Abstract #134, 223rd ECS Meeting, © 2013 The Electrochemical Society

Battery-aware Design for Wireless Sensing Systems

Y. Zhang and J. N. Harb*

Department of Chemical Engineering
Brigham Young University, Provo, Utah 84602

**Corresponding Author: john_harb@byu.edu*

Prolonging the operating life of battery-powered wireless systems (WS) is a principal objective in the design of wireless sensing systems and networks. There is a growing awareness that sensor duty cycles can greatly impact the amount of deliverable energy available from a battery [1-3]. "Battery-aware" or "battery-driven" system design incorporates an understanding of battery behavior into the design process, and promises further improvements in battery life beyond those achievable through conventional low-power design alone [4, 5]. Such design requires an understanding of the factors that control battery behavior in WS applications and a description of that behavior in a form that is usable for WS system design and optimization.

This paper describes our efforts to examine, model and optimize battery performance for sensor duty cycles consisting of multiple pulse discharges. The transient behavior of lithium coin cells, frequently used in wireless sensing systems, is examined during and following a discharge pulse, and described with a simple mathematical model. The voltage response during a pulse is characterized by a region of rapid change, associated with ohmic and interfacial resistances, followed by a region of slower change. A similar pattern was observed for relaxation between pulses. Solid phase diffusion in the cathode was found to be the major contributor to the "slow" voltage change. A simple analytical model, validated for this system, was found to accurately describe the time-dependent voltage and the corresponding non-uniform concentration distribution for the porous electrode [6].

Pulse cycling tests were performed to evaluate the impact of key operating parameters including the peak current, standby current, pulse length, and standby period. Due to the small magnitude of the standby current, its influence on the operating voltage and battery capacity was negligible. In contrast, the pulse current had a significant impact on both the voltage and the maximum capacity that could be extracted from the battery. For each pulse length studied, the battery capacity increased with increasing standby time until a maximum was reached, corresponding to full relaxation between pulses (Fig. 1). In situations of incomplete relaxation, the voltage behavior was the result of both a background concentration gradient and the relaxation of the concentration gradient caused by the discharge pulse. The results and methods from this study will help to enable battery-aware design for WS systems.

References

1. C. Park, K. Lahiri, A. Raghunathan, IEEE SECON 2005 Proceedings 430-440.
2. C. Chau, F. Qin, S. Sayed, M.H. Wahab, Y. Yang, IEEE Journal on Selected Areas in Communications 28 (2010) 1222-1232.
3. C.F. Chiasserini, R.R. Rao, Proc. of Mobicom'99, Seattle, 1999, 88-95.
4. K. Lahiri, A. Raghunathan, S. Dey, and D. Panigrahi, Proc. ASPDAC/Int. Conf. VLSI Design, 2002, 261–267.
5. R. Rao, S. Vrudhula, and D. Rakhmatov, Battery Models for Energy Aware System Design, IEEE Computer, 36 (2003) 1019–1030
6. Y. Zhang and J.N. Harb, submitted to J. Power Sources (2012).

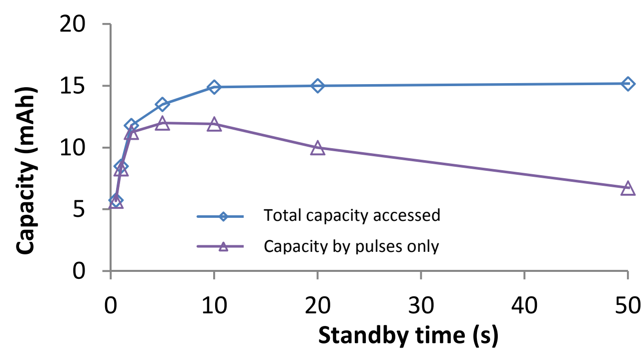

Figure 1. Impact of standby time on accessible capacity during pulse discharge.