 ft)
7007-4	Double Shielded Premium IEEE-488 Interface Cables, 4m (13 ft)
KPCI-488LPA	IEEE-488.2 Interface Board for the PCI Bus
KUSB-488B	IEEE-488.2 USB-GPIB Interface Adapter for USB Port with 2m (6.6 ft) cable
USB-B-1	USB Cable Type A to B, 1 m (3.3 ft)

SERVICES AVAILABLE

2281S-20-6-EW	1 Additional Year of Factory Warranty (total of 4 years)
2281S-20-6-3Y-STD	3 Calibrations within 3 Years of Purchase
2281S-20-6-3Y-DATA	3 (ANSI-Z540-1 compliant) Calibrations within 3 Years of Purchase
2281S-20-6-3Y-17025	3 (ISO 17025 Accredited) Calibrations within 3 Years of Purchase
2281S-20-6-5Y-STD	5 Calibrations Within 5 Years of Purchase
2281S-20-6-5Y-DATA	5 (ANSI-Z540-1 compliant) Calibrations within 5 Years of Purchase

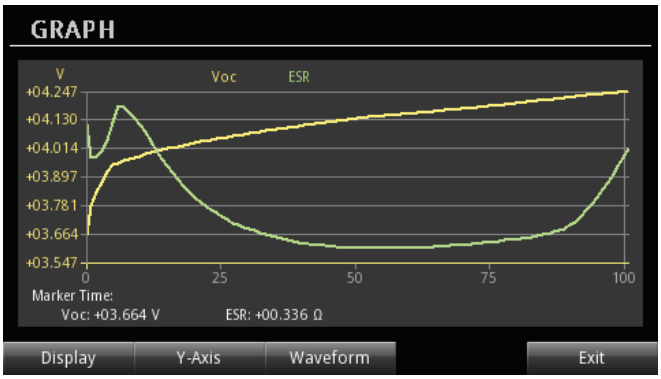


Figure 3. Graph of V_{oc}, ESR, and SOC.

Determine SOC and ESR and create a battery model during battery testing

In the 2281S battery test function, charge/discharge test on a battery can be performed. Charging current ranges from 0 to 6A, and the maximum discharging current is 1A. During the charging, the sampling interval can be set for the internal 6½-digit multimeter to sample the charging current and voltage continuously. In this way, the capacity of the battery and its internal resistance (ESR value) are automatically computed.

After the test, a battery model can be generated based on the measurement result of the battery charging process. A battery model can be edited, created, imported, or exported in a CSV file format.

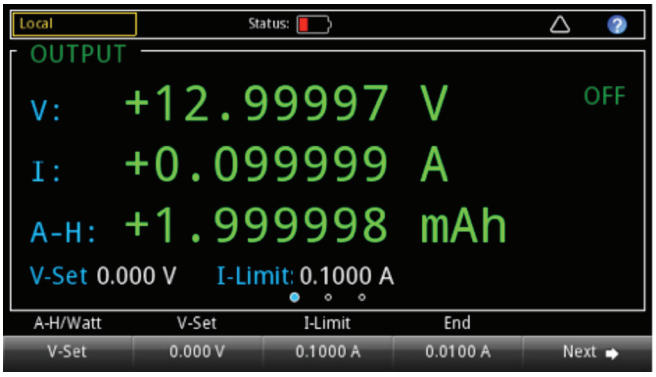


Figure 4. Battery test display.

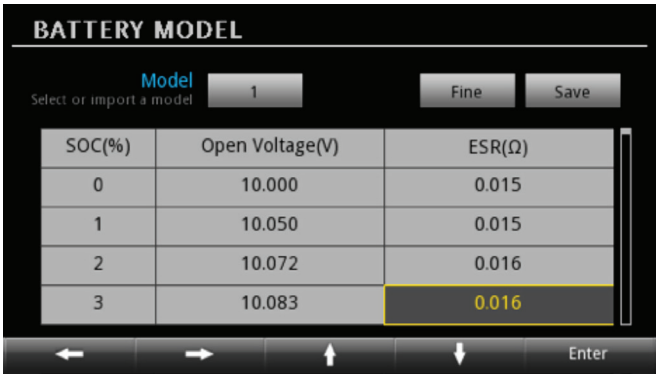


Figure 5. Battery model.

