

# 2302, 2302-PJ, 2306, 2306-PJ, 2306-LAN Battery Simulator, Battery/Charger Simulators



The single-channel 2302 Battery Simulator and dual-channel 2306 Battery/Charger Simulator were designed specifically for development and test applications of portable, battery-operated products, such as cellular phones, wireless devices and wearables. These precision power supplies have ultrafast transient response so they can have output characteristics identical to actual batteries. These supplies employ a unique variable output resistance so the voltage output can emulate a battery's response (U.S. Patent No. 6,204,647). They provide stable voltage outputs, even when a device-under-test (DUT) makes the rapid transition from the standby (low current) state to the RF transmission (high current) state. In addition, they can monitor DUT power consumption by measuring both DC currents and pulse load currents. The 2302's and the 2306's battery-simulator channel can be programmed to operate like a discharged rechargeable battery, sinking current from a separate charger or from the 2306's charger-simulator channel.

## Key Features

- Ultrafast response to transient load currents
- Choice of single- or dual-channel supplies
- Optimized for development and testing of battery-powered devices
- Variable output resistance for simulating battery response at a fixed point (U.S. Patent No. 6,204,647)
- Pulse peak, average, and baseline current measurements
- 100 nA DC current sensitivity
- Current step measure function
- Sink up to 3 A
- Open sense lead detection
- Built-in digital voltmeter
- LAN communication (2306-LAN only)

## Maximize Test Throughput with Accurate Battery Simulation

The battery-output channels of the 2302 and 2306 are designed to simulate the output response of a battery. *This capability, combined with their fast transient response, makes it possible to power the device during testing in exactly the same way as a battery will power the device during actual use.* The output resistance of the 2302's and the 2306's battery channel can be programmed (with 10 m $\Omega$  resolution) over the range from 0  $\Omega$  to 1  $\Omega$  so that the output resistance can be set to the same level as the output resistance of the battery that powers the device. See **Figure 1**.

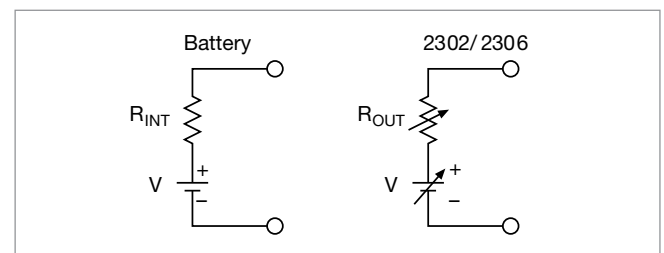


Figure 1. Simplified schematic of a battery and the 2302/2306.

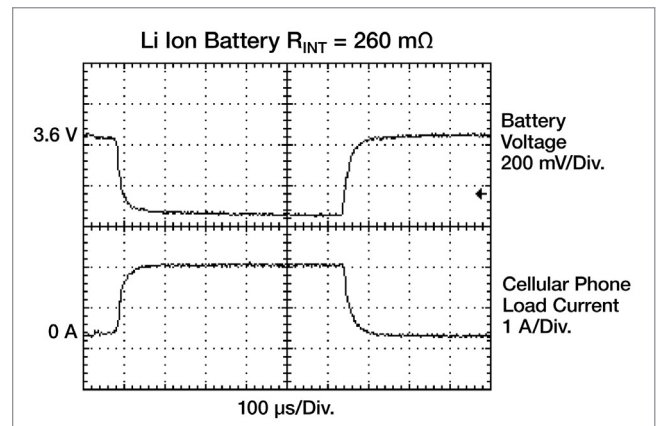
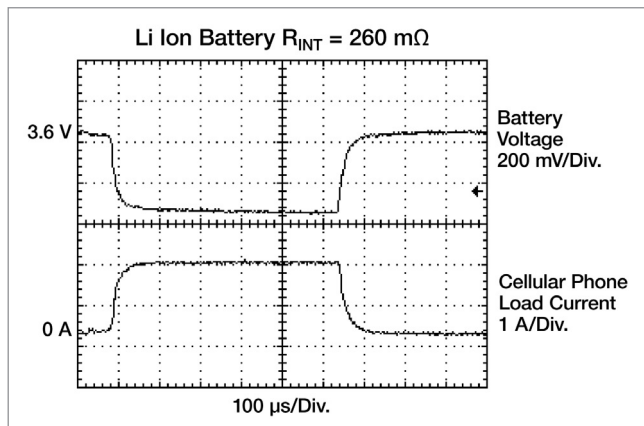


Figure 2. Comparison of the voltage outputs of a lithium-ion battery (with an internal resistance of 260 mΩ) and the 2306's battery channel (programmed with an output resistance of 260 mΩ) when powering a cellular telephone as it makes the transition from standby mode to transmit mode.

