

## Battery Drain Analysis Improves Mobile-Device Operating Time

Using specialized tools and analysis techniques can help you create mobile-device designs that extend battery life and improve your productivity.

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Battery operating time continues to be a critical factor in the design of mobile wireless devices. With the trend toward smaller and lighter mobile devices, using a larger battery is not a viable option. Instead, designs must get the most out of the battery. Analysis of battery current drain can help with optimizing the battery operating time of these devices.

Battery drain analysis is more than estimating battery life. Battery drain analysis entails testing and characterizing the device, its subcircuits, and the battery, both independently and in combination. It includes employing methods of characterizing current drain out of

the battery using different device operating modes and parameters, thereby providing insight into how device operation affects battery drain. This enables analysis of design tradeoffs that impact current drain, so that the device can be designed to maximize battery life.

Examples of how battery drain analysis during the design stage of a mobile wireless device can be used to extend battery life include:

- Analyze differences in current drain due to variations made in data transmission to optimize operating life. Some variations include packet size versus number of packets, and number of data channels used versus transmit time.

- Quantify differences in current drain due to changes made in digital baseband operation to optimize the power efficiency of data processing.
- Identify anomalous behaviors and measuring their effects on power consumption. Anomalies include unusually long or high pulses, and random overloads that lead to early low-voltage shut-down and reduced battery operating time.
- Quantify the current drain distribution to help with determining the dynamic power and current requirements, allowing selection of the appropriate battery, power regulator, and power management circuits.



**An ideal system**

Based on these tasks, an ideal system for performing battery drain measurement and analysis would:

- Properly source power to the DUT.
- Log battery rundown voltage for validating operating time.
- Accurately measure current from milliamps to ampere levels.
- Be able to log the current drain and other data for durations from minutes to days, to address the variety of test scenarios required.
- Provide a post-test summary of basic test results such as runtime, average current, average voltage, and amp-hours and watt-hours consumed.
- Provide data analysis for understanding how operational anomalies affect battery life, and to enable design optimization.

A generic system for battery drain measurement and analysis having these elements is shown in Figure 1.

**A traditional approach**

A traditional approach to implementing such a system for performing battery drain measurement and analysis would entail integrating several pieces of general purpose test equipment and software. One is typically beset with a number of challenges in creating a system using a traditional approach which includes, but is not limited to the following:

- The equipment required can cost \$10,000 or more, depending on choice.
- General purpose power supplies are not well suited for powering mobile wireless devices that draw high peaks of current.

- Making accurate current measurements is a challenge. Current shunts are limited, inflexible, and induce voltage drop. Voltage drop must be extremely small to minimize losses when dealing with low battery voltages. Inductive current probes are relatively inaccurate and drift a lot, requiring frequent correction.
- High speed digitizing of a current drain signal over longer periods of time generates massive amounts of data, which is problematic to deal with.
- Developing software to capture, save, manage, visualize, and analyze the data can take several persons-months of development time. This is time better spent on developing one's products.

