

Model 2308 Portable Device Battery/Charger Simulator

Quick Start Guide

2308-903-01 Rev. A / July 2008

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of one (1) year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, software, rechargeable batteries, diskettes, and documentation.

During the warranty period, Keithley Instruments will, at its option, either repair or replace any product that proves to be defective.

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KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

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The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.


The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.


When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.


If a  screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the user documentation.

The  symbol on an instrument shows that it can source or measure 1000V or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits - including the power transformer, test leads, and input jacks - must be purchased from Keithley Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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Cleveland, Ohio, U.S.A.

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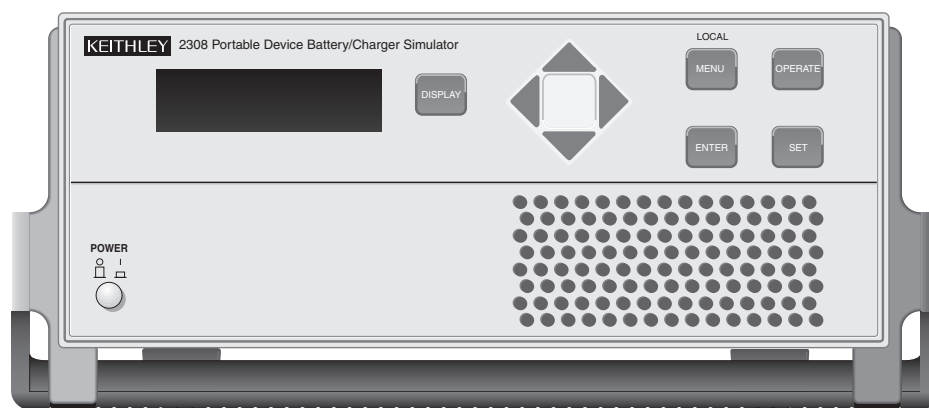
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Introduction

NOTE For additional information about any feature discussed in this guide (including programming examples), refer to the Model 2308 Portable Device Battery/Charger Simulator User's Manual (part number 2308-900-01 (A - July 2008)).

This guide is designed to familiarize users of the Keithley Model 2308 Portable Device Battery/Charger Simulator with the basic operating features available from the instrument's front panel and also the GPIB bus. The sequence of operating instructions reflects the order in which the instrument would be configured for a typical application. For each operating mode, an example set of bus commands is provided. While the SCPI command strings are generic, the exact programming syntax will depend on the test program language.

Figure 1
Model 2308 front panel



Performance features

- The Model 2308 is a specialized power supply that has a very fast recovery to large, near instantaneous load current transitions. Conventional power supplies do not have this capability. The Model 2308 is designed specifically to respond to large load changes and very short pulsed loads with small transient voltage drop and a very fast recovery time. Typical devices that have these types of characteristic loads are mobile phones,

wireless communication modules, and other portable, battery operated devices. The Model 2308 can maintain a near-constant output, even under quickly-changing load conditions.

- The power supply can measure a wide range of load currents. It can resolve down to 0.1 μA and measure up to 5 A. It has fast measurement capability as well and can measure load current pulses as narrow as 50 μsec .
- The Model 2308 can simulate the output of a battery. Its programmable output resistance can simulate a battery's internal resistance so that the voltage output looks like that of a battery's output.
- The two channels can also sink current so that one channel (the battery channel) simulates a discharged battery, while the other channel (the charger channel) can be used to simulate a charger

Proper supply connections to the DUT

WARNING	<p><i>When installing a unit into a test system, make sure the external power sources do not apply voltage to the power supply in excess of its maximum limits (see specifications). Failure to do so could result in personal injury or death.</i></p> <p><i>The power cord supplied with the Model 2308 contains a separate ground for use with grounded outlets. When proper connections are made, instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.</i></p>
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[Figure 2](#) shows a detailed rear-panel view of the Model 2308 detailing the connector sockets for the battery channel OUTPUT #1 and the charger channel OUTPUT #2. [Figure 3](#) and [Figure 4](#) show optimum remote 4-wire connections for device-under-test (DUT) preferred connection ([Figure 3](#)) and fastest transient response connection ([Figure 4](#)).

NOTE	The Model 2308 does not have an internal local sense connection. Therefore, you must connect the DUT to the supply in either a remote or local sense configuration so that the Model 2308 can output a controlled voltage.
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For the most accurate 4-wire remote sense application, the source and the sense inputs to the supply must be connected as close to the inputs of the load as possible through twisted pair leads as shown in [Figure 3](#), [Figure 4](#), and [Figure 5](#).

Figure 2
Rear-panel view of Model 2308

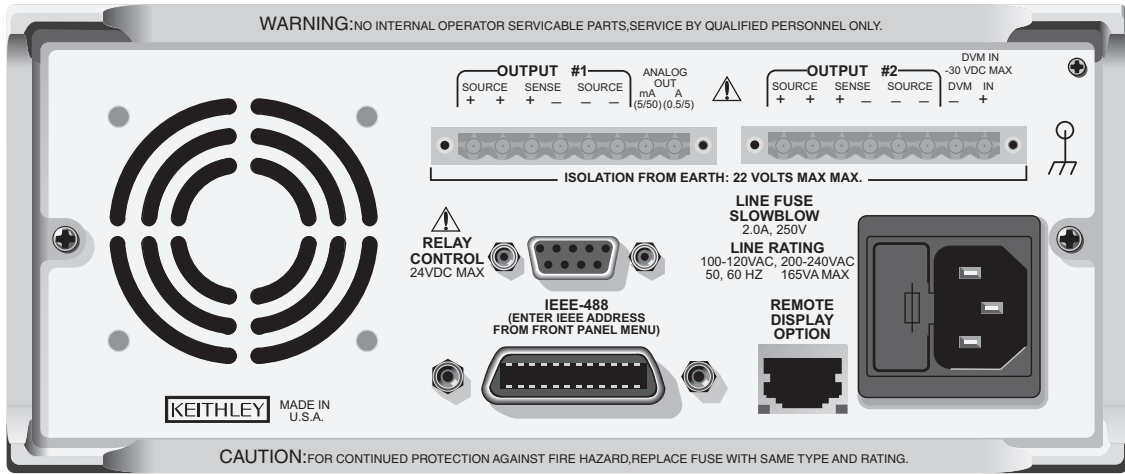
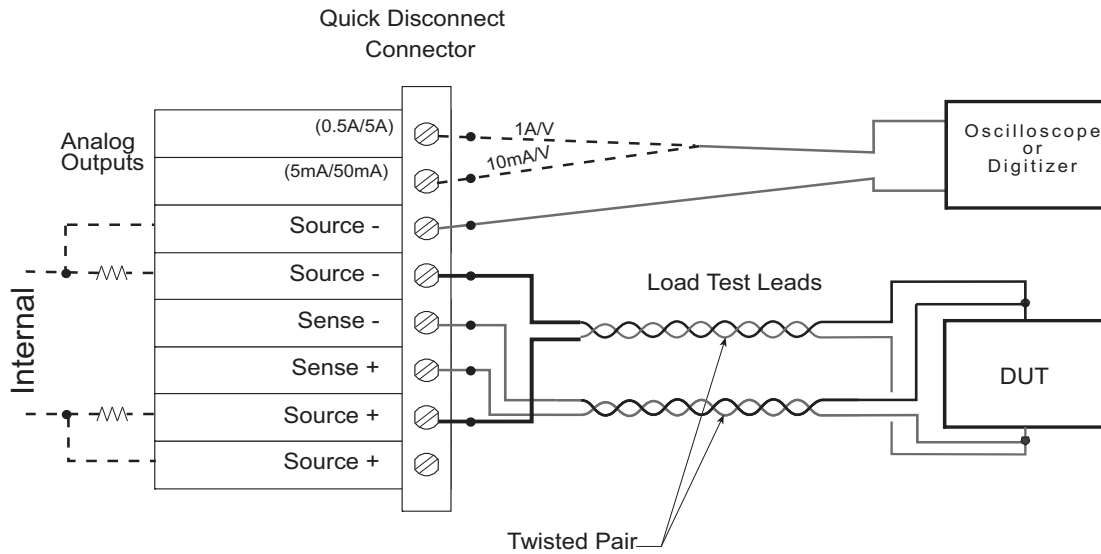


