ONFI 4.0: Faster I/O speeds at lower power consumption

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ONFI 4.0: Adopted April 2014

- Reduces I/O power consumption
  - Lower I/O voltage
  - Reduced termination requirements

- Increases I/O performance
  - Scale I/O speeds faster as NAND page sizes grow
  - Soft data requirements
  - Latency reduction

- Continues interoperability between vendors
  - Collaboration in JC42.4 ONFI/JEDEC Joint Task Group
ONFI Workgroup Continues To Produce Results!

<table>
<thead>
<tr>
<th>Major Revisions</th>
<th>ONFi 1.0: Standard electrical &amp; protocol interface, including base command set</th>
<th>ONFi 2.0: Defined a high speed DDR i/f, tripling the traditional NAND bus speed in common use</th>
<th>ONFi 2.x: Additional features and support for bus speeds up to 200 MB/s</th>
<th>EZ NAND / ONFi 2.3: Enabled ECC/management offload option</th>
<th>ONFi 3.0: Scaled high speed DDR i/f to 400 MT/s</th>
<th>ONFi 3.x: Scaled high speed DDR i/f to 533 MT/s</th>
<th>ONFi 4.0: Scaled high speed DDR i/f to 800 MT/s, Reduce VccQ support to 1.2V (NV-DDR3)</th>
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<tbody>
<tr>
<td>Speed</td>
<td>50 MB/s</td>
<td>133 MB/s</td>
<td>200 MB/s</td>
<td>400 MB/s</td>
<td>533 MB/s</td>
<td>800 MB/s</td>
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<tr>
<td>Industry</td>
<td>ONFi – JEDEC Collaboration</td>
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ONFI has and continues to deliver innovation & interoperability enabling faster NAND adoption
ONFI 4.0 Features

- **NV-DDR3:**
  - $V_{ccQ} = 1.2V$ (1.14V – 1.26V)
  - Evolutionary interface from NV-DDR2
    - Same packaging, Opcodes, timing diagrams/parameters, etc
    - All of the ONFI 3.x features will continue to be supported
      - Matrix Termination, CE reduction, Volume addressing, Differential signaling, VPP, External VrefQ, Warm Up cycles, etc…
    - Same output drive strength and RTT settings

- **Maximum I/O speeds increased**
  - 667 MT/s and 800 MT/s timing modes added

- **ZQ calibration supported**
  - $R_{ZQ} = 300$ ohms +/- 1%
  - Long (F9h) and Short (D9h) Calibration commands
ONFI 4.0 Differences

- Devices that support NV-DDR3 may not support VccQ = 3.3V
- NV-DDR3 Interface will not power up in SDR (i.e. Async)
  - SDR, NV-DDR, NV-DDR2 not supported at VccQ=1.2V
  - Agnostic READ ID will provide information on power on interface
- tADL and tCCS will push out due to larger page sizes and data path design requirements to achieve faster I/O speeds
- Electrical Package Specifications for Zpk and Tpd
  - Same methodology as DRAM DDR4
- Possible reduced Driver strength settings supported
ONFI 4.0 Performance

- Numbers are highly dependent on NAND/system architecture
  - Page size / number of LUNs
  - Number of planes
  - tPROG/tR
  - Programming Algo
  - Available System buffering

- SI highly dependent on a number of factors
  - Topology
  - Channel length
  - Package Zpk/Tpd
  - PCB Design
    - Impedance
    - Trace matching
  - Available drive strengths/RTT
  - RON/RTT variance
  - Controller overshoot restrictions
  - Controller/NAND capacitance

Case 1: 32KB “super” page, tPROG(typ) = 1300us, 8 die active
Case 2: 64KB “super” page, tPROG(typ) = 1100us, 12 die active
Read Latency

4KB read latency has diminishing returns
ONFI 4.0 Bus Power Reduction

- **Switching power reduction**
  - $P = FV^2C$  
    - $V$: 1.8V -> 1.2V  
    - $C$: Significantly Reduced
- **Termination power reduction**
  - Rtt requirements reduced
- **NAND data path power reduction**
  - Can provide improved NAND data path power biasing
Power comparisons

SSD topology with two QDP packages per channel (8 die)
Reduced Loading

• Reduced Die Capacitance and smaller signaling also enables new topologies and increased fan-out:
  • 8 Die per channel at 400 MT/s with no termination
  • 16 Die per channel at 533 MT/s
  • 12 Die per channel at 667 MT/s
  • 8 Die per channel at 800 MT/s

Estimates are based on Signal Integrity analysis, actual performance may vary based on a number of system variables
More LUNs per channel

At lower power consumption
Summary

• ONFI 4.0 provides:
  • I/O Performance improvements
  • I/O and NAND Power consumption improvements
  • Straightforward evolutionary enablement
  • Industry interoperability

• ONFI 4.0 specification available for download
  • www.onfi.org/specifications