BritePower™ SSD - Faster, Safer, Longer

Supercapacitors in Solid State Drives

March, 2009

SSDs are the Next Big Thing

- Solid State Drives (SSDs) are a growing presence in data storage markets because they offer:
  - Plug & play compatibility with HDDs (form factor, interface,++)
  - Faster access, read & write speeds > more IOPS than HDDs
  - More rugged & durable (shock, vibration, temperature)
  - More reliable over a longer operational life (no moving parts)
  - Lower power consumption, quieter & cooler than HDDs
- Which in turn, delivers a lower total cost of ownership:
  - lower maintenance costs
  - higher productivity
  - less redundancy requirements
  - longer operational life
  - lower power consumption, etc.

SSDs Use NAND Flash Memory

NAND flash memory has some limitations:

- **Because**
  - Blocks must be erased before a page can be programmed, and
  - Erase performance & block utilization degrades with use, and
  - Write speed decreases as density increases (MLC<<SLC)…
- **Data transfer speed exceeds flash write speed**

- **Because**
  - Data retention decreases with use (bit degradation), and
  - Flash cells have a limited erase/write cycle life (endurance), and
  - Endurance decreases as density increases (MLC<<SLC)…
- **Wear leveling & error correction algorithms are essential to SSD performance, reliability & life**

Impact on SSD Design

Because data transfer speed exceeds flash write speed…

- SSD write performance will benefit from a data cache
  - The designer has 3 options:
    1. No cache (poor write performance - limited to flash write speed)
    2. Unprotected cache (better write speed, but cache can be lost)
    3. Protected cache (cache is saved to flash memory at power down)

Because metadata* requires many writes for every file operation, and is growing with SSD capacity…

- SSDs need a large metadata cache
  - The designer has 3 options:
    1. Use flash memory (has integrity, capacity & endurance costs)
    2. Use a non-volatile cache (nvRAM has cost & scalability issues)
    3. Use a volatile cache (with a back-up power supply)

* Metadata includes information on wear leveling, error correction, translation tables, physical/logical address maps, erase counts, scratch pads, bad/free block lists, file allocation tables, and so on

