Ultra High Throughput LDPC Schemes for SSD

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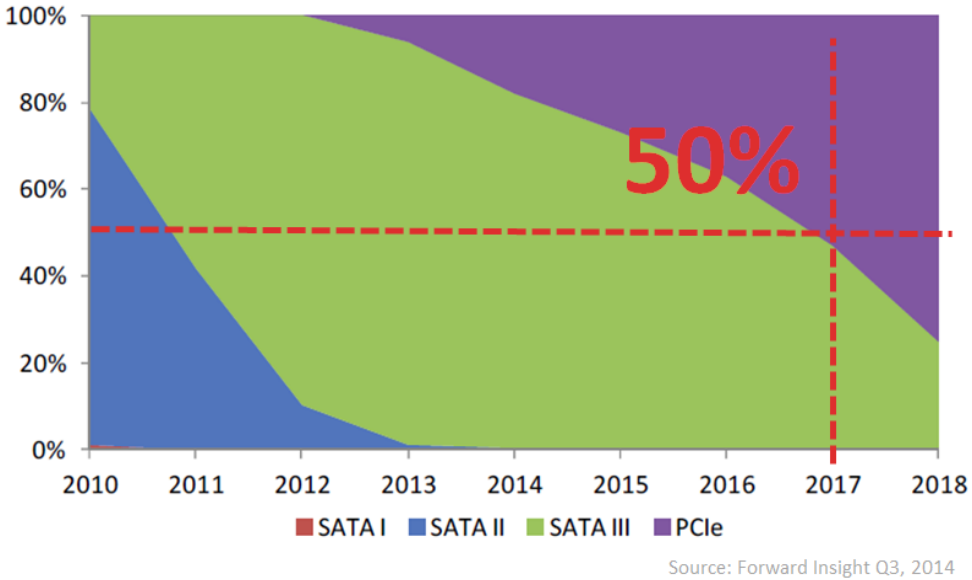
Forward Insight SSD Market Trend



Source: Forward Insight Q3, 2014

- SSD controllers with a host throughput of 8GB/s (PCIe 4.0 x4) will emerge in the next year
- Providing a high throughput and low power ECC solution has become one of the most challenging tasks in SSD controller design

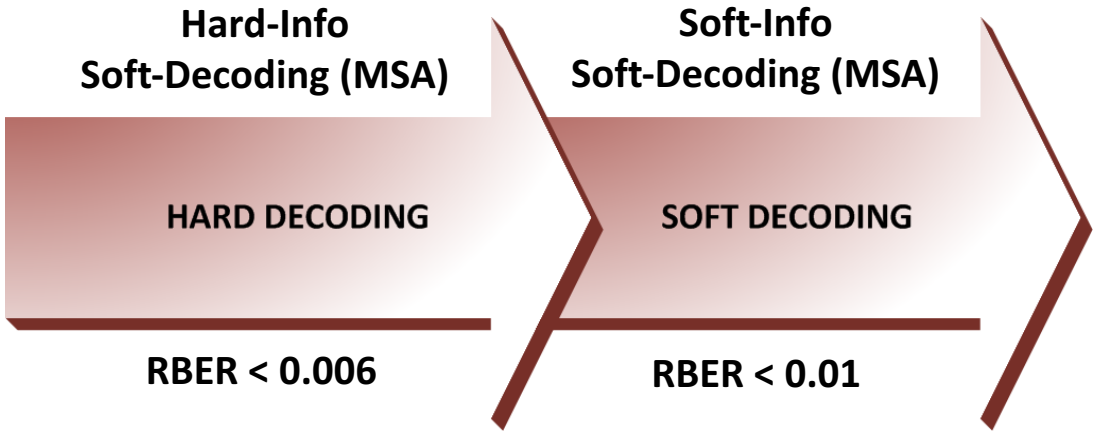
Flash Characteristics

	2D	3D
EDURANCE	Keeps a low RBER when P/E grows (below 1000 P/E)	Keeps a low RBER when P/E grows (below 1000 P/E)
DATA RETENTION	The Vth shifts, and has degradations in voltage distribution	The Vth shifts, but the distribution is well-maintained