Portable wireless devices make great demands on their battery power sources. The battery must source load currents that can jump virtually instantaneously from a standby current level (100–300 mA) to a full-power RF transmission current level (1–3 A). In other words, the load current on the battery can increase rapidly by a factor of 700–1000%. As a result, the battery voltage drops by an amount equal to the value of the current change multiplied by the battery's internal resistance. The 2302 and 2306 power supplies enable test systems to duplicate this voltage drop by programming their output resistance to be equivalent to that of the battery that will power the device. This allows wireless device manufacturers to test their products under the same power conditions that they will encounter in actual use. (See **Figure 2**.)

In response to large load changes, the 2302 and the battery channel of the 2306 have transient voltage droops of less than 100 mV and transient recovery times of less than 60 μs, even when the test leads between the power supply and the DUT are long. This fast transient response, combined with the supplies' variable output resistance, allows engineers to test their portable products under the most realistic operating conditions and eliminate false failures due to conventional power supplies with slow response times. (See the sidebar titled "Conventional Power Supplies and Wireless Device Testing.") These supplies also eliminate the large stabilizing capacitors needed at the DUT to compensate for the large droop that occurs when testing with conventional power supplies. By varying the output resistance, which can be done while the output is turned on, test engineers can simulate the operation of different battery types, as well as batteries nearing the end of their useful lives.

### Conventional Power Supplies and Wireless Device Testing

During production testing, supplying power to a device that undergoes large, instantaneous load current changes can be extremely difficult. Changes like this force a conventional power supply's output voltage to fall instantaneously. When the power supply's control circuitry senses the error condition (the difference in voltage between the programmed level and the actual level), it attempts to correct or restore the voltage to the programmed level. During this time, the voltage will fall or droop substantially, with the amount of the droop depending on the size of the load current change. The recovery time depends on the transient response of the power supply's control loop. Conventional power supplies have transient voltage drops of >1 V when confronted with load current changes of up to 1000%, and take up to a millisecond to recover to the programmed voltage. For portable devices such as cellular phones that operate at full power for only short intervals, the full power event is over before the conventional power supply can recover. For example, as shown in **Figure 3**, a cellular phone designed to the GSM cellular phone standard transmits and receives information in 576 μs pulses. If the power supply used to test these types of phones cannot recover quickly enough, the performance of the phone during testing will be compromised by the power supply. If the power supply voltage drops below the threshold of the phone's low battery detection circuitry for long enough, then the phone will turn off during testing, giving a false indication of a failed device.

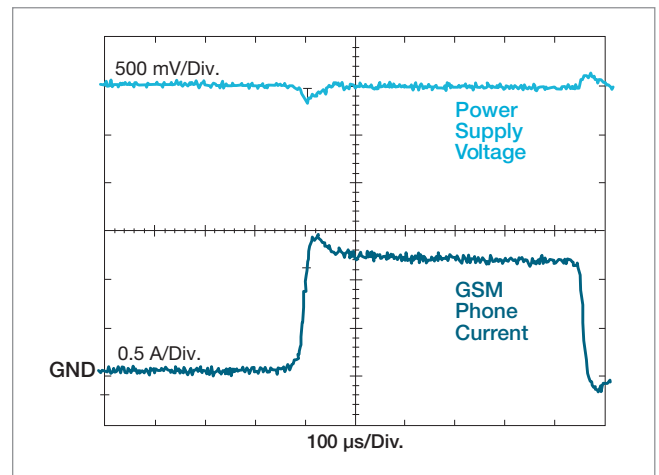
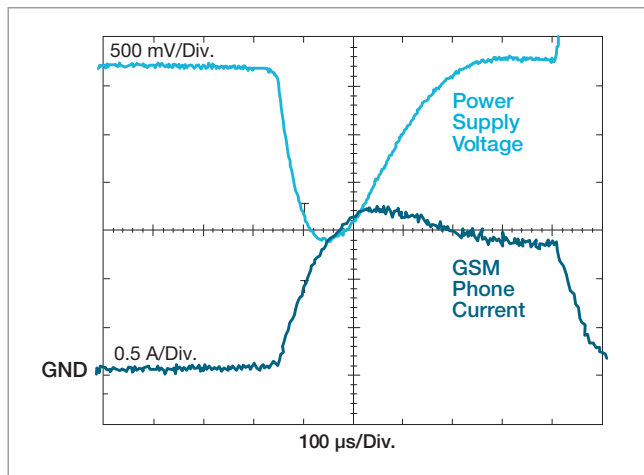


Figure 3. a) Typical Power Supply. Transient response with 4.5 m (15 ft) of cable and 1  $\Omega$ /lead between source and GSM phone load. b) Keithley's High Speed Power Supply. Transient response with 4.5 m (15 ft) of cable and 1  $\Omega$ /lead between source and GSM phone load.