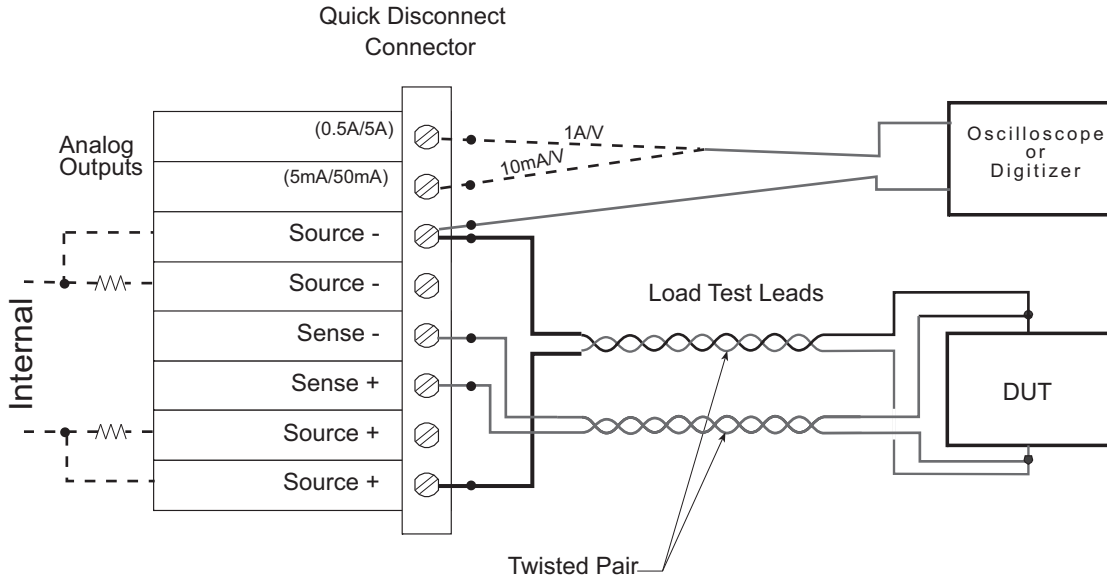
Figure 3
Battery channel preferred connection (maximum stability)



NOTE Twist source leads together and twist sense leads together for optimum performance.

The analog outputs provide a voltage output based on the measured current as follows:
 0.5/5 A Output referenced to Source - : 1 A/V (each volt out represents 1A)
 5/50 mA Output referenced to Source - : 10 mA/V (each volt out represents 10 mA)

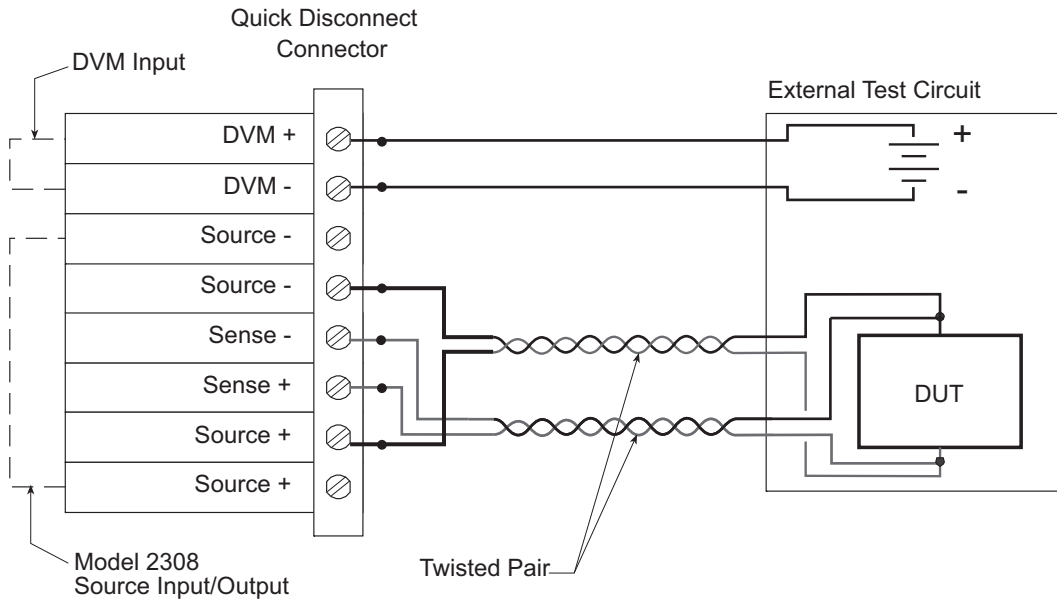
Figure 4
Battery channel fastest transient response connection



NOTE Twist source leads together and twist sense leads together for optimum performance.

