



# LDPC Parity Code Matrix Update for Improved Alignment (rev 1a)



**Mark Laubach, Yang Han, Shaohua Yang, Ryan Hirth, Glen Kramer**

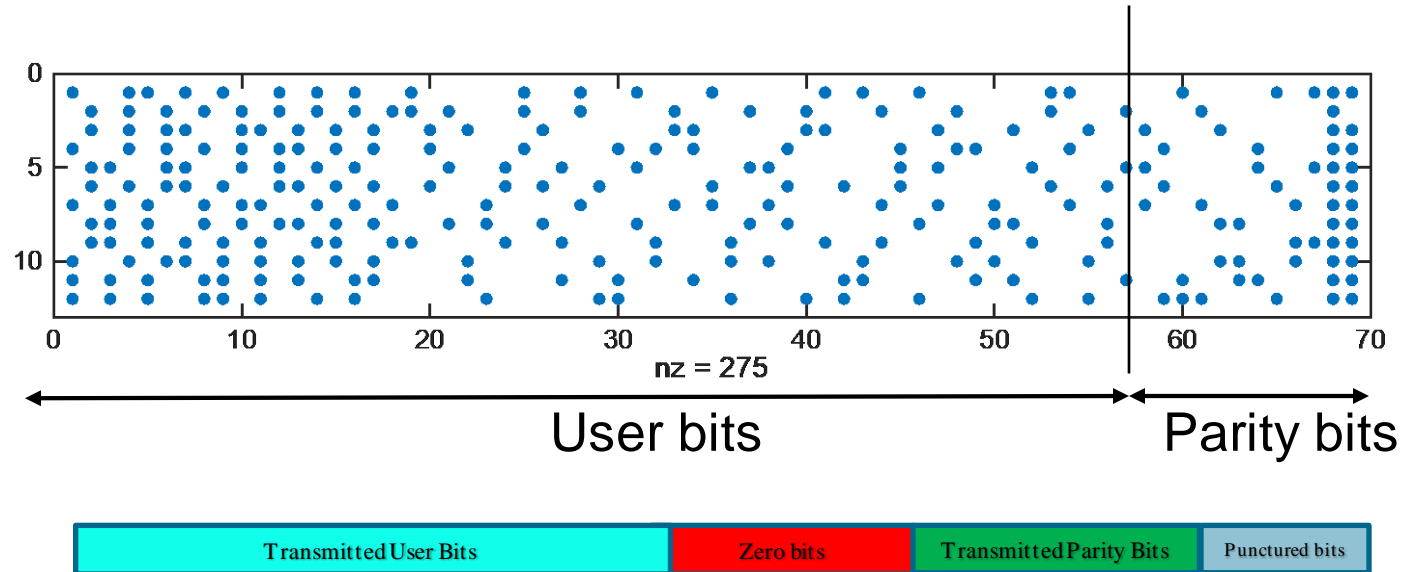
5 March 2018 IEEE 802.3 Plenary, Chicago, IL, USA

# Introduction

- kramer\_3ca\_1\_0318.pdf examines two options for adjusting LDPC FEC codeword length to improve alignment and state diagrams for data rate to line rate conversion.
- This presentation reviews the performance impact of the two options for consideration:
  - Option 1: Keep the adopted matrix as Jan18, only change puncture and shortening length.
  - Option 2: Re-optimize H matrix dimension to fit the new codeword size and maintain 256-bit circulant size.
- The previously adopted Omega256 interleaver is used for simulations.