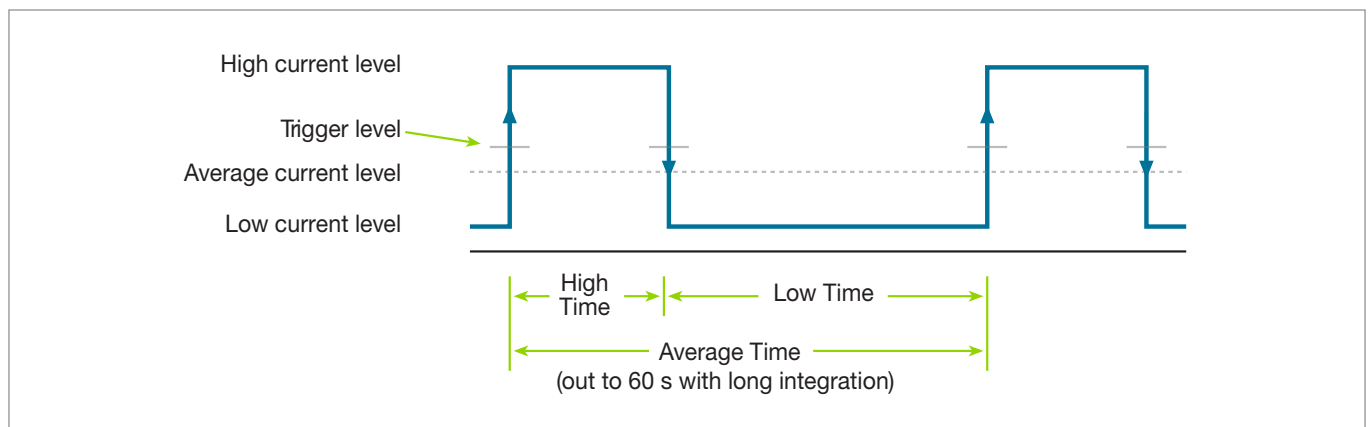


Figure 4. Built-in pulse current measurement functions allow test engineers to measure peak, average, and baseline load currents.

The 2302 and 2306 ensure maximum production throughput when testing portable devices by minimizing false failures, minimizing the number of test setups by performing multiple tests with the same power supply, and minimizing test fixture complexity by eliminating the need for voltage-stabilizing capacitors.

## Measure Load Currents for Power Consumption Verification or Analysis

As manufacturers of portable devices strive to extend their products' battery life, measuring load currents accurately has become increasingly essential in both design and production test in order to ensure the product meets its demanding specifications. Comprehensive testing of

these devices requires measuring peak currents, average currents, and baseline currents in various operation modes. When testing these devices, these measurements are complicated by the pulsating nature of load currents, such as the transmit and receive load currents of digital cellular phones. The 2302 and 2306 can measure the peak and average currents of pulses as short as 60  $\mu$ s and as long as 833 ms. (See **Figure 4**.)

## Measure Long-Period Waveform Currents

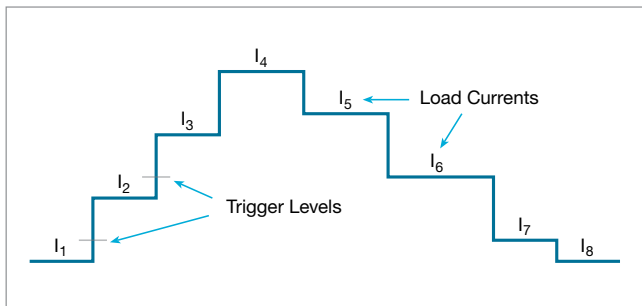
For pulse trains with periods longer than 850ms, the 2302 and 2306 offer a unique, long integration current measurement mode. This mode can provide an average measurement of a current waveform from 850ms up to 60 seconds long.

## Measure Low Currents Accurately

The 2302 and 2306 are based on Keithley's expertise in low current measurement technologies, so they're well-suited for making fast, accurate measurements of sleep and standby mode currents. With 100 nA resolution and 0.2% basic accuracy, they provide the precision needed to monitor the low sleep mode currents of both today's battery-operated products and tomorrow's.

## Verify Load Currents in All Operating States

The 2302 and 2306 employ a unique pulse current step function for measuring the load current at each level of a device's operational states. (See **Figure 5**.) For example, if a cellular phone is ramped up and down through as many as 20 discrete power consumption states, the 2302 and 2306 can measure the load currents in synchronization with the current steps. This capability allows a test engineer to verify performance at each operational state and simultaneously acquire power consumption information. The fast current measure capability is another way the 2302 and 2306 power supplies save test time and production costs.

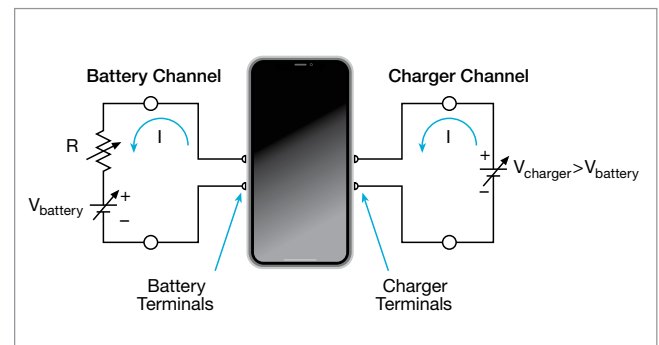


**Figure 5.** These power supplies can obtain a load current profile synchronized to the transitions of a DUT as it is stepped through its operating states.

