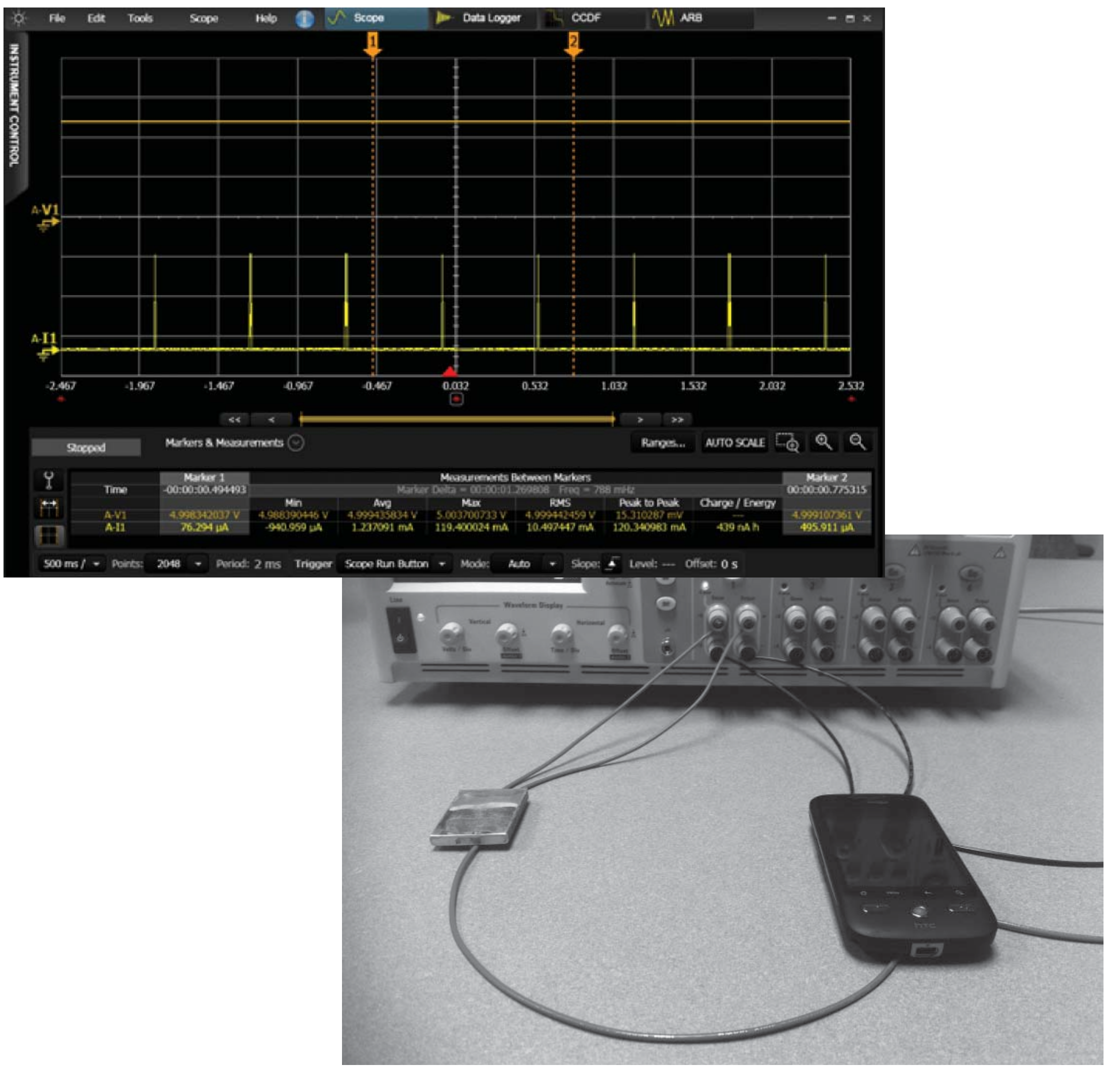
Evaluating Battery Run-Down with the N6781A 2-Quadrant Source/Measure Unit and the 14585A Control and Analysis Software

Application Note



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Analyzing and optimizing battery run time requires running tests on your battery and on your battery-powered device, both separately and in combination as a system. Evaluating the battery and battery-powered device as a system provides certain advantages.

Advantages of Measuring Battery Run-down Performance

- Validate the actual, or real-world, operating time to compare it against expected values
- Verify battery capacity and performance in its end application to correlate with the battery manufacturer's standard specifications
- Evaluate peak and average current and power consumption of the device when it is powered by the battery to compare against expected values and aid in optimizing device performance
- Verify correct performance of low voltage shutdown

These items require long-term accurate current measurement and logging.

