WHITE PAPER

4 Ways to Enhance IoT Battery Performance Using Emulation Software

Battery life is a critical factor for IoT devices

KEYSIGHT

Battery life affects the cost and reliability of IoT-based infrastructure and is a key purchasing consideration for consumer electronic IoT devices.

Ensuring IoT manufacturers correctly calculate battery life is critical.

This white paper examines how battery emulation and test software can help you accurately measure battery life and extend the battery life of an IoT device.

Battery life can contribute significantly to the cost and reliability of Internet of Things (IoT) infrastructure. While for consumer electronic devices, battery life is often a critical purchase consideration. Therefore, the fact that the calculated battery life of IoT devices is often inaccurate is a significant issue for manufacturers.

One method to measure battery life is to divide the battery capacity in amp-hours by the average current drain in amps, which gives you a time in hours. However, in the real world, this calculation is overly simplistic.

In fact, the formula can generate inaccurate results because devices use different power modes, including active, sleep, and hibernate. Additionally, operating modes such as constant power and constant resistance will draw current from the battery differently and change the battery's run time. It is essential to fully understand how a battery responds to these different scenarios and the typical usage patterns of the device to predict battery life accurately.

In addition to varying current drain, battery capacity is variable depending on the average discharge current and usage patterns. In Figure 1, you can see a considerable variation in discharge capacity based on the discharge current level for an alkaline cell.

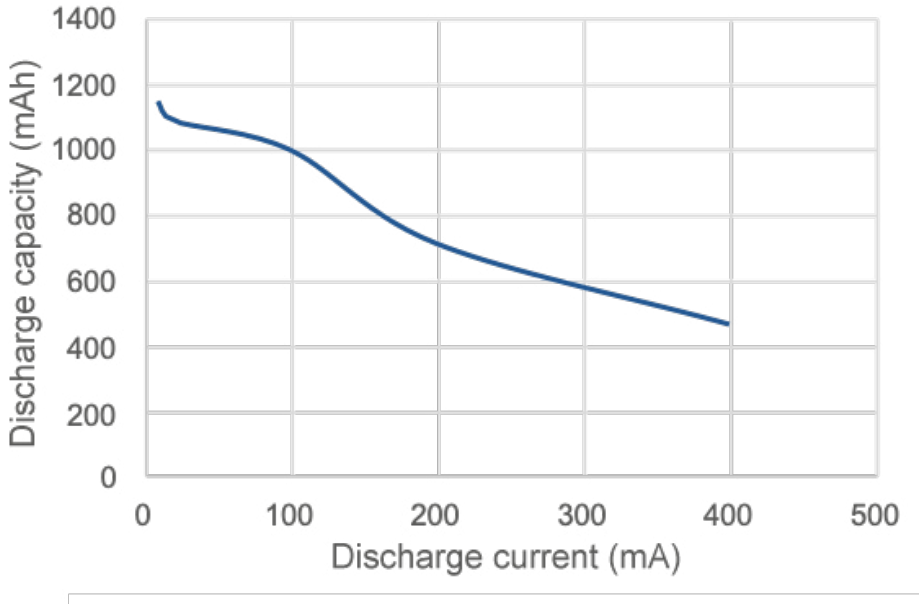

Figure 1. 1,100 mAh alkaline cell, 0.9V cutoff voltage - discharge capacity variation

Further, temperature can affect battery life, which is another critical consideration. Figure 2 shows how temperature can affect the capacity curves of a battery.