## Simulate a Discharged Battery for Charger Testing

The 2302 and 2306 can sink up to 3 A continuously, just like an electronic load. This allows these supplies to simulate a discharged rechargeable battery for use in testing the performance of battery chargers or battery charger control circuitry.

The 2306 Battery/Charger Simulator combines the functionality of both the charging current source (the charger channel) and the current sinking to simulate the recharging of a discharged battery (the battery channel) in a single enclosure. (See **Figure 6**.)



**Figure 6.** For charger control circuit testing applications, the 2306, 2306-PJ, and 2306-LAN can provide the functions of both a charger-simulating source and a discharged battery simulator.

## Open-Sense Lead Detection

The 2302 and 2306 have an automatic open-sense lead detection capability, which indicates if there is a broken remote sense lead or an open connection from a remote sense lead to the test fixture. To ensure the output voltage does not change from the programmed level, which could cause production devices to be improperly calibrated, the user can set high and low limits around the desired voltage level.

## Independent Digital Voltmeter Inputs

Many programmable power supplies offer output readback capabilities, but the 2302 and 2306 also offer DVM inputs. Both instruments allow measuring signals from  $-5\text{ V}$  to  $+30\text{ VDC}$  anywhere in the test system with the same rated accuracy as the voltage readback. The 2306 has two sets of DVM inputs; the 2302 has one. The DVMs and the power sources can operate simultaneously. For many applications, these built-in DVMs eliminate the expense and space required to add a separate voltage measurement instrument.

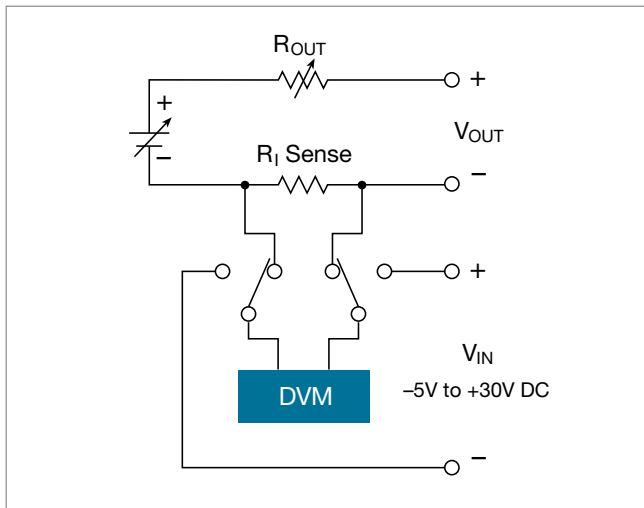


Figure 7. 2302 and 2306 Battery Channel Block Diagram. The 2306 charger channel is identical except it does not have the variable output resistance.

## Big Functionality in a Small Package

For high volume production environments where floor and test rack space are at a premium, the 2306 packs two power supplies into one half-rack enclosure. In addition to power control, both the 2302 and 2306 provide extensive measurement capabilities in the same half-rack case. The front panel of each unit displays the user's choice of either the output voltage and output current, the average, peak, and baseline pulse current levels, long integration currents, or DC DVM measurements. A minimum of front panel buttons ensures that operation is simple and straightforward.

For additional control requirements, the 2302 and 2306 each have four digital relay control outputs and a  $5\text{ VDC}$  output to power a relay coil.

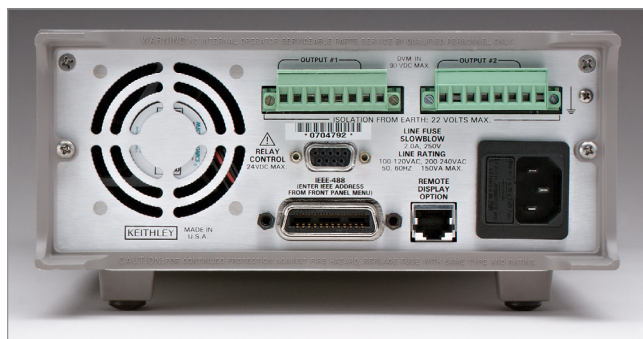


Figure 8. 2306 Rear Panel showing 8-position power output connectors, RJ-45 remote display connector, DB-9 relay output connector, IEEE-488 connector, and power input socket.

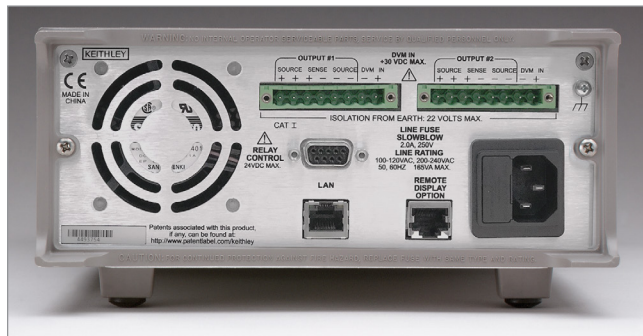


Figure 9. 2306-LAN rear panel.

