The dual-channel Model 2306-VS Battery/Charger Simulator with External Triggering is designed specifically for development and high speed production testing of DC battery-operated products, such as cellular handsets, cellular components like RFIC power amplifiers, and other high volume precision electrical components that require a DC voltage supply. Like Keithley’s original single-channel Model 2302 Battery Simulator and dual-channel Model 2306 Battery/Charger Simulator, this precision power supply has ultra-fast transient response to provide output characteristics identical to actual batteries. However, in addition to the capabilities offered by these models, the Model 2306-VS (voltage step) provides two external trigger inputs, which allow independent control of the instrument’s output channels. These trigger inputs speed and simplify control of the output channels by eliminating the time lags associated with GPIB data communications. The Model 2306-VS combines these external trigger inputs with built-in test sequencing to create an extremely fast voltage supply and measurement instrument that minimizes the need for computer and GPIB interaction.

**External Triggering Allows High Speed Control of Output Channels**

When triggered, the output channels can be instructed to operate at pre-defined voltages or to initiate current, voltage, or pulse current measurements. The availability of two inputs makes it possible to program each channel to act independently or, if the test developer prefers, to act in parallel. For example, Channel #1 can be programmed to operate at user-specified voltage levels while Channel #2 is triggered to take measurements. Measurements are stored in a reading buffer and can be downloaded to a PC controller after the test routine is complete, minimizing GPIB command and data transfer delays. Trigger outputs indicate event completion, allowing users to minimize step delays between trigger-in sequences.

External triggering also allows the Model 2306-VS to exercise tight control over signal capture timing for greater measurement and load condition coordination. As a result, manufacturers can achieve greater confidence in their own compliance testing and can offer their customers more accurate component specifications.

This precision power supply has ultra-fast transient response to duplicate the output characteristics of actual batteries. In response to large load changes, voltage droops on the Model 2306-VS’s battery channel are less than 100mV and transient recovery times are less than 60µs, even when the instrument is used with long test leads. The Model 2306-VS also employs a unique variable output resistance so that the voltage output can emulate a battery’s true response (U.S. Patent No. 6,204,647). By providing stable output voltage, a device-under-test (DUT) can transition from standby power (low current) to RF transmission (high current) seamlessly without nuisance tripping.

**Built-in Test Sequencing Maximizes Throughput**

The Model 2306-VS’s built-in test sequencing capabilities allow setting up and executing up to 20 individual voltage and measurement sequences. By minimizing the need to transfer instrument commands or data over the GPIB.

**APPLICATIONS**

Development and high speed testing of DC battery-operated products, such as:

- **Cellular handsets**
- **Cellular components like RFIC power amplifiers**
- **Other high volume precision electrical components**
Dual-Channel Battery/Charger Simulator with External Triggering

bus, these test sequences support faster, easier production testing by allowing users to pre-define a variety of test configurations, such as:

• Trigger up to 20 voltage setpoints on Channel #1, Channel #2, or both
• Trigger up to 20 measurement readings on Channel #1, Channel #2, or both
• Trigger voltage setpoints on Channel #1 while triggering Channel #2 measurement readings

Figure 1. This graph illustrates Channel #1 output voltage response times based on a four-point voltage step sequence (0.5V/1.0V/1.5V/0.5V). The Model 2306-VS can complete this sequence within 1.5ms.

Figure 2. This magnified view of the first 500mV voltage step from the signal shown in Figure 1 illustrates how the Channel #1 output reaches the voltage setpoint within 160µs of the trigger-in pulse.
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Measure Load Currents for Power Consumption Verification or Analysis
The Model 2306-VS is based on Keithley's expertise in low current measurement technologies, so it is well-suited for making accurate measurements of load currents. With 100nA resolution and 0.2% basic accuracy, it provides the precision needed to monitor the low sleep mode currents of today's battery-operated products.

