Reconfigurable Battery System for
Power Management in Mobile Applications

Introduction

In order to satisfy the increasing power demands of mobile electronics, engineers have placed considerable effort into designing low-power circuitry to offset the increasing number of features and components in the device. While most of the work has been placed into efficient power consumption, there has been very little investigation into efficient power dissipation from the battery. Nearly all mobile devices run off a single battery-source system, whether it be a lone battery or a series combination of batteries. Removing the constraint of using all the batteries simultaneously in a fixed configuration allows a new opportunity to increase the efficiency of power supply from batteries.

A reconfigurable battery system takes an aggressive approach by selecting which batteries to drain and in which configuration (i.e. parallel, serial). This type of system can take advantage of battery properties that a fixed configuration cannot. For instance, batteries in this system can be used periodically to allow the recovery effect to take place which reattaches chemical bonds and in turn extends the battery life as can be seen in figure 1. When the device draws higher current, multiple batteries can be placed in parallel to reduce the discharge on a single battery, which increases the drained capacity of the battery as shown in figure 2. Using these schemes will greatly increase the percentage capacity of the battery that is drained and thus extend battery life for the device.

Figure 1 Recovery Effect[1]

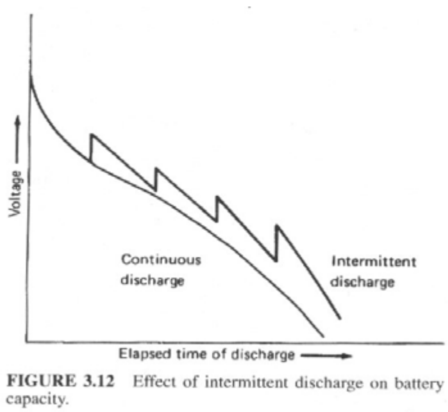
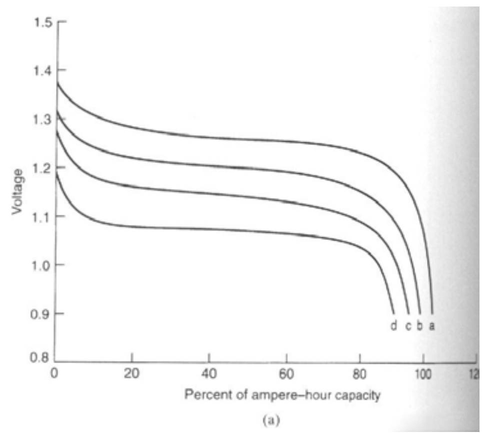


Figure 2 Decreased Discharge Rate[1]



Problem Statement

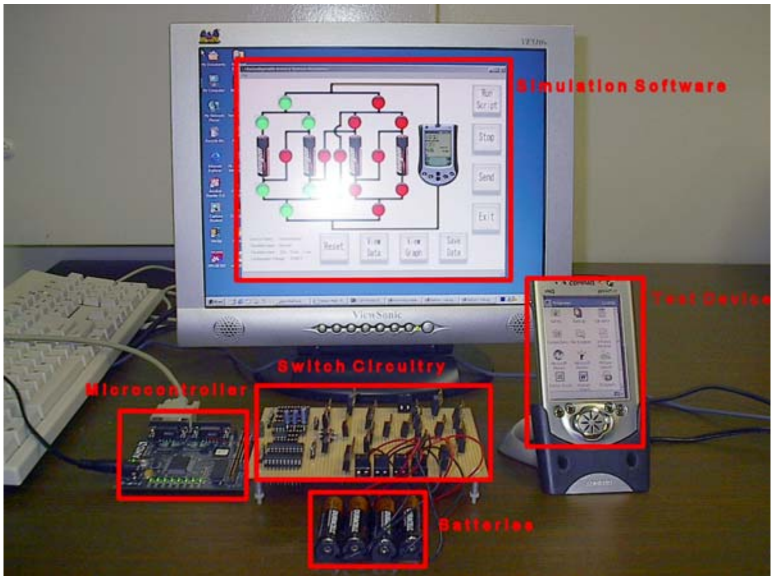
This projects aims to find the optimal power scheduling of four batteries in multiple configurations, including serial, parallel, and many combinations of the two, to fully discharge the capacity of the battery and thus extend the operating time of a mobile device.