The Agilent N6781A 2-quadrant source/measure unit (SMU) for battery drain analysis (BDA) is ideally suited for directly powering and measuring current drain on battery-powered devices. This N6781A SMU module is a part of the N6700 modular power system, which includes the N6700 low-profile mainframes for Automated Test Environments (ATE) and the N6705B DC power analyzer mainframe for R&D. The product family has four mainframes and 25 DC power modules to choose from providing a complete spectrum of solutions, from R&D through design validation and manufacturing.

When you use the N6705B DC power analyzer mainframe and N6781A SMU with the 14585A control and analysis software, you can easily measure short-term and long-term battery current drain and analyze your results. When you evaluate current drain to get real-world results, at times it is advantageous to use the actual battery instead of a DC source to power battery-powered devices. This application note explains how to use the N6781A SMU and the 14585A control and analysis software to easily and accurately evaluate performance of a battery-powered device that is being directly powered by its battery.

Challenges of Traditional Approaches

Traditional approaches to measuring battery drain involve using current transducers, such as current shunts and probes. Likewise, many test standards for measuring current drain on battery powered battery-powered devices, such as GSM Association's DG09 Battery Life Measurement Technique provide guidelines for a generic test setup using ADC cards and current shunts to log current drain over an extended period for assessing battery life for a variety of scenarios. While adequate under certain situations, this approach falls short of meeting the level of accuracy needed for a wide dynamic range of current drawn by a battery-powered device. In addition, the voltage drop on the shunt introduces another layer of inaccuracy to the setup, detracting from the low voltage of the battery. Lastly, battery run-down testing can run from hours to days. This raises the issue of how to log and store a large quantity of data for post-test analysis.

Recommended Setup Using the N6781A SMU and 14585A Software

The N6781A SMU has features that address the challenges and shortcomings of traditional approaches. For battery run-down test, the N6781A SMU can be used in current measure only mode and become a zero-burden current measurement shunt. Unlike a shunt, voltage drop will not be an issue. The N6781A SMU also has a patented seamless range-switching measurement feature. As the current transitions from sleep level to active, the seamless range-switching measurement feature dynamically adjusts the measurement range to allow the highest accuracy at each point in the current waveform.

You can also use the programmable output resistance feature to enable the N6781A to more accurately emulate the internal resistance of a battery. Finally, the 14585A control and analysis software provides the platform to easily data log, visualize, and analyze a large quantity of measurement data. This setup readily meets the requirements of the GSM Association's DG09 test standard for battery life and other similar standards, and actually improves on it by overcoming the limitations that come with using a fixed shunt.

The N6781A has a "current measurement only" mode that sets the power supply to behave like a zero-ohm shunt. When its output is connected in series with the battery and the battery-powered device, as in Figure 1, the N6781A emulates a zero-burden ammeter. The voltage is regulated where the remote sense lines are connected.

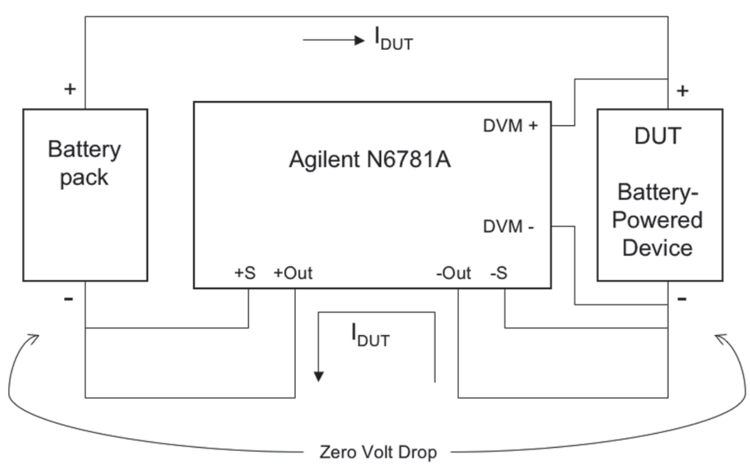

Figure 1: The recommended setup for measuring battery run-down performance using the N6781A SMU. Note that remote voltage sensing eliminates the voltage drop in the wiring between the battery pack (-) and DUT (-). In this setup, the N6781A SMU module will be installed inside an N6705B DC power analyzer mainframe.

In Figure 2, you can see a picture of an actual setup. After you configure the setup, select *Current Measure Only* as the emulating mode in the 14585A source settings screen, as shown in Figure 3. The voltage priority mode is set by default and the +/- current limits are set to their maximum allowable value. The output is programmed to zero volts, hence zero-burden.

