Keysight Technologies
Power Consumption Solutions for Battery-Operated Medical Devices

Application Brief
Characterizing battery life is critical for developers of portable battery-powered medical devices. Advances in semiconductor technology have enabled most components in a medical device to be integrated onto a single chip, or systems-on-a-chip (SoC). Further reductions in size are constrained by powering technologies like energy storage and harvesting elements. Long periods of sleep/idle, wakeup/active, and short RF bursts create a tough demand on the battery.

The typical peak current consumption for wireless technologies is shown below:

<table>
<thead>
<tr>
<th>Wireless technologies</th>
<th>Peak current draw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluetooth® Low Energy</td>
<td>&lt; 15 mA (read and transmit)</td>
</tr>
<tr>
<td>NFC</td>
<td>&lt; 15 mA (read)</td>
</tr>
<tr>
<td>ZigBee</td>
<td>~ 5.9 mA to 34 mA</td>
</tr>
</tbody>
</table>

Long battery life is critical for portable battery-powered medical devices, especially in emergency and rescue situations. Although implantable devices themselves may last through the patient’s lifetime, periodic surgical is required for battery replacement once the battery is depleted. Therefore, understanding and accurately measuring battery current drain is extremely important in the design and development of medical devices.

Keysight power measurement solutions for a typical wireless battery-operated medical device

Figure 1. Example of current drain profile.

Figure 2. The diagram above shows a typical wireless battery-operated medical device module. Keysight’s DC power analyzer and digital multimeter target module-level power consumption, while the device current waveform analyzer, low noise power source and high-sensitivity current probe address power consumption at the chip-level within the module.
Source and Measurement Solutions

N6705B DC power analyzer and N6781A/N6785A source measurement unit

- Gain insights of your device-under-test (DUT) power consumption in minutes
- Visualize current drain from nA to A in one pass
- Performs wide dynamic range current measurements using patented seamless current ranging technology and gapless measurement sweep
- Ideal for battery run-down test

B2961A/B2962A 6.5 digit low noise power source

- Precision low noise voltage/current sourcing while also monitoring them.
- Best noise floor of 10 μVrms (1 nVrms/√Hz@10 kHz) outperforms that of even linear power supplies. This satisfies the phase noise requirement for testing medical devices that require precise low-noise voltage supplies/sources for proper characterization.

Figure 3. Battery run-down test results

Figure 4. B2961A/B2962A with Option LN2 (low noise filter). This is actual observed data from oscilloscope at 350 Vrms: 10 Hz to 20 MHz
Current Measurement Solutions

CX3300 Series device current waveform analyzers
- Industry’s lowest current measurements down to 100 pA to analyze sleep mode abnormalities
- Ideal for low-power medical device measurements
- Maximum bandwidth: 140 MHz, to capture sharp current spikes and quick transient effects
- Current range: 100 pA to 10 A
- Max. sampling rate: 1 GSa/s

N2820A/N2821A high sensitivity, high dynamic range current probes
- Measure wide range of current from 50 µA to 5 A
- Probing with the Make-Before-Break connector
- Essential troubleshooting tool for any engineer or technician

34465A/34470A Truevolt digital multimeter
- Most basic tool to measure current consumption and voltage
- Measure high active mode current and ensure current drops below a certain level during sleep mode
- Cost-effective
- Current range: 1 µA to 10 A
## Specification in a glance

<table>
<thead>
<tr>
<th>Source and measurement solutions</th>
<th>Current measurement solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>N6705B/N6781A(^1) DC power analyzer and SMU</td>
<td>B2900A Series SMU(^2)</td>
</tr>
<tr>
<td>Normal</td>
<td>HI res</td>
</tr>
<tr>
<td>Display size</td>
<td>5.9”</td>
</tr>
<tr>
<td>Bandwidth, sample rate</td>
<td>29 kHz, 200 kSa/sec</td>
</tr>
<tr>
<td>Measurement resolution</td>
<td>18 bits</td>
</tr>
<tr>
<td>Min. measurable static current(^4)</td>
<td>800 nA</td>
</tr>
<tr>
<td>Min. measurable dynamic current (10 kHz BW)</td>
<td>2.4 µA</td>
</tr>
<tr>
<td>Max. measurable current</td>
<td>3A</td>
</tr>
<tr>
<td>Burden voltage(^5)</td>
<td>0 mV</td>
</tr>
<tr>
<td>Price</td>
<td>$$$</td>
</tr>
</tbody>
</table>

1. Using N6700 frame with N6781A SMU in manufacturing, N6705B frame with N6781A SMU in R&D and N6785A for 20V,8A application solutions.
2. 1 pA is RMS noise (NBW = 0.1 Hz to 10 Hz)
3. 150 pA is RMS noise (NBW = 10 Hz to 20 MHz)
4. Accounts for typical noise with 1% error and quasi-DC current measurement
5. When measuring 10 mA on appropriate range, the N6781A and B2900A Series both source current, so the burden voltage is always 0 mV

## Literature

<table>
<thead>
<tr>
<th>Power consumption for battery-operated medical devices</th>
<th>Publication number</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC power analyzer</td>
<td>5989-6319EN</td>
</tr>
<tr>
<td>B2961A/B2962A 6.5 digit low noise power source</td>
<td>5991-1388EN</td>
</tr>
<tr>
<td>Device current waveform analyzer</td>
<td>5992-1430EN</td>
</tr>
<tr>
<td>Digital multimeter</td>
<td>5990-5315EN</td>
</tr>
<tr>
<td>N2820A/N2821A high sensitivity, high dynamic range current</td>
<td>5991-1711EN</td>
</tr>
</tbody>
</table>
Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology. From Hewlett-Packard to Agilent to Keysight.

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

www.keysight.com/find/emt_product_registration
Register your products to get up-to-date product information and find warranty information.

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument’s lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight’s measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/medical
Bluetooth is a trademark owned by Bluetooth SIG, Inc., U.S.A. and licensed to Keysight Technologies, Inc.