# Option 2 Parity Code Matrix

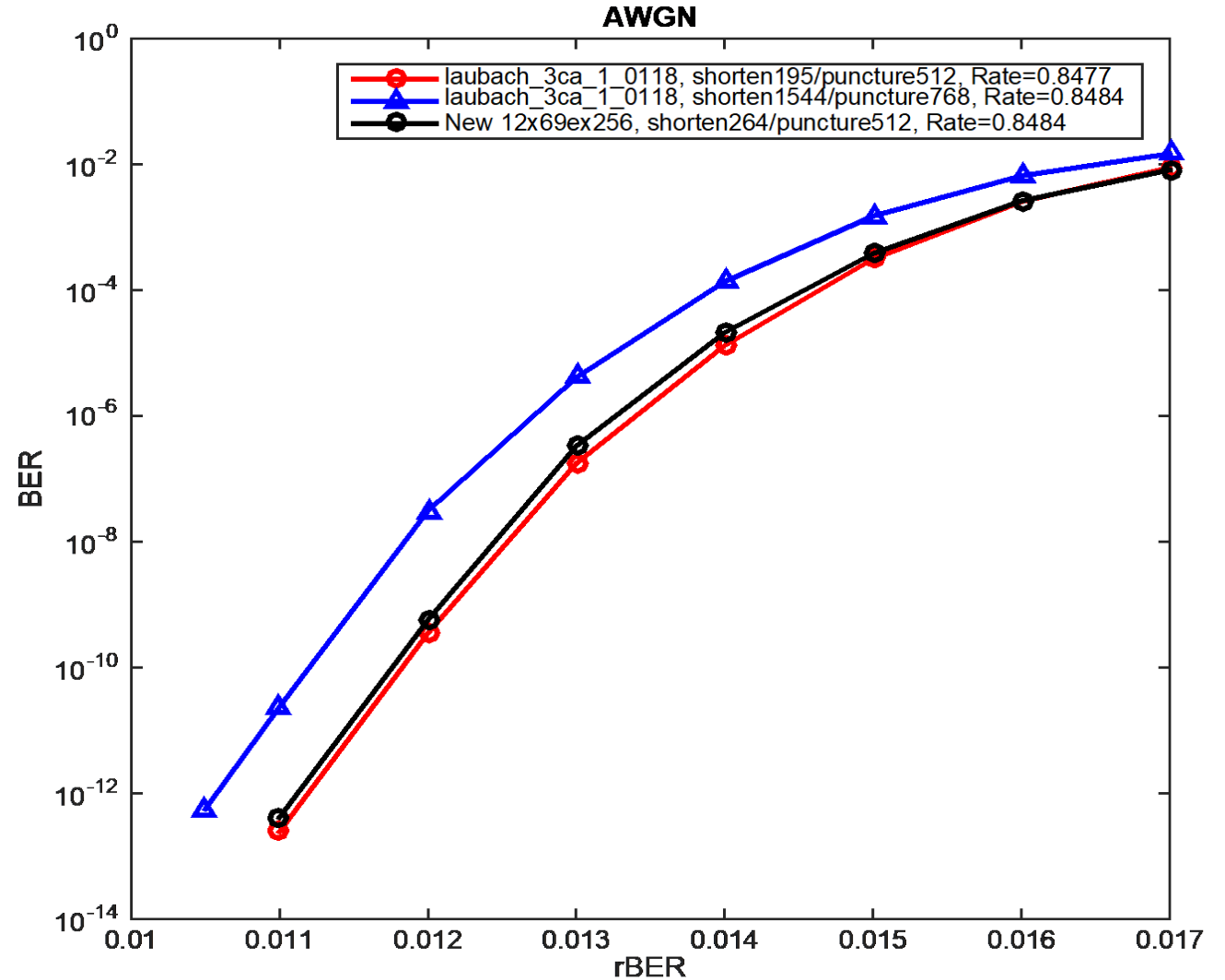
- Reduced matrix dimension (12x69ex256).



