Reliable Flash-Backed Cache Using UltraCaps

Lane Hauck
Sr Member of Technical Staff
AgigA Tech, Inc
Agenda

- NV cache methods
  - Battery-Backed DRAM
  - NAND Flash (NF)-backed DRAM
- New power source: UltraCaps
  - How they work (+Demo)
  - Test Data
- In-System Advantages
  - Ultracap charge/discharge curves
  - Unmanaged NF
- Summary
Battery-Backed RAM and Flash-Backed RAM

Battery-Backed

NF-Backed
Capacitor Evolution

0.001 Farad

33,000X Capacitance

~4X Volume...

33 Farad

How is this possible?
Standard Capacitor

\[ C \propto \frac{A}{d} \]
Electrochemical Double-Layer Capacitor (UltraCap)

\[ C \propto \frac{A}{d} \]

- Electrolyte
- Activated Charcoal
- Electrode

\[ d = 1-5 \text{ nM} \]

\[ A = 1\text{K}-2\text{K m}^2/\text{g} \]
UltraCap Reliability Testing

Santa Clara, CA
August 2010
UltraCap Charge/Discharge Cycles

Cycles at elevated temp & voltage

Capacitance

Data Sheet Value

Best of the lot

Worst of the lot

Required Capacitance

Source: AgigA Tech

Santa Clara, CA
August 2010
UltraCap Charge/Discharge Cycles

Cycles at elevated temp & voltage

Data Sheet Value

Best of the lot

Worst of the lot

Required Capacitance

Capacitance

Battery

Source: AgigA Tech

Santa Clara, CA
August 2010
All data taken at same elevated temp, well above spec limit.
In-System PowerGEM™ Energy Measurement

Backup Time = 10 sec.

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Design Tradeoffs

9W*23 sec = 207J

- Architectural Changes
- Backup Time
- Smaller Caps

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Reliability: How Much Energy?

Voltage

\[ \frac{1}{2}CV^2_{\text{START}} \]

Extracted Energy

\[ \frac{1}{2}CV^2_{\text{NOW}} \]

Time

\[ \text{Capacitor} \]

\[ \text{Battery} \]
Other Reliability Issues For Flash-Backed Cache Systems

• **Unmanaged Flash Has Advantages**
  • Low-level visibility can give early warning
  • Wear tracking can be made available to host
  • Trending over service lifetime

• **UltraCap-powered system remains powered when host loses power**
  • Safety Interlock Signals
    • Host can glitch signals during power up/down
    • Qualifiers (Enables) require normally-operating host
  • Complex system readiness reduced to single GTG (Good To Go) signal
    • Multiple readiness factors readable over I²C registers
NF-backed SDRAMS make excellent reliable power-loss protected caches
- High densities, e.g. 1GB-8GB

UltraCaps are ideally suited to this application

UltraCaps wear, but not a system issue if properly selected, sized and rated

Fine control over system “internals” like managing the NF allows precise health monitoring and tracking

Special attention is required to operate a powered system while its “master” loses power