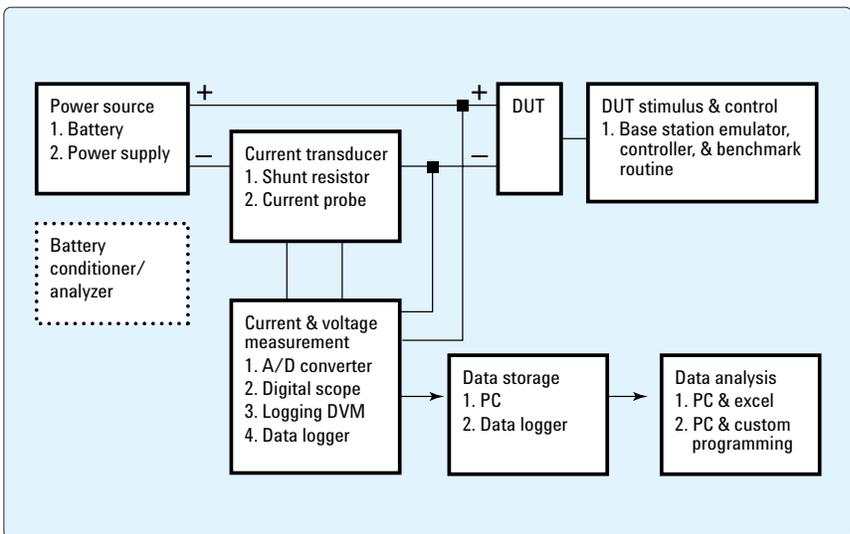


Figure 1. A generic system for battery current drain measurement and analysis

### A better approach

Taking advantage of a commercially available solution already tailored for performing battery drain measurement and analysis can save considerable money, minimize or eliminate any development time, and potentially provide better performance. An example of such a solution is the Agilent 14565B device characterization software for performing battery drain analysis, which works in conjunction with an Agilent 66319B/D or 66321B/D power supply, having specialized sourcing and measurement capabilities for testing mobile wireless devices. This solution is depicted in Figure 2. The major capabilities of this solution are as follows:

- Battery emulation sourcing
- Specialized measurement system for current drain
- Current waveform capture and analysis
- Long-term current drain data logging and analysis
- Long-term current drain capture and statistical analysis
- Automated program control from other software packages

The behavior of the output of a general purpose power supply is very different than that of the actual battery used to power a mobile wireless device. A general purpose power supply typically suffers with large transient voltage drop and slow recovery when powering a wireless device. The resulting current drain is not comparable to that when the device is powered by its battery. Unlike a general purpose power supply the Agilent 66319B/D and 66321B/D power supplies feature fast output transient voltage drop and programmable output resistance, accurately emulating the behavior of a battery, with current drain matching that of when the device is powered by its battery.

The Agilent mobile communications DC source uses a high-speed DSP-based digitizing measurement system, much like that of a digital oscilloscope. It has three DC current ranges to provide accurate current measurements in active, standby, and off modes, specially tailored for digital wireless device testing. Incorporating specialized current measurement capabilities into the power supply resolves the challenges of using an external current shunt or probe. Having a digitizer built in eliminates the need and complexities of a separate digitizing oscilloscope or data acquisition system in order to digitize the current signal.

Most important, however, is a means for capturing, saving, displaying, and analyzing the data. The Agilent 14565B device characterization software is

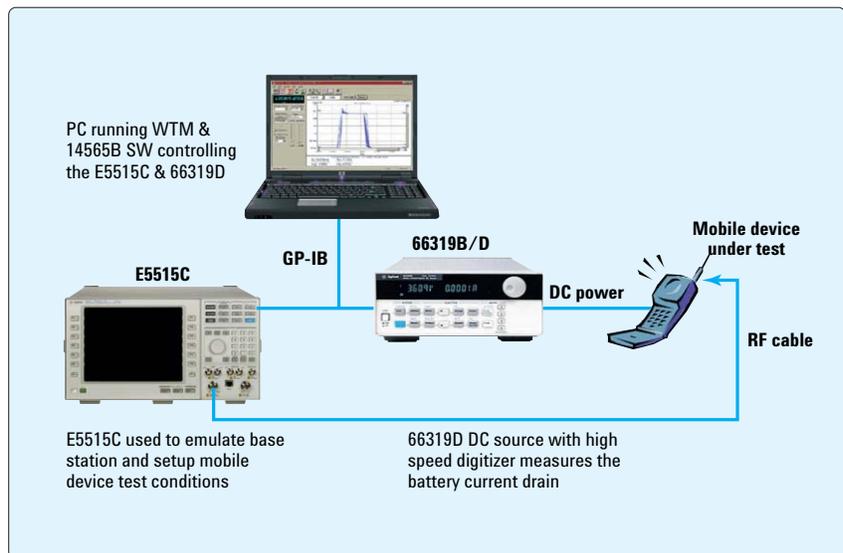


Figure 2. Agilent automated solution for battery current drain measurement and analysis

an easy-to-use graphical user interface that works specifically with the Agilent 66319B/D and 66321B/D power supplies for battery current drain capture and analysis. It runs on a PC and features three modes of operation to provide source control, measurement, and analysis without requiring any programming.

The waveform capture and analysis operating mode provides an effective means of capturing and displaying an oscilloscope-like view of the battery current drain over a short period of time. Built-in measurement functions include average, and pulse minimum, low, high, and maximum values. These capabilities permit making basic estimates and analysis on battery current drain and operating time. This first mode of operation is depicted in Figure 3.