The analog outputs provide a voltage output based on the measured current as follows:
 0.5/5 A Output referenced to Source - : 1 A/V (each volt out represents 1A)
 5/50 mA Output referenced to Source - : 10 mA/V (each volt out represents 10 mA)

Figure 5
Charger channel 4-wire remote sense connection of the DUT to the output



NOTE Twist Source leads together and twist Sense leads together for optimum performance.

Front-panel operation

Menu controls

- Press the **MENU** key to activate the main menu.
- Use the **▲** and **▼** keys to scroll through the primary menu items.
- Changing channels: when the main menu is displayed, use the **◀** or **▶** keys to change the active channel (each press of the **◀** or **▶** keys will toggle between Channel #1 and Channel #2). If no change happens then the feature is most likely a single channel or system feature.

Setting the output voltage, current limit, and current range

The default current measurement range is 5 A.

For a lower current range, select the CURRENT RANGE item of the menu:

1. Press the **MENU** key.
2. Press **▲** or **▼** keys to scroll to Current Range.
3. Press the **◀** or **▶** keys to scroll to Current Range #1 or Current Range #2.
4. Press the **ENTER** key to select.
5. Press the **▲** or **▼** keys to scroll to the desired current range.
6. Press the **ENTER** key to select.

To set the output voltage and current limit:

1. Press the **SET** key to select the output settings mode. A blinking cursor appears in the voltage field of the display.
2. Press the **▲**, **▼**, **◀**, or **▶** keys to scroll to the desired output voltage value.
 - The cursor position (blinking digit) is controlled by the **◀** or **▶** keys.
 - With the cursor positioned on a digit, increment or decrement the value using the **▲** or **▼** keys.
3. Press **SET** to move the blinking cursor to the current limit field.
4. Press the **▲**, **▼**, **◀**, or **▶** keys to scroll to the desired current limit.
5. Press **SET** to exit from output settings mode.

Turning supply output ON/OFF

The OPERATE key is used to control the output of the power supply. This key toggles the output between on and off. While in one of the display modes, output ON or OFF is displayed in the upper right corner of the display. The key is active in any front-panel menu or display mode. In menus, the ON/OFF state of operate is not displayed.

V and I display modes (Single and Dual)

Measured output voltages and currents are displayed with the Single or Dual V and I display modes selected. These display modes are selected as follows:

NOTE To display measured readings if the instrument is in the settings mode, press the SET key until the blinking stops (the measured readings can then be displayed). To determine if the instrument is in the settings mode, check for a blinking cursor in a digit of the voltage or current field (if present, the instrument is in the setting mode).

1. Press the **DISPLAY** key.
2. Press the **▲** or **▼** keys to scroll to **SINGLE V AND I** or **DUAL V AND I**.
3. For Single V and I, press the **◀** or **▶** keys to scroll to Channel **#1** or **#2**.
4. Press the **ENTER** key to select.

Voltage readings are located on the top line of the display and current readings are located on the bottom line for single V and I mode. For Dual V and I mode, the top line shows voltage, current and output state for Channel 1 while the bottom line shows voltage, current and output state for Channel 2.

NOTE For dual channel mode, the Dual Channel display mode shows voltages, current and output state for both channels. For single channel mode, the single channel display mode shows voltage, current and output state for the active channel only.

Table 1
Display mode examples

Display mode	Samples for battery channel (#1)	Samples for charger channel (#2)
Single V and I:	6.116V #1 ON 1.2058 A	6.116 V #2 ON 1.2058 A
Dual V and I:	2.97V 25.7m 1# 0.00V 0.00A 0	2.97V 25.7m 1 1.00V 0.17A 1#

NPLC rate

The integration (reading) rate of the instrument is specified as a parameter based on the number of power-line cycles (NPLC), where 1 PLC for 60Hz line frequency

is 16.67msec. In general, the fastest integration time (0.002 PLC) results in increased reading noise. The slowest integration time (10 PLC) provides the best common-mode and normal-mode rejection. In between settings are a compromise between speed and noise. The NPLC RATE #2 item of the menu is also used to set the reading rate for DVM measurements on the charger channel.

NOTE NPLC RATE is not used to set the integration rate for pulse current and long integration measurements. These measurements are covered in the paragraphs titled *Pulse current mode* and *Long integration mode*.

Average readings

The average reading count (1 to 10) specifies the number of measurement conversions to average for each reading. For example, with a reading count of 5, each displayed reading will be the average of five measurement conversions. The AVER READINGS #2 menu items are also used to set the average reading count for DVM measurements on the charger channel.

NOTE AVER READINGS is not used to set the average reading count for pulse current and long integration measurements. Refer to applicable sections of this guide for information on setting the average reading count for pulse current and long integration measurements.

Programming examples: outputting and reading back V and I

The following command sequences demonstrate how to output voltage and current, and read back (measure) the actual voltage and current:

Battery channel (#1)

```
VOLT 5
SENS:CURR:RANG:AUTO ON
CURR 750e-3
CURR:TYPE TRIP
SENS:FUNC 'VOLT'
SENS:NPLC 2
SENS:AVER 5
OUTP ON
READ?
SENS:FUNC 'CURR'
```

- \ Set output voltage to 5 V.
- \ Enable auto range for current.
- \ Set current limit to 750 mA.
- \ Select Trip mode for current limit.
- \ Select the voltage measurement function.
- \ Set integration rate to 2 PLC.
- \ Set average reading count to 5.
- \ Turn on the power supply output.
- \ Trigger 5 voltage measurement conversions and return the average of those 5 conversions. The average reading is displayed on the front panel.
- \ Select current measurement function.

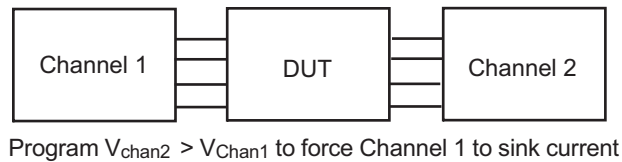
READ? ` Trigger 5 current measurement conversions and return the average of those 5 conversions. The average of the 5 readings is displayed on the front panel.

Charger channel (#2)

SOUR2:VOLT 5 ` Set output voltage to 5 V.
SENS2:CURR:RANG:AUTO ON ` Enable auto range for current.
SOUR2:CURR 750e-3 ` Set current limit to 750 mA.
SOUR2:CURR:TYPE LIM ` Select LIM mode for current limit.
SENS2:FUNC 'VOLT' ` Select the voltage measurement function.
SENS2:NPLC 4 ` Set integration rate to 4 PLC.
SENS2:AVER 4 ` Set average reading count to 4.
OUTP2 ON ` Turn on the power supply output.
READ2? ` Trigger 4 voltage measurement conversion and return the average of those 4 conversions.

