Flash Memory Summit

Ultra Low Power for Consumer Wearables

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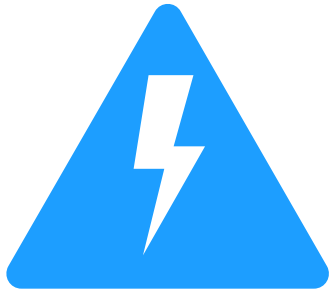
Garmin International

35 YEARS OF NAND FLASH MEMORY INNOVATION

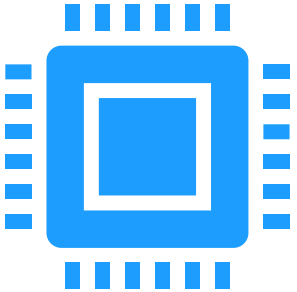
Garmin Wearables

Design Challenges - General

Wide variety of products



Power consumption is a very dynamic variable



Limited PCB space

Scenario – Watch Mode

Memory Usage

- Mostly idle and/or unpowered
- ~1 data access per second
- Data flush every 2-5 minutes

Power Consumption

150-200uW

Scenario – Activity Mode

Memory Usage

- Processor ‘Wakeups’
- RAM computations increase
- Frequent 1-2KiB reads and writes

Power Consumption

900-1000uW

Scenario – Music Mode

Memory Usage

- Large sequential reads
- Decoding, audio buffering

Power Consumption

2.5mW-3.5mW

Design Challenges – Low Power

- eMMC Power Efficiency
  - Power performance varies wildly between supplier and technology node
  - Observed up to 95mW (!!!) from some off-the-shelf solutions
- RAM Optimizations
  - Performing all hardware management computations in the external octal RAM led to excessive current consumption in certain conditions
  - Identified specific routines where running algorithms in SoC's internal RAM is more efficient
- NOR flash – Cost vs Power
  - Dedicated NOR flash for SoCs provide additional power optimization
    - adds cost and takes up physical board space

Design Challenges - Size

- Memory takes up most of the PCB
  - eMMC (11.5x13mm) is larger than all other components
  - Limits innovation/addition of new features
  - EMI shielding limits chip height to 0.8mm
- Low storage density requirements
  - Many products only need 4/8GB
    - 2D MLC NAND is challenging to design in smaller package
    - Longevity concerns
    - No options for 3D TLC other than moving up in density

Future Requirements

- Standard eMMC 153-ball in 11x10mm package or smaller
- 0.8mm maximum chip height
- 30% reduction in power consumption every process node/generation
  - 1.2/1.5V I/O support
- More WLCSP package options for non-volatile memory
  - Smaller footprint
  - Simpler pinout