Measuring Battery Voltage Using the Auxiliary Voltmeter

The N6781A SMU power module has an auxiliary voltage metering input that can be used to measure battery voltage in battery drain applications. Measurements from the auxiliary voltmeter are used to validate battery run-time and performance. Refer to DVM+ and DVM- connections in Figure 1 for setup configuration of the auxiliary voltmeter. To enable auxiliary voltage measurements using the 14585A, expand the *Instrument Control* tab and select *Meter* then *Properties*.

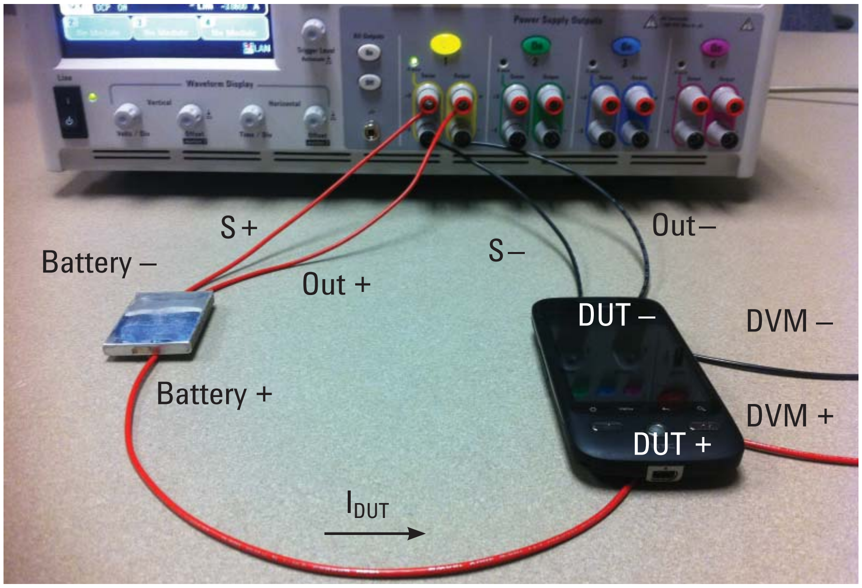

Figure 2: The actual setup for measuring battery run-down performance using the N6781A SMU installed as output 1 in an N6705B DC power analyzer mainframe.

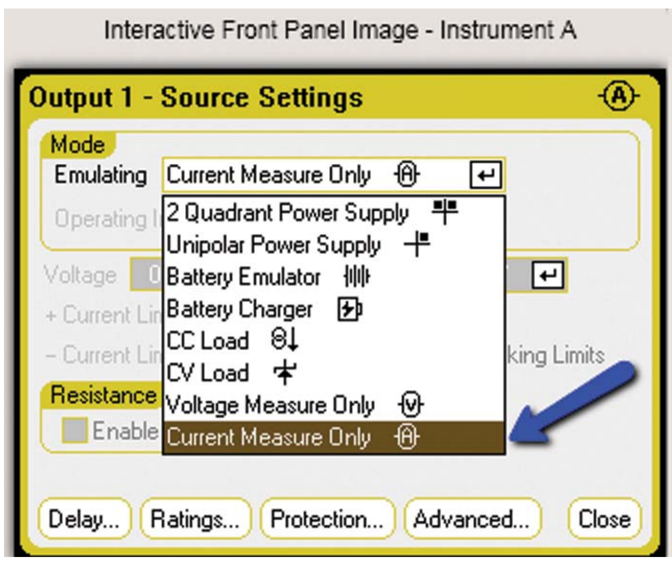

Figure 3: Source setting menu on the 14585A control and analysis software

On the menu that appears, make sure the *Aux Voltage* option is selected, as shown in Figure 4. The auxiliary voltmeter will capture measurement with a digitization rate of up to 100 ksa/s simultaneously with the current.