SENS2:FUNC 'CURR' ` Select current measurement function.
READ2:ARR? ` Trigger 4 current measurement conversions and return all 4 conversions. The average of the 4 readings is displayed on the front panel.

Figure 6
Charger Control Circuit Testing



NOTE For Channel 1 to simulate a discharged battery (by sinking current) and for Channel 2 to simulate a charger, program the Channel 2 voltage to be greater than the Channel 1 voltage.

DVM input mode (Channel 2 Only)

The DVM input display mode must be selected in order to measure voltage applied to the DVM input of the power supply. This display mode is selected as follows:

1. Press the **DISPLAY** key to access the display menu.
2. Press the ◀ or ▶ keys to scroll to **DISPLAY TYPE #2** since DVM is channel 2 only feature.
3. Press the ▲ or ▼ keys to scroll to **DVM INPUT**.
4. Press **ENTER** to select.

Programming examples: making voltage measurements with the DVM

The following command sequence demonstrates how to measure voltage applied to the DVM input of the power supply:

Charger channel (#2)

SENS2:FUNC 'DVM'	` Select the DVM input function.
SENS2:NPLC 3	` Set integration rate to 3 PLC.
SENS2:AVER 8	` Set average reading count to 8.
READ2:ARR?	` Trigger and return 8 readings. The average of the 8 readings is displayed on the front panel.

Pulse current mode

Description

The Model 2308 can perform pulsed current measurements for dynamic loads. The built-in measurements include:

1. Peak measured current - measures the peak (high) current of the pulse train.
2. Idle measured current - measures the idle (low) current of the pulse train.
3. Average transmitted current - measures the average current of the pulse train.

The high measurement is triggered on the rising edge of the pulse ([Figure 7](#)) and integration is performed for the time specified for the high measurement. The falling edge of the pulse triggers the low measurement, and an integration is performed for the time specified for the low measurement. An average measurement is triggered on the rising edge, and covers both the high and low periods of the pulse as specified by the average measurement time setting. The Model 2308 computes one measurement parameter, high, low, or average, at a time. The desired measurement mode on the front panel is selected with the ▲ or ▼ keys.

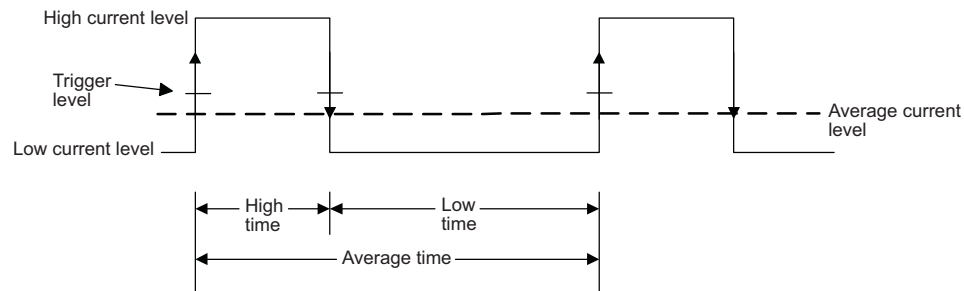
NOTE	See Section 3 in the Model 2308 Instruction Manual for information on pulse current step and digitizing commands.
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The GPIB commands TIMEOUT, SEARCH, DETECT, and FAST are available in pulse current mode to optimize measurement speed. For the relevance and use of these commands regarding a particular measurement application, refer to the Model 2308 Instruction Manual, Section 3, Pulse Current Measurements.

The pulse measurement period can be selected manually or be automatically set by the Model 2308. First, the user must specify a trigger level that serves as a

threshold to initiate the integration process. Once the trigger level is selected, the output is turned on and the pulsed load measurement is operational, the 2308 can be prompted to automatically determine the high time, low time, and average time in pulsed current mode according to [Figure 7](#). These parameters may also be set manually from the front panel or over the GPIB bus.

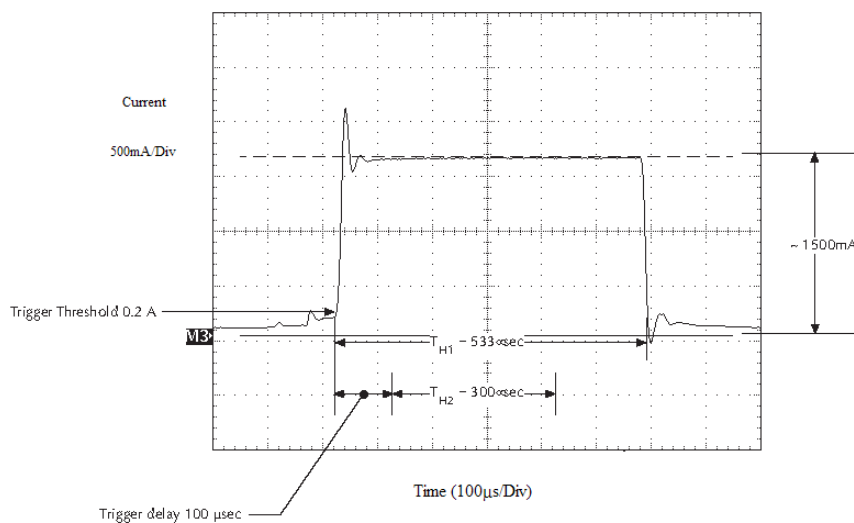
Figure 7
Pulsed waveform



NOTE The pulsed waveform in [Figure 7](#) shows trigger level and the high, low, and average times set by the Model 2308 using the auto-time feature.

The pulsed response of a device is rarely a perfect square wave. [Figure 8](#) shows the current response of a typical GSM handset during the transmit portion of the data frame. Using the built in auto-time feature with a trigger threshold of 0.2 amp and no trigger delay, the Model 2308 will automatically set the HIGH integration time, denoted by T_{H1} , to 533 μs . For this value of HIGH integration time, the effect of the current transient at the beginning of the pulse is included in the measurement. Although in this example the effect of the current transient on the measurement is small, the user can eliminate the effect of the transient by adding a suitable amount of trigger delay. In this case, a delay of 100 μs is sufficient to eliminate the effect of the transient, approximately 70 μs , from the measurement. Accordingly, the HIGH integration time, T_{H2} , must be reduced, in this case 300 μs was chosen, so the integration time does not extend into a section of the pulse the user does not want to measure.