Series 2281S

Battery Simulator and Precision DC Power Supply

Easily view and control every parameter of the battery test and simulation function

The bright, 4.3-inch TFT display shows voltage, current, and amp-hour readings, source settings, and many additional settings in large, easy-to-read characters. The icon-based main menu provides all the functions users can control and program for fast access to source setup, measurement setup, display formats, trigger options, and system settings. Menus are short, and menu options are easy to find and are clearly described, enabling test parameters to be setup quickly by using the navigation wheel, keypad, or soft-keys. Many setup parameters, such as voltage and current settings, can be entered directly from the home screen; less complex tests don't require access to the main menu to make adjustments - just use soft keys on the home screen. Whether test requirements are simple or complex, the Series 2281S supplies provide a simple way to set up all required parameters.

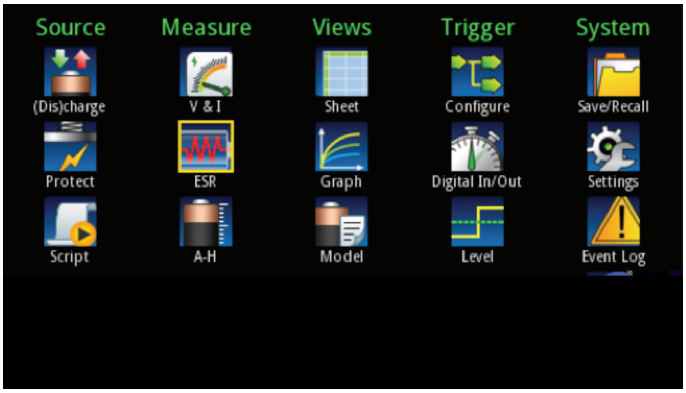


Figure 6. Battery test menu.

Precision DC power supply, with DMM-quality high resolution, low current measurements capability

Unlike conventional power supplies, Series 2281S supplies feature up to 120W, 20V, and 6A output and can also make measurements with up to 6½ digits of resolution. Voltage output measurements can be resolved down to 100μV. These supplies measure load currents from 100nA to amps. Four load current measurement ranges (10A, 1A, 100mA, and 10mA) support measuring a device's full load current, standby mode current, and small sleep mode current with DMM-quality accuracy. The high resolution allows discerning small changes in load currents with confidence. It also makes it possible to make a broad range of measurements or a single range with excellent accuracy across both low and high current values.

Optimized performance for production test

Series 2281S are as powerful in a production test system as they are flexible on the R&D benchtop. They provide SCPI commands for all measurement functions. In addition, several other features can help minimize test time in automated systems. For example, an external trigger input allows hardware synchronization and control by other instruments in the test system. For the battery test and battery simulator function, the digital I/O can be configured as input or output. If the digital I/O is configured as input, the measurement can be triggered by external signals; if the digital I/O is configured as output, the digital I/O pin will send out a signal when the measurement is finished. Furthermore, to reduce measurement time, reading speed can be increased by reducing the acquisition time from 16.6ms (or 20ms) to 33μs (40μs).

A choice of front or rear panel terminals provides enhanced connection flexibility. For maximum voltage accuracy, 4-wire remote sensing ensures that the output voltage programmed is actually the level applied to the load. In addition, the sense lines are monitored in order to detect any breaks in them. These features ensure that any production problems can be quickly identified and corrected. Series 2281S supplies can be controlled via their built-in GPIB, USB, or LAN interfaces. The USB interface is test and measurement system (TMC) compliant. The LXI Core compliant LAN interface supports controlling and monitoring a Series 2281S supply remotely, so test engineers can always access the power supply and view measurements, even if located on a different continent than the test systems.

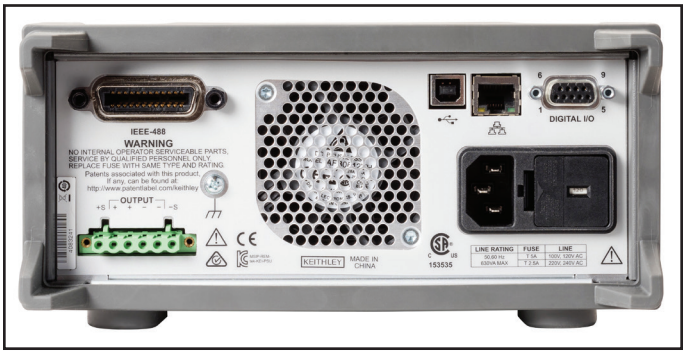


Figure 7. 2281S rear panel.

Series 2281S

Battery Simulator and Precision DC Power Supply

Specifications

23°C ±5°C with 1-hour instrument warm-up.

