

2302  
2306, 2306-PJ

# Battery Simulator Battery Charger/Simulators



The single-channel Model 2302 Battery Simulator and Model 2306 Dual Channel Battery/Charger Simulator were designed specifically for development and test applications for portable, battery-operated products, such as cellular and cordless telephones, mobile radios, and pagers. 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 Model 2302's and the Model 2306's battery-simulator channel can be programmed to operate like a discharged rechargeable battery, sinking current from a separate charger or the Model 2306's charger-simulator channel.

- 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 (U.S. Patent No. 6,204,647)
- Pulse peak, average, and baseline current measurements
- 100nA DC current sensitivity
- Current step measure function
- Sink up to 3A
- Open sense lead detection
- Built-in digital voltmeter

## Maximize Test Throughput with Accurate Battery Simulation

The battery-output channels of the Models 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 Model 2302's and the Model 2306's battery channel can be programmed (with 10m $\Omega$  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.

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 (100–300mA) to a full-power RF transmission current level (1–3A). 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 Models 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 1**.)

In response to large load changes, the Model 2302 and the battery channel of the Model 2306 have transient voltage droops of less than 100mV and transient recovery times of less than 60 $\mu$ s, even when the

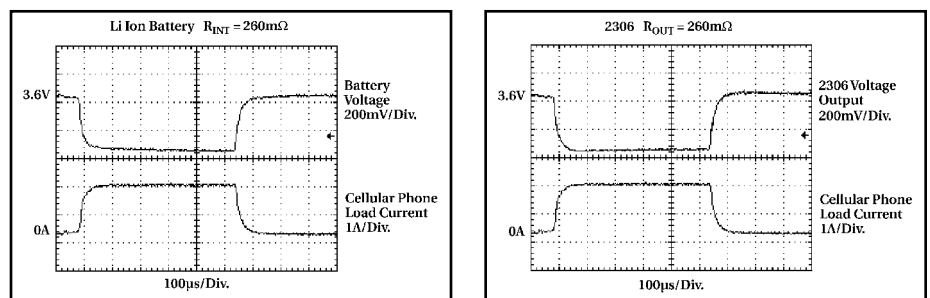


Figure 1. Comparison of the voltage outputs of a lithium-ion battery (with an internal resistance of 260m $\Omega$ ) and the Model 2306's battery channel (programmed with an output resistance of 260m $\Omega$ ) when powering a cellular telephone as it makes the transition from standby mode to transmit mode.

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Fast Transient Response Power Supplies

POWER SOURCES

# 2302

# 2306, 2306-PJ

### Ordering Information

2302 Battery Simulator

2306 Dual-Channel Battery Charger/Simulator

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

These products are available with an Extended Warranty.

### Accessories Supplied

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

### 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 >1V 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, a cellular phone designed to the GSM cellular phone standard transmits and receives information in 576µs 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.

# Battery Simulator Battery Charger/Simulators

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.

The Models 2302 and 2306 ensure maximum production throughput when testing portable devices by minimizing false failures, minimizing the number of test set-ups 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

### ACCESSORIES AVAILABLE

2306-DISP	Remote Display
<b>CABLES</b>	
7007-1	Shielded IEEE-488 Cable, 1m (3.3 ft)
7007-2	Shielded IEEE-488 Cable, 2m (6.6 ft)
<b>RACK MOUNT KITS</b>	
4288-1	Single Fixed Rack Mount Kit
4288-2	Dual Fixed Rack Mount Kit
<b>OTHER</b>	
2304-EW	1 Year Warranty Extension
2306-EW	1 Year Warranty Extension
KPCI-488	IEEE-488 Interface/Controller for the PCI Bus
KPC-488.2AT	IEEE-488 Interface Card for IBM PC/AT (full slot)
TestPoint	Test Development Software

Models 2302 and 2306 can measure the peak and average currents of pulses as short as 60µs and as long as 833ms. (See Figure 2.)

### Measure Long-Period Waveform Currents

For pulse trains with periods longer than 850ms, the Models 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 Models 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 100nA 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.