The Model 2306-VS can monitor DUT power consumption by measuring both DC currents and pulse load currents. The instrument's battery-simulator channel can be programmed to operate like a discharged rechargeable battery, sinking up to 3A from the charger-simulator channel.

Maximize Test Throughput with Accurate Battery Simulation
The Model 2306-VS's battery-output channel is designed to simulate the output response of a battery. This capability, combined with its fast transient response, makes it possible to power the device during testing in exactly the same way as a battery powers the device during actual use. The output resistance of the battery channel can be programmed (with 10mΩ resolution) over the range from 0Ω to 1Ω 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 Model 2306-VS enables 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.

The Model 2306-VS also eliminates the large stabilizing capacitors needed at the DUT to compensate for the large voltage drop 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 Model 2306-VS ensures 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.

Open Sense Lead Detection
The Model 2306-VS has 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 that 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 2306-VS also offers two digital voltmeter (DVM) inputs. These inputs can be used to measure signals from −5V to +30V DC anywhere in the test system with the same rated accuracy as the voltage readback. For many applications, this built-in DVM eliminates the expense and space otherwise required to add a separate voltage measurement instrument to the system.
Output #1 (Battery)

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

**OUTPUT VOLTAGE:** 0 to +15VDC

**OUTPUT ACCURACY:** ±(0.05% + 3mV)

**PROGRAMMING RESOLUTION:** 1mV

**READBACK ACCURACY:** ±(0.05% + 3mV)

**READBACK RESOLUTION:** 1mV

**LOAD REGULATION:** ±(0.01% + 2mV)

**LINE REGULATION:** ±0.5mV

**STABILITY:** ±(0.01% + 0.5mV)

**MEASUREMENT TIME CHOICES:** 0.01 to 10 PLC, in 0.01PLC steps.

**AVERAGE READINGS:** 1 to 10.

**READING TIME:** 31ms, typical.

**TRANSIENT RESPONSE:**

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 µs - 200 µs</td>
<td>0.2% + 900 µA + 1.5 mA</td>
</tr>
<tr>
<td>200 µs - 500 µs</td>
<td>0.2% + 900 µA + 1 mA</td>
</tr>
<tr>
<td>500 µs - 1 PLC</td>
<td>0.2% + 600 µA + 0.8 mA</td>
</tr>
<tr>
<td>1 PLC</td>
<td>0.2% + 400 µA + 0 mA</td>
</tr>
<tr>
<td>&gt;1 PLC</td>
<td>0.2% + 400 µA + 100 µA</td>
</tr>
</tbody>
</table>

**BURST MODE CURRENT MEASUREMENT**

**MEASUREMENT APERTURE:** 33.3µs to 833ms, in 33.3µs steps.

**CONVERSION RATE:** 3650/second at 33.3µs meas. aper., typical.

**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:** 850ms (840ms) to 60 seconds in 1ms steps.

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

**INPUT VOLTAGE RANGE:** –5 to +50VDC.

**INPUT IMPEDANCE:** 2MΩ typical.

**MAXIMUM VOLTAGE (either input terminal) WITH RESPECT TO OUTPUT LOW:** <5V, ±30V.

**READBACK ACCURACY:** ±(0.05% + 3mV)

**LOAD REGULATION:** ±0.5mV

**LINE REGULATION:** ±0.5mV

**STABILITY:** ±(0.01% + 50µA)

**MEASUREMENT TIME CHOICES:** 0.01 to 10 PLC, in 0.01PLC steps.

**AVERAGE READINGS:** 1 to 10.

**READING TIME:** 31ms, typical.

**VOLTAGE SETTLING TIMES**

**VOLTAGE STEP SETTLING TIMES (typical)**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Rise Time</th>
<th>Settling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10V</td>
<td>50 µs</td>
<td>300 µs</td>
</tr>
<tr>
<td>10V</td>
<td>50 µs</td>
<td>1.2 ms</td>
</tr>
<tr>
<td>&gt;10V</td>
<td>50 µs</td>
<td>1.8 ms</td>
</tr>
</tbody>
</table>

