Measuring Battery Life on Battery-Powered Medical IoT Devices

Batteries are increasingly important in Healthcare IoT

The Internet of Things (IoT) and modern connectivity technology increasingly connect healthcare and medical devices. In the Healthcare IoT, battery-powered wireless medical devices are increasingly prevalent in our daily lives. These Healthcare IoT devices include fitness bands and smart watches that monitor pulse and heart rate, blood pressure monitors, pacemakers, pulse oximeters, glucose monitors, thermometers, ultrasound hearing aids, insulin pumps, and many other devices that are currently being developed.

These devices are all low power, battery-operated, mobile, lightweight, small, and wireless. The consequences of insufficient battery life can range from inconvenience and buying preference to life-threatening situations and possibly legal liability. Device designers must understand the power consumption patterns and battery life requirements of medical IoT devices.

Considerations for Battery Run-Down Test

A battery run-down test measures the time that a device can operate from a full battery charge. This is easier said than done, as there are many aspects in this test that every design engineer must consider.

Here are four considerations for battery run-down test:

Consideration 1: Inconsistencies in battery life

Inconsistencies in battery life are common, even from one manufacturer, because the batteries may come from different manufacturing batches or factories.

Recommendation:

Perform the run-down test with batteries purchased at different times.
Consideration 2: Battery’s charging condition

Use a new, fully charged battery when performing the test. Old or partially charged batteries will have lower run-time.

Recommendation:

Ensure that the battery is fully charged and use a battery cycler to condition the battery by cycling the battery from fully discharged to fully charged.

Consideration 3: Different use cases

Different operation modes of the IoT device operate at different current levels.

Recommendation:

Keep the use case and its test parameters constant.

Consideration 4: Determine when the IoT device stops working or the battery is fully discharged

Devices may not have an LED that indicates low battery charge.

Recommendation:

Measure the battery voltage at the low voltage threshold, and use that as the indicator of when the device stops working.

Power Supply as Battery Simulation

Some design engineers use a power supply to simulate the battery for the run-down test. However, this method is not accurate or practical as it introduces errors and variables to the overall testing. A typical power supply never runs down like a battery.

Other engineers try to use a power supply with specialized features such as controllable output resistance and excellent transient response on current pulses to emulate the battery. This is very complicated, because the power supply’s output voltage needs to drop off as the charge is pulled from the power supply into the medical IoT device during the run-down test. The simulation data collection process will be time consuming and the results may not match with the results obtained using a battery.

Until a more realistic simulation approach is available, a run-down test using batteries is still the preferred method.
More than Run-Time

Medical device design engineers need fast, visual insights into voltage and current during the run-down test. Graphing these values versus time gives a clear picture of battery run-down.

![Graph showing battery run-down test results](image)

Figure 1: Battery run-down test results

To measure the voltage and current flowing through the battery and the medical IoT device, testers normally need the following:

- Two digital multimeters (DMMs)
- 2-channel data logger or 2-channel digitizer
- Oscilloscope

Battery voltage measurement is less critical than current measurement. A normal DMM or data logger can capture a decaying voltage waveform. However, current measurement requires a fast digitizer, as each IoT devices transition quickly between sleep mode, standby mode, active mode, and wireless data transmission mode. An IoT device can draw up to hundreds of milliamperes in the active mode, but will only draw microamperes or even hundreds of nanoamperes during the sleep mode. High current spikes and transient effects occur when the device is turned on and off frequently. A DMM cannot capture the rapidly changing current waveform. Additionally, a DMM in ammeter mode has a burden voltage, as there is a calibrated current shunt inside the DMM. This reduces the voltage at the DUT and burden the overall circuit up to hundreds of millivolts.

![Diagram showing DMM burden voltage](image)

Figure 2. DMM presents burden voltage when measuring current

Typical ammeter shunt values:

- 0.1 Ω for 1 A and higher
- 5 Ω for 100 mA and lower
For example, on a 100-mA measurement range, 50 mA of battery current yields a burden voltage of 250 mV. Therefore, a 4.2-V battery yields just 3.95 V at the device under test.

Digitizers offer the better choice when measuring rapidly changing waveforms for a long period of time as they have enough bandwidth to capture any rapid changes in the waveform. However, a current shunt is needed as digitizers do not directly measure current. Selecting the right shunt for a wide dynamic current measurement that switches from microamperes to amperes is important. If the selected shunt size is for measuring low current, there will be a large voltage drop across the shunt and this will create burden voltage on the circuit. If the selected shunt size is for measuring high current, there will be inaccuracy in the low current measurement as there may not be sufficient voltage to pass through the digitizer. Therefore, a compromise has to be made between burden voltage or low currents inaccuracy when selecting the current shunt size.

The oscilloscope is the best choice for displaying both the current and voltage measurements of the waveform, as it has good bandwidth for dynamic current measurement and an excellent update rate. In addition to that, oscilloscopes have good time correlation with the digital bus and various triggering capabilities to capture the signal accurately. Like the digitizers, oscilloscopes must be used with the right current shunt to ensure a good low current measurement and tolerable burden voltage at high current measurement. Oscilloscopes can also be used with high sensitivity current probes that go down to as low as 50 μA and have a maximum current range of 5 A. This allows both the large signals and details on fast and wide waveforms to be displayed. The limitation on this solution is that it cannot perform long-term measurements.

**Solution for Battery Run-Down Test**

Keysight Technologies offers the N6781A Battery Drain Analyzer and turnkey software for performing run-down tests for battery powered medical IoT devices requiring up to 3 A of current. The N6781A can be configured as a zero-burden ammeter. This means that there is zero voltage drop across the instrument as it measures the current flow between the battery and the IoT device. It also offers a unique feature called seamless ranging. This allows instant-and-automatic range change and measure currents from microamperes to amperes at a speed of 100,000 samples per second without losing any data during the range change. The seamless ranging feature makes it ideally suited for measuring dynamic currents during run-down tests. Furthermore, it can also simultaneously measure the voltage across the battery.

With the Keysight 14585 Control and Analysis Software, a battery run-down test can quickly be set up and the run-down measurements can be captured and plotted without coding any software.
N6705C DC power analyzer and BV9200 Control and Analysis Software

The Keysight N6705C DC power analyzer supports dozens of modules. Two that are particularly useful for battery run-down are the N6781A and N6785A Battery Drain Analyzer modules. These modules are two-quadrant source and measure units (SMUs) that plug into the N6705C DC power analyzer mainframe. Keysight's new BV9200B/BV9201B Control and Analysis Software is a great solution for fast battery run-down insights on battery-powered medical IoT devices.

Learn more at: www.keysight.com

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