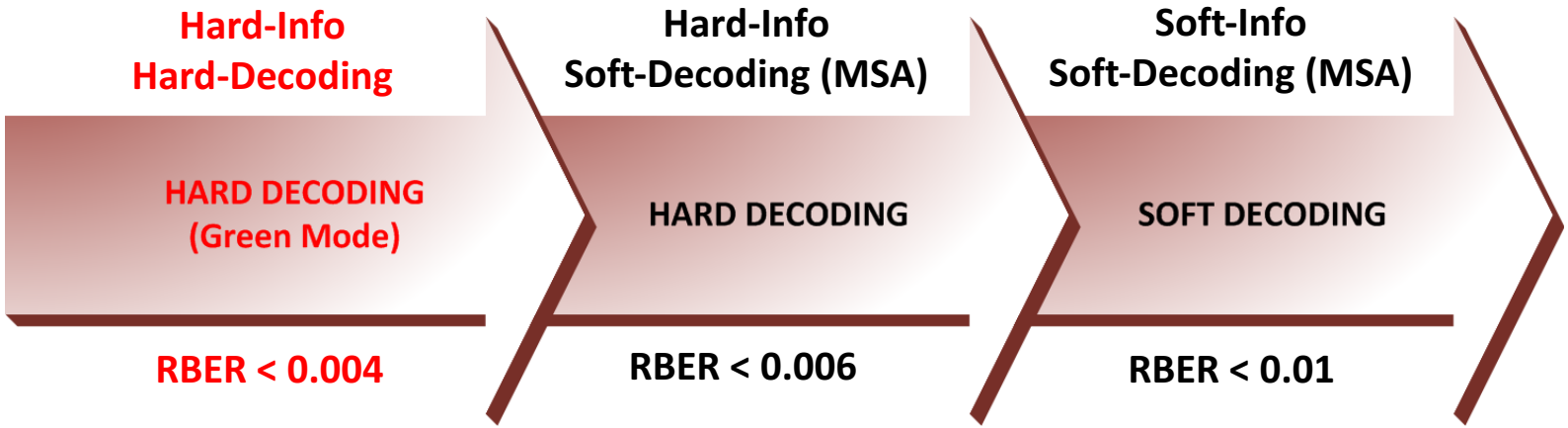
ECC Requirements

	Target	RBER Requirement
Normal operation	Low power Maintains host throughput	RBER = **3e-3**
Reliability extension	Utilize Soft-info for stronger correction capability	RBER = 1e-2