Figure 8
Eliminating the effect of a current transient on a pulse current measurement



NOTE In [Figure 8](#), a trigger delay of 100 μs is used to eliminate the effect of a current transient on the pulse current measurement.

Front-panel operation for performing pulse current measurements

All of the following settings are available in submenus of PULSE CURRENT #1/#2 main menu items. Scroll through the main menu and when PULSE CURRENT #1/#2 is displayed, press ENTER to access the sub-menus.

Turn on the output

Press the OPERATE key after setting the appropriate voltage and current limits for the DUT.

Select CURRENT RANGE

Select appropriate range:

battery channel (#1) = 5 A, 500 mA, 50 mA, or 5 mA

charger channel (#2) = 5 A

Set trigger level and range

TRIGGER LEVEL - For the battery channel (#1), use to specify the trigger level for the 5 A, 500 mA, 50 mA, or 5 mA current ranges. Pulse current only works on the 5 A current range for the charger channel. Pulses less than the specified level are not detected.

Battery channel (#1): The following table shows the trigger levels for each current range along with trigger hysteresis:

Table 2

Current range and trigger level settings

Current range	Trigger level setting	Trigger hysteresis	Setting step size
5 A	0-5 A	10 mA	5 mA
500 mA	0-500 mA	1 mA	0.5 mA or 500 μ A
50 mA	0-50 mA	0.1 mA	0.05 mA or 50 μ A
5 mA	0-5 mA	0.01 mA	0.005 mA or 5 μ A

Trigger hysteresis is built into the hardware. If a pulse does not exceed the appropriate hysteresis level, trigger detection will not occur. The trigger level ranges for the battery channel (#1) are displayed as follows:

5 A range:	PCUR TRIG LEV #1 A(5.0) 0.000 A
500 mA range:	PCUR TRIG LEV #1 A(500) 0.0000 A
50 mA range:	PCUR TRIG LEV #1 mA (50) 0.00000A
5 mA range:	PCUR TRIG LEV #1 mA (5) 0.000000A

To change the trigger level setting for a current range, place the blinking cursor on the "A" at the far right end of line two of the display, and press the \blacktriangle or \blacktriangledown keys until the desired current range is displayed at the beginning of line two. After keying in the trigger level (in amps), press ENTER to update the displayed trigger level setting for that current range only.

Charger channel (#2): Set the trigger level from 0 to 5 A in 5 mA steps. However, there is approximately 10mA of trigger hysteresis built into the hardware. Therefore, if a pulse does not exceed this level, trigger detection will not occur.

If the trigger level is incorrect or the DUT is not functioning properly, the PULSE CURR TRIG NOT DETECTED message will be displayed. (See note No Pulses Detected message on [page 18](#).)

Integration time (manual setting) AVERAGE TIME, LOW TIME, and HIGH TIME sub-menus

The values for HIGH, LOW, and AVERAGE time may be changed in 33.3333 μ sec intervals with the \blacktriangle , \blacktriangledown , \blacktriangleleft , or \blacktriangleright keys. Range of values is 33.3333 μ sec to 833.33 msec.

Integration time (auto time setting) AUTO TIME submenu

Press ENTER when ACQUIRE TIMES appears on the display. If the correct trigger level is selected in the previous step and the DUT is operating, the Model 2308 will automatically determine the HIGH, LOW, and AVERAGE times. If the trigger level is incorrect or the DUT is not functioning properly, the message PULSE CURR TRIG NOT DETECTED will be displayed. (See note No Pulses Detected message on [page 18](#).)

Timeout – TIMEOUT submenu

When the TIMEOUT value is reached, NO PULSE is displayed (top line of the front-panel display). The value for TIMEOUT should be set to a value greater than the pulse period. The default value is 1 second.

Trigger delay (if necessary) Channel #1 and Channel #2:

The trigger delay is changed in the TRIGGER DELAY submenu by using the \blacktriangle , \blacktriangledown , \blacktriangleleft , or \blacktriangleright keys to scroll to the desired delay value. Range is 0 – 0.100sec in 10 μ sec increments.

NOTE	The high, low, or average integration times can be set either manually or automatically. When a pulse is detected, there is a 10 μ sec trigger latency before the integration time begins. An additional user trigger delay can be set to allow the leading edge pulse overshoot to settle. Regardless of the user trigger delay setting, the internal trigger delay is always present.
-------------	---

Average readings count (if necessary) Channel #1 and Channel #2:

The AVERAGE READINGS submenu of the PULSE CURRENT #1/#2 menu item is used to set the average readings count for pulse current measurements. This count specifies the number of measurements (integrations) to average for each reading. Range is 1–100.

Pulse current display mode

Pulse current measurements are displayed with the pulse current display mode selected. This display mode is selected as follows:

NOTE	To display measured readings if the instrument is in the settings mode, press the SET key until the blinking stops (the measured readings can then be displayed). To determine if the instrument is in the settings mode, check for a blinking cursor in a digit of the voltage or current field (if present, the instrument is in the settings mode).
-------------	---

1. Press the **DISPLAY** key to access the display menu.
2. If the desired active channel is not selected, use the ◀ or ▶ keys to scroll to **DISPLAY TYPE #1** or **DISPLAY TYPE #2**.
3. Press the ▲ or ▼ keys to scroll to **PULSE CURRENT**.
4. Press the **ENTER** key to select.
5. Use the ▲ or ▼ keys to scroll to the desired pulse measurement; **PULSE HI**, **PULSE LO**, or **PULSE AVG**.

