Demo Abstract: RocketLogger - Mobile Power Logger for Prototyping IoT Devices

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ABSTRACT

We demonstrate the RocketLogger, a mobile data logger designed for prototyping energy harvesting IoT devices. Novel IoT applications require new dataloggers with a highly increased dynamic range for current measurement to accommodate both ultra-low sleep currents of few nanoamperes as well as wireless communication currents in the range of hundreds of milliamperes. In parallel to ultra-low currents and high dynamic range measurements, novel applications require mobile measurements for easy in-situ characterization or wearable device testing. The RocketLogger is a solution that fulfills these requirements. While being fully mobile, it measures currents from 5 nA up to 500 mA with very fast and seamless range-switching. Using a sample energy harvesting application, we demonstrate its low-current measurement capabilities, fast, seamless auto-ranging and easy-to-use remote user interface.

1. INTRODUCTION

Energy harvesting is seen as a key long-term technology to power the billion devices in the emerging IoT, since batteries alone are too limited, expensive and require too much maintenance. To efficiently integrate energy harvesting techniques, system designers need to address both hardware and software issues, since dimensioning energy buffers depends on both. Measurements are an important tool for prototyping and characterizing these new energy harvesting applications at several steps in the design process. Profiling the used energy harvesting source is necessary for simulating early design. Measurements on first prototypes characterize application performance and energy requirements, and finally, in-situ measurements are required for evaluation and validation of first real-world deployments.

Commonly used low power architectures support several power states to save energy, drawing nanoamperes in sleep state and up to hundreds of milliamperes in active state. Characterizing these systems is challenging, because current measurement devices need to be accurate over a large dynamic range of eight orders of magnitude or more. Moreover, novel energy harvesting applications that rely on devices embedded into the environment, e.g. smart buildings, demand for portable data loggers for in-situ characterization of their energy harvesting sources. Similarly, characterization and evaluation of wearable devices such as smartwatches require portable measurement equipment.

To best of our knowledge, none of today’s data logger provides all of these features. While existing solutions focus on a subset of these new requirements, they lack ultra-low current measurement in the nanoampere range [1, 2, 3], do not feature the desired dynamic range from below micro-amp to hundreds of milliamperes [2, 4, 5, 6], or do not target portable measurements with remote control [3, 5].

To address the needs of system-level designers, we propose a new data logger design. The RocketLogger not only features a very large dynamic current measurement range of more than 165 dB, but at the same time has a small form factor suitable for mobile measurement and provides remote data acquisition control.

2. ARCHITECTURE

The RocketLogger is based on the BeagleBone Black and consists of two parts: an analog measurement front-end extension including seamless auto-ranging and the software for acquisition management and control. The most relevant performance metrics of the RocketLogger are summarized in Table 1.

Analog Measurement Front-End. Low power techniques have greatly increased the power range between an active device and one in a sleep state, currently up to eight orders of magnitude. No single measurement circuit can
3. DEMONSTRATION

To demonstrate the low current measurement capabilities of the RocketLogger, the software stack of the RocketLogger is responsible for initiating, controlling, and observing the analog-to-digital converters (ADC) and processing their conversion results. To process the large amount of data up to 10.8 GB per hour in real-time, the very small voltage drop that gets lost in the measurement noise.

The RocketLogger system for wireless sensor networks includes the low-current measurement and high-current measurement. The fast transition between sleep and active states and the more seamless auto-ranging and the small size or small make the combination of high-bandwidth and low-cost measurement instrument makes the RocketLogger a versatile measurement instrument for prototyping harvest-powered IoT devices.

4. ACKNOWLEDGEMENTS

This work is supported by the Sierra National Science Foundation under grant 10-08-03. The fast and seamless auto-ranging and the small size or small make the combination of high-bandwidth and low-cost measurement instrument makes the RocketLogger a versatile measurement instrument for prototyping harvest-powered IoT devices.

5. REFERENCES


Table 1: Performance Characteristics of the RocketLogger

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage</th>
<th>Current</th>
<th>Noise Low Current Range</th>
<th>Noise High Current Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMU</td>
<td>5 V</td>
<td>0.1 A</td>
<td>27 nV</td>
<td>10 pA</td>
</tr>
<tr>
<td>Blinky</td>
<td>5 V</td>
<td>1 A</td>
<td>100 nV</td>
<td>10 nA</td>
</tr>
<tr>
<td>Node</td>
<td>5 V</td>
<td>1 A</td>
<td>100 nV</td>
<td>10 nA</td>
</tr>
<tr>
<td>Ethernet/WiFi</td>
<td>5 V</td>
<td>1 A</td>
<td>100 nV</td>
<td>10 nA</td>
</tr>
</tbody>
</table>

Figure 2: The energy harvesting setup to demonstrate the RocketLogger's low-current measurement and range-switching capabilities. A shunt resistor-based circuit either results in an intolerable high burden voltage in the high current region or a tiny voltage drop that gets lost in the measurement noise. A feedback ammeter based circuit for low current measurements, but they saturate at high currents and are out of range and create an uncontrolled burden voltage. Combining two circuits to cover the full measurement range of more than eight orders of magnitude results in the switching time is seamless auto-ranging and the small size or small make the combination of high-bandwidth and low-cost measurement instrument makes the RocketLogger a versatile measurement instrument for prototyping harvest-powered IoT devices.