DC OUTPUT RATINGS

VOLTAGE: 0 to 20V.

CURRENT: 0 to 6A.

MAXIMUM POWER: 120W.

VOLTAGE [1]

SOURCE SETTING

ACCURACY: ±(0.02% + 3mV).

RESOLUTION: 1mV.

MEASUREMENT [2] (0.5V over-range)

ACCURACY: ±(0.02% + 2 mV).

RESOLUTION: 0.1mV.

ADDITIONAL OFFSET AT FASTER MEASUREMENT SETTINGS

5½ (0.1 PLC): 0.21mV.

4½ (0.01 PLC): 1.44mV.

3½ (0.002 PLC): 7.60mV.

REGULATION

LOAD: ±(0.01% + 2mV).

LINE: ±(0.01% + 1mV).

OUTPUT RIPPLE AND NOISE

BANDWIDTH 20Hz–20MHz: <1mV RMS, <6mV p-p.

LOAD TRANSIENT RECOVERY TIME: Resistive load change 50% load to 100% load or 100% load to 50% load: <50µs to within 15mV of V-set.

SLEW RATE: Rising Voltage and Falling Voltage: 10V/s to 100V/s. Up to 1000V/s under limited conditions [3]. 100V/s (default).

MAXIMUM SOURCE VOLTAGE DROP PER LEAD: To Maintain Specified Voltage Accuracy: 1V.

MAXIMUM SENSE HI AND SENSE LO LEAD RESISTANCE: To Maintain Specified Voltage Accuracy: 2Ω.

CURRENT

CURRENT LIMIT SETTING

FULL-SCALE AMPS: 6.1A.

ACCURACY: ±(0.05% + 5mA).

RESOLUTION: 0.1mA.

MEASUREMENT [4] (120% over-range except 10A)

Range	Resolution	Accuracy
10 mA	10 nA	±(0.04% + 10 µA)
100 mA	100 nA	±(0.04% + 10 µA)
1 A	1 µA	±(0.04% + 250 µA)
10 A	10 µA	±(0.05% + 250 µA)

ADDITIONAL OFFSET AT FASTER MEASUREMENT SETTINGS [9]

Measure Resolution and (NPLC)	Range	Resolution
5½ (0.1 PLC)	10 mA	5.0 µA
	100 mA	20 µA
	1 A	80 µA
	10 A	2.0 mA
4½ (0.01 PLC)	10 mA	20 µA
	100 mA	40 µA
	1 A	500 µA
	10 A	10 mA
3½ (0.002 PLC)	10 mA	30 µA
	100 mA	250 µA
	1 A	20 mA
	10 A	75 mA

CURRENT PULSE MEASUREMENT [5]

MINIMUM PULSE WIDTH (10mA and 100mA range) [6]: 2ms.

MINIMUM PULSE WIDTH (1A AND 10A RANGE) [6]: 140µs.

MINIMUM TIME TO CAPTURE TWO CONSECUTIVE PULSES: 0.5ms.

REGULATION

LOAD: ±(0.01% + 0.25 mA).

LINE: ±(0.01% ± 0.25 mA).

OUTPUT RIPPLE AND NOISE

BANDWIDTH 20Hz–20MHz: <3mA RMS.

MAXIMUM CONTINUOUS AVERAGE SINK CURRENT

NON-PROGRAMMABLE: 1.02A ± 0.1A (typical).

Series 2281S

Battery Simulator and Precision DC Power Supply

SYSTEM MEASUREMENT SPEEDS

Readings/s	Settings: Measure Resolution and (NPLC)	Concurrent (V+I): Autozero On 60 Hz (50 Hz)	Concurrent (V+I): Autozero OFF 60 Hz (50 Hz)
'Read?' with BUS Transfer	6½ (5 PLC)	2.0 (1.5)	5.4 (4.5)
	6½ (1 PLC)	9.0 (8.0)	20 (18)
	5½ (0.1 PLC)	48 (38)	50 (48)
'*TRG and TRACe:DATa?' with BUS Transfer	4½ (0.01 PLC) [7]	680 (646)	
	3½ (0.002 PLC) [7]	845 (833)	

OTHER TIMING DATA

CV TO CC TRANSITION TIME (V-Set = 5V, I-limit = 0.5A, Resistive Load change 25Ω to 2.5Ω): 2.4ms.