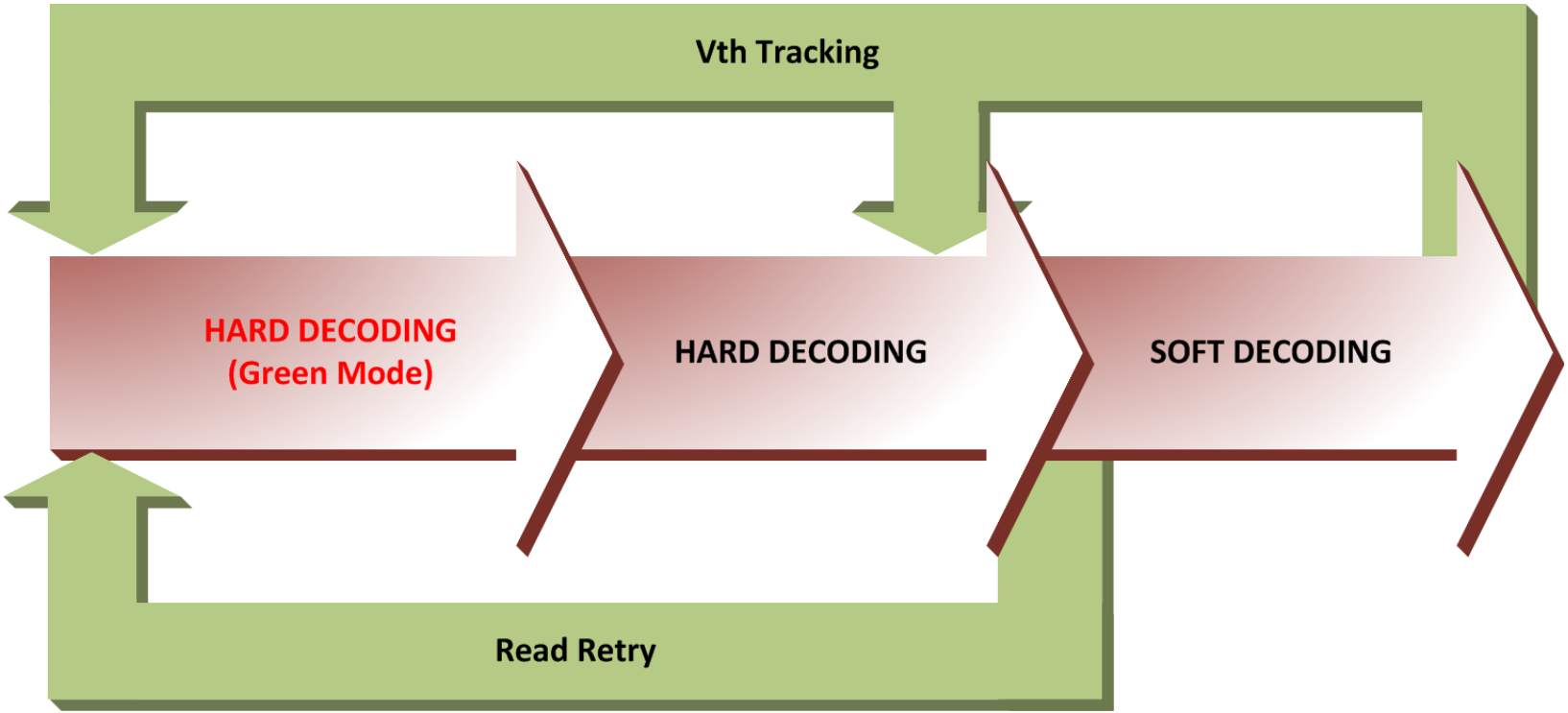
LDPC Decoding Flow



LDPC Decoding Flow



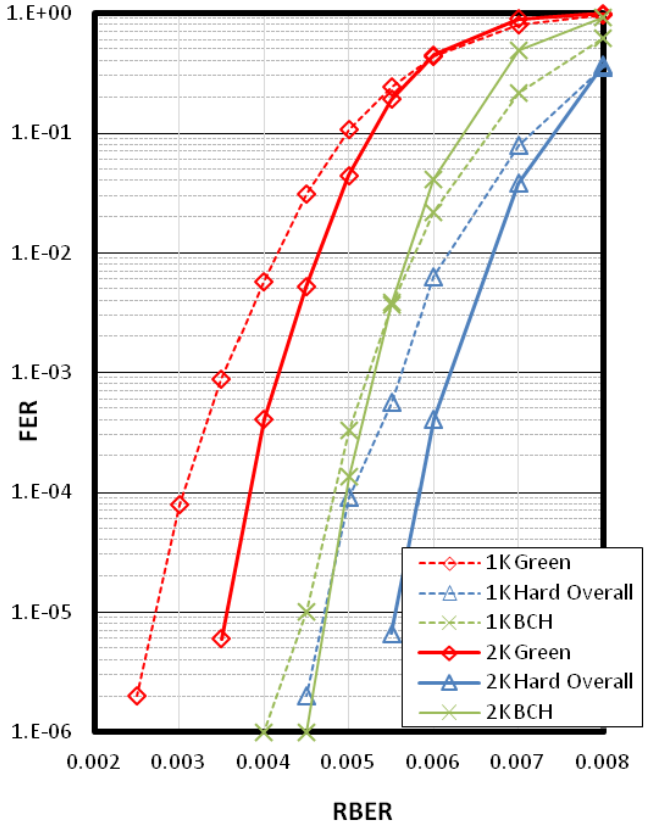
LDPC Decoding Flow

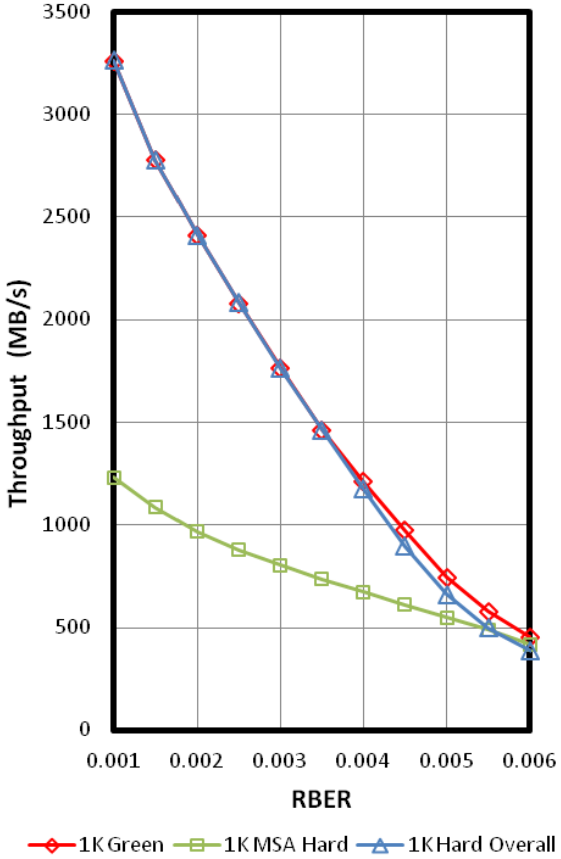


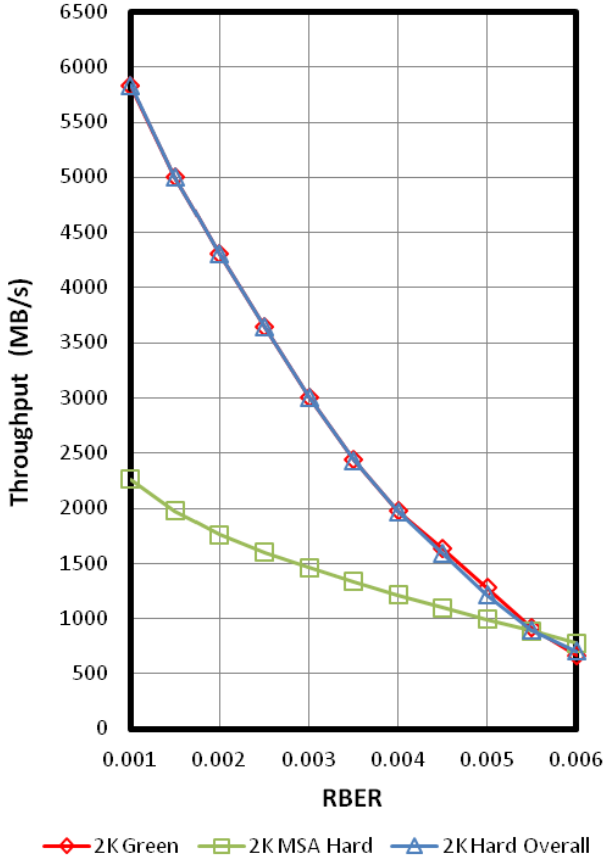
Why do we need Green mode?

- **2x throughput compared to MSA hard decoding**
- **5x energy efficiency compared to MSA hard decoding**
- **6x energy efficiency compared to BCH decoding**
- **Covers the normal operation region**
- **Introduces very little additional cost overhead**
  - Share the existing SRAM
  - Increase in logic gate count is less than 10%

