PCle In Industrial Application

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Embedded Flash VP of innodisk
Agenda

- Flash Storage for Industrial Applications
- Generations of Storage Interface
  - IDE
  - SATA
  - Other Interfaces
- PCIe Interface & Form factor
- Summary
NAND Flash Process

<table>
<thead>
<tr>
<th>Year</th>
<th>Process (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>60</td>
</tr>
<tr>
<td>2007</td>
<td>50</td>
</tr>
<tr>
<td>2008</td>
<td>42</td>
</tr>
<tr>
<td>2009</td>
<td>34</td>
</tr>
<tr>
<td>2010</td>
<td>27</td>
</tr>
<tr>
<td>2011</td>
<td>24</td>
</tr>
<tr>
<td>2012</td>
<td>21</td>
</tr>
<tr>
<td>2013</td>
<td>19</td>
</tr>
<tr>
<td>2014</td>
<td>19</td>
</tr>
<tr>
<td>2015</td>
<td>15</td>
</tr>
</tbody>
</table>
**Flash Performance**

**High Speed Performance:**

**DDR2 Interface**

<table>
<thead>
<tr>
<th></th>
<th>ONFI 3.1/3.2</th>
<th>ONFI 4.0 Preliminary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDR</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>NV-DDR</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>NV-DDR2</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>50</strong></td>
<td>DDR-200</td>
<td>DDR-400 (3.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DDR-533 (3.2)</td>
</tr>
<tr>
<td><strong>1.8V/3.3V</strong></td>
<td>1.8V/3.3V*</td>
<td>1.8V, SSTL_18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2V (NV-DDR3)</td>
</tr>
</tbody>
</table>

Source by www.onfi.org
Performance

ONFI 3.2 NV-DDR2 Flash Performance

MLC Flash
16KB Page Performance*

533 MB/s
533 MB/s
533 MB/s
533 MB/s
164 MB/s

20 MB/s
41 MB/s
82 MB/s

Number of die per channel

*Maximum sequential performance assuming no controller overhead

SLC Flash
16KB Page Performance*

533 MB/s
533 MB/s
533 MB/s
291 MB/s
533 MB/s

73 MB/s
146 MB/s

Number of die per channel

*Maximum sequential performance assuming no controller overhead

Source by www.onfi.org
High-Speed Flash

The speed of Flash Interface is not a bottleneck anymore.

You can design a high speed SSD with the Flash that is currently available on the market. It’s time to move to the next-gen interface for SSDs.
# Flash For Industrial Applications

## SLC
High demand for devices under 2GB.
- Embedded OS drive
- Higher reliability
- Better lifespan

<table>
<thead>
<tr>
<th>Industrial PC</th>
<th>Gaming</th>
<th>Automation</th>
<th>Military Equipment</th>
</tr>
</thead>
</table>

## MLC
High demand for devices over 32GB.
- Application data drive
- Higher SSD capacity
- Cost-driven orientation

| surveillance | POS | Networking | Digital Signage |
Many different interfaces are used for industrial applications.
All Interfaces Will Remain In Demand For A Few More Years.

Industrial products
- have a lifespan of more than 5 years.
- cover a large range of different applications.
- Small form factors are required due to limited space.
- SATA is the dominant interface currently.

What is next?
In 1999, SanDisk, Matsushita, and Toshiba agreed to develop and market the Secure Digital (SD) Memory Card.

Revision 1.0a was released on 7 January, 2003, offering 150MB/s and 1.5G.

In 2003, PCI-SIG introduced PCIe 1.0a, with a per-lane data rate of 250 MB/s and a transfer rate of 2.5G.
SSD Form Factor Evolution, 2006 – 2010

mSATA was announced by the SATA-IO on 21 September, 2009

SATA revision 2.0 - 3 Gbit/s - 300 MB/s.

2006

SATA revision 3.0 - 6 Gb/s - 600 MB/s.

2008

500MB/s, 5GT/s PCI-SIG announced the availability of the PCI Express Base 2.0 specification on 15 January 2007

2007

SATA Slim by JEDEC

2009

PCIE Gen 3, 1GB/s, 8GT/s announced

2009

2010
SSD Form Factor Evolution, 2011 & 2012

The Evolution Continues...

