Endurance Stretching Flash Memory With Serial SRAM

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Agenda

- Example Application & Requirements
- Flash Memory
  - Both limits & increases endurance
- Application Solutions
  - High-Endurance Flash
  - Serial SRAM & Flash Hybrid
  - Serial NVSRAM
- Conclusion
Example High-Endurance Application

- Smart Meter
  - 60 Hz sample rate
    - 24-bit samples
  - Average usage
    - Definable time block average
    - Definable duration moving average

- Storage worst case
  - 512 Kb of non-volatile storage
  - Rewritten every 5 minutes for 25 years
  - Endurance of 2,629,800 program/erase cycles/bit
High-Endurance Flash Memory Solution
Flash Memory Endurance

- Flash memory has finite endurance
  - NOR 100,000+ cycles, typical

- Trap generation in oxide
  - Accumulation limits endurance

- Stress-induced leakage limits endurance
  - Note: Split-gate SuperFlash® memory has greater immunity
Memory-cell endurance can be increased by:

- Longer delay between writes
  - Allows trapped charge to relax
- Temperature
  - High temperatures accelerate charge relaxation
- Data variance
  - Repeated writes of same data causes higher wear
  - ‘1’ no charge transfer, thus less wear
High-Endurance Flash Solution

- Higher density Flash to achieve higher endurance
- Wear leveling
  - Partition the Flash
  - Cycle through the partitions
  - Need to manage partitions
    - Store which is current partition
High-Endurance Flash Solution, Cont.

- 16 Mbit NOR Flash
  - Flash endurance 100,000 cycles
  - Required endurance of 2,629,800 cycles
    - Wear leveling across 27 partitions
      - Each 512 Kb
  - 2.5 Mbit available for partition management & other storage
  - Flash offers low cost/bit nonvolatile storage
    - NOR offers high reliability
Hybrid Memory Solution
Hybrid Memory Solution

- 2-chip solution
- SRAM & Flash
  - SRAM for endurance
  - Flash for NV storage

- SRAM is volatile memory
  - Power-up: Load SRAM from Flash
  - Modify individual bytes in SRAM
  - Power-down: Copy SRAM data to Flash
  - Power-down
    - Detect loss of power, low voltage
      - Must store to Flash before brown-out
Hybrid Memory Solution, Cont.

- **Serial vs. Parallel SRAM**
  - SRAM traditionally Parallel
  - Flash is migrating to Serial

- **Serial SRAM**
  - Supports SPI, SDI & SQI™ buses
  - Shared bus with Flash
  - SQI allows 80 Mbps reads on power-down
  - Small 8-pin packages
  - Low cost
• Required application endurance
  • 512 Kb of storage
  • 2,629,800 writes to every bit

• 512 Kb SRAM & 512 Kb Flash
  • Flash program cycle per power down
  • Application endurance 100,000 power downs

• Must detect power-down and store
  • Loss of AC signal
  • Low voltage on supply
NVSRAM Memory Solution
NVSRAM Solution

• Non-Volatile SRAM (NVSRAM)
  • Unlimited endurance & non-volatile
    ▪ Battery back-up
      ▪ Preserves data when system unpowered
    ▪ Byte level modifiable
    ▪ Immediate read/writes to NV storage
NVSRAM Solution, Cont.

• Using NVSRAM
  ▪ Parallel & Serial NVSRAM
    ▪ Legacy Parallel NVSRAM
      ▪ Many control signals
      ▪ Highest speeds
    ▪ Serial NVSRAM
      ▪ Standard SPI interface
      ▪ SDI for higher speeds
      ▪ Long battery life*
      ▪ Low cost

*CR2032 battery with <1 µA max. current draw. Life limited by battery 10-year warranty
NVSRAM Solution, Cont.

• NVSRAM has no endurance limit
  • 512 Kb NVSRAM for storage requirement

• Back-up Battery
  • Low current draw
  • Handling of data loss on battery failure
  • Increased component count
    • Could share battery with RTCC
Conclusion

- Can meet High-Endurance NV requirements by:
  - Partitioning Flash and wear leveling
  - Buffering the data in a SRAM device
  - Using a battery-backed NVSRAM

- Serial SRAM & NVSRAM
  - Compatible with common Serial Flash interfaces
    - Minimizes signals and pins
  - Small packages and simple design
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