The data logging and analysis operating mode allows data logging for up to 1000 hours. Over this duration the Agilent 66319B/D or 66321B/D continuously samples the current at a 64-kHz rate to capture high-speed details and random overloads. At the same time a special integrating feature reduces the data to meaningful and manageable results as the measurement is captured in real time. Figure 4 depicts this second mode of operation

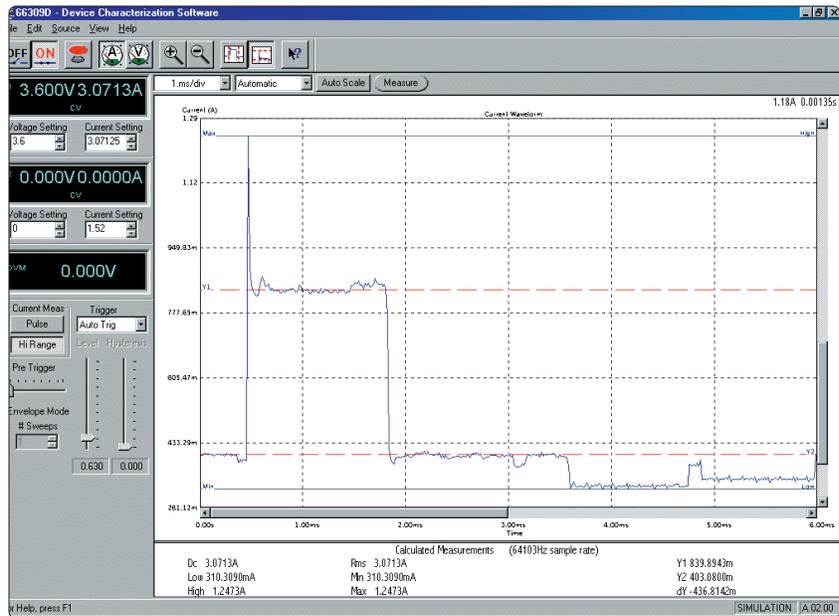


Figure 3. Agilent 14565B waveform capture and analysis mode of operation.

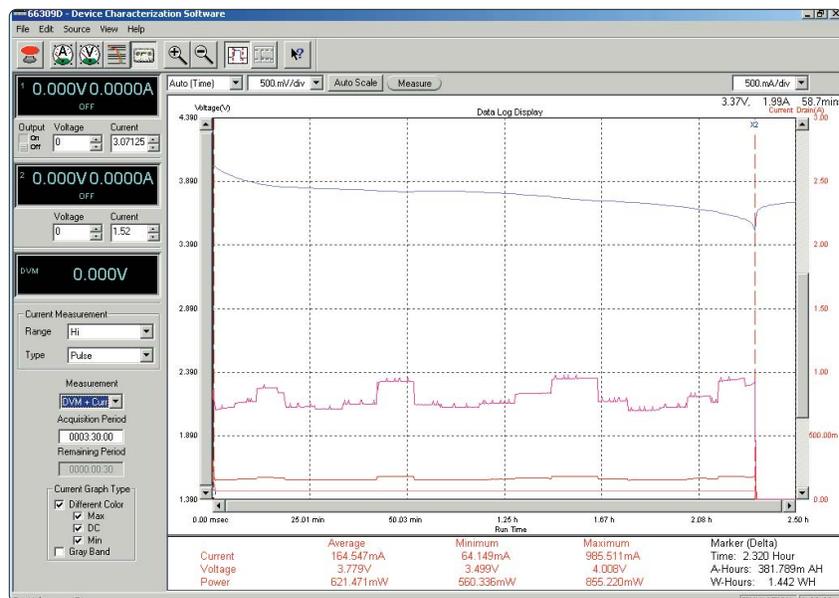


Figure 4. Agilent 14565B data log long-term capture and analysis mode of operation.

showing the display of minimum, maximum, and average currents, voltage, numerical values, and amp-hour and watt-hour values over time.

Newer digital communications systems for 3G use complex modulation formats with high levels of amplitude modulation for transmitting higher data rates. The resulting current drain waveforms are complex and random when viewed in the time domain. The current drain similarly gets more complex and unpredictable when run over long periods typical of a battery operating time test. As a result it becomes difficult to predict average and peak values for estimating battery-operating time or to easily observe the effects of design changes on current drain for optimizing battery operating time. A better way to visualize and analyze complex current-drain patterns is to examine their statistical distribution, such as with a complimentary cumulative distribution function (CCDF) graph.