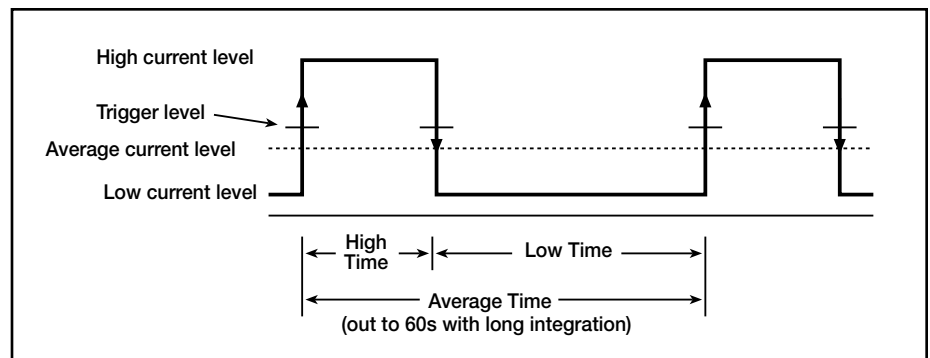


Figure 2. Built-in pulse current measurement functions allow test engineers to measure peak, average, and baseline load currents.

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# 2302 2306, 2306-PJ

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## Simulate a Discharged Battery for Charger Testing

The Models 2302 and 2306 can sink up to 3A 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.

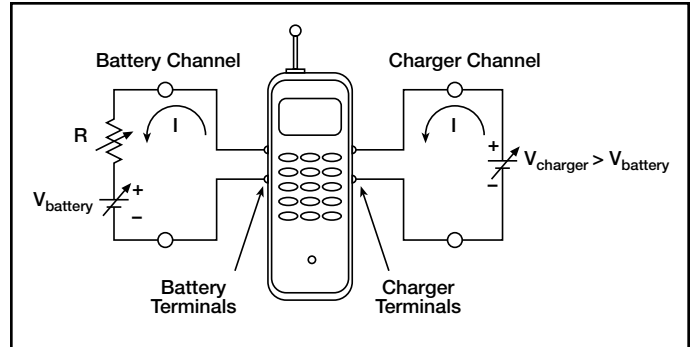
The Model 2306 Battery/Charger Simulator combines the functionality of both the charging current source (the charger channel) and the current sinking to simulate the recharging of a discharged battery (the battery channel) in a single enclosure. (See **Figure 3**).

## Open-Sense Lead Detection

The Model 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 Model 2302 and 2306 also offer DVM inputs. Both instruments allow measuring signals from  $-5V$  to  $+30V$  DC anywhere in the test system with the same rated accuracy as the voltage readback. The Model 2306 has two sets of DVM inputs; the Model 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 3.** For charger control circuit testing applications, the Model 2306 and 2306-PJ can provide the functions of both a charger-simulating source and a discharged battery simulator.

## Remote Display Option

If the Model 2302, 2306, or 2306-PJ must be mounted in a location in which the display is not readily visible, an optional Model 2306-DISP Display Module can be mounted at a more convenient point, then plugged into the power supply unit. The display module also includes all instrument controls, so that the power supply can be operated remotely from the more accessible location.

## GENERAL

**ISOLATION (low-earth):** 22V DC max. Do not exceed 60V DC between any two terminals of either connector.

**PROGRAMMING:** IEEE-488.2 (SCPI).

**USER-DEFINABLE POWER-UP STATES:** 5.

**REAR PANEL CONNECTORS:** Two 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  $(0.1 \times \text{specification})^\circ\text{C}$ .

**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:** 89mm high × 213mm wide × 411mm deep (3½ in × 8½ in × 16¼ in).

**NET WEIGHT:** 3.2kg (7.1 lbs).

**SHIPPING WEIGHT:** 5.4kg (12 lbs).

**INPUT POWER:** 100–120V AC/220–240V AC, 50 or 60Hz (auto detected at power-up).

**POWER CONSUMPTION:** 150VA max.

**WARRANTY:** Two years parts and labor on materials and workmanship.

**EMC:** Conforms with European Union Directive directive 89/336/EEC.

**SAFETY:** Conforms with European Union Directive 73/23/EEC (meets EN61010-1/IEC 1010).

**AC LINE LEAKAGE CURRENT:** 450µA @ 110VAC, typ.; 600µA @ 220V, typ.

**RELAY CONTROL PORT:** 4-channel, each capable of 100mA sink, 24V max. Total port sink capacity (all 4 combined) is 250mA max. Accepts DB-9 male plug.



