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

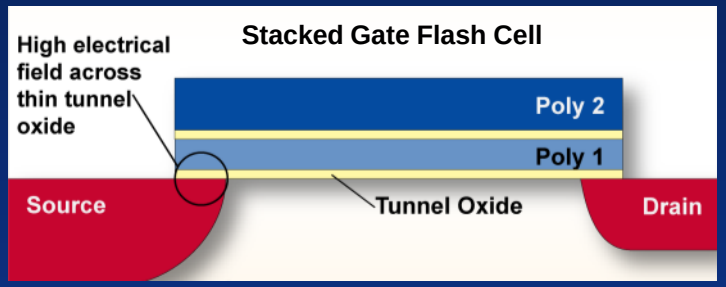
Example High-Endurance Application

- 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

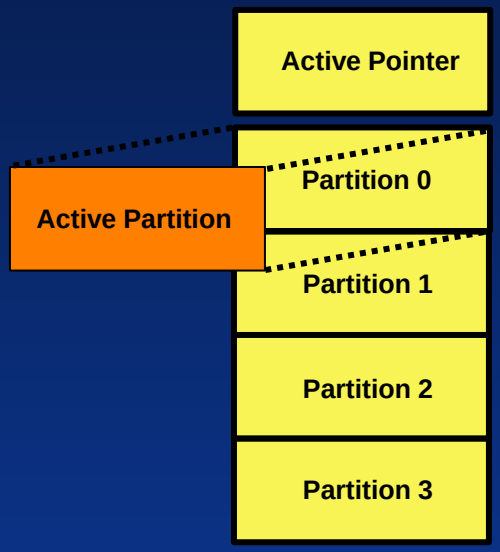
Flash Memory Endurance, Cont.

- 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

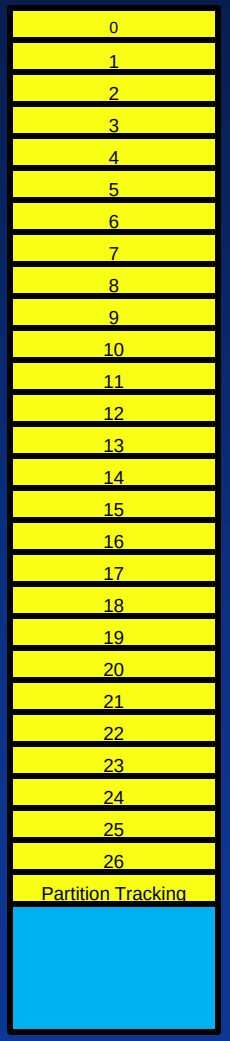
- Higher density Flash to achieve higher endurance

- Wear leveling
  - Partition the Flash
  - Cycle through the partitions
  - Need to manage partitions
    - Store which is current partition



High-Endurance Flash Solution, Cont.

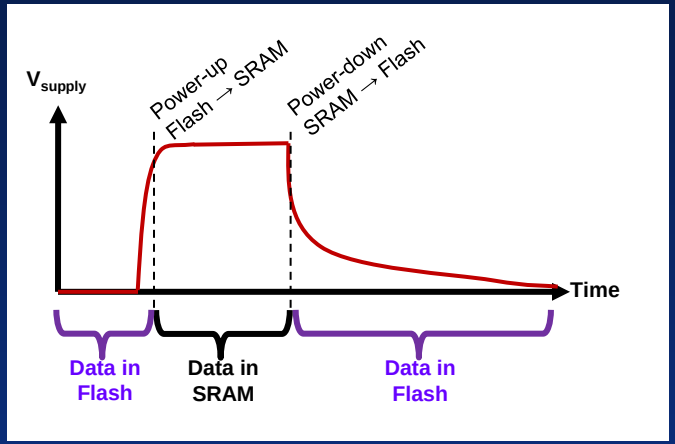
- 16 Mbit NOR Flash
  - Flash endurance 100,000 cycles
  - Required endurance of 2,629,800 cycles
    - Wear leveling across 27 partitions
      - Each 512 Kb
    - 2.5 Mbit available for partition management & other storage
  - Flash offers low cost/bit nonvolatile storage
    - NOR offers high reliability



