Practical Erase Suspension for Modern Low-latency SSDs

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NAND Flash-based SSD
NAND Flash-based SSD

1) Superior Throughput  
   (e.g., Sequential Read $\rightarrow$ 6.4GB/s)

2) Low average Latency  
   (e.g., 4KB Random Read QD1 $\rightarrow$ 15us)

3) Relatively Low Price  
   (e.g., QLC SSD $\rightarrow$ 0.1$/GB$)
NAND Flash-based SSD

Read Latency
(4KB Random, Read 70%, Write 30%, QD 16)

- Average: 160us
- 99.999%
- Maximum: 10ms
- Maximum: 11ms
The source of long read tail latency

Read Tail Latency
(4KB Random, Read 70%, Write 30%, QD 16)

AS–IS
Over-10ms

Maximum

READ Request

A block is
ERASING (~10ms)
NAND

11ms
The source of long read tail latency

Read Tail Latency
(4KB Random, Read 70%, Write 30%, QD 16)

AS–IS
Over-10ms

TO-BE
Sub-200us

A block is ERASING (~10ms)
NAND

A block is ERASING
NAND
With Practical Erase Suspension

Maximum
Sub-200us
The source of long read tail latency

Read Tail Latency
(4KB Random, Read 70%, Write 30%, QD 16)

AS–IS
Over-10ms

TO-BE
Sub-200us
Competitive with the emerging NVM-based SSD
NAND Erase Operation

Incremental Step Pulse Erasing (ISPE) scheme

Erase Voltage

Time (ms)

1 2 3 4 5

Erase pulse
Verify pulse
Practical Erase Suspension

Suspending/Resuming at well-aligned safe points

![Diagram showing Immediate Erase Suspension]

- Erase pulse
- Verify pulse
- READ request

Time (ms):
1 2 3 4 5

Erase Voltage
Practical Erase Suspension

Suspending/Resuming at well-aligned safe points

Erase Voltage

Time (ms)

1 2 3 4 5

READ request

Deferred Erase Suspension

\[\text{Erase pulse}\]

\[\text{Verify pulse}\]
Practical Erase Suspension

Suspending/Resuming at well-aligned safe points

Timeout-based switching mechanism

<table>
<thead>
<tr>
<th>Erase Voltage</th>
<th>Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>READ request</td>
<td></td>
</tr>
<tr>
<td>Immediate Erase Suspension</td>
<td></td>
</tr>
<tr>
<td>Deferred Erase Suspension</td>
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</tr>
</tbody>
</table>

- : Erase pulse
- : Verify pulse

- Erase pulse
- Verify pulse
Summary

• Practical erase suspension harnesses the full potential of NAND flash-based SSDs
Summary

- Practical erase suspension harnesses the full potential of NAND flash-based SSDs
Thank You 😊

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