SSD Design Options: Summary

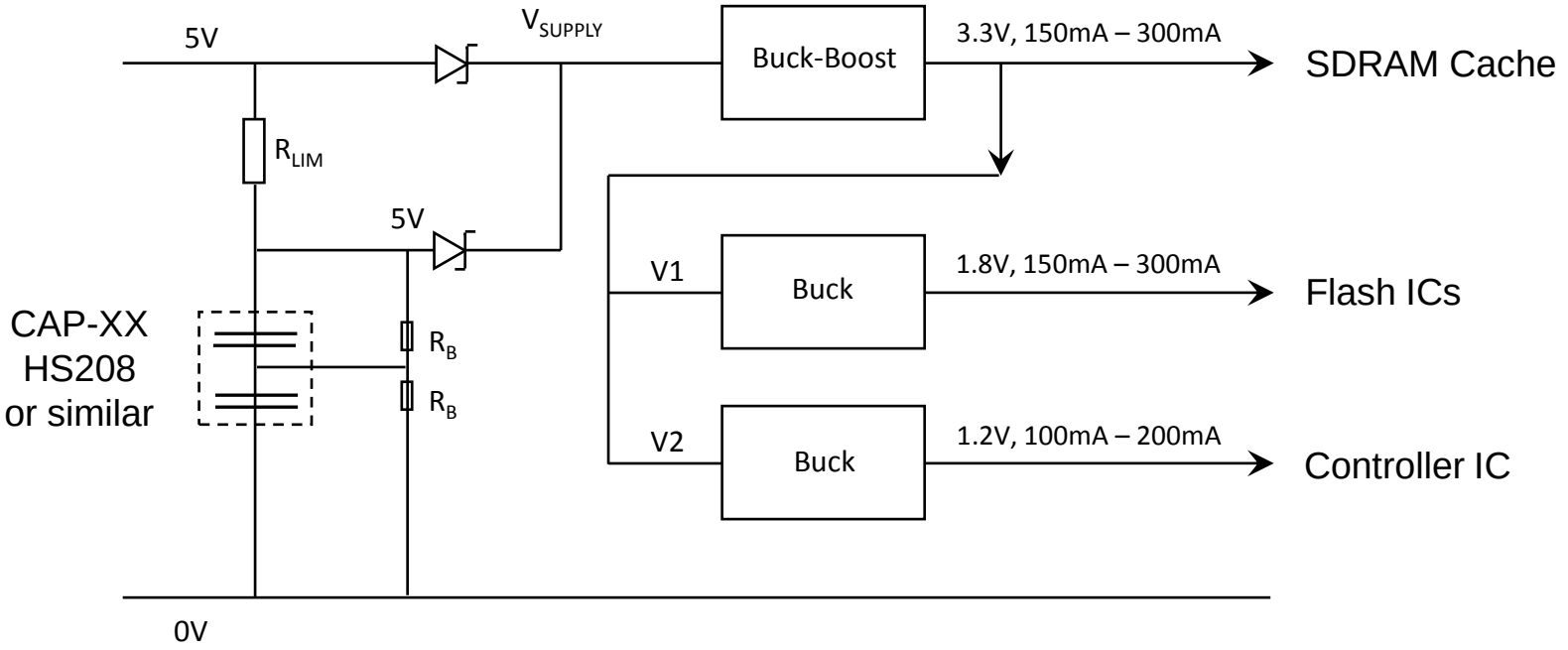
- No data cache:
  - Performance cost (lower write speed)
  - Integrity cost (lose latest metadata on power loss)
  - Capacity & endurance cost (metadata is stored in flash memory)
- Unprotected cache:
  - Performance benefit (faster write speed)
  - Integrity cost (lose data cache & latest metadata on power loss)
  - Capacity & endurance cost (metadata is stored in flash memory)
- Protected cache:
  - SDRAM with a supercap providing a back-up power supply
  - Performance benefit (faster write speed)
  - Integrity benefit (data cache & latest metadata is protected)
  - Capacity & endurance benefit (metadata is stored in cache)

Why use CAP-XX?

- CAP-XX supercapacitors offer:
  - **Thin, flat & small prismatic package** (cf. batteries & can supercaps)
  - **High energy** (up to 1.8F for longer write times after power loss)
  - **High power** (minimizes voltage droop & supports high currents)
  - **High cell voltage** (increases headroom for longer hold-up times)
  - **Long life** (low rate of C loss & >100K charge/discharge cycles)
  - **Excellent low temperature operation** (unlike batteries)
  - **High temperature rating** (85 C, better than batteries & can supercaps)
  - **Environmentally friendly** (RoHS, WEEE, no hazardous materials)

A high initial C, high voltage/cell & high temperature rating means CAP-XX supercaps offer a longer operational life & greater reliability in a thin, flat small package ideal for SSDs

SSD Backup Power Supply



This diagram illustrates a simple design for power backup in an SSD using a supercapacitor.
The NAND flash is typically powered at 1.8V (sometimes 3.3V), SDRAM at 3.3V & the controller at ~1.2V (sometimes 3.3V or 1.8V). Load currents & backup duration depend on the size of the SSD & cache. Typically, a 5V supply is available.
RLIM protects the 5V supply from the supercapacitor in-rush current. Over-voltage protection is not required with a CAP-XX H series supercapacitor. If RLIM = 5Ω, maximum in-rush current = 1A & it will take ~4.5s to charge the supercap. Using a buck-boost for the 3.3V rail allows the supercapacitor to discharge to the minimum input voltage of the converter. This will support the SSD for longer, enabling safe storage of a greater amount of cached data.

