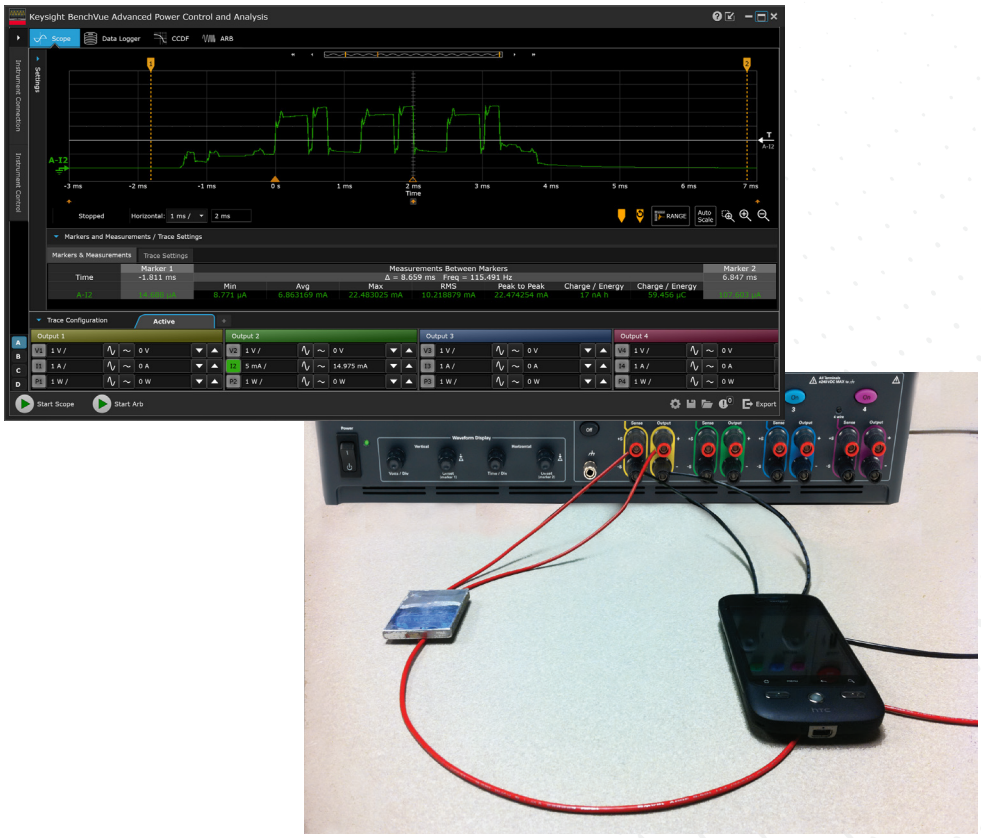
APPLICATION NOTE

Evaluating Battery Run-Down with the N6781A or N6785A 2-Quadrant Source/Measure Unit and the BV9200B Control and Analysis Software



KEYSIGHT TECHNOLOGIES

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.

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 advantages.

Keysight Integrated Solution

The Keysight Technologies, Inc. N6781A (20 W) and N6785A (80 W) (SMUs) are tuned for battery drain analysis of battery-powered devices, which helps reduce test time and ensure product performance. The N6781A SMU produces a DC output of up to 20W, which is suitable for small portable devices such as smartphones and music players. The N6785A SMU produces a DC output of up to 80W, which is suitable for bigger portable devices such as tablets. These SMU modules are part of the N6700 modular power system, which includes the N6700 low-profile mainframes for Automated Test Environments (ATE) and the N6705C DC power analyzer mainframe for R&D. The product family has four mainframes and over 30 DC power modules to choose from providing a complete spectrum of solutions from R&D through design validation and manufacturing.

When you use the N6705C DC power analyzer mainframe and any of the N6780 Series SMUs with the BV9200B PathWave BenchVue Advanced Power Control and Analysis Software, you can easily measure short-term and long-term battery current drain and analyze your results. For 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 advanced capabilities of the N6781A or N6785A SMU with the BV9200B PathWave BenchVue Advanced Power Control and Analysis Software to easily and accurately evaluate performance of a battery-powered device directly powered by it's 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. The setup uses analog-to-digital converter 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 the 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 take 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 or N6785A SMU and BV9200B PathWave BenchVue Advanced Power Control and Analysis Software

The N6780 Series SMUs have advanced features for sourcing and measuring that address the challenges and shortcomings of traditional approaches. For battery rundown test, the N6780 Series SMUs can be used in current measure only (ammeter) mode and become a zero-burden current measurement shunt. Unlike a shunt, voltage drop will not be an issue (as seen in Figure 1 below). The N6781A and N6875A SMUs also have a patented seamless range-switching measurement feature called “seamless measurement ranging technology”. As the current transitions from sleep level to active, the seamless measurement ranging 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 N6780 Series SMUs to more accurately emulate the internal resistance of a battery. Finally, the BV9200B PathWave BenchVue Advanced Power Control and Analysis Software provides the platform to easily 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 N6780 Series SMUs have a “current measurement only” mode that sets the power supply to behave like a zero-ohm shunt. When the output is connected in series with the battery and the battery-powered device, as in Figure 1, the SMUs emulate a zero-burden ammeter. The voltage is regulated to zero volts where the remote sense lines are connected.