80 -1 -1 60 169 -1 11 -1 143 -1 -1 222 -1 59 -1 218 -1 -1 178 -1 -1 -1 -1 -1 105 -1 -1 19 -1 -1 126 -1 -1 -1 211 -1 -1 -1 -1 247 -1 255 -1 -1 85 -1 -1 -1 -1 -1 246 94 -1 -1 -1 -1 -1 242 -1 -1 -1 -1 129 -1 19 58 27  
-1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 -1 -1 -1 0 -1 -1 -1 -1 0 -1 -1 -1 0 -1 -1 -1 0 -1 -1 -1 0 -1 -1 -1 -1 0 -1 -1 -1 -1 0 -1 -1 -1 -1 -1 -1 0 -1  
-1 91 -1 74 -1 237 202 -1 -1 201 136 -1 178 -1 239 -1 183 -1 -1 217 -1 232 -1 -1 -1 169 -1 -1 -1 -1 -1 129 60 -1 -1 -1 -1 -1 19 76 -1 -1 -1 -1 177 -1 -1 -1 2 -1 -1 -1 101 -1 -1 217 -1 -1 -1 48 -1 -1 -1 -1 -1 172 42  
105 -1 -1 87 -1 43 -1 165 -1 180 -1 80 227 -1 221 -1 77 -1 -1 0 -1 -1 -1 -1 16 -1 -1 -1 -1 252 -1 96 -1 0 -1 -1 -1 -1 17 -1 -1 -1 -1 -1 219 -1 -1 198 165 -1 -1 -1 -1 36 -1 -1 -1 -1 171 -1 -1 -1 -1 228 -1 -1 -1 39 234  
-1 170 250 -1 -1 195 139 -1 -1 135 -1 92 -1 147 -1 1 -1 -1 -1 -1 13 -1 -1 98 -1 -1 142 -1 -1 -1 225 -1 -1 -1 -1 23 108 -1 -1 -1 -1 -1 0 -1 0 -1 -1 -1 -1 135 -1 -1 -1 -1 121 0 -1 -1 -1 -1 -1 0 -1 -1 46 242 228  
-1 46 -1 37 -1 49 150 -1 65 -1 -1 177 144 -1 70 -1 95 -1 -1 221 -1 -1 -1 192 -1 128 -1 -1 214 -1 -1 -1 -1 51 -1 -1 -1 100 -1 -1 19 -1 -1 235 -1 -1 -1 -1 -1 4 -1 -1 251 -1 -1 109 -1 -1 -1 -1 140 -1 -1 193 241  
137 -1 104 -1 238 -1 -1 228 -1 225 247 -1 -1 191 -1 177 -1 255 -1 -1 -1 -1 192 -1 -1 -1 -1 51 -1 -1 -1 -1 195 -1 0 -1 -1 172 -1 -1 -1 -1 219 -1 -1 236 -1 -1 136 -1 -1 -1 0 -1 -1 -1 159 -1 -1 10 -1 -1 -1 -1 5 -1 25 94  
-1 118 15 -1 93 -1 -1 228 -1 78 -1 16 0 -1 48 -1 0 -1 -1 -1 62 -1 0 -1 -1 0 -1 -1 -1 -1 112 -1 0 -1 -1 -1 -1 -1 0 -1 -1 -1 0 0 -1 -1 -1 22 -1 -1 -1 -1 0 0 -1 -1 -1 120 192  
-1 208 0 -1 0 -1 0 -1 0 -1 -1 251 0 -1 -1 44 123 -1 -1 -1 -1 0 -1 -1 0 -1 -1 -1 -1 0 -1 -1 -1 153 -1 -1 -1 -1 0 -1 -1 -1 0 -1 -1 -1 -1 -1 -1 -1 0 0 16 0  
0 -1 -1 123 -1 41 191 -1 211 -1 217 -1 243 -1 97 -1 252 -1 -1 -1 -1 0 -1 -1 -1 -1 -1 0 -1 -1 41 -1 -1 -1 29 -1 0 -1 -1 -1 0 -1 -1 -1 193 -1 145 -1 -1 -1 -1 0 -1 -1 -1 -1 -1 140 46 -1 -1 58 -1 202 215  
209 -1 252 -1 39 -1 -1 159 69 -1 37 -1 134 -1 -1 201 49 -1 -1 -1 104 -1 -1 -1 129 -1 -1 157 -1 -1 -1 222 -1 -1 -1 -1 -1 139 39 -1 -1 -1 -1 203 -1 94 -1 -1 -1 -1 194 -1 -1 3 -1 -1 43 153 -1 -1 -1 207 109  
53 -1 93 -1 216 -1 -1 57 9 -1 130 -1 -1 130 -1 238 -1 -1 -1 -1 -1 144 -1 -1 -1 -1 162 0 -1 -1 -1 -1 175 -1 -1 -1 145 -1 0 -1 -1 -1 36 -1 -1 -1 -1 91 -1 -1 22 -1 -1 -1 0 212 -1 -1 -1 0 -1 -1 69 88