SSD Power Management

- Key questions on SSD power architecture:
  - What is the source voltage?
    - USB, PCI, etc.
    - LDO or Buck? Current limit? Voltage good?
  - What's the Max & Min supply voltage & current for the
    - SSD controller?
    - SDRAM cache?
    - NAND flash memory?
    - Buck-boost vs LDO/Buck to loads
  - What back-up duration is required?
  - What is the form factor / SSD capacity / SDRAM capacity?
  - What realistic operating conditions are expected?
  - What is the target operational life?

More about CAP-XX

What Supercapacitors Do

Supercapacitor functions

- **Secure power**

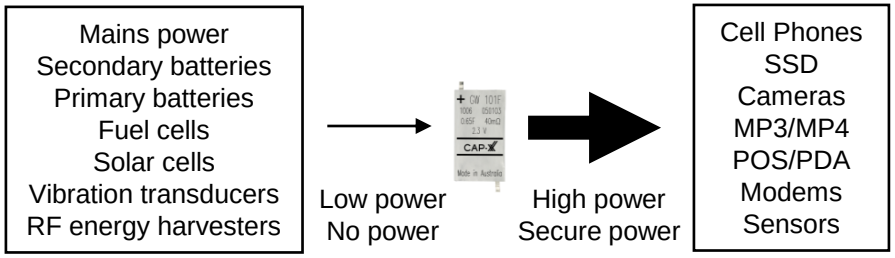
  Provides reliable interim power, even if the primary source fails or fluctuates