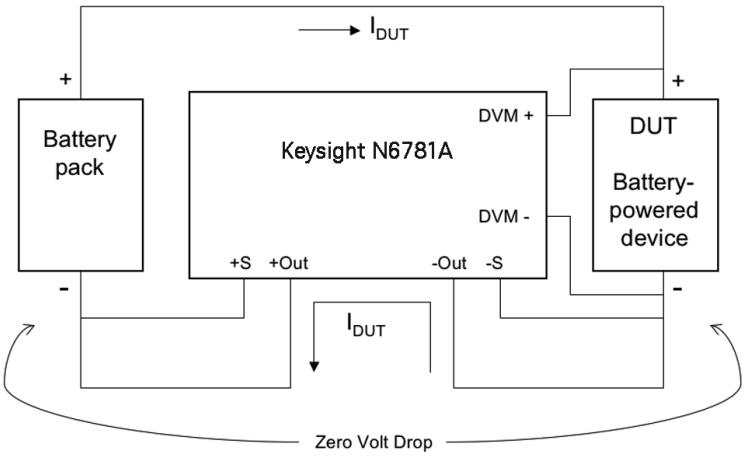


Figure 1: The recommended setup for measuring battery run-down performance using the N6780 Series SMUs. Note that remote voltage sending eliminates the voltage drop in the wiring between the battery pack (-) and DUT (-). In this setup, the N6780 Series SMU modules would be installed inside an N6705C 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 BV9200B 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 N6780 Series SMUs have an auxiliary voltage metering (DVM) 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 BV9200B, expand the *Instrument Control* tab and select *Meter* then *Properties*.

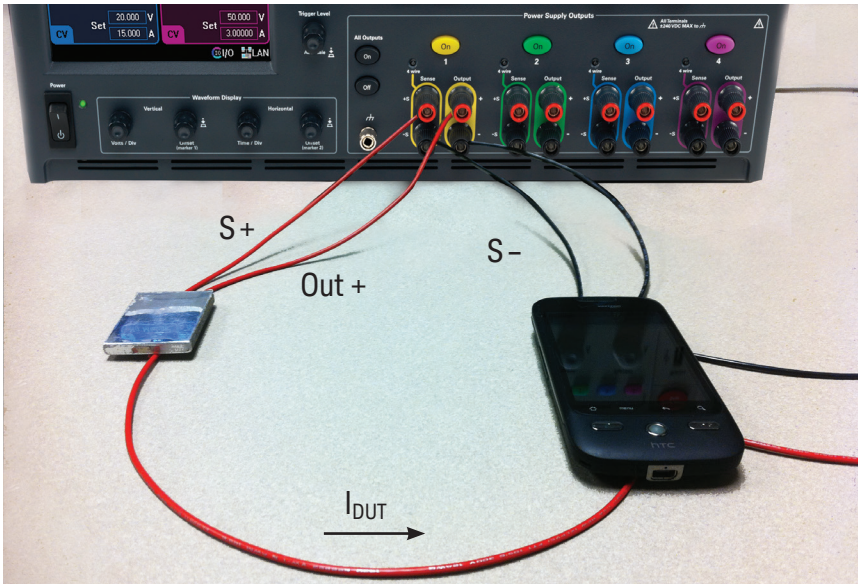


Figure 2: The actual setup for measuring battery run-down performance using an N6781A or N6785A SMU installed as output 1 in an N6705 DC power analyzer mainframe (N6781A shown).

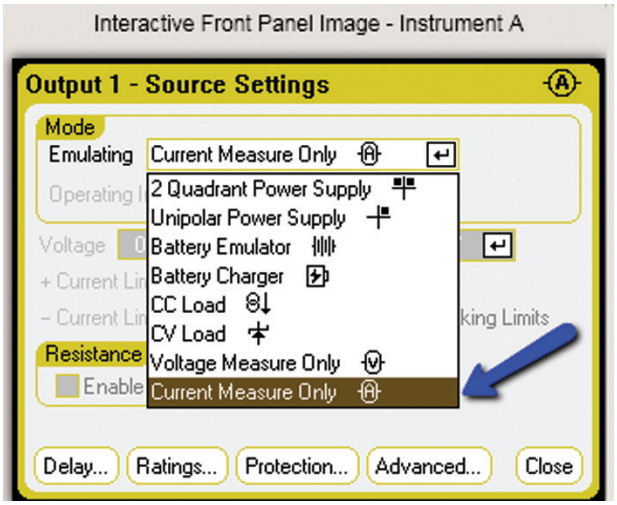


Figure 3: Source setting menu on the BV9200B BenchVue Advanced Power Control and Analysis Software can also be performed from the front panel of the N6705 DC power analyzer mainframe.