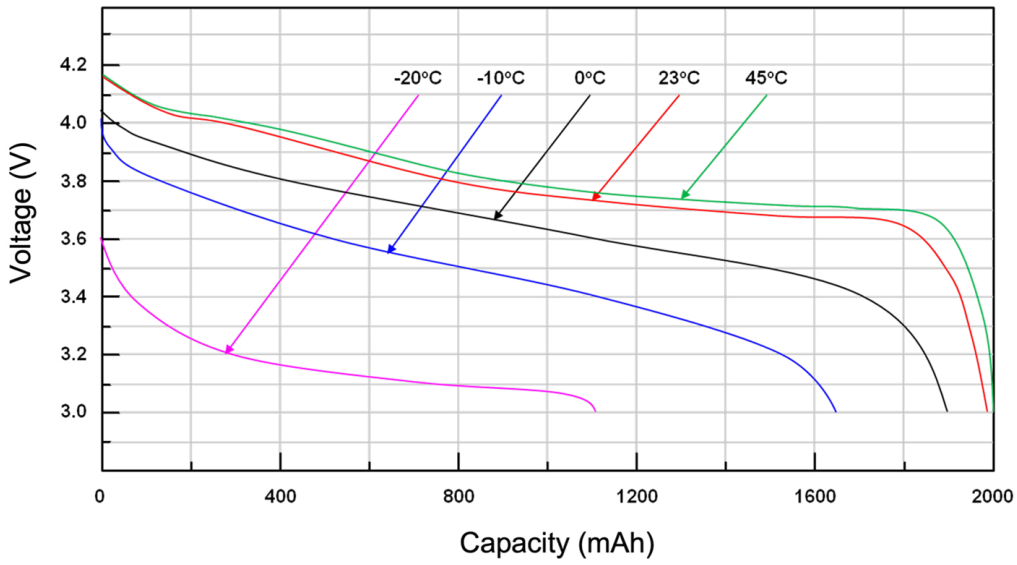

Figure 2. 1,000 mAh Li-ion cell, 3 V cutoff voltage – temperature variation

The following are additional factors that can lead to a longer computed battery runtime compared to real-world usage:

- Battery models / profiles are not available.
- Battery profiles are not generated with accurate device operating conditions.
- Current consumption measurements are inaccurate.
- Voltage drops, such as when a device shuts down when the voltage reaches a cutoff range, are not considered.

Battery emulation and profiling software is a solution you can use to predict battery life accurately. In addition, you can use insight into current drain that emulation software provides to change device designs resulting in longer battery run time.

This white paper discusses how to use emulation software to achieve these objectives and includes the following topics:

1. Profiling batteries through charging / discharging to create unique battery models.
2. Emulating charge states to reduce test time, improve safety, and gain insight to extend battery life.
3. Visually track the charging and discharging of batteries to determine capacity.
4. Cycling batteries to determine capacity loss and battery life reduction.

1. Profiling batteries to create unique battery models

It is important to profile and characterize batteries for several reasons. You need to understand the amount of energy the battery can store and supply as a battery discharges over time. The open-circuit voltage (VOC) and internal resistance (IR) vary as the battery discharges. It is crucial to map these out, so that battery profiles accurately reflect the real-world performance of the battery. Figure 3 is an example of a typical plot.

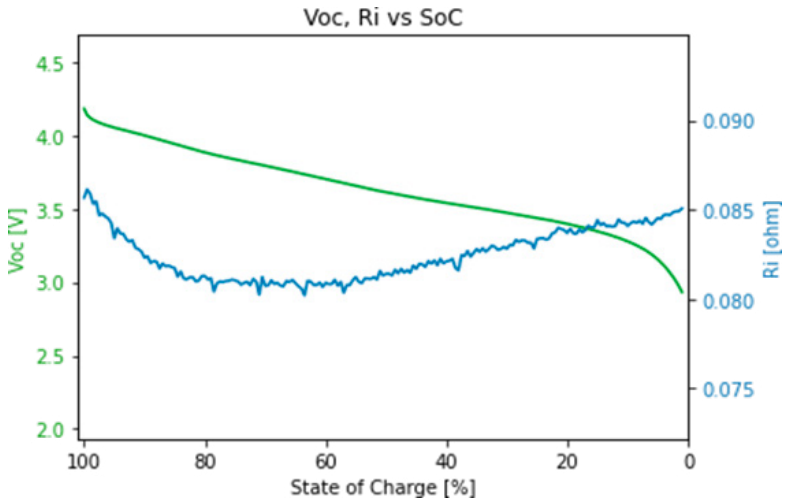

Figure 3. Battery profile created with Keysight BV9210B/11B PathWave BenchVue Advanced Battery Test and Emulation software

Also, it is essential to confirm the battery's performance under specific discharge conditions and operating modes. Parameters that affect the battery behavior include:

- temperature
- load current profiles (constant / dynamic)
- different operating modes, including constant current, power, and resistance

These parameters can affect battery life, so it is vital to create different battery profiles to match specific discharge conditions.

2. Emulating charge states to reduce test time, improve safety, and gain insight to extend battery life

Why use a battery emulator instead of a battery for device testing?

- **Create a safer test environment.** You do not have to charge and discharge batteries when you use an emulator. Charging and discharging batteries can become dangerous with repeated cycles.
- **Achieve repeatable results.** The characteristics of an emulated battery do not vary versus physical batteries, whose characteristics can fluctuate after charging / discharging. They can also vary between different batteries, even if they are the same model.
- **Reduce test setup times.** Instantly simulate any state of charge (SoC) versus manually draining a battery to the desired level.