**Model 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.

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# 2302

## 2306, 2306-PJ

# Battery Simulator

## Battery Charger/Simulators

### OUTPUT #1 (BATTERY)

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

OUTPUT VOLTAGE: 0 to +15V DC.  
 OUTPUT ACCURACY: ±(0.05% + 3mV).  
 PROGRAMMING RESOLUTION: 1mV  
 READBACK ACCURACY<sup>1</sup>: ±(0.05% + 3mV).  
 READBACK RESOLUTION: 1mV  
 OUTPUT VOLTAGE SETTling TIME: 5ms to within stated accuracy.  
 LOAD REGULATION: 0.01% + 2mV  
 LINE REGULATION: 0.5mV  
 STABILITY<sup>2</sup>: 0.01% + 0.5mV  
 MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.  
 AVERAGE READINGS: 1 to 10.  
 READING TIME<sup>1,8,9</sup>: 31ms, typical.

TRANSIENT RESPONSE:	High Bandwidth	Low Bandwidth
Transient Recovery Time <sup>13</sup>	<40μs <sup>3</sup> or <60μs <sup>4</sup>	<80μs <sup>3</sup> or <100μs <sup>4</sup>
Transient Voltage Drop	<75mV <sup>3</sup> or <100mV <sup>4</sup>	<250mV <sup>3</sup> or <400mV <sup>4</sup>

REMOTE SENSE: 1V max. drop in each lead. Add 2mV to the voltage load regulation specification for each 1V 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 ±8V) around normal voltage exceeded.

#### VARIABLE OUTPUT IMPEDANCE

RANGE: 0 to 1.00Ω in 0.01Ω steps. Value can be changed with output on.

#### DC CURRENT (2 Years, 23°C ± 5°C)

CONTINUOUS AVERAGE OUTPUT CURRENT (2302):

0–4V: 5A max.  
 >4V:  $I_{MAX} = 60W / (V_{SET} + 6)$  (not intended to be operated in parallel).

CONTINUOUS AVERAGE OUTPUT CURRENT (2306):

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

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

The power consumed by channel #2 is calculated as:

Channel #2 sourcing current:  
 Power consumed =  $(V_{SET} \text{ channel 2} + 6V) \times (\text{current supplied})$   
 Channel #2 sinking current:  
 Power consumed =  $5 \times (\text{sink current})$

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

CONTINUOUS AVERAGE SINK CURRENT:

Channel #2 (Charger) OFF:  
 0–5V: 3A max.  
 5–15V: Derate 0.2A per volt above 5V. Compliance setting controls sinking.

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

SOURCE COMPLIANCE ACCURACY: ±(0.16% + 5mA)<sup>5</sup>.

PROGRAMMED SOURCE COMPLIANCE RESOLUTION: 1.25mA.

READBACK ACCURACY<sup>1</sup>: 5A Range: ±(0.2% + 200μA).  
 5mA Range: ±(0.2% + 1μA).  
 500mA Range: ±(0.2% + 20μA) (2306-PJ only).

READBACK RESOLUTION: 5A Range: 100μA.  
 5mA Range: 0.1μA.  
 500mA Range: 10μA (2306-PJ only).

LOAD REGULATION: 0.01% + 1mA.

LINE REGULATION: 0.5mA.

STABILITY<sup>2</sup>: 0.01% + 50μA.

MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.

AVERAGE READINGS: 1 to 10.

READING TIME<sup>1,8,9</sup>: 31ms, typical.

#### PULSE CURRENT MEASUREMENT OPERATION

TRIGGER LEVEL:

5A CURRENT RANGE

5A Range: 5mA to 5A, in 5mA steps.  
 1A Range: 1mA to 1A, in 1mA steps.  
 100mA Range: 0.1mA to 100mA, in 100μA steps.

