Serial NOR Flash Applications Drive Growth

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NOR Flash market is migrating from Parallel to Serial

- Serial revenue will grow from $1B in 2010 to ~$4B in 2017, while Parallel declines
- Revenue crossover in 2013, Units crossover in 2009 (2011 6B units ~2/3 Serial)
- Serial Flash replacing Parallel due to cost, space & pin-count advantages

† Source Web-Feet Research July 2012 & Winbond Marketing
* Forecast
### Why SPI?

<table>
<thead>
<tr>
<th></th>
<th>Parallel NOR Flash</th>
<th>Serial NOR Flash</th>
<th>SPI Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interface Pins</strong></td>
<td>28 to 44</td>
<td>4 to 6</td>
<td>Lower system cost</td>
</tr>
<tr>
<td><strong>Packaging</strong></td>
<td>48-56 pin TSOP</td>
<td>8-pin SOP, WSON,</td>
<td>Smaller, Lower cost</td>
</tr>
<tr>
<td></td>
<td>48-64 ball BGA</td>
<td>USON, WLBGA</td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>8/16/32-bit bus,</td>
<td>Quad SPI Speed</td>
<td>Comparable performance with fewer pins</td>
</tr>
<tr>
<td></td>
<td>Best Random Access</td>
<td>Comparable to PF for Fast Boot &amp; XIP</td>
<td></td>
</tr>
<tr>
<td><strong>Architecture</strong></td>
<td>128KB Sector erase</td>
<td>4KB Sector erase</td>
<td>PC Requirement, Efficient memory usage</td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>4Mb to 2Gb</td>
<td>512Kb to 2Gb</td>
<td>Serial Flash has caught up</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>110nm, 90nm, 75nm,</td>
<td>110nm, 90nm, 75nm,</td>
<td>Advanced technologies for Serial Flash</td>
</tr>
<tr>
<td></td>
<td>65nm, 45nm</td>
<td>65nm, 58nm</td>
<td>= Smaller Packages</td>
</tr>
</tbody>
</table>
Flash Memory Applications

**PC-Related**
- Desktop, Notebook, Server
- Optical Disk Drives
- Hard Disk Drives
- LCD Monitors
- Printers

**Communications**
- DSL and Cable Modems
- Router & Switches
- Wireless LAN, M2M
- Bluetooth, GPS, Mobile Phones

**Consumer**
- LCD & Digital TV, Tablets
- DVD Player & Recorders
- Set Top Box, Cordless Phone
- Electronic Toys/Games
- Digital Cameras, Appliances

**Automotive/Industrial**
- Infotainment, Driver Assist
- Instrument Cluster, Camera
- Telematics, Digital Radio
- Smart Meters, Smart Grid

*Aug. 2012*
Application Trends for Serial Flash

Optical Disk Drive (ODD) Serial Flash Evolution Example:
- Early designs used Controller + Parallel Flash + DRAM on a PCB
- To reduce cost and space, designs moved to Serial and eventually to System In Package (SIP) 2-Chip or 3-Chip solutions with Known Good Die (KGD)
- This trend is very similar for other applications like Mobile Phones
### Quad SPI & QPI Performance

<table>
<thead>
<tr>
<th>Type</th>
<th>SPI Protocol</th>
<th>Number of Clocks</th>
<th>Command Overhead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fast Read Instruction</td>
<td>Instr.</td>
<td>Add.</td>
</tr>
<tr>
<td><strong>SPI</strong></td>
<td>Single I/O</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td><strong>Dual SPI</strong></td>
<td>Dual Output</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Dual I/O</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Quad SPI</strong></td>
<td>Quad Output</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Quad I/O</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Quad I/O</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td><strong>QPI</strong></td>
<td>QPI Read</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

* QPI allows programmable dummy clocks to adjust to performance required

- Number of clock cycles reducing, and performance increasing
  - QuadSPI and QPI (Quad Peripheral Interface) offer XIP (eXecute In Place) = Direct code execution – No need for DRAM or buffer memory
Space Efficient Packaging

Parallel Flash

Serial Flash

BGA24
8x6mm
(TC)=4x6

BGA24
8x6mm
(TB)=5x5

WSON8
8x6mm*
(ZE)

WSON8
6x5mm*
(ZP)

USON8
2x3mm*
(UX)

WLBGA8
1.4x2.4mm*
8Mb (BY)

WLBGA8
1.8x2.7mm*
16Mb (BY)

TSSOP8
173mil
(SD)

SOP8
150mil
(SN)

SOP8
208mil
(SS)

SOP16
300mil
(SF)

* <1mm thickness
Ultra-Small Form Factor Packages

- New USON & WLBGA (CSP) packages
  - <20% the size of popular Serial Flash packages like 8-pin SOIC and WSON
- Ideal for space constrained applications including
  - Mobile Phones, Tablets, GPS, M2M, WLAN, HDD, Bluetooth, MP3 & more

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Serial Flash has become a popular alternative to Parallel Flash as well as the solution of choice for emerging applications due to:

- Pin-count
- Space Efficiency
- System cost
- Chip cost
- Performance