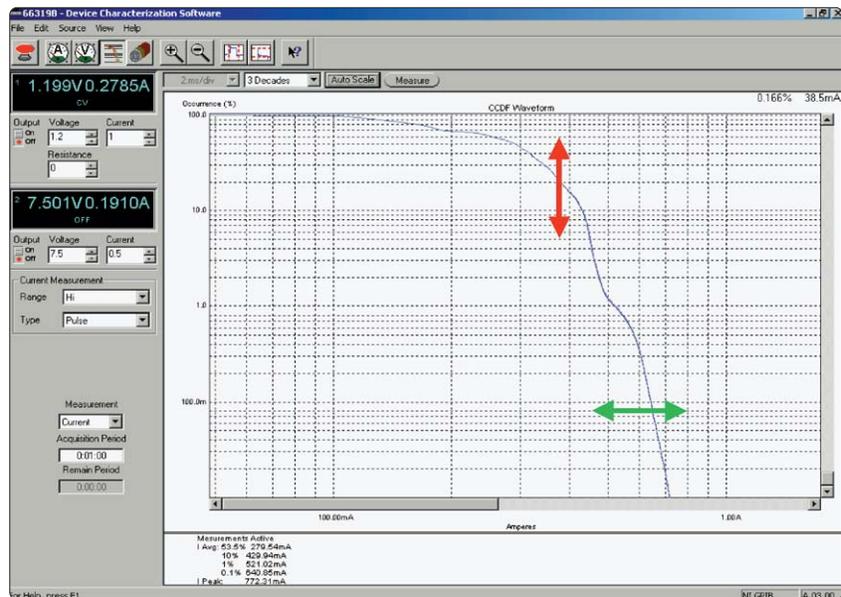


Figure 5. Agilent 14565B CCDF long-term capture and analysis mode of operation.

CCDF long-term capture and analysis is the third operating mode of the 14565B software, depicted in Figure 5. A CCDF graph is an alternate form of a histogram. It very concisely displays the current or voltage on the x-axis versus its % of occurrence on the y-axis. In CCDF mode current or voltage is continuously accumulated for up to 1,000 hours. Data is sampled at 64 kHz to capture and characterize high speed details of the signal. Zoom and marker controls provide means for measurement and analysis of the CCDF graph. Saving, recalling, and comparing CCDF

graphs taken before and after design changes are made on a device are useful for analyzing the impact of the design change for optimizing current drain and battery operating life:

- Horizontal shifts indicate changes in amplitude, such as the device drawing higher or lower peak pulsed current.
- Vertical shifts indicate time related changes, such as the device drawing wider or a greater number of current pulses than expected for a given operation.

**Now with program automation capabilities**

Many times it is desirable to make current drain measurements that are synchronized to activity of the device under test, which is also often under control of another test program. One example of this is to validate the drain current for mobile phone for all of its RF transmit power levels and channels. Performing this task manually is very time consuming and laborious. As illustrated in Figure 2, the Agilent E656xC wireless test manager (WTM) software is used to sequence the Agilent E5515C RF one box tester through a series of steps (which is in turn controlling the mobile phone under test through its RF input). At the same time the WTM software also sends commands to the 14565B software to set up, make, and then return current drain measurements to the WTM software for each sequence

step, greatly simplifying this task. The 14565B software can be controlled from a variety of programs, such as Agilent WTM, Agilent VEE, and National Instruments' LabView, and programming languages, such as MicroSoft Visual Basic 6.0 and Visual Basic.NET, just to name a few examples.

**In closing, specialized tools facilitate design optimization of wireless devices**

Employing battery current drain analysis tools and techniques in your battery-life testing allows you to analyze and optimize designs for maximum battery run time. The Agilent 14565B device characterization software along with an Agilent 66319B/D or 66321B/D power supply

provide an effective ready-to-use solution for capturing, saving, visualizing, and analyzing long-term current drain. Now incorporating program control automation from other programs and programming languages, many repetitive manual tasks can now be automated. Such capabilities greatly frees up time to focus on optimizing one's design instead of developing tools and performing manual tasks. Battery current drain analysis is a useful complement to an overall test portfolio for mobile wireless device product development.



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