Measuring Battery Voltage Using the Auxiliary Voltmeter (continued)

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

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 N6780 Series SMUs. That eliminates the need for an external protection circuit for this application.

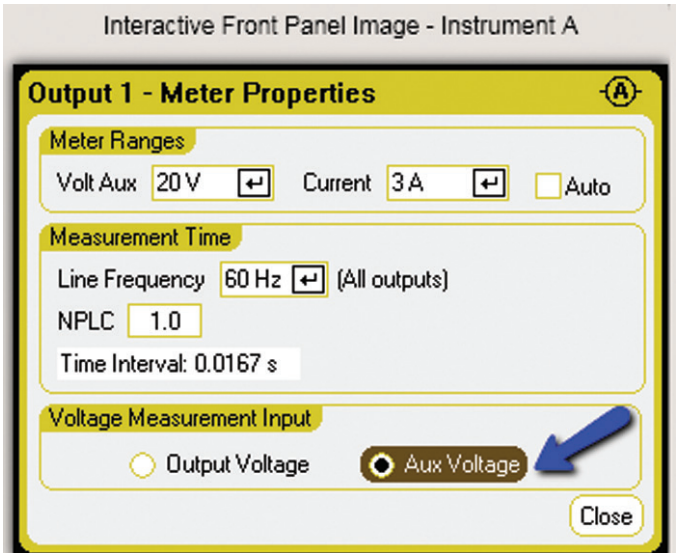


Figure 4: Auxiliary voltmeter setup

Using the Scope Mode

The BV9200B PathWave BenchVue Advanced Power Control and Analysis Software includes scope mode. The mode allows you to monitor the current drain as it happens. In the scope mode, the graphical user interface lets you 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.

These features are also available from the front panel of the N6705 using *Scope View*.

The scope acquisition can be started or stopped by pressing the "play" 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. Markers 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.

Figure 5: Scope acquisition with markers

Using the Data Logging Mode

The data-logging mode in the N6705 mainframe and BV9200B software permit long-term data collection. The settings let you 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 cycle. You can define the integration period for the data logging from 20 µs to 60 s, depending on the setup. 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 of the N6705 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.

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. Another useful feature is the 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. This is a distribution plot of the current amplitude versus its relative frequency of occurrence and is a powerful tool to quickly visualize and analyze large amounts of data.

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

Figure 7: Measurements between markers in data logging mode

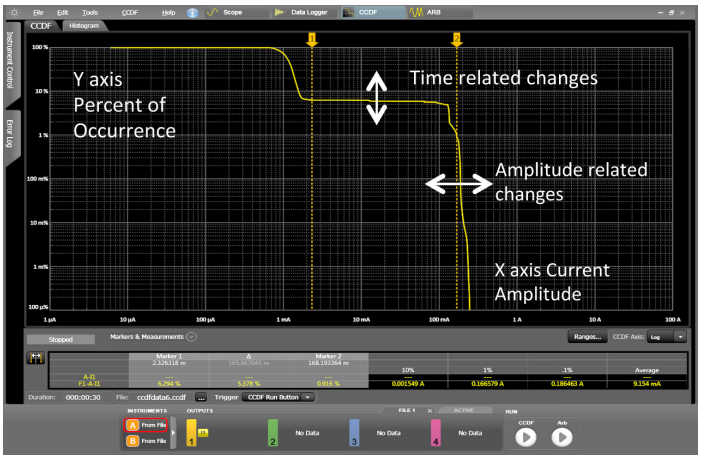


Figure 8. This CCDF measurement reveals the key attributes of standby current in a smartphone.

Summary

Using the actual battery, instead of a DC power source when performing battery-drain analysis on a battery-powered device, gives you greater insight into real-world operating time and actual battery capacity delivered, for the most accurate results. The patented seamless range-switching measurement feature (seamless measurement ranging) available on the N6780 SMUs overcomes accuracy shortcomings of traditional approaches that use 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 and N6785A SMUs and N6705 power analyzer mainframe that help you in evaluating battery run-down. You can control the N6781A and N6785A SMUs inside an N6705C DC power analyzer mainframe with the front panel or you can control it with the BV9200B control and analysis software. For a free trial of the BV9200B PathWave BenchVue Advanced Power Control and Analysis Software, go to **www.keysight.com/find/BV9200**.

Related Keysight Literature

Keysight BV9200B BenchVue Advanced Power Control and Analysis Software for Advanced Power Supplies, Data Sheet, **5992-4328EN**

Keysight N6780 Series Source/Measure Units (SMUs) for the N6700 Modular Power System, Data Sheet, **5990-5829EN**

Keysight N6780 Series SMUs Essential Configuration Guide, **5991-3408EN**

Keysight N6705 DC Power Analyzer, User's Guide, **N6705C-90901**

Enhance the Battery Life of Your Mobile or Wireless Device, **5991-0519EN**

www.keysight.com/find/N6705C

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