A battery emulator works in multiple steps. The first step is loading a battery profile. This profile is the data from a plot of the battery voltage and internal resistance versus the SoC which appears in Figure 3. You can create a battery profile by using battery modeling software to measure the profile or by receiving a profile from a battery supplier.

When you use modeling software to create a profile, the profile will reflect the current consumption for a specific device which is more accurate than a battery supplier's generic profile. For example, a generic profile is not helpful if the battery supplier creates the profile based on a constant current draw when the device under test consumes a dynamic current. In Figure 4, you can see a device's current consumption profile loaded into a battery profiler. The software repeats the waveform until the battery is completely drained.

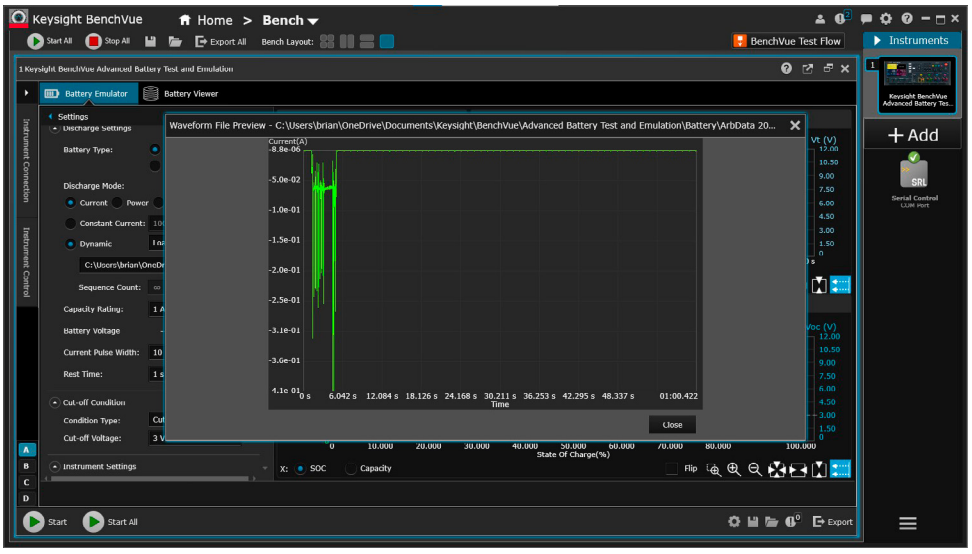

Figure 4.
Device current consumption waveform loaded into Keysight BV9210B/11B PathWave BenchVue advanced battery test and emulation software

The next emulation step is for you to select the starting SoC and the cutoff voltage. You will then connect the device to the emulator and start the battery emulation. Battery emulators continuously measure the current, charging or discharging, and dynamically calculate emulated SoC. The emulator continuously changes its output (voltage and resistance) based on the SoC to conform to the loaded battery profile. If the emulator is discharging, the test ends when the emulator reaches the cutoff voltage.

Figure 5. Battery emulation using BV9210B/11B PathWave BenchVue advanced battery test and emulation software

You can quickly gain deep insight into a device's behavior by rapidly emulating a battery at different SoCs. Figure 6 shows the insight you can gain into a device's current drain. You can use the measurements from this analysis to change the design of the IoT device to enhance battery runtime.

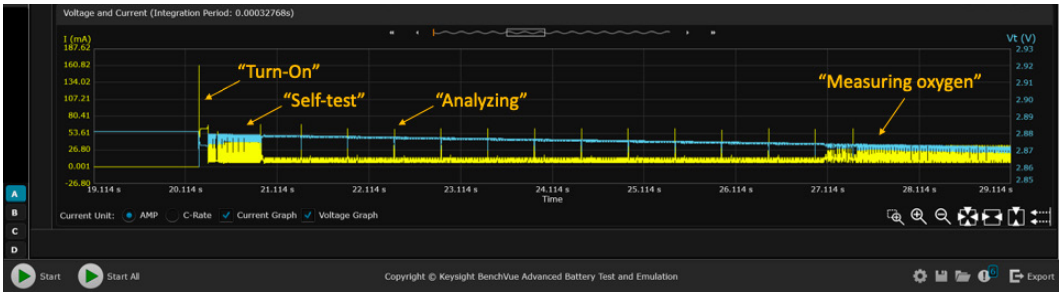

Figure 6. Current drain analysis of a pulse oximeter medical IoT device using BV9210B/11B PathWave BenchVue advanced battery test and emulation software

3. Visually track charging / discharging batteries to determine capacity

For IoT devices, you need to understand the energy a battery can store and deliver. Battery test and emulation software enables you to visually track battery charging and discharging to determine capacity.