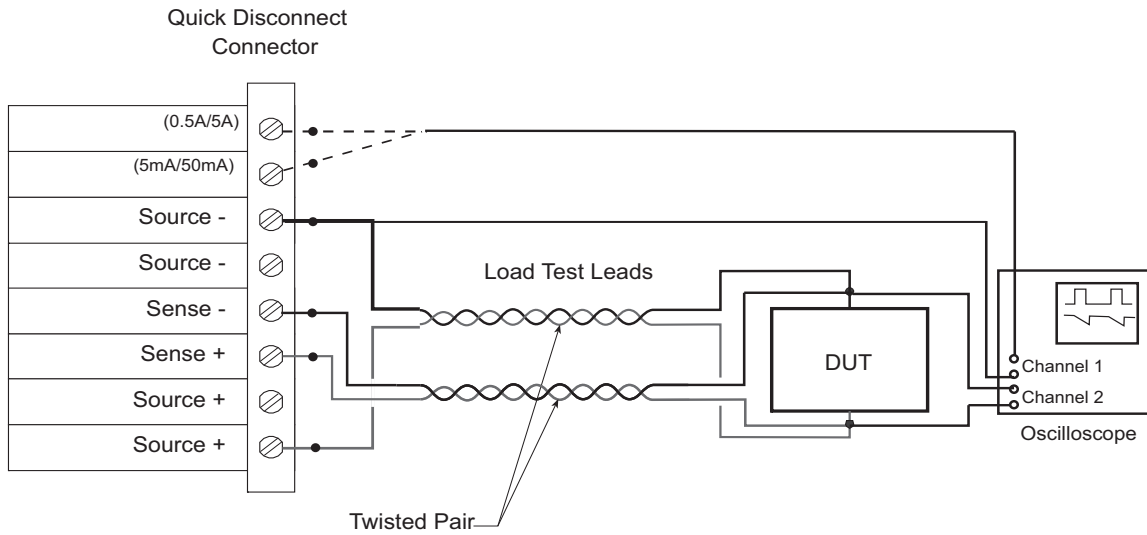
NOTE No Pulses Detected message:

If no pulses are detected, current will not be measured (i.e., ---- A), and the NO PULSE message will be displayed. The NO PULSE message is displayed with dashes or the last valid pulse reading. Dashes are shown if the pulse-current measurement settings are not appropriate for detecting pulses. The last valid pulse is shown if the pulse disappears while taking readings and no change in pulse settings was made.

Pulses are not detected with the output OFF. With the output ON, pulses will not be detected if the trigger level is too low or too high. Adjust the trigger level as necessary and toggle back to the display mode until pulse measurements are displayed.

If possible, the user should always use the analog output, an oscilloscope, or a data acquisition card to determine the timing and transient characteristics of a DUT. The waveform information is very useful in setting up the Model 2308, reducing setup time, and achieving maximum performance and productivity. The voltage and current characteristics of the DUT can be determined with a two-channel oscilloscope as shown in [Figure 9](#).

Figure 9
Determining voltage and current characteristics for battery channel



NOTE *Figure 9* contains a simple circuit for determining the dynamic voltage and current characteristics of the DUT.

Programming examples: pulse current measurements

The following command sequence will return the average of 10 peak pulse current measurements:

Battery channel (#1)

```

SENS:RANG 5           ` Select 5 A range.
VOLT 15              ` Set output voltage to 15 V.
CURR 0.75           ` Set current limit to 75 0mA.
OUTP ON             ` Turn output on.
SENS:PCUR:SYNC ON   ` Enable trigger synchronization.
SENS:PCUR:AVER 10   ` Set average count to 10.
SENS:PCUR:SYNC:TLEV 0.1 ` Set trigger level to 100 mA for 5 A trigger
                        level range.
SENS:PCUR:TIME:AUTO ` Set integration times automatically.
SENS:PCUR:SYNC:DEL 50e-3 ` Set trigger delay to 50 msec.
SENS:FUNC "PCUR"    ` Select pulse current function.
SENS:PCUR:MODE HIGH ` Configure to measure peak pulse.
READ?              ` Trigger 10 measurement conversions and
                        return the average of those 10 conversions.
                        The average of the 10 conversions is
                        displayed on the front panel. Each of the 10
                        conversions syncs to the rising edge.

```

Charger channel (#2)

```

SENS2:RANG 5         ` Select 5 A range.
SOUR2:VOLT 15       ` Set output voltage to 15 V.
SOUR2:CURR 0.75    ` Set current limit to 750 mA.
OUTP2 ON           ` Turn output on.
SENS2:PCUR:SYNC ON ` Enable trigger synchronization.
SENS2:PCUR:AVER 10 ` Set average count to 10.
SENS2:PCUR:SYNC:TLEV 0.1 ` Set trigger level to 100 mA.
SENS2:PCUR:TIME:AUTO ` Set integration times automatically.
SENS2:PCUR:SYNC:DEL 50e-3 ` Set trigger delay to 50 msec.
SENS2:FUNC "PCUR"  ` Select pulse current function.
SENS2:PCUR:MODE HIGH ` Configure to measure peak pulse (trigger
                        on).
READ2             ` Trigger 10 measurement conversions and
                        return the average of those 10 conversions.
                        The average of the 10 conversions is
                        displayed on the front panel. Each of the ten
                        conversions syncs to the rising edge.

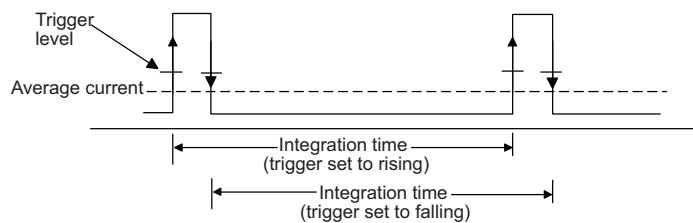
```

Long integration mode

In the long integration mode, a current measurement results from a continuous integration of the dynamic current for a period ranging from approximately 850 ms to 60 sec set in 1msec increments. The Model 2308 can determine the integration time automatically or the user can set the integration time manually from the front panel. A pulse edge can be used to trigger the start of the measurement as shown in [Figure 10](#). Select RISING to use a rising pulse edge to start the measurement. Select FALLING to use a falling pulse edge to start the measurement. A third option is available if you do not want measurements controlled by pulse edges. With NEITHER selected, measurements will start as soon as the long integration function is selected. Note that a pulse has to be detected before a RISING or FALLING pulse edge can trigger a long integration measurement (see [Set trigger level on page 22](#)). To average over several pulse periods, the user must enter the sum of the pulse periods as the integration time.

The GPIB commands TIMEOUT, SEARCH, DETECT, and FAST are available in the long integration mode to optimize measurement speed. For the relevance and use of these commands regarding a particular measurement application, refer to the Model 2308 Instruction Manual, Section 4, Long Integration Measurements.

Figure 10
Pulsed waveform



NOTE The pulse waveform contained in [Figure 10](#) shows trigger level and the integration time used by the Model 2308 for long integration measurements.

Front-panel operation for performing long integration measurements

All of the following settings are available in submenus of the **LONG INTEGRAT #1/#2** main menu item. Scroll through the main menu until **LONG INTEGRAT #1/#2** is displayed, press **ENTER** to access the submenus.

Turn on the output

Press the **OPERATE** key after setting the appropriate voltage and current limits for the **DUT**.