M.2 (NGFF) By Intel

2011

SATA Express on 2011

2012
# PCIe Interface

<table>
<thead>
<tr>
<th>Gen</th>
<th>Transfer Rate</th>
<th>Encoding</th>
<th>x1</th>
<th>x16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2.5GT/s</td>
<td>8b/10b</td>
<td>250MB/s</td>
<td>4GB/s</td>
</tr>
<tr>
<td>2.0</td>
<td>5.0GT/s</td>
<td>8b/10b</td>
<td>500MB/s</td>
<td>8GB/s</td>
</tr>
<tr>
<td>3.0</td>
<td>8.0GT/s</td>
<td>128b/130b</td>
<td>1GB/s</td>
<td>16GB/s</td>
</tr>
<tr>
<td>4.0</td>
<td>16GT/s</td>
<td></td>
<td>2GB/s</td>
<td>~32GB/s</td>
</tr>
</tbody>
</table>
## PCIe performance

<table>
<thead>
<tr>
<th>PCIe I/F</th>
<th>Gen 2 x 2 or Gen 3 x 1</th>
<th>Gen 2 x 4 or Gen 3 x 2</th>
<th>Gen 3 x 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theoretical Speed</strong></td>
<td>1GB/s</td>
<td>2GB/s</td>
<td>4GB/s</td>
</tr>
<tr>
<td><strong>SSD Real Speed</strong></td>
<td>800~900 MB/s</td>
<td>1600~1800 MB/s</td>
<td>3200~3600 MB/s</td>
</tr>
</tbody>
</table>
PCIe Form Factor

Mini PCIe
- 52-pin card edge type connector

PCI Express 3.0 x2; 2GB/s
- SATA Express

Server
- Enterprise serviceability

PCI Express 3.0 x4; 4GB/s
- SFF 8639

Ultrabook

PCIe SSD
- NGFF: 2242/2260/2280
- M.2

2.5” SATA III
- Up to 600 MB/s

2.5” SATA Express
- Up to 1GB/s (Gen 2)
- Up to 2GB/s (Gen 3)

2.5” SFF-8639
- Up to 2GB/s (Gen 2)
- Up to 4GB/s (Gen 3)
2.5” SSD Trend

2.5” SATA SSD
600MB/s (SATA III)

2.5” SATA Express
1GB/s (Gen2x2)
2GB/s (Gen3x2)

2.5” SFF-8639
2GB/s (Gen2x4)
4GB/s (Gen3x4)
SATA Express is designed for Desktop Applications

Source: https://www.sata-io.org/
Trend: SFF-8639 Connector (F2)

- Enterprise backplane connector for 2.5” storage connects PCIe, SATA*, and SAS* devices

- SFF-8639: Supports 6 lanes, but only 4 lanes are used at one time
  - PCIe: 4 red lanes on CPU PCIe lanes
  - SATA & SAS: 2 blue lanes on HBA/RAID controller or chipset

- Compatible with SATA and SAS devices
Over the years, module form factors and interface protocols have evolved and changed along with chipsets, but most industrial manufacturers are still using the miniPCIe form factor for various modules, including wireless devices, Bluetooth, some communication devices, and even for storage—mSATA.

The miniPCIe form factor is suited for space-constrained applications and swap-ability (swapping different miniPCIe modules could bring more benefit in flexibility of product matrix).
**Objective:**
Make three sockets available for Notebooks, Ultrabooks™ & Tablets

**Support Interfaces:** PCIe/USB/SDIO/UART/PCM/I2C/SATA

- **Socket 1:** Connectivity
- **Socket 2:** An SSD cache/WWAN / Other slot
- **Socket 3:** SSD high performance

**Socket 2:** PCIe x4 / SATA

**Socket 3:** PCIe x4 / SATA

**Socket 1:** PCIe x2 / SATA
## PCIe Interface SSD

![Flash Memory Summit Logo](image)

<table>
<thead>
<tr>
<th></th>
<th>Mini PCIe</th>
<th>M.2</th>
<th>SFF-8639</th>
<th>PCiE SSD(Card)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specification</strong></td>
<td>PCI-SIG</td>
<td>PCI-SIG M.2</td>
<td>SATA Express</td>
<td>SFF-8639</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>(L) 50.8mm, (W) 29.8mm, (H) 4.4mm</td>
<td>2280/22110, 2242/2260 mm</td>
<td>(L) 100.45 mm (W) 69.85 mm (H) 5/7mm</td>
<td>(L) 176.65mm (W) 111.15mm</td>
</tr>
<tr>
<td><strong>Speed(Gen3)</strong></td>
<td>1GT/s</td>
<td>1GTx4=4GT/s</td>
<td>1Gtx2=2GT/s</td>
<td>1GTx4=4GT/s</td>
</tr>
<tr>
<td><strong>Lanes</strong></td>
<td>1</td>
<td>1,2,4</td>
<td>1,2</td>
<td>1,2,4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2.5” SATA Express SSD</th>
<th>2.5” PCiE SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>(W) 69.85 mm (H) 7mm</td>
<td>(W) 111.15mm</td>
</tr>
<tr>
<td>Speed(Gen3)</td>
<td>1GTx4=4GT/s</td>
<td>1GTx16=16GT/s</td>
</tr>
</tbody>
</table>
Summary

More on the PCIe Interface:

• SFF-8639 will be 2.5” connector

• M.2 will become the next popular form factor for industrial application.

• SATA Express is designed for desktop PC now, and industrial field may use it in near future.

• PCIe SSD (Card) is still used for high IOPS server applications