# AWGN Performance

- Option 1: puncturing and shortening
  - Puncturing: 512 bits -> 768 bits
  - Shortening: 195 bits -> 1544 bits
  - Reduces gain by 0.08 dB
  - Rate 0.8477 -> 0.8484 (minor change)
- Option 2: new matrix [12x69ex256]
  - Puncturing: 512 bits
  - Shortening: 264 bits
  - Reduces gain by ~~0.022~~ 0.012 dB
  - Rate 0.8477 -> 0.8484 (minor change)



Rev a: updated plot

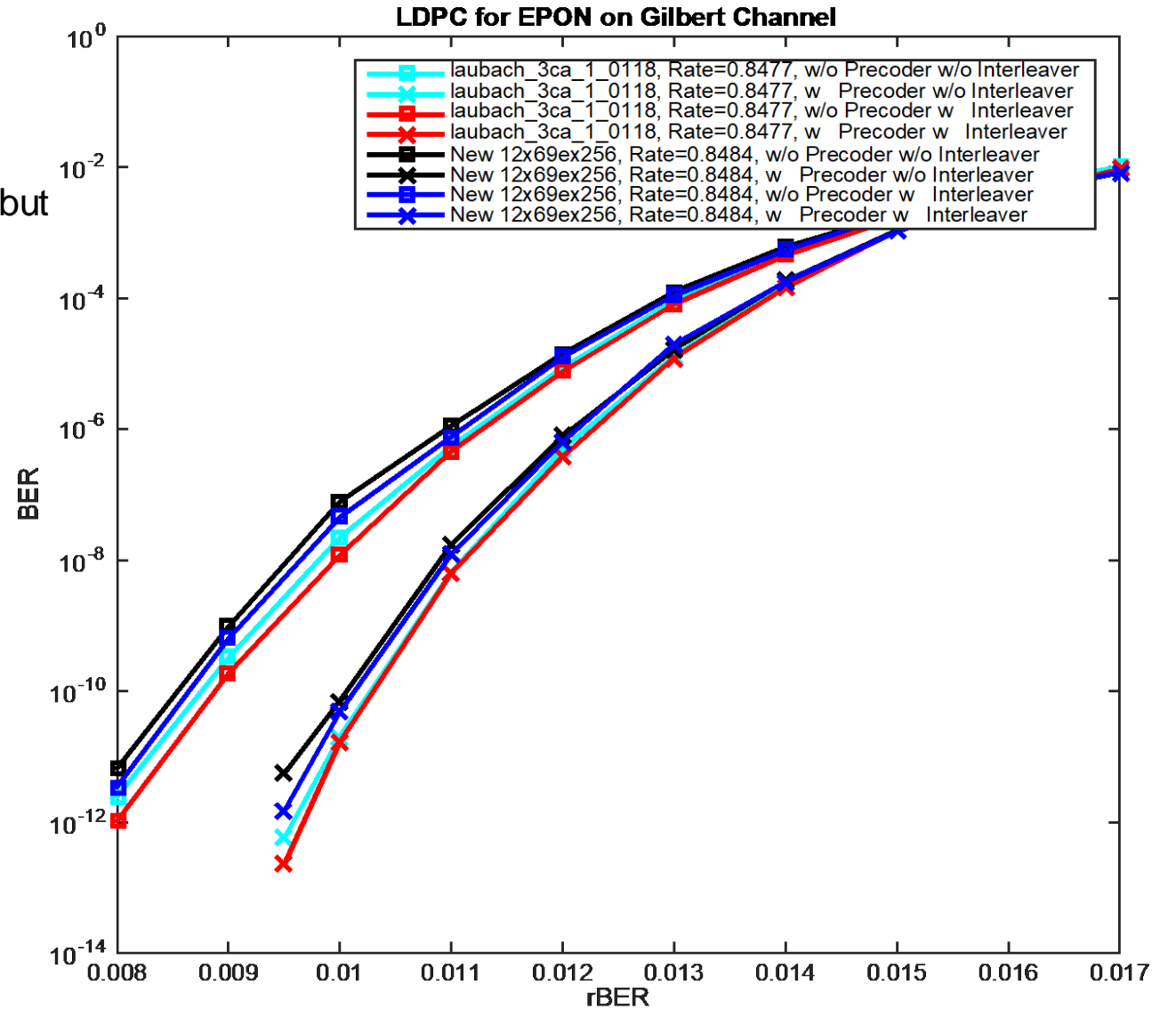
# Gilbert Burst Model Performance

## NOTE:

- For the “New” matrix, the previously adopted Omega256 interleaver is used in these simulation, but with an updated seed file.

Machine readable update is provided in laubach\_3ca\_4\_0318.txt

Rev 1a: updated entire slide.



# Latency comparison

- New code is slightly more efficient due to fewer non-zero circulants compared to adopted matrix:

LDPC	laubach_3ca_1_0118	New Code
	µsec @ 15 iterations	µsec @ 15 iterations
Encoder	1.842	<del>1.698</del> 1.331
Buffer	0.77	<del>0.77</del> 0.655 <sup>a</sup>
Decoder	2.145	2.0625 (fewer non-zero circulants)
Buffer	0.77	<del>0.77</del> 0.655 <sup>a</sup>
Total one-way	5.527	<del>5.3005</del> 4.704

<sup>a</sup> Based on reduction of codeword size to 16888 bits @ 25.78125 Gb/s line rate.

# LDPC Performance Review

	Length	Rate	Non-Zero Blocks	NECG <sup>1</sup> (dB <sup>2</sup> ) (optical gain)				Reference	
				AWGN	Gilbert Burst				
					Precoder Off	Precoder On	Precoder Off		Precoder On