Software must support both constant current (CC) and constant voltage (CV) modes for charging batteries. As the battery reaches full capacity when charging using CC mode, the software needs to move from CC mode into a combination of CC and CV. This combination is necessary because a battery cannot be charged at the same rate when it gets close to peak voltage or peak capacity.

It is also important for the software to support constant current, constant resistance, and constant power modes when discharging a battery. You can use test and emulation software to create a current consumption profile generated directly from a device. This capability enables you to easily discharge the battery with a profile that closely aligns with the real-world current drain during usage. It is difficult to simulate this using the actual device to perform the battery drain test unless you operate it throughout the rundown test.

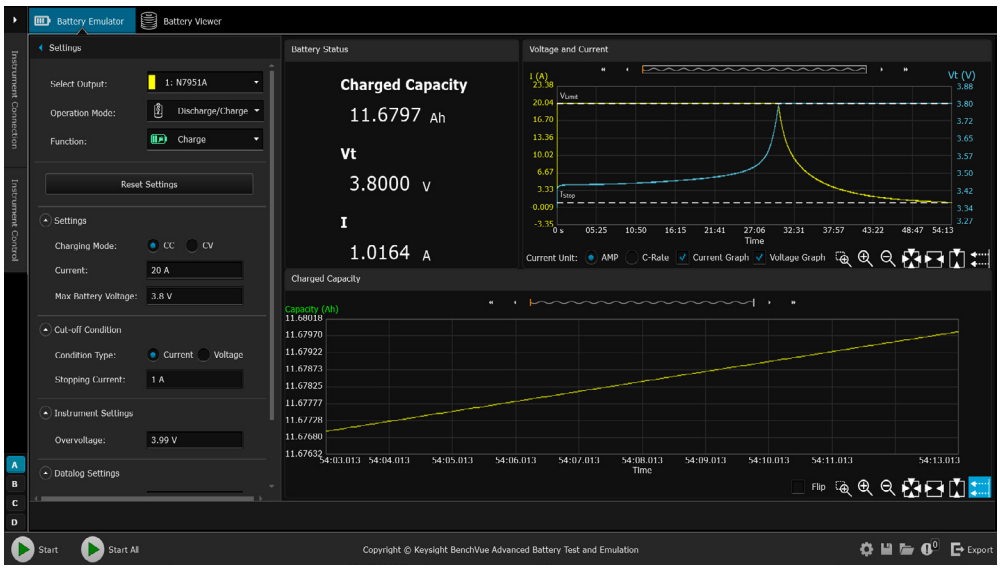

Figure 7. Visually tracking battery charging using BV9210B/11B PathWave BenchVue advanced battery test and emulation software

4. Cycling batteries to determine loss of capacity and reduction of battery life

Battery performance can decline significantly over a lifetime of charging and discharging. That is why it is vital to simulate battery cycling. Battery test and emulation software is an easy solution for this, but the software needs to support data logging. Also, the ability to create varying charging and discharging profiles for a battery is of real value in a battery test and emulation software solution.

You can combine disparate charging and discharging sequences to simulate complex charging and discharging cycling profiles. Then they can confirm how a battery's performance degrades over time. Emulation software solutions are ideal for this as they can enable you to make, for example, up to one thousand cycle operations to determine the battery's ageing effect and reliability under sequence test conditions.

Figure 8. Battery cycling testing using BV9210B/11B PathWave BenchVue advanced battery test and emulation software

Complete Test Solutions Available from Keysight

Keysight offers a low power (<200W) battery emulation portfolio that combines software and hardware to perform battery profiling, battery emulation, current drain analysis, and battery run-down and cycle testing. To select the correct solution for your application, please review the Low-Power (< 200 W) Battery Emulation Portfolio brochure.

For more information, please visit:

- E36731A battery emulator and profiler product page
- N6705C DC power analyzer
- BV9210B/11B PathWave BenchVue advanced battery test and emulation software Multiple Instrument License / Single Instrument License
- Low-Power (< 200 W) Battery Emulation Portfolio brochure