Hybrid Memory Solution

Hybrid Memory Solution

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

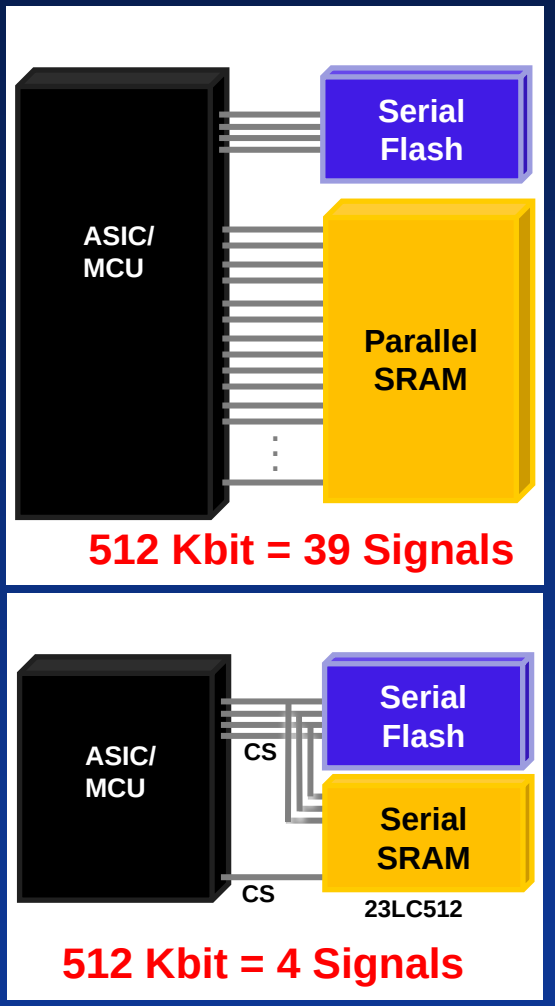


- SRAM is volatile memory
  - Power-up: Load SRAM from Flash
  - Modify individual bytes in SRAM
  - Power-down: Copy SRAM data to Flash
  - Power down
    - Detect loss of power, low voltage
      - Must store to Flash before brown-out

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



Hybrid Memory Solution, Cont.

- 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

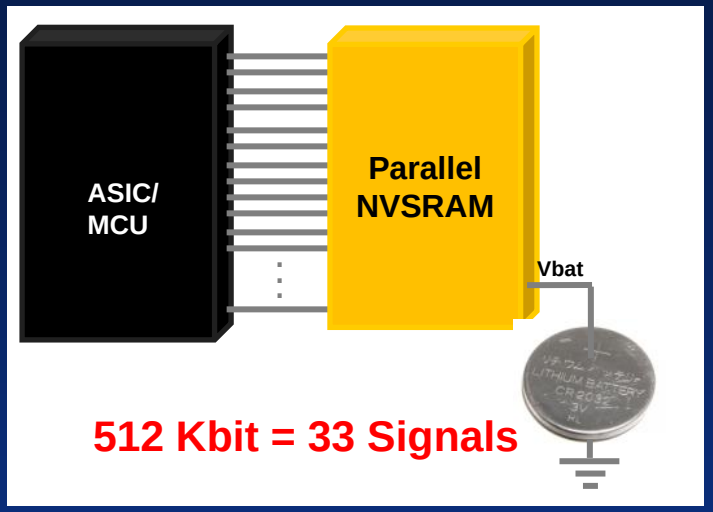
NVSRAM Memory Solution

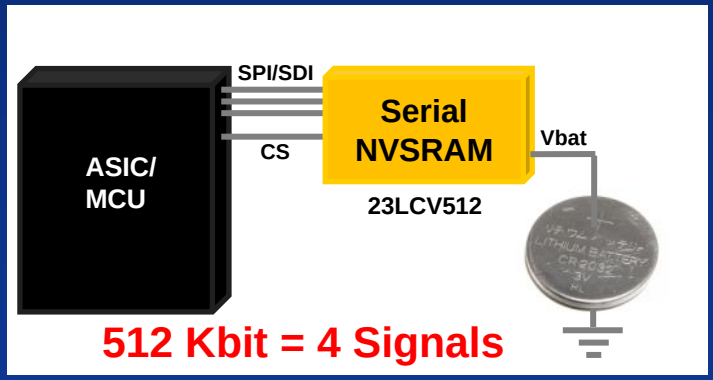
NVSRAM Solution

- 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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