## Output #1 (Battery)

### DC VOLTAGE OUTPUT (2 Years, 23°C ± 5°C)

Output Voltage	0 to +15 V DC.									
Output Accuracy	±(0.05% + 3 mV).									
Programming Resolution	1 mV.									
Readback Accuracy <sup>1</sup>	±(0.05% + 3 mV).									
Readback Resolution	1 mV.									
Output Voltage Settling Time	5 ms to within stated accuracy.									
Load Regulation	0.01% + 2 mV.									
Line Regulation	0.5 mV.									
Stability <sup>2</sup>	0.01% + 0.5 mV.									
Measurement Time Choices	0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.									
AVERAGE READINGS	1 to 10.									
Reading Time <sup>1, 8, 9</sup>	31 ms, typical.									
Transient Response	<table><tr><th></th><th>High Bandwidth</th><th>Low Bandwidth</th></tr><tr><td>Transient Recovery Time<sup>12</sup></td><td>&lt;40 μs<sup>3</sup> or &lt;60 μs<sup>4</sup></td><td>&lt;80 μs<sup>3</sup> or &lt;100 μs<sup>4</sup></td></tr><tr><td>Transient Voltage Drop</td><td>&lt;75 mV<sup>3</sup> or &lt;100 mV<sup>4</sup></td><td>&lt;250 mV<sup>3</sup> or &lt;400 mV<sup>4</sup></td></tr></table>		High Bandwidth	Low Bandwidth	Transient Recovery Time <sup>12</sup>	<40 μs <sup>3</sup> or <60 μs <sup>4</sup>	<80 μs <sup>3</sup> or <100 μs <sup>4</sup>	Transient Voltage Drop	<75 mV <sup>3</sup> or <100 mV <sup>4</sup>	<250 mV <sup>3</sup> or <400 mV <sup>4</sup>
	High Bandwidth	Low Bandwidth								
Transient Recovery Time <sup>12</sup>	<40 μs <sup>3</sup> or <60 μs <sup>4</sup>	<80 μs <sup>3</sup> or <100 μs <sup>4</sup>								
Transient Voltage Drop	<75 mV <sup>3</sup> or <100 mV <sup>4</sup>	<250 mV <sup>3</sup> or <400 mV <sup>4</sup>								

**Remote Sense** 1 V max. drop in each lead. Add 2 mV to the voltage load regulation specification for each 1 V change in the negative output lead due to load current change. Remote sense required. Integrity of connection continually monitored. If compromised, output will turn off automatically once settable window (±0 to ±8 V) around normal voltage exceeded.

### VARIABLE OUTPUT IMPEDANCE

**Range** 0 to 1.00 Ω in 0.01 Ω steps. Value can be changed with output on.

### DC CURRENT (2 Years, 23°C ± 5°C)

#### Continuous Average Output Current (2302, 2302-PJ)

**0–4V:** 5 A max.

**>4 V:**  $I_{MAX} = 60 \text{ W}/(V_{SET} + 6)$  (not intended to be operated in parallel).

Peak currents can be a maximum of 5 A provided the average current is within the above limits.

#### Continuous Average Output Current (2306, 2306-PJ, 2306-LAN)

**Channel #2 (Charger) OFF**  $I = 50 \text{ W}/(V_{SET} \text{ channel 1} + 6 \text{ V})$ ; 5 A max. Output Power = 45 W.

**Channel #2 (Charger) ON**  $I = (50 \text{ W} - \text{Power consumed by channel \#2})/(V_{SET} \text{ channel 1} + 6 \text{ V})$ ; 5 A max.

The power consumed by channel #2 is calculated as:

**Channel #2 sourcing current:** Power consumed =  $(V_{SET} \text{ channel 2} + 6 \text{ V}) \times (\text{current supplied})$

**Channel #2 sinking current:** Power consumed =  $5 \times (\text{sink current})$

Peak currents can be a maximum of 5 A provided the average current is within the above limits.

#### Continuous Average Sink Current

**Channel #2 (Charger) OFF** **0–5 V:** 3 A max.

**5–15 V:** Derate 0.2 A per volt above 5 V. Compliance setting controls sinking.

**Channel #2 (Charger) ON** Available current =  $(50 \text{ W} - \text{Power consumed by channel \#2})/5$ ; 3A max. (0–5V). Derate 0.2 A per volt above 5 V.

**Source Compliance Accuracy** ±(0.16% + 5 mA)<sup>5</sup>.

**Programmed Source Compliance Resolution**  
1.25 mA.



Readback Accuracy <sup>1</sup>	<b>5 A Range:</b>	$\pm(0.2\% + 200\ \mu\text{A})$ .
	<b>5 mA Range:</b>	$\pm(0.2\% + 1\ \mu\text{A})$ (2302, 2306, and 2306-LAN).
	<b>500 mA Range:</b>	$\pm(0.2\% + 20\ \mu\text{A})$ (2302-PJ and 2306-PJ only).
Readback Resolution	<b>5 A Range:</b>	100 $\mu\text{A}$ .
	<b>5 mA Range:</b>	0.1 $\mu\text{A}$ (2302, 2306, and 2306-LAN).
	<b>500 mA Range:</b>	10 $\mu\text{A}$ (2302-PJ and 2306-PJ only).
Load Regulation		0.01% + 1 mA.
Line Regulation		0.5 mA.
Stability <sup>4</sup>		0.01% + 50 $\mu\text{A}$ .
Measurement Time Choices		0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.
Average Readings		1 to 10.
Reading Time <sup>1, 8, 9</sup>		31 ms, typical.