500mA CURRENT RANGE (2306-PJ)

500mA Range: 0.5mA to 500mA, in 0.5mA steps.  
 100mA Range: 0.1mA to 100mA, in 100μA steps.  
 10mA Range: 100μA to 10mA, in 100μA steps.

TRIGGER DELAY: 0 to 100ms, in 10μs steps.

INTERNAL TRIGGER DELAY: 15μs.

HIGH/LOW/AVERAGE MODE:

Measurement Aperture Settings: 33.3μs to 833ms, in 33.3μs steps.  
 Average Readings: 1 to 100.

PULSE CURRENT MEASUREMENT ACCURACY<sup>11</sup> (2 Years, 23°C ± 5°C):

APERTURE	ACCURACY ±(% reading + offset + rms noise <sup>10</sup> )
<100 μs	0.2% + 900 μA + 2 mA
100 μs – 200 μs	0.2% + 900 μA + 1.5 mA
200 μs – 500 μs	0.2% + 900 μA + 1 mA
500 μs – <1 PLC	0.2% + 600 μA + 0.8 mA
1 PLC <sup>12</sup>	0.2% + 400 μA + 0 mA
>1 PLC	0.2% + 400 μA + 100 μA

#### BURST MODE CURRENT MEASUREMENT

MEASUREMENT APERTURE: 33.3μs.

CONVERSION RATE: 3650/second, typical.

INTERNAL TRIGGER DELAY: 15μs.

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: Available on 5A range.

2306-PJ: Available on 5A and 500mA ranges.

MEASUREMENT TIME<sup>6</sup>: 850ms (840ms) to 60 seconds in 1ms steps.

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

INPUT VOLTAGE RANGE: –5 to +30V DC.

INPUT IMPEDANCE: 2MΩ typical.

MAXIMUM VOLTAGE (either input terminal) WITH RESPECT TO OUTPUT LOW: –5V + 30V

READING ACCURACY<sup>1</sup>: ±(0.05% + 3mV).

READING RESOLUTION: 1mV

CONNECTOR: HI and LO input pair part of Output #1's terminal block.

MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.

AVERAGE READINGS: 1 to 10.

READING TIME<sup>1,8,9</sup>: 31ms, typical.

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# 2302 2306, 2306-PJ

# Battery Simulator Battery Charger/Simulators

## OUTPUT #2 (CHARGER)

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

OUTPUT VOLTAGE: 0 to +15V DC.  
 OUTPUT ACCURACY: ±(0.05% + 10mV).  
 PROGRAMMING RESOLUTION: 10mV  
 READBACK ACCURACY<sup>1</sup>: ±(0.05% + 3mV).  
 READBACK RESOLUTION: 1mV  
 OUTPUT VOLTAGE SETTLING TIME: 5ms to within stated accuracy.  
 LOAD REGULATION: 0.01% + 2mV  
 LINE REGULATION: 0.5mV  
 STABILITY<sup>2</sup>: 0.01% + 0.5mV  
 MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.  
 AVERAGE READINGS: 1 to 10.  
 READING TIME<sup>1,8,9</sup>: 31ms, typical.  
 TRANSIENT RESPONSE: 

	<b>High Bandwidth</b>	<b>Low Bandwidth</b>
Transient Recovery Time <sup>13</sup>	<50μs <sup>3</sup> or <80μs <sup>4</sup>	<60μs <sup>3</sup> or <100μs <sup>4</sup>
Transient Voltage Drop	<120mV <sup>5</sup> or <150mV <sup>4</sup>	<160mV <sup>5</sup> or <200mV <sup>4</sup>

 REMOTE SENSE: 1V max. drop in each lead. Add 2mV to the voltage load regulation specification for each 1V 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 ±8V) around normal voltage exceeded.