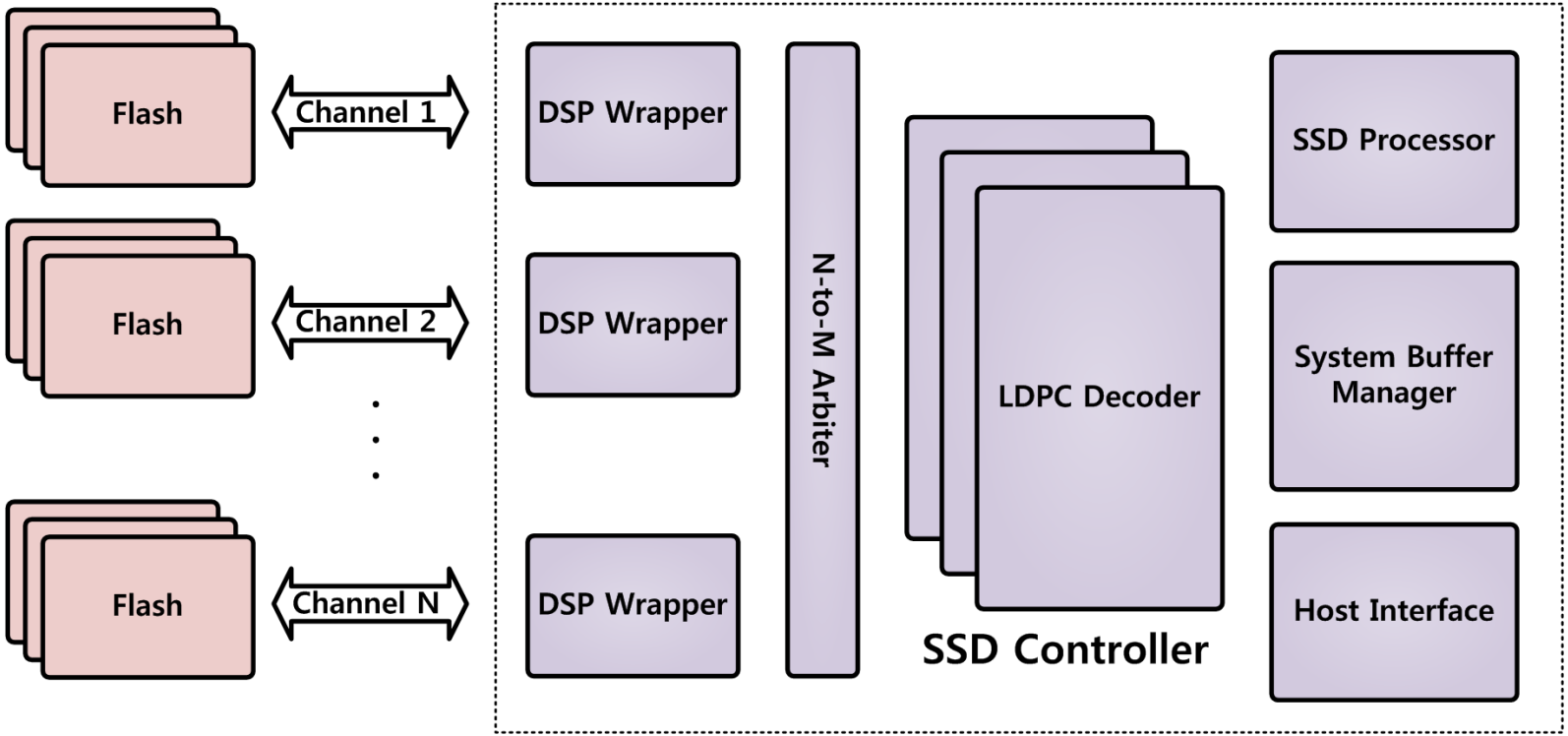
Performance Analysis



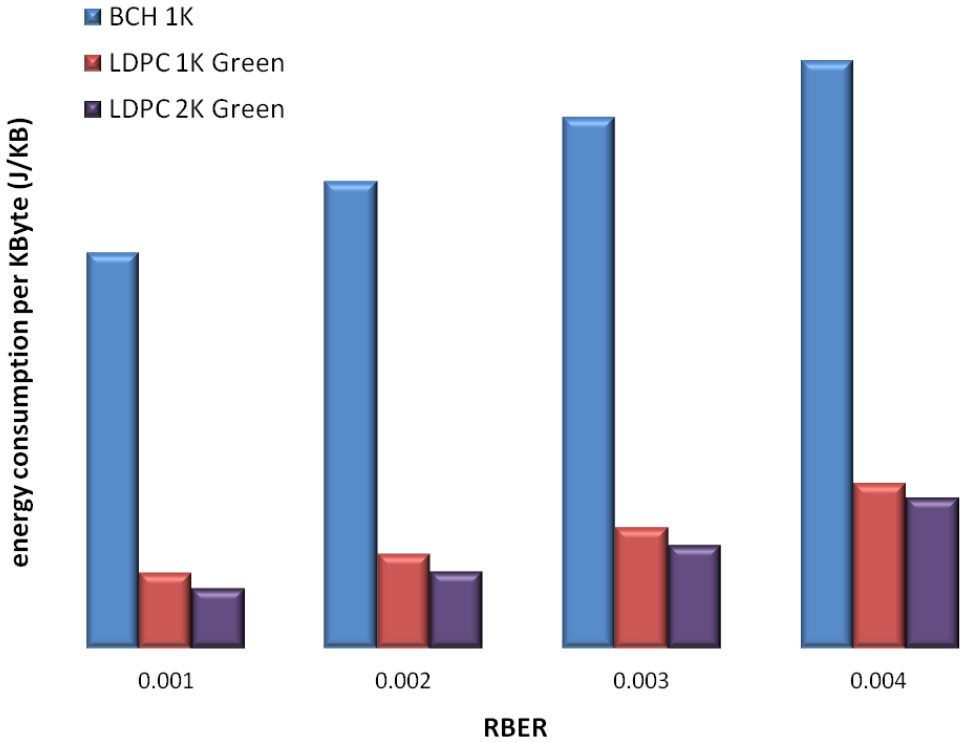




Combine Multiple Decoders into a Single Controller



Energy Consumption



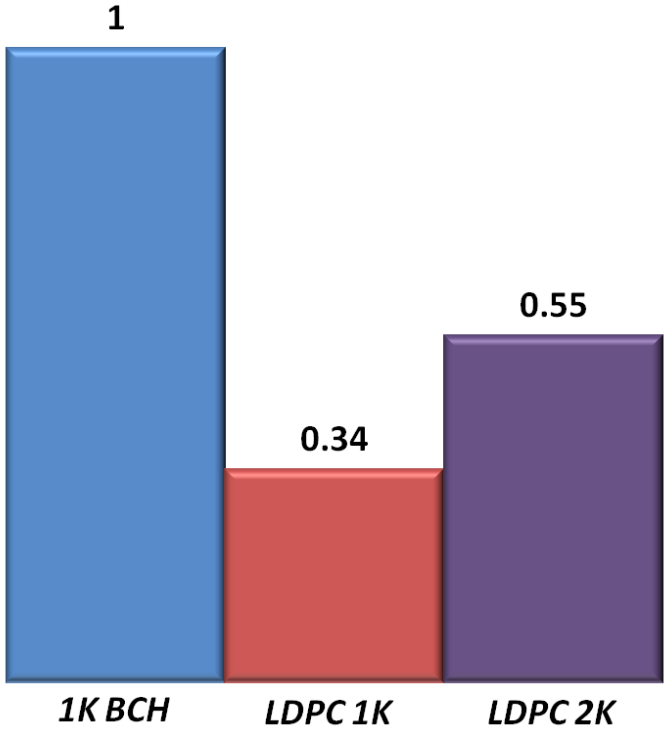
Definition of energy consumption:

$$\frac{\text{power}\left(J/s\right)}{\text{throughput}\left(KB/s\right)} \text{ in } \left(J/KB\right)$$

It represents the amount of energy (in Joules) required for decoding each unit of data (e.g., 1 KB)

Encoding Power

We also focused on reducing the LDPC encoding power



Lite Versions also Available

- **All benefits from Green Mode**
- **More cost-effective – half the price of the full version**
- **MSA decoding performs 10 times slower than the full version**
  - Soft decoding throughput is also degraded by flash soft-read
  - System throughput suffers in the MSA hard decoding region. This is a trade-off between the cost and product definition.

Comparison of LDPC Schemes

	1K Lite	1K Full	2K Lite	2K Full
Green Mode Capability+	RBER < 0.0035	RBER < 0.0035	RBER < 0.004	RBER < 0.004
Throughput @ RBER = 0.003	1700 MB/s	1700 MB/s	3000 MB/s	3000 MB/s
Hard Decoding Capability+	RBER < 0.0055	RBER < 0.0055	RBER < 0.006	RBER < 0.006
Soft Decoding Capability#	RBER < 0.01	RBER < 0.01	RBER < 0.01	RBER < 0.01
MSA Throughput	0.1 T_{1K}	T_{1K}	0.1 T_{2K}	T_{2K}
Area (Single Engine)	A	2A	1.7A	3.4A
Area needed to achieve 8GB/s @ RBER = 0.003	5A	10A	5.1A	10.2A

+: Green Mode capability and hard decoding capability are defined as FER < 10^{-3}
#: Soft decoding capability is defined as UBER < 10^{-15}

Flash Memory SUMMIT

Thank you for your attention