**DECREASING VOLTAGE**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Fall Time</th>
<th>Settling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5V</td>
<td>50 µs</td>
<td>250 µs</td>
</tr>
<tr>
<td>&gt;5V</td>
<td>50 µs</td>
<td>300 µs</td>
</tr>
</tbody>
</table>

**NOTE:** Times are under no load condition and settling times defined at ±2% of step size.
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Dual-Channel Battery/Charger Simulator with External Triggering

Output #2 (Charger)

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

- **Output Voltage**: 0 to +15VDC
- **Output Accuracy**: ±(0.05% + 10mV)
- **Programming Resolution**: 10mV
- **Output Voltage Settling Time**: 5ms to within stated accuracy

**Output Voltage**: 0 to +15VDC

**Output Accuracy**: ±(0.05% + 10mV)

**Programming Resolution**: 10mV

**Output Voltage Settling Time**: 5ms to within stated accuracy

Loading and line regulation:

- **Load Regulation**: ±(0.01% + 2mV)
- **Line Regulation**: ±0.5mV
- **Stability**: ±(0.01% + 0.5mV)

Measurement time choices:

- **Measurement Time**: 0.01 to 10 PLC, in 0.01 PLC steps.
- **Average Readings**: 1 to 10.

Reading times:

- **Reading Time**: 31ms, typical.

Voltage settling times:

Increasing Voltage: 0 to 100μs, 100μs to 1.5 ms

Decreasing Voltage: 0 to 100μs, 100μs to 1.5 ms

Pulse current measurement operation:

- **Trigger Level**: 5mA to 5A, in 5mA steps
- **Trigger Delay**: 0 to 100μs, in 10μs steps
- **Internal Trigger Delay**: 15μs

Measurement Aperture Settings:

- **3.3μs to 833ms**, in 3.3μs steps.
- **5μA Range**: 0.2% + 200μA + 2 mA
- **200μA Range**: 0.2% + 900μA + 1.5 mA
- **500μA Range**: 0.2% + 600μA + 0.8 mA
- **2.5mA Range**: 0.2% + 400μA + 0 mA

Measurement time choices:

- **Measurement Time**: 850ms (840ms) to 60 seconds in 1ms steps.

Digital voltmeter input (2 Years, 23°C ± 5°C)

- **Input Voltage Range**: –5 to +50VDC
- **Input Impedance**: 2MΩ typical
- **Maximum Voltage (either input terminal)** with respect to output LOW: –5V, +30V
- **Input Accuracy**: ±(0.05% + 3mV)
- **Input resolution**: 1mV

Connector: HI and LO input pair part of Output #2's terminal block.

Measurement time choices:

- **Measurement Time**: 0.01 to 10 PLC, in 0.01 PLC steps.
- **Average Readings**: 1 to 10.

Reading time:

- **Reading Time**: 31ms, typical.

VOLTAGE SETTLING TIMES (typical)

- **Increasing Voltage**: 0 to 100μs, 100μs to 1.5 ms
- **Decreasing Voltage**: 0 to 100μs, 100μs to 1.5 ms

NOTE: Times are under no load condition and settling times defined at ±2% of step size.
### 2306-VS

**Dual-Channel Battery/Charger Simulator with External Triggering**

#### Voltage Stepping Only

**TEST CONDITIONS:**
1. Trigger external is enabled on both channels.
2. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
3. Times based on 0 programmable user delay.

#### Voltage Stepping With Auto Measurement

**TEST CONDITIONS:**
1. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
2. Times based on 0 programmable user delay.
3. Measurement time = 167¬µs (0.01 PLC).

#### Auto Measurement Only

**TEST CONDITIONS:**
1. Trigger external is enabled on both channels.
2. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
3. Times based on 0 programmable user delay.
4. Measurement time = 167¬µs (0.01 PLC).
5. Steps points = 4.