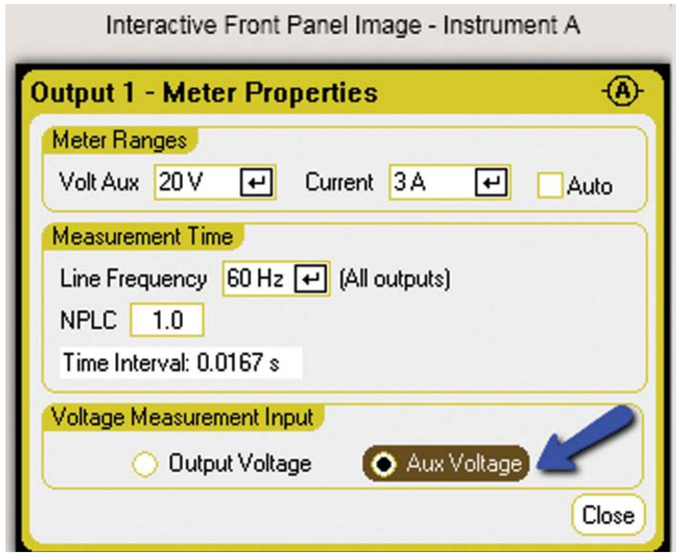

Figure 4: Auxiliary voltmeter setup

Protecting Against Battery Pack Over-Currents and Reverse Polarity

Traditionally, an external protection network would be required in this setup, as batteries are capable of supplying extremely high currents if misapplied or shorted. However, protection features are incorporated into the N6781A SMU. That eliminates the need for an external protection circuit for this application.

Using the Scope Mode

There is a scope mode in 14585A control and analysis software. The mode allows you to monitor the current drain as it happens. In the scope mode, the graphical user interface allows you to control the choices of voltage/current measurements, measurement ranges, and the scaling of the display much like an oscilloscope. You can also adjust the number of sample points per trace to a maximum of up to 256 K points for a single trace.

Figure 5: Scope acquisition with markers

These features are also available from the front panel using *Scope View*.

The scope acquisition can be started or stopped by pressing the circular button on the lower right-hand corner under the word “Scope.” You can pull up markers to further analyze the trace, as shown in Figure 5. Marker can be used to narrow in on a specific time interval and extract information specific to that time interval such as min, max, and average value.

Using the Data Logging Mode

The data logging mode in the N6705B and 14585A software permit long-term data collection. The settings allow you to define the duration and the period of the data logging. The duration can be up to several hours or even days at a time. Set it to run longer than the expected actual battery rundown duration to ensure that you capture the entire event. You can define the integration period for the data logging. For each integration period, a set of min, max, and average values is generated and logged. In the data log display, the min, max, and average values are all plotted together in the same graph. Figure 6 shows a data log plot of an actual battery rundown. These features are also available from the front panel using *Data Logger*.

Markers are available to use with data logging. Turn on the vertical measurement markers and place them at the start and shut-down points. This will set up the software to base all of its numerical calculations just over the enclosed time interval rather than the entire display.

Figure 6: Data logging acquisition showing voltage, current, and power (actual battery rundown)

Measurements Between Markers

Marker Delta = 00:00:03.965953 Freq = 252 mHz

Min	Avg	Max	Peak to Peak	Charge / Energy
4.133285046 V	4.145959177 V	4.15293026 V	19.645214 mV	---
31.436499 mA	113.316957 mA	299.732208 mA	268.295709 mA	449.775565 mC
130.467156 mW	469.457483 mW	1.238878654 W	1.108411498 W	1.863362884 J

Figure 7: Measurements between markers in data logging mode

You can set the data logging function to measure current as well as the voltage reading from the auxiliary DVM. Once the data is captured, it is stored in a binary format. There is an option to export the binary file into a CSV (comma-separated variable) file format. A CCDF (Complimentary cumulative distribution function) is another display feature. It is a cumulative form of a histogram that provides a concise display of short- and long-term battery drain measurement. It is a distribution plot of the current amplitude versus its relative frequency of occurrence.

Summary

Using the actual battery, instead of a DC power source when performing battery drain analysis on a battery-powered device allows you to evaluate and verify real-world operating time and actual battery capacity delivered, for most accurate results. The patented seamless range-switching measurement feature available on the N6781A SMU overcomes accuracy shortcomings of traditional approaches which uses current transducers. This seamless measurement feature dynamically adjusts the measurement range to allow the highest accuracy at each point in the battery run-down current waveform.

The auxiliary voltmeter, scope mode, and data logging mode are additional tools and features available on the N6781A SMU and N6705B power analyzer mainframe that helps you in evaluating battery run-down. You can control the N6781A SMU inside a N6705B DC power analyzer mainframe with the front panel or you can control it with the 14585A control and analysis software. For a 30-day free trial of the 14585A control and analysis software, go to **www.agilent.com/find/14585**.

Related Agilent Literature

Title	Type	Publication number
Evaluating Battery Run-down Performance Using the Agilent 66319D or 66321D and the 14565B Device Characterization Software	Application note	5988-8157EN
Using Battery Drain Analysis to Improve Mobile-Device Operating Time		5988-7772EN
Agilent N6780 Series Source/Measure Units (SMUs) for the N6700 Modular Power System	Data Sheet	5990-5829EN
N6705 DC Power Analyzer	User's guide	N6705-90001

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