CC TO CV TRANSITION TIME (V-Set = 5V, I-limit = 0.5A, Resistive Load change 2.5Ω to 25Ω): 1.1ms.

FUNCTION CHANGE (from detection of bus command to function change completed): 10ms (typical).

OUTPUT OFF/ON (from detection of bus command to voltage beginning to decrease): 5ms (typical).

REVERSE LEADS ACTUATION: >1.5ms.

PROTECTION

OVERVOLTAGE PROTECTION (OVP)

SETTING ACCURACY: ±(0.25% + 0.25V).

RESOLUTION: 125mV.

RESPONSE TIME: <1.5ms.

OVERCURRENT PROTECTION (OCP)

SETTING ACCURACY: ±(0.25% + 0.10A).

RESOLUTION: 25mA.

RESPONSE TIME: <1.5ms.

OVERTEMPERATURE PROTECTION (OTP)

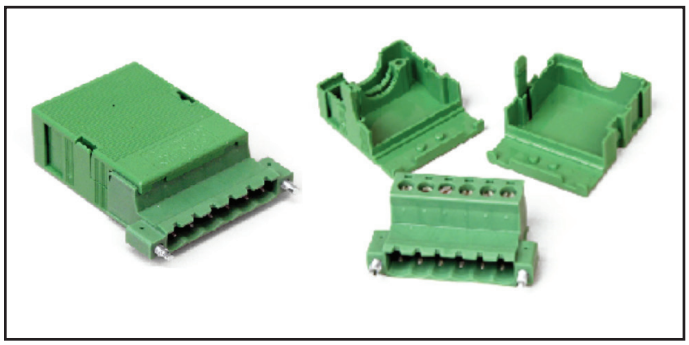
OUTPUT TURN-OFF TEMPERATURE: >93°C (typical).

RESPONSE TIME: <1.5 ms (typical)[8].

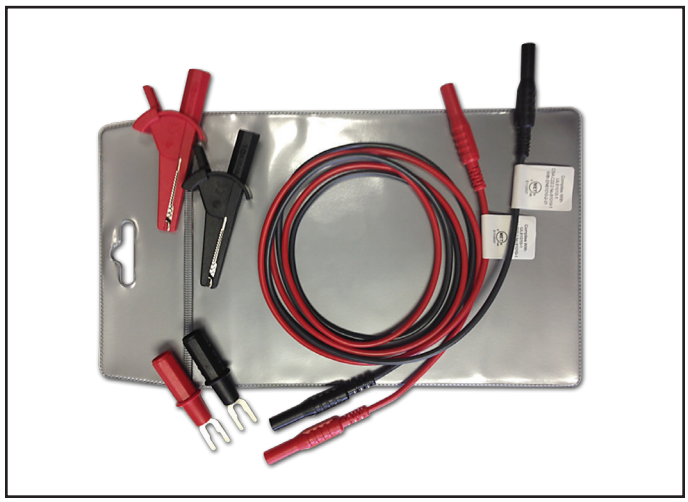
NOTES

1. Specifications based on using remote sense connections. For 2-wire connections, add an offset of 0.5mV/A (front terminals).
2. 6½-digit resolution, 1 PLC reading rate, Filter on, Autozero on.
3. 100V/s to 1000V/s slew rate is limited to 5V changes at a maximum of 3A for the 2281S-20-6 supply.
4. 6½-digit resolution, 1 PLC reading rate, filter on, autozero on.
5. Settings: Autozero off, 0.002 PLC, Arm Source:external, Trigger Source:Immediate.
6. Time includes trigger detection, latency plus jitter of start of measurement, and measurement integration time, 0.002 PLC.
7. Settings:Autozero Off, Output On, Output Delay Off, Fixed Source:Voltage.
8. Settings: Autozero Off, Output On, Output Delay Off, Fixed Source:Voltage, Arm or Measure count 1000.

Series 2280S Accessories



Model 2280-001: Rear Panel Mounting Connector and Cover (assembled view on the left, and connector and top and bottom cover shown separately on the right)



Model 2280-TEST-LEAD: Power Supply Test Lead Kit, 1000V, 20A Rating: Contains 122cm (4ft) of cable, spade lug adapters, and alligator clips

Series 2281S

Battery Simulator and Precision DC Power Supply

GENERAL

COMMON MODE CURRENT: < 6μA peak-peak (typical).

CHASSIS ISOLATION: ±240V, any terminal to chassis. >1GΩ in parallel with <6.8nF.