### DC CURRENT (2 YEARS, 23°C ± 5°C)

CONTINUOUS AVERAGE OUTPUT CURRENT:  
 Channel #1 (Battery) OFF:  
 $I = 50W / (V_{SET} \text{ channel } 2 + 6V)$ ; 5A max.  
 Channel #1 (Battery) ON:  
 $I = (50W - \text{Power consumed by channel } \#1) / (V_{SET} \text{ channel } 2 + 6V)$ ; 5A max.  
 The power consumed by channel #1 is calculated as:  
 Channel #1 sourcing current:  
 Power consumed =  $(V_{SET} \text{ channel } 1 + 6V) \times (\text{current supplied})$   
 Channel #1 sinking current:  
 Power consumed =  $5 \times (\text{sink current})$   
 Peak currents can be a maximum of 5A provided the average current is within the above limits.  
 CONTINUOUS AVERAGE SINK CURRENT:  
 Channel #1 (Battery) OFF:  
 0–5V: 3A max.  
 5–15V: Derate 0.2A per volt above 5V Compliance setting controls sinking.  
 Channel #1 (Battery) ON:  
 Available current =  $(50W - \text{Power consumed by channel } \#1) / 5$ ; 3A max. (0–5V).  
 Derate 0.2A per volt above 5V  
 SOURCE COMPLIANCE ACCURACY: ±(0.16% + 5mA)<sup>5</sup>.  
 PROGRAMMED SOURCE COMPLIANCE RESOLUTION: 1.25mA.  
 READBACK ACCURACY<sup>1</sup>: **5A Range:** ±(0.2% + 200μA).  
**5mA Range:** ±(0.2% + 1μA).  
 READBACK RESOLUTION: **5A Range:** 100μA.  
**5mA Range:** 0.1μA.  
 LOAD REGULATION: 0.01% + 1mA.  
 LINE REGULATION: 0.5mA.  
 STABILITY<sup>2</sup>: 0.01% + 50μA.  
 MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.  
 AVERAGE READINGS: 1 to 10.  
 READING TIME<sup>1,8,9</sup>: 31ms, typical.

### PULSE CURRENT MEASUREMENT OPERATION

TRIGGER LEVEL: 5mA to 5A, in 5mA steps.

TRIGGER DELAY: 0 to 100ms, in 10μs steps.  
 INTERNAL TRIGGER DELAY: 15μs.  
 HIGH/LOW/AVERAGE MODE:  
 Measurement Aperture Settings: 33.3μs to 833ms, in 33.3μs steps.  
 Average Readings: 1 to 100.  
 PULSE CURRENT MEASUREMENT ACCURACY<sup>11</sup> (2 Years, 23°C ± 5°C):

APERTURE	ACCURACY ±(% reading + offset + rms noise <sup>10</sup> )
<100 μs	0.2% + 900 μA + 2 mA
100 μs – 200 μs	0.2% + 900 μA + 1.5 mA
200 μs – 500 μs	0.2% + 900 μA + 1 mA
500 μs – <1 PLC	0.2% + 600 μA + 0.8 mA
1 PLC <sup>12</sup>	0.2% + 400 μA + 0 mA
>1 PLC	0.2% + 400 μA + 100μA

### BURST MODE CURRENT MEASUREMENT

MEASUREMENT APERTURE: 33.3μs.  
 CONVERSION RATE: 2040/second, typical.  
 INTERNAL TRIGGER DELAY: 15μs.  
 NUMBER OF SAMPLES: 1 to 5000.  
 TRANSFER SAMPLES ACROSS IEEE BUS IN BINARY MODE: 4800 bytes/s, typical.

### LONG INTEGRATION MODE CURRENT MEASUREMENT

MEASUREMENT TIME<sup>6</sup>: 850ms (840ms) to 60 seconds in 1ms steps.

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

INPUT VOLTAGE RANGE: –5 to +30V DC.  
 INPUT IMPEDANCE: 2MΩ typical.  
 MAXIMUM VOLTAGE (either input terminal) WITH RESPECT TO OUTPUT LOW: –5V + 30V  
 READING ACCURACY<sup>1</sup>: ±(0.05% + 3mV).  
 READING RESOLUTION: 1mV  
 CONNECTOR: HI and LO input pair part of Output #2's terminal block.  
 MEASUREMENT TIME CHOICES: 0.01 to 10PLC<sup>7</sup>, in 0.01PLC steps.  
 AVERAGE READINGS: 1 to 10.  
 READING TIME<sup>1,8,9</sup>: 31ms, typical.