#### Voltage Stepping Both Channels With Channel 1

**TEST CONDITIONS:**
1. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
2. Times based on 0 programmable user delay.
3. Measurement time = 167¬µs (0.01 PLC).
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Dual-Channel Battery/Charger Simulator with External Triggering

Voltage Stepping Both Channels With Channel 2

TEST CONDITIONS:
1. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
2. Times based on 0 programmable user delay.

<table>
<thead>
<tr>
<th>Channel 2 Trigger In</th>
<th>Output Voltage Channel 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Voltage Channel 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 2 Trigger Out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Channel 2 Trigger In</th>
</tr>
</thead>
</table>

Output #1 (Battery)/Output #2 (Charger)

A = 55 µs typical
B = 70 µs typical
C = 775 µs typical
D = Programmable user delay (0–5 seconds)
E = 900 µs typical with D as 0

Auto Measurement Both Channels With Channel 1

TEST CONDITIONS:
1. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
2. Times based on 0 programmable user delay.
3. Measurement time = 167 µs (0.01 PLC).

<table>
<thead>
<tr>
<th>Channel 1 Trigger In</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Measurement Time Channel 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 2 Trigger Out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Channel 2 Trigger In</th>
</tr>
</thead>
</table>

Output #1 (Battery)/Output #2 (Charger)

A = 45 µs typical
B = Programmable user delay (0–5 seconds)
C = 18 µs typical
D = Measurement time channel 1
E = Measurement time channel 2
F = 872 µs typical with steps 1, 2, and 3
G = 1.1 ms typical for steps 1, 2, and 3 with B as 0
16.0 ms typical step 4 with B as 0

Voltage Stepping With Sync Measurement

TEST CONDITIONS:
1. Trigger external is enabled on both channels.
2. Only a single channel is externally triggered during the sequence while remaining channel stays idle.
3. Times based on 0 programmable user delay.

<table>
<thead>
<tr>
<th>Channel Trigger In</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Output Voltage</th>
</tr>
</thead>
</table>

Output #1 (Battery) Output #2 (Charger)

A = 70 µs typical
B = Programmable user delay (0–5 seconds)
C = 18 µs typical
D = Measurement time channel 1
E = Measurement time channel 2
F = 872 µs typical with steps 1, 2, and 3
G = 1.1 ms typical for steps 1, 2, and 3 with B as 0
16.0 ms typical step 4 with B as 0

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www.keithley.com
2306-VS

Dual-Channel Battery/Charger Simulator with External Triggering

### GENERAL

**ISOLATION (LOW–EARTH):** 22VDC max. Do not exceed 60VDC between any two terminals of either connector.

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

**USER-DEFINABLE POWER-UP STATES:** 3.

**REAR PANEL CONNECTORS:** Two trigger in and two trigger out (BNC) connectors. Two 8-position quick disconnect terminal block for output (4), sense (2), and DVM (2).

**TRIGGER IN/OUT CONNECTORS:** IN High 3–5V, IN Low ≤0.8V, OUT High >4V, OUT Low <0.8V.

**TEMPERATURE COEFFICIENT (outside 23°C ±5°C):** Derate accuracy specification by $(0.1 \times \text{specification})/°C$.

**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.

**DIMENSIONS:** 89mm high × 213mm wide × 411mm deep (3½ in × 8 3⁄8 in × 163⁄16 in).

**NET WEIGHT:** 3.9kg (8.6 lbs).

**SHIPPING WEIGHT:** 6.4kg (14 lbs).

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

**POWER CONSUMPTION:** 165VA max.

**EMC:** Conforms with European Union Directive directive 89/336/EEC, EN 61326.


**VIBRATION:** MIL-PRF-28800F Type III, Class 3.

### 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, 0.5A to 5A typical.
4. Remote sense, with 4.5m (15 ft) of 16 gauge (1.31mm²) 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.** PLC = 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.

### Model 2306-VS specifications

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[www.keithley.com](http://www.keithley.com)