



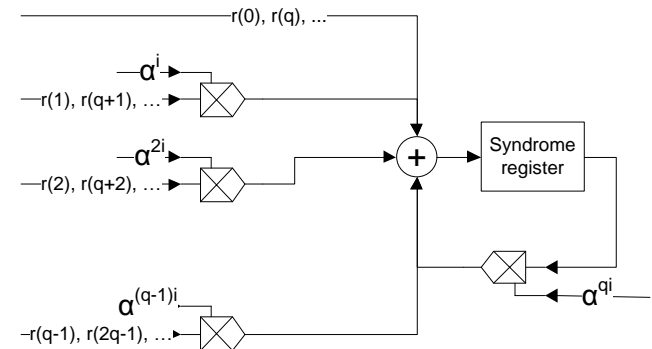
# ECC in NAND Flash controller

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- To recall ECC basics
  - BCH
  - LDPC
- ECC inside the controller
  - Performance
  - Architecture
  - Many factors to tweak the engine

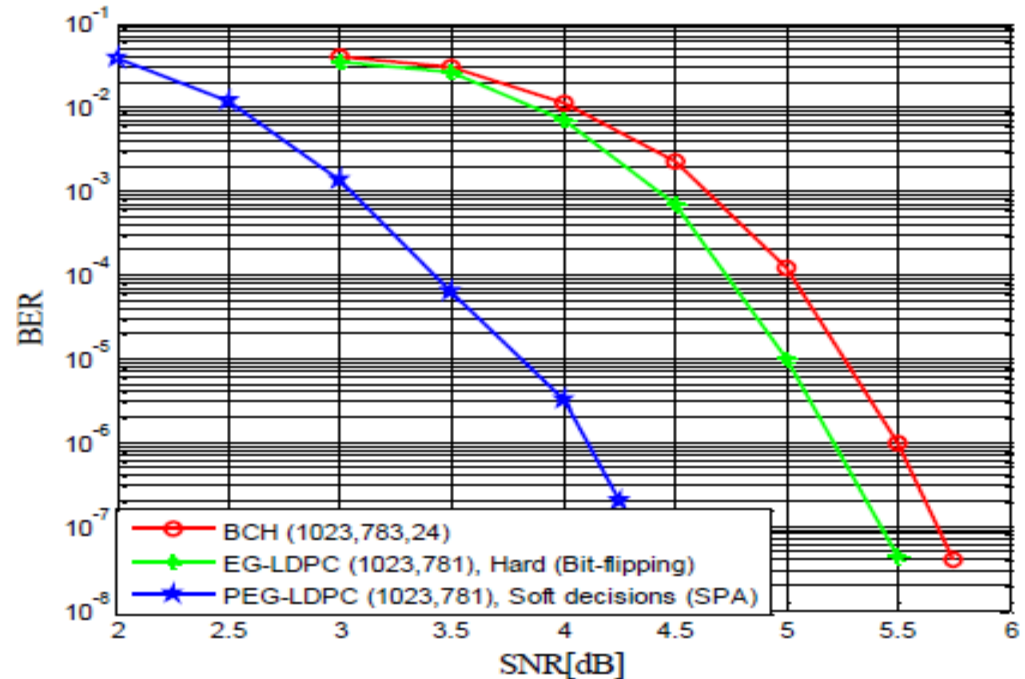
# BCH – recall the basics

- Still the most popular algorithm
- Based on Galois Field operation
- Correction strength known a priori
- Decoder
  - Syndromes calculations
  - Solving key equations
  - Error bit locations



# LDPC – all are talking about it

- Correction based on probability
- Non-guaranteed correction of n-bit errors
- Better error rate vs. BCH for the same amount of parity bits
- Effective for high error rates



- Soft decisions
- Based on probability
- Requires precise information of charge at the floating gate
- Requires good noise model for memory cell
- More information to be transmitted to external controller

## LDPC – BCH – who will win?

- BCH – defined correction capabilities
- BCH – hard decision based 0 or 1
- LDPC – more tight to hardware features
- LDPC – requires more data from NAND matrix

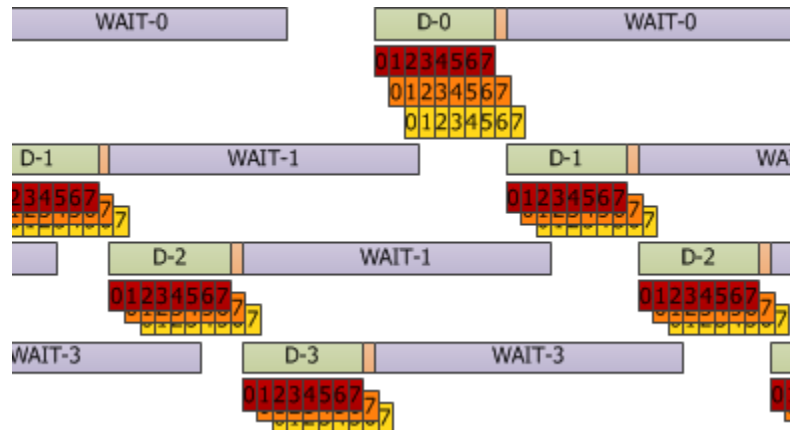
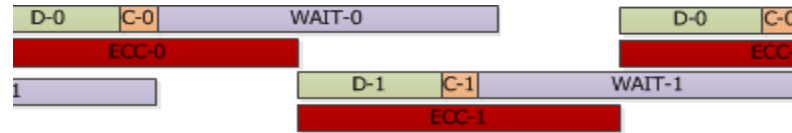
LDPC as inner memory correction,  
BCH as outer in-controller correction

# BCH in NF IP controller

- Integration of BCH within controller
- Choosing architecture
- Balancing algorithm throughput
- Configurability

# Overcoming performance limitation

- Source: blocking ECC architecture
- Solving:
  - Dividing calculation into stages
  - Increasing performance by parallel operation







# Distributing ECC stages throughout controller logic

- Syndrome generation
- Solving equation & Error correction
- Integration with DMA engine

- Parameters with multiple selections
  - Parallel factor
  - Error correction strength
  - Codeword size
- Traditional configuration not enough
  - Hardware description language
  - Tools proprietary methods
  - In-house built tools

# Facing configurability challenges

- Software tool based generator
- Intermediate Language
- Algorithm description
- Architecture modifications & optimization
- Output file generation
- Any other output processor can be developed

- ECC basics of BCH and BCH
  - BCH & LDPC Hybrid
- Integration of ECC within the controller
- Solving configurability challenge of ECC engine