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

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易迪拓培训推荐课程列表: <http://www.edatop.com/peixun/tuijian/>



### 射频工程师养成培训课程套装

该套装精选了射频专业基础培训课程、射频仿真设计培训课程和射频电路测量培训课程三个类别共 30 门视频培训课程和 3 本图书教材;旨在引领学员全面学习一个射频工程师需要熟悉、理解和掌握的专业知识和研发设计能力。通过套装的学习,能够让学员完全达到和胜任一个合格的射频工程师的要求...

课程网址: <http://www.edatop.com/peixun/rfe/110.html>

### 手机天线设计培训视频课程

该套课程全面讲授了当前手机天线相关设计技术,内容涵盖了早期的外置螺旋手机天线设计,最常用的几种手机内置天线类型——如 monopole 天线、PIFA 天线、Loop 天线和 FICA 天线的设计,以及当前高端智能手机中较常用的金属边框和全金属外壳手机天线的设计;通过该套课程的学习,可以帮助您快速、全面、系统地学习、了解和掌握各种类型的手机天线设计,以及天线及其匹配电路的设计和调试...

课程网址: <http://www.edatop.com/peixun/antenna/133.html>



### WiFi 和蓝牙天线设计培训课程

该套课程是李明洋老师应邀给惠普 (HP)公司工程师讲授的 3 天员工内训课程录像,课程内容是李明洋老师十多年工作经验积累和总结,主要讲解了 WiFi 天线设计、HFSS 天线设计软件的使用,匹配电路设计调试、矢量网络分析仪的使用操作、WiFi 射频电路和 PCB Layout 知识,以及 EMC 问题的分析解决思路等内容。对于正在从事射频设计和天线设计领域工作的您,绝对值得拥有和学习!...

课程网址: <http://www.edatop.com/peixun/antenna/134.html>



## CST 学习培训课程套装

该培训套装由易迪拓培训联合微波 EDA 网共同推出,是最全面、系统、专业的 CST 微波工作室培训课程套装,所有课程都由经验丰富的专家授课,视频教学,可以帮助您从零开始,全面系统地学习 CST 微波工作的各项功能及其在微波射频、天线设计等领域的设计应用。且购买该套装,还可超值赠送 3 个月免费学习答疑...

课程网址: <http://www.edatop.com/peixun/cst/24.html>



## HFSS 学习培训课程套装

该套课程套装包含了本站全部 HFSS 培训课程,是迄今国内最全面、最专业的 HFSS 培训教程套装,可以帮助您从零开始,全面深入学习 HFSS 的各项功能和在多个方面的工程应用。购买套装,更可超值赠送 3 个月免费学习答疑,随时解答您学习过程中遇到的棘手问题,让您的 HFSS 学习更加轻松顺畅...

课程网址: <http://www.edatop.com/peixun/hfss/11.html>

## ADS 学习培训课程套装

该套装是迄今国内最全面、最权威的 ADS 培训教程,共包含 10 门 ADS 学习培训课程。课程是由具有多年 ADS 使用经验的微波射频与通信系统设计领域资深专家讲解,并多结合设计实例,由浅入深、详细而又全面地讲解了 ADS 在微波射频电路设计、通信系统设计和电磁仿真设计方面的内容。能让您在最短的时间内学会使用 ADS,迅速提升个人技术能力,把 ADS 真正应用到实际研发工作中去,成为 ADS 设计专家...

课程网址: <http://www.edatop.com/peixun/ads/13.html>



### 我们的课程优势:

- ※ 成立于 2004 年,10 多年丰富的行业经验,
- ※ 一直致力并专注于微波射频和天线设计工程师的培养,更了解该行业对人才的要求
- ※ 经验丰富的一线资深工程师讲授,结合实际工程案例,直观、实用、易学

### 联系我们:

- ※ 易迪拓培训官网: <http://www.edatop.com>
- ※ 微波 EDA 网: <http://www.mweda.com>
- ※ 官方淘宝店: <http://shop36920890.taobao.com>