TEMPERATURE COEFFICIENT: Add the following to all accuracy specifications when outside the range, 23°C ±5°C: (0.15 × specification)/°C for 0° to 18°C and 28° to 40°C.

MEASUREMENT DISPLAY MODES: Voltage and current, voltage only, current only.

MEASUREMENT ACQUISITION CONTROL: Continuous, manual, external digital input, PC bus.

LIST MODE: **Maximum number of stored lists:** 9.
Number of points in a list: 2–99.
List Storage Location: Internal memory or USB memory stick.

MATH AND FILTER FUNCTIONS:

REL: Removes offset from current reading display, Range: -1×10^6 to $+1\times10^6$.

Mx+b: Reading = x, M = -1×10^6 to $+1\times10^6$, b = -1×10^6 to $+1\times10^6$.

Filter: Moving average, Count: 2–100, Window: 0.01% to 100%.

MEMORY BUFFER:

2500 locations; each location contains: Voltage measurement, current measurement, CV/CC Mode, and time stamp.

9 memory slot for saving battery model.

NVRAM.

DISPLAY: 4.3 in. front panel color display, resolution: 480 pixels × 272 pixels.

Display Modes:

Real time voltage and current readings and settings.

Plots of stored data: Voltage vs. data point, current vs. data point, voltage and current vs. data point, 100 point resolution.

Plots can also display statistics: mean, maximum, minimum, peak-peak, standard deviation.

Table of stored data: Time/date, voltage, current.

Soft button and navigation wheel control.

COMMUNICATIONS:

GPIB: IEEE-488.2 compliant and status model topology.

LAN: RJ-45 connector, 10/100BT, Auto MDIX.

IP Configuration: Static or DHCP.

LXI Core 2011, version 1.4,

USB: USB2.0 device (rear panel, type B), USBTMC compliant.
USB2.0 host (front panel, type A), full speed, support U-disk drives.

INPUT CONNECTIONS:

Front: (2-wire). Adjustable supporting, safety shrouded banana, spade lug, or wire.

Rear: (4-wire sense). 6-pin removal screw terminal, safety shrouded cover, removable local sense jumpers.

REAL-TIME CLOCK: Capacitive charged, 20 days between next power on cycle at 23°C and ≤50%RH.

DIGITAL I/O: 9-pin female D-sub. 6 Input/Output pins.

Input Signal Levels:
0.7V (maximum logic low).
3.7V (minimum logic high).

Input Voltage Limits:
–0.25V (Absolute minimum).
+5.25V (Absolute maximum).

Maximum Source Current: +2.0mA@ >2.7V (per pin).

Maximum Sink Current: –50mA @ 0.7V (per pin, solid-state fuse protected).

5V power supply, limited to 0.5A @ >4V (solid-state fuse protected).

Trig In minimum pulse ≥4μs, Logic Low pulse.

Meter Ready Pulse, 15–30μs, Logic Low Pulse.

EMC: Conforms to European Union EMC directive.

SAFETY:

U.S. NRTL Listing: UL61010-1 3rd ed 2012.

Canadian Certification: CAN/CSA C22.2 No. 61010-1 3rd ed 2012.

European Union Compliance: Low Voltage Directive, EN/IEC 61010-1 3rd ed 2010.

COOLING: Forced air, side intake, and rear exhaust.

POWER SUPPLY: 100V/120V/220V/240V ±10%.

POWER LINE FREQUENCY: 50/60Hz ±3Hz, automatically sensed at power-on.

POWER CONSUMPTION: 630VA peak.

OPERATING ENVIRONMENT: 0° to 40°C, ≤80% RH up to 35°C, non-condensing.
Altitude: up to 2000 meters.

STORAGE ENVIRONMENT: –25° to 70°C.

LXI WEB BROWSER COMPATIBLE OPERATING SYSTEM AND SOFTWARE: Windows 2000, Win 7, and XP compatible, supports Web browsers with Java plug-in (requires Java plug-in 1.7 or higher). Web page served by Model 2281S.

RACK DIMENSIONS: (W×H×D), without boot: 213.8 × 88.4 × 383.3mm (8.42 × 3.48 × 15.1 in.).

BENCH DIMENSIONS: (W×H×D) with boot: 255.3 × 107.2 × 415.0mm (10.1 × 4.22 × 16.34 in.)

SHIPPING WEIGHT: 13.29kg (29.3 lbs.).

NET WEIGHT: 10.85kg (23.9 lbs.).

WARRANTY: 3 years.

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