The work will further continue by building an automated system for power scheduling and battery reconfigurations. The battery system will be self-containing and running in the background so that the user, and even the device itself, will need not be aware of its presence.

Current Work

1 LINDEN, D. 1995. *Handbook of Batteries*. McGraw-Hill, New York.

Figure 3 Current Work



A prototype board as shown above in Figure 3 has been created along with a user interface to the PC to control the switches as well as gather battery data. The current setup can reconfigure the battery into many formations including single/double/triple/quadruple batteries, parallel, serial, and countless combinations of the three. The user interface on the PC can change configurations as well as save voltage and current data through manually pressing the buttons or reading a script and executing time-driven events. The system is very close to start simulations on draining batteries on a PocketPC.

Proposed Work

The first step in the project is to run simulations on the existing prototype board. Battery types including Nickel-Metal Hydride and Lithium-Ion as well as various handheld electronics such as PocketPCs, Palm Pilots, and digital cameras will be used for the simulation to measure the power improvements in a wide arena of applications.

Once the simulation data supports a level of appreciable battery life improvement, a major revision of the prototype board will be designed with automation in mind. A microcontroller will be used to control the switches and implement the optimum power scheduling found in simulations.

The system must also be designed with power consumption two orders of magnitude less than the main device so that any battery life gains from the system will not be countered by power loss from this additional overhead circuitry. At the same time, cost and size must be kept at a minimum to ensure the technology will become commercially viable. The Texas Instrument MSP430 microcontroller is an excellent choice that can satisfy all the constraints of the system. The SBSIM430 IDE software will also be required to program that particular microcontroller.

The revised board will be reconstructed on a printed circuit board (PCB) layout by a vendor such as ExpressPCB to render a more robust and portable system that can be more easily integrated into devices. The system at this point can be "fine-tuned" in software for various devices and batteries.

Project Schedule

First Quarter

Week	Activities
1 - 4	Undergo simulations on various batteries and devices
5	Formalize optimal power schemes
6 - 10	Design revised battery system board

Second Quarter

Week	Activities
1	Submit PCB layout for manufacturing
2	Assemble battery system on PCB boards
3 - 6	Test performance of boards on various batteries and devices
7 - 10	Prepare system and documentation for publication

Budget Justification

The first half of the project is devoted to simulations on various batteries and mobile devices. This will use the iPaq PocketPC initially but will also venture into other devices such as the Palm Tungsten E mentioned in the budget. This will ensure that the results are not limited to a single device but can be demonstrated on a variety of devices. Some additional iPaq batteries will be needed so that multiple batteries are drained in simulation which is the essence of the whole project. The batteries will in fact not be limited to iPaq simulations but will be used for other devices such as the Palm Pilot and later a digital camera. The simulations will include Lithium-Ion batteries but will also test out Ni-MH and Alkaline batteries as shown in the budget. Instead of purchasing multiple battery chargers for these various battery compositions, it would be convenient to use a single universal battery charger that will charge all the various batteries.

In the second half of the project, a major revision of the prototype board will require a development kit for the new microcontroller unit. The Texas Instruments MSP430 is an inexpensive yet powerful solution. The ES1232 MSP430 hardware along with the SBSIM430 software development kit will be necessary to develop the new board. Once the design is complete, a printed circuit board will be constructed from a vendor such as ExpressPCB. The boards will mainly consist of the microcontroller mentioned above, International Rectifier MOSFETs, and some other components. All of these parts have been mentioned in the budget.

Proposed Budget

Item	Cost
ES1232 Evaluation System MSP430 microcontroller	200.00
Palm Tungsten E	200.00
2 iPaq Batteries- Part # DLP305590-01	104.00
4 Prototype ExpressPCB boards	119.00
SBSIM430 IDE software development tool	100.00
MH-C777PLUS-II Universal Battery Charger	90.00
30 International Rectifier HEXFET Power MOSFETs	69.00

Item	Cost
Miscellaneous PCB components	30.00
20 Alkaline AA batteries	20.00
Rechargeable Ni-MH AA batteries	12.00
Total	$944.00