## PULSE CURRENT MEASUREMENT OPERATION

Trigger Level	<b>5 A Current Range</b>
	<b>5 A Range:</b> 5 mA to 5 A, in 5 mA steps.
	<b>1 A Range:</b> 1 mA to 1 A, in 1 mA steps.
	<b>100 mA Range:</b> 0.1 mA to 100 mA, in 100 $\mu\text{A}$ steps.
	<b>500 mA Current Range (2302-PJ and 2306-PJ)</b>
	<b>500 mA Range:</b> 0.5 mA to 500 mA, in 0.5 mA steps.
	<b>100 mA Range:</b> 0.1 mA to 100 mA, in 100 $\mu\text{A}$ steps.
	<b>10 mA Range:</b> 100 $\mu\text{A}$ to 10 mA, in 100 $\mu\text{A}$ steps.
Trigger Delay	0 to 100 ms, in 10 $\mu\text{s}$ steps.
Internal Trigger Delay	15 $\mu\text{s}$ .
High/Low/Average Mode	
Measurement Aperture Settings	
	33.3 $\mu\text{s}$ to 833 ms, in 33.3 $\mu\text{s}$ steps.
Average Readings	1 to 100.

Pulse Current Measurement Accuracy<sup>11</sup> (2 Years, 23°C  $\pm$ 5°C):

Aperture	Accuracy $\pm$ (% reading + offset + rms noise <sup>10</sup> )	
	5A Range	500mA Range (2302-PJ and 2306-PJ)
<100 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 2 mA	0.2% + 90 $\mu\text{A}$ + 2 mA
100 $\mu\text{s}$ – 200 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 1.5 mA	0.2% + 90 $\mu\text{A}$ + 1.5 mA
200 $\mu\text{s}$ – 500 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 1 mA	0.2% + 90 $\mu\text{A}$ + 1 mA
500 $\mu\text{s}$ – <1 PLC	0.2% + 600 $\mu\text{A}$ + 0.8 mA	0.2% + 60 $\mu\text{A}$ + 0.8 mA
1 PLC <sup>12</sup>	0.2% + 400 $\mu\text{A}$ + 0 mA	0.2% + 40 $\mu\text{A}$ + 0 mA
>1 PLC	0.2% + 400 $\mu\text{A}$ + 100 $\mu\text{A}$	0.2% + 40 $\mu\text{A}$ + 100 $\mu\text{A}$

## BURST MODE CURRENT MEASUREMENT

Measurement Aperture	33.3 $\mu\text{s}$ .
Conversion Rate	3650/second, typical.
Internal Trigger Delay	15 $\mu\text{s}$ .
Number of Samples	1 to 5000.
Transfer Samples Across IEEE Bus in Binary Mode	
	4800 bytes/s, typical.

## LONG INTEGRATION MODE CURRENT MEASUREMENT

2302, 2306, and 2306-LAN	Available on 5 A range only.
2302-PJ and 2306-PJ	Available on both 5 A and 500 mA current ranges.
Measurement Time <sup>6</sup>	850 ms (840 ms) to 60 seconds in 1 ms steps.

## DIGITAL VOLTMETER INPUT (2 Years, 23°C ± 5°C)

Input Voltage Range	–5 to +30 V DC.
Input Impedance	2 MΩ typical.
Maximum Voltage (either input terminal) with respect to output low	–5 V, +30 V.
Reading Accuracy <sup>1</sup>	±(0.05% + 3 mV).
Reading Resolution	1 mV.
Connector	HI and LO input pair part of Output #1's terminal block.
Measurement Time Choices	0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.
Average Readings	1 to 10.
Reading Time <sup>1, 8, 9</sup>	31 ms, typical.

## Output #2 (Charger)

### DC VOLTAGE OUTPUT (2 Years, 23°C ± 5°C)

Output Voltage	0 to +15 V DC.
Output Accuracy	±(0.05% + 10 mV).
Programming Resolution	10 mV.
Readback Accuracy <sup>1</sup>	±(0.05% + 3 mV).
Readback Resolution	1 mV.
Output Voltage Settling Time	5 ms to within stated accuracy.
Load Regulation	0.01% + 2 mV.
Line Regulation	0.5 mV.
Stability <sup>2</sup>	0.01% + 0.5 mV.
Measurement Time Choices	0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.
Average Readings	1 to 10.
Reading Time <sup>1, 8, 9</sup>	31 ms, typical.