Select the current range

Select appropriate range:

battery channel (#1) = 5 A, 500 mA, 50 mA, or 5 mA

charger channel (#2) = 5 A

Set trigger level

TRIGGER LEVEL submenu

Before a RISING or FALLING pulse edge can trigger the start of a long integration, the pulse must first be detected. TRIGGER LEVEL specifies the minimum pulse level that will cause detection on the selected current range. For battery channel (#1), all four current ranges can be used, and the trigger level setting corresponding to the selected current range will be used to detect the pulse. For the charger channel (#2), only the 5 A range is used for pulse measurements.

For battery channel (#1): Set the trigger level to either the 5 A, 500 mA, 50 mA, or 5 mA current range. For the 5 A current range, the trigger level can be set from 0 to 5 A in 5 mA steps. For the current 500 mA range, the trigger level can be set from 0 to 500 mA in 0.5 mA steps. For the current 50 mA range, the trigger level can be set from 0 to 50 mA in 0.05 mA steps. For the 5 mA current range, the trigger level can be set from 0 to 5 mA in 0.005 mA steps.

The four trigger level ranges are displayed as follows using the TRIGGER LEVEL menu option:

5 A range:	PCUR TRIG LEV #1 A(5.0) 0.000 A
500 mA range:	PCUR TRIG LEV #1 A(500) 0.0000 A
50 mA range:	PCUR TRIG LEV # mA (50) 0.00000A
5 mA range:	PCUR TRIG LEV # mA (5) 0.000000A

To change the trigger level setting for a current range, place the blinking cursor on the "A" at the far right end of line two of the display, and press the ▲ or ▼ keys until the desired current range is displayed at the beginning of line 2. After keying in the trigger level (in amps), press ENTER to update the displayed trigger level setting for that current range only.

Charger channel (#2): Set the trigger level from 0 to 5 A in 5 mA steps for the 5 A current range. Recall, you are only able to perform pulse current readings on 5 A current range for charger channel.

If the trigger level is incorrect or the DUT is not functioning properly, the message LONG INT TRIG NOT DETECTED will be displayed (see the LONG INT TRIG NOT DETECTED note on [page 24](#)).

Trigger edge – TRIGGER EDGE submenu

Toggle between the RISING, FALLING, and NEITHER settings with the ▲ or ▼ keys. With NEITHER selected, measurements will start as soon as the long integration function is selected.

Timeout – TIMEOUT submenu

When the TIMEOUT value is reached, NO PULSE is displayed (top line of the front-panel display). The value for TIMEOUT should be set to a value greater than the long integration time for a long integration reading. This is true when the integration time represents a single pulse period. However, when the integration time is used to average multiple pulses then, set the TIMEOUT value to a value greater than a single pulse period. The default setting is 16 ms.

Manually setting long integration time (INTEGRATION TIME submenu)

The value for LINT INT TIME for Channel #1 or Channel #2 can be specified in 0.850 sec to 60 sec (i.e. @ 60Hz) with the ▲, ▼, ◀, or ▶ keys.

Automatically setting long integration time (AUTO TIME submenu)

Press ENTER when LINT AUTOTIME #1, #2, ACQUIRE TIMES appears on the display. If the correct trigger level is selected in the previous step and the DUT is operating, the Model 2308 will automatically determine the INTEGRATION times. If the trigger level is incorrect or the DUT is not functioning properly, the message LONG INT TRIG NOT DETECTED will be displayed. (See the LONG INT TRIG NOT DETECTED note on [page 24](#).)

Long integration display mode

Long integration measurements are displayed with the long integration display mode selected.

NOTE	To display measured readings if the instrument is in the settings mode, press the SET key until the blinking stops (the measured readings can then be displayed). To determine if the instrument is in the settings mode, check for a blinking cursor in a digit of the voltage or current field (if present, the instrument is in the setting mode).
-------------	--

This display mode is selected as follows:

1. Press the **DISPLAY** key to access the display menu.
2. Press the ◀ or ▶ keys to scroll to **DISPLAY TYPE #1** or **DISPLAY TYPE #2**.
3. Press the ▲ or ▼ keys to scroll to **LONG INTEGRATION**.
4. Press **ENTER** to select.
5. To stop taking long integration readings, press any front-panel key.
6. As long as the instrument remains in the long integration display state, the measurement process can be resumed by pressing the ▲ or ▼ keys.

NOTE LONG INT TRIG NOT DETECTED message:

This message may take a few seconds to appear. With the trigger edge set to RISING or FALLING, this message may appear if the level setting causes no rising or falling edge detection. A valid trigger level is not required if the trigger edge is set to NEITHER. For the battery channel (#1), this message will only appear if the trigger level setting corresponds to the selected current range. For the charger channel (#2), the trigger level setting only applies to the 5 A current range.

If you select AUTO TIME to set the integration time, the pulse timeout message LONG INT TRIG NOT DETECTED will display if the output is OFF. This message indicates that the integration time has not been updated. To update the integration time, select AUTO TIME after the output is turned ON.

Programming examples: long integration measurements

The following command sequence will trigger and return one long integration measurement:

Battery channel (#1)

```
SENS:RANG 5           ` Select 5 A range.
VOLT 15              ` Set output voltage to 15 V.
CURR 0.75           ` Set current limit to 750 mA.
OUTP ON             ` Turn output on.
SENS:LINT:TEDG RISING ` Select rising trigger edge to initiate
                    ` measurement.
SENS:LINT:TLEV 0.1  ` Set trigger level to 100mA for 5 A trigger
                    ` level range.
SENS:LINT:TIME:AUTO ` Set integration time automatically for
                    ` single pulse.
SENS:FUNC "LINT"    ` Select long integration function.
```

READ?

` Trigger and return one reading and reading shown on display.

Charger channel (#2)

SENS2:RANG 5

` Select 5 A range.

SOUR2:VOLT 15

` Set output voltage to 15 V.

SOUR2:CURR 0.75

` Set current limit to 750 mA.

OUTP2 ON

` Turn output on.

SENS2:LINT:TEDG RISING

` Select rising trigger edge to initiate measurement.

SENS2:LINT:TLEV 0.1

` Set trigger level to 100 mA.

SENS2:LINT:TIME:AUTO

` Set integration time automatically for single pulse.

SENS2:FUNC "LINT"

` Select long integration function.

READ2?

` Trigger and return one reading and reading shown on display.

Variable output impedance control on battery channel

The Model 2308 battery channel (#1) has a variable output impedance control that can be used to simulate the impedance of a battery pack.