					With interleaver		Without interleaver		
LDPC	(18493,15677) [13x75x256]	0.848	290	2.6 (1.82-2.34)	1.76 (1.23 - 1.58)	2.03 (1.41 - 1.82)		laubach_3ca_1a_1117	
			286	2.63 (1.84 - 2.37)	1.87 (1.31 - 1.68)	2.12 (1.48 - 1.91)	1.85 (1.3 - 1.67)	2.11 (1.48 - 1.9)	laubach_3ca_1_0118
	Option 1		286	2.55 (1.79 - 2.30)	-na-	-na-	-na-	-na-	laubach_3ca_1_0318
	Option 2		275	2.618 (1.83 - 2.36)	1.82 (1.27 - 1.64)	2.09 (1.46 - 1.88)	1.8 (1.26 - 1.62)	2.06 (1.44 - 1.85)	

<sup>1</sup> Electrical gain over RS(255,223) of 7.1 dB. Optical gain is 0.7 to 0.9 \* NECG.

<sup>2</sup> Capped at 15 iterations.

# Summary

- Option 2 is preferred:
  - Supports conclusions stated in [kramer\\_3ca\\_1\\_0318](#).
  - Small loss in gain relative to adopted LPDC matrix from [laubach\\_3ca\\_1\\_0118](#).
  - **15%** reduction in one-way latency.
- Updated draft text changes are provided in [laubach\\_3ca\\_2\\_0318.pdf](#).
- Updated Parity code  $H_c$  matrix is provided in [laubach\\_3ca\\_3\\_0318.txt](#) for machine readable format.



# Proposed motion

- Adopt the indicated draft text changes in “laubach\_3ca\_2\_0318.docx” and update Draft 0.7 142.2.2.3.1 Low Density Parity Check Coding and 142.2.2.3.2 LDPC Encoder as needed. Provide machine readable format in “laubach\_3ca\_3\_0318.txt” to the Editor. Update machine readable Omega256 interleaver seed as contained in laubach\_3ca\_4\_0318.txt.

Thank you



**BROADCOM**®

connecting everything®