

Performance of