- **Energy storage**

  Stores energy from low power sources, enabling support for high power loads

- **Pulse power**

  Supplies peak power to the load while drawing average power from the source



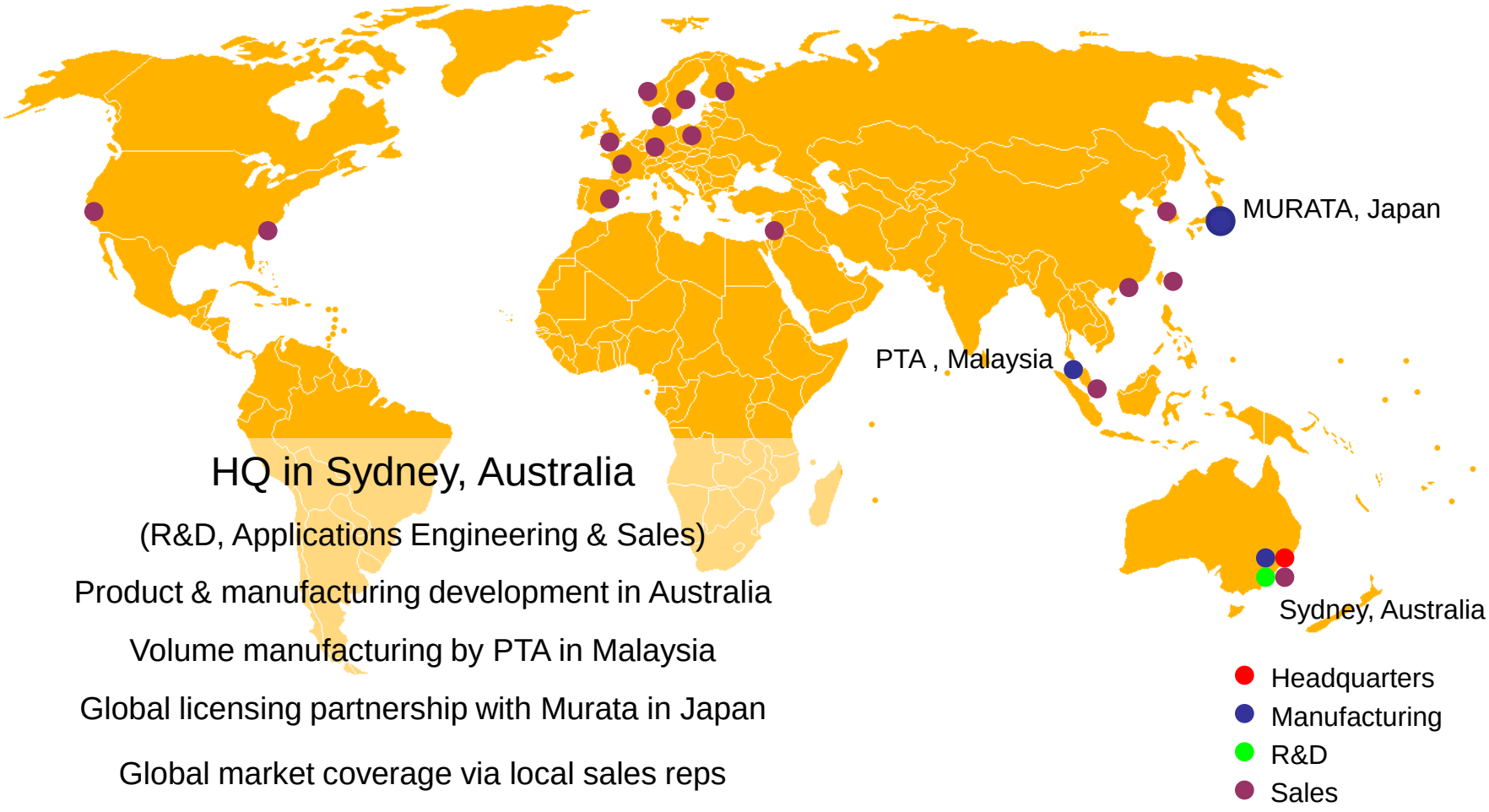
User benefits

- Reduces the size & weight of the battery / power source required
- Improves run-time & battery life, particularly at cold temperatures
- Enables more power-hungry features, being used more often
- Can remove the need for a battery & harvest energy from clean sources
- Protects against accidental power loss or fluctuations/interruptions
- Doesn't need to be replaced like batteries (unlimited discharge cycles)
- Environmentally friendly & safe

Major Applications

- **BritePower™**
  - Secure power solutions for SSDs, ruggedized PDAs, handheld POS terminals, wireless data loggers, condition monitors, location trackers, automated metering, etc.
  - Energy storage & power support solutions for renewable & recaptured energy
  - Pulse power solutions for wireless modems & other high current applications such as LED flash, electronic locks, GPS, etc.
- **BriteFlash™**
  - Driving high power LED flash for high quality images in digital cameras & phones
- **BriteSound™**
  - Peak power support in portable audio

Global Presence



HQ in Sydney, Australia

(R&D, Applications Engineering & Sales)

Product & manufacturing development in Australia

Volume manufacturing by PTA in Malaysia

Global licensing partnership with Murata in Japan

Global market coverage via local sales reps

Quality Standards

- Certifications achieved
  - ISO 9001
  - Sony Green Partner
- Compliances established
  - Full MSDS available under NDA
  - RoHS & WEEE compliant
  - Lead free, organo-halogen free, bromine free
  - Sony Ericsson Design for Environment requirements
  - Motorola Restricted Substances list
- Ongoing Approvals
  - Nokia Global Supplier requirements
  - Samsung CST component approval

Reliability

Reliability tests to international standards available for:

- Vibration
- Mechanical shock (acceleration)
- Thermal shock
- Temperature cycling
- High temperature
- Low temperature
- Humidity

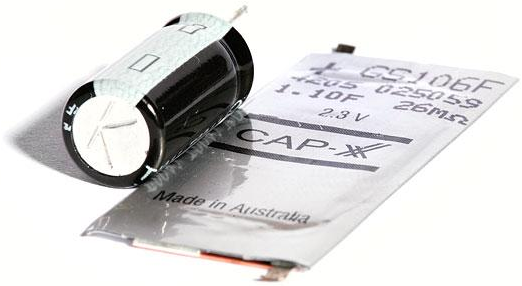
Safety

Safety tests to international standards available for:

- Flammability
- Over-heating
- Compression
- Puncture

CAP-XX supercapacitors are completely safe

- Do not burn (no fire risk)
- Do not explode
- Can be over-charged or over-heated with no dangerous outcome
- Self protecting: fails open-circuit if abused



CAP-XX

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