Transient Response		High Bandwidth	Low Bandwidth
	Transient Recovery Time <sup>12</sup>	<50 μs <sup>3</sup> or <80 μs <sup>4</sup>	<60 μs <sup>3</sup> or <100 μs <sup>4</sup>
	Transient Voltage Drop	<120 mV <sup>3</sup> or <150 mV <sup>4</sup>	<160 mV <sup>3</sup> or <200 mV <sup>4</sup>

Remote Sense	1 V max. drop in each lead. Add 2 mV to the voltage load regulation specification for each 1 V change in the negative output lead due to load current change. Remote sense required. Integrity of connection continually monitored. If compromised, output will turn off automatically once settable window (±0 to ±8 V) around normal voltage exceeded.
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## DC CURRENT (2 Years, 23°C ± 5°C)

### Continuous Average Output Current

Channel #1 (Battery) OFF	$I = 50 \text{ W} / (V_{\text{SET}} \text{ channel 2} + 6 \text{ V})$ ; 5 A max. Output Power = 45 W.
Channel #1 (Battery) ON	$I = (50 \text{ W} - \text{Power consumed by channel 1}) / (V_{\text{SET}} \text{ channel 2} + 6 \text{ V})$ ; 5 A max.

The power consumed by channel #1 is calculated as:

Channel #1 Sourcing Current	Power consumed = $(V_{\text{SET}} \text{ channel 1} + 6 \text{ V}) \times (\text{current supplied})$
Channel #1 Sinking Current	Power consumed = $5 \times (\text{sink current})$

Peak currents can be a maximum of 5 A provided the average current is within the above limits.

### Continuous Average Sink Current

Channel #1 (Battery) OFF	0–5 V: 3 A max. 5–15 V: Derate 0.2 A per volt above 5 V. Compliance setting controls sinking.
Channel #1 (Battery) ON	Available current = $(50 \text{ W} - \text{Power consumed by channel \#1}) / 5$ ; 3 A max. (0–5 V). Derate 0.2 A per volt above 5 V.

Source Compliance Accuracy	$\pm(0.16\% + 5 \text{ mA})^5$ .
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Programmed Source Compliance Resolution	1.25 mA.
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Readback Accuracy <sup>1</sup>	5 A Range: $\pm(0.2\% + 200 \mu\text{A})$ . 5 mA Range: $\pm(0.2\% + 1 \mu\text{A})$ .
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Readback Resolution	5 A Range: 100 $\mu\text{A}$ . 5m A Range: 0.1 $\mu\text{A}$ .
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Load Regulation	0.01% + 1 mA.
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Line Regulation	0.5 mA.
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Stability <sup>4</sup>	0.01% + 50 $\mu\text{A}$ .
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Measurement Time Choices	0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.
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Average Readings	1 to 10.
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Reading Time <sup>1, 8, 9</sup>	31 ms, typical.
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## PULSE CURRENT MEASUREMENT OPERATION

Trigger Level	5 mA to 5 A, in 5 mA steps.
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Trigger Delay	0 to 100 ms, in 10 $\mu\text{s}$ steps.
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Internal Trigger Delay	15 $\mu\text{s}$ .
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High/Low/Average Mode	Measurement Aperture Settings: 33.3 $\mu\text{s}$ to 833 ms, in 33.3 $\mu\text{s}$ steps. Average Readings: 1 to 100.
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### Pulse Current Measurement Accuracy<sup>11</sup> (2 Years, 23°C ± 5°C)

Aperture	Accuracy $\pm(\% \text{ reading} + \text{offset} + \text{rms noise}^{10})$
<100 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 2 mA
100 $\mu\text{s}$ – 200 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 1.5 mA
200 $\mu\text{s}$ – 500 $\mu\text{s}$	0.2% + 900 $\mu\text{A}$ + 1 mA
500 $\mu\text{s}$ – <1 PLC	0.2% + 600 $\mu\text{A}$ + 0.8 mA
1 PLC <sup>12</sup>	0.2% + 400 $\mu\text{A}$ + 0 mA
>1 PLC	0.2% + 400 $\mu\text{A}$ + 100 $\mu\text{A}$

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## BURST MODE CURRENT MEASUREMENT

Measurement Aperture	33.3 $\mu$ s.
Conversion Rate	2040/second, typical.
Internal Trigger Delay	15 $\mu$ s.
Number of Samples	1 to 5000.
Transfer Samples Across IEEE Bus in Binary Mode	4800 bytes/s, typical.

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## LONG INTEGRATION MODE CURRENT MEASUREMENT

Measurement Time <sup>6</sup>	850 ms (840 ms) to 60 seconds in 1 ms steps.
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## DIGITAL VOLTMETER INPUT (2 Years, 23°C $\pm$ 5°C)

Input Voltage Range	-5 to +30 V DC.
Input Impedance	2 M $\Omega$ typical.
Maximum Voltage (either input terminal) with respect to output low	-5 V, +30 V.
Reading Accuracy <sup>1</sup>	$\pm$ (0.05% + 3 mV).
Reading Resolution	1 mV.
Connector	HI and LO input pair part of Output #2's terminal block.
Measurement Time Choices	0.01 to 10 PLC <sup>7</sup> , in 0.01 PLC steps.
Average Readings	1 to 10.
Reading Time <sup>1, 8, 9</sup>	31 ms, typical.