To manually set the output impedance:

1. Press the **MENU** key.
2. Press the **▲** or **▼** keys to scroll through the menu items until **OUTPUT IMPEDANCE** is displayed.
3. Press the **ENTER** key and use the **▲**, **▼**, **◀**, or **▶** keys to set an output impedance between 0.00 Ω and 1.00 Ω in 0.01 Ω steps.
4. Press the **ENTER** key to program the value.
5. Press the **MENU** key to exit from the menu options.

To program the output impedance from a remote interface:

Send the `OUTput:IMPedance<NRF>` command over the GPIB bus.

NOTE The output impedance can be changed while the output is on.

Variable output bandwidth

For high impedance test lead - DUT circuits, Model 2308 channel's output could become unstable. To improve stability, the channel's output bandwidth can be reduced. This action reduces voltage transient response, but the output becomes more stable for a wider range of load impedances. The default bandwidth is: LOW Bandwidth.

Front-panel operation for output bandwidth

The following settings are available in main menu under OUT BANDWIDTH #1,#2. Use the ▲ or ▼ keys to set the desired output bandwidth, either HIGH or LOW.

Table 3
GPIB commands

Command	Description
:OUTPut:BANDwidth HIGH or LOW	' Specifies HIGH or LOW bandwidth when the output state is ON. When output is OFF, the bandwidth is LOW, regardless of the user setting. Once the output is ON, the user setting takes effect.
:OUTPut2:BANDwidth HIGH or LOW	' Same as above, but for output channel #2.

Advanced features

Analog output

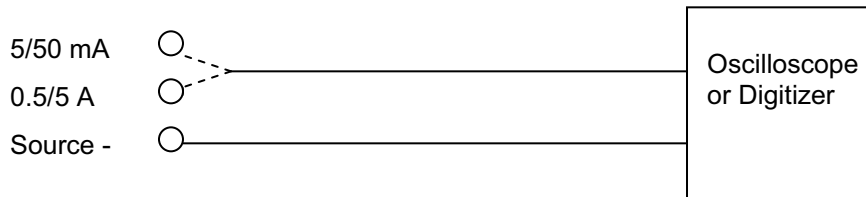
There are two analog output terminals: a 0.5/5 A output terminal for use when the battery channel is programmed for either the 5 A or the 500 mA range and a 5/50 mA output terminal for use when the battery channel is programmed for either the 50 mA or the 5 mA range. Connect to the appropriate analog output terminal and the Source - terminal.

The analog outputs provide a voltage output based on the measured current as follows:

- 0.5/5 A Output referenced to Source - : 1 A/V (each volt out represents 1 A)
- 5/50 mA Output referenced to Source - : 10 mA/V (each volt out represents 10 mA)

Each output internal impedances is nominally 1000 Ω .

Figure 11
Analog output



Optimizing measurement speed

Auto Zero State

In general, to optimize speed of any application code, you should turn auto zero off. To turn auto zero off, use the AUTO ZERO STATE option under the Main Menu or send the following command over the bus: `SYSTEM :AZERo :STATe 0`.

The system auto zero state setting indicates whether background readings are taken. A background reading is an internal calibration measurement taken by the power supply between user triggered readings. The selected function dictates how many background readings are taken between user triggered readings. Certain settings, such as changes to integration time, force backgrounds to update regardless of this state. Other changes, such as changing voltage level settings, don't force backgrounds to update if already updated. When backgrounds are forced to update, all must be refreshed before a user triggered reading can be measured.

When auto zero state is set to ON, background readings continuously refresh by cycling when the instrument is idle. When auto zero state is set to OFF, background readings do not occur after being updated unless a change forces them to update. When a change forces an update, the background readings get updated once and stop until the next change forces an update.

To refresh the backgrounds when the state is OFF, set the state to ON then back to OFF. This will refresh the backgrounds only once and stop after that.

Programming examples

Programming examples for methods of combining commands to speed up measurements:

```
*rst                                ' restore factory default settings
syst:azer:stat 0                    ' turn auto zero state off
disp:chan 1                          ' sets active channel to battery
sens:func 'curr'                    ' select the current measurement function
volt 3                               ' set output voltage to 3
curr 1                               ' set current limit to 1
sens:nplc 0.5                       ' set nplc to 0.5
```

NOTE For faster measurements, the NPLC can be as short as 0.002

```
outp on                             ' turn the output on
```

```
read:five?                ' switch to the 5mA current range, trigger a
                           current reading and return it
```

NOTE To optimize speed, the `read:five?` command combines range changing, triggering a DC current measurement, and taking a reading.

```
sens:func 'volt'          ' select the voltage measurement function
read:fift?                ' switch to the 50mA current range, trigger a
                           voltage reading and return it
```

NOTE To optimize speed, the `read:fift?` command combines range changing, triggering a DC voltage measurement, and taking a reading.

```
sens:func 'pcur'          ' select the pulse current measurement
                           function
sens:pcur:sync:tlev:hund  0.3 ' set the trigger level to 300 mA for 500 mA
                           current range
sens:pcur:sync:tlev:amp   0.7 ' set the trigger level to 700 mA for 5 A
                           current range
sens:pcur:time:high 350e-6 ' set pulse high time to 350 microseconds
read:hund?                ' switch to the 500 mA current range, trigger
                           a pulse current high reading and return it.
```

NOTE To optimize speed, the `read:hund?` command combines range changing, triggering a pulse current measurement, and taking a reading.

```
read:amp?                ' switch to the 5 A current range, trigger a
                           pulse current high reading and return it.
```

NOTE To optimize speed, the `read:amp?` command combines range changing, triggering a pulse current measurement, and taking a reading.

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Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

- | | | |
|--|--|--|
| <input type="checkbox"/> Intermittent | <input type="checkbox"/> Analog output follows display | <input type="checkbox"/> Particular range or function bad; specify _____ |
| <input type="checkbox"/> IEEE failure | <input type="checkbox"/> Obvious problem on power-up | <input type="checkbox"/> Batteries and fuses are OK |
| <input type="checkbox"/> Front panel operational | <input type="checkbox"/> All ranges or functions are bad | <input type="checkbox"/> Checked all cables |

Display or output (check one)

- | | |
|---|--|
| <input type="checkbox"/> Drifts | <input type="checkbox"/> Unable to zero |
| <input type="checkbox"/> Unstable | <input type="checkbox"/> Will not read applied input |
| <input type="checkbox"/> Overload | |
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of calibration required |
| <input type="checkbox"/> Data required | |

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

What power line voltage is used? _____ Ambient temperature?°F _____

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

Be sure to include your name and phone number on this service form.

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A G R E A T E R M E A S U R E O F C O N F I D E N C E

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