### NOTES

1. PLC = 1.00.
2. Following 15 minute warm-up, the change in output over 8 hours under ambient temperature, constant load, and line operating conditions.
3. Remote sense, at output terminals, 0.5 A to 5 A typical.
4. Remote sense, with 4.5 m (15 ft) of 16 gauge (1.31 mm<sup>2</sup>) wire and 1  $\Omega$  resistance in each lead to simulate typical test environment, 1.5 A load change (0.15 A to 1.65 A).
5. Minimum current in constant current mode is 6 mA.
6. 60 Hz (50 Hz).
7. PLC = Power Line Cycle. 1 PLC = 16.7 ms for 60 Hz operation, 20 ms for 50 Hz operation. Display off.
8. Speed includes measurement and binary data transfer out of GPIB.
9. Typical values, peak-to-peak noise equals 6 times rms noise.
10. Based on settled signal: 100  $\mu$ s pulse trigger delay.
11. Also applies to other apertures that are integer multiples of 1 PLC.
12. Recovery to within 20 mV of previous level.

## General

Isolation (low-earth)	22 VDC max. For 2302-PJ, 2306, 2306-PJ, and 2306-LAN, do not exceed 60 V DC between any two terminals of either connector.
Programming	IEEE-488.2 (SCPI for 2302, 2302-PJ, 2306 and 2306-PJ).
Ethernet (For 2306-LAN only)	<b>LAN:</b> RJ-45 Connector, 10/100BT, no auto MDIX. <b>IP Configuration:</b> Static or DHCP (manual or auto).
User-Definable Power-Up States	5 (4 for 2302-PJ and 2306-PJ).
Rear Panel Connectors	Two (one for 2302, 2302-PJ) 8-position quick disconnect terminal block for output (4), sense (2), and DVM (2).
Temperature Coefficient (outside 23°C ±5°C)	Derate accuracy specification by (0.1 × specification)/°C.
Operating Temperature	0° to 50°C (Derate to 70%). 0° to 35°C (Full power).
Storage Temperature	-20° to 70°C.
Humidity	<80% @ 35°C non-condensing.
Display Type	2-line × 16-character VFD.
Remote Display/Keypad Option	Disables standard front panel.
Dimensions	89 mm high × 213 mm wide × 411 mm deep (3½ in × 8⅝ in × 16⅜ in).
Net Weight	3.2 kg (7.1 lbs).
Shipping Weight	5.4 kg (12 lbs).
Input Power	100–120 VAC/220–240 VAC, 50 or 60 Hz (auto detected at power-up).
Power Consumption	150 VA max.
EMC	<b>2302, 2306, 2306-LAN:</b> Conforms with European Union Directive 89/336/EEC, EN 55011, EN 50082-1, EN 61000-3-2 and 61000-3-3, FCC part 15 class B. <b>2302-PJ, 2306-PJ:</b> Conforms with European Union Directive 89/336/EEC.
Safety	<b>2302, 2306, 2306-LAN:</b> Conforms with European Union Directive 73/23/EEC, EN 61010-1. <b>2302-PJ, 2306-PJ:</b> Conforms with European Union Directive 73/23/EEC.
AC Line Leakage Current	450 µA @ 110 VAC, typ.; 600 µA @ 220 V, typ.
Relay Control Port	4-channel, each capable of 100 mA sink, 24 V max. Total port sink capacity (all 4 combined) is 250 mA max. Accepts DB-9 male plug.

## Ordering Information

2302	Battery Simulator
2302-PJ	Battery Simulator with 500mA Range
2306	Dual-Channel Battery/Charger Simulator
2306-PJ	Dual-Channel Battery/ Charger Simulator with 500mA Range
2306-LAN	Dual-Channel Battery/Charger Simulator with LAN communication

## Supplied Accessories

	User and service manuals, CS-846 output connectors mating terminal
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## Available Accessories

2306-DISP	Remote Display
CS-846	Mating Output Connector
<b>CABLES</b>	
7007-1	Shielded IEEE-488 Cable, 1m (3.3 ft)
7007-2	Shielded IEEE-488 Cable, 2m (6.6 ft)
SC-182	Low-Inductance Coaxial Cable (42nH/ft)
<b>RACK MOUNT KITS</b>	
4288-1	Single Fixed Rack Mount Kit
4288-2	Dual Fixed Rack Mount Kit
<b>IEEE-488 INTERFACES</b>	
KPCI-488LPA	IEEE-488 Interface/Controller for the PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter

## Available Services

2302-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
2302-PJ-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
2306-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
2306-LAN-3Y-EW	1-year factory warranty extended to 3 years from date of shipment.
2306-PJ-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
C/2302-3Y-ISO	3 (ISO-17025 accredited) calibrations within 3 years of purchase for 2302, 2302-PJ
C/2306-3Y-ISO	3 (ISO-17025 accredited) calibrations within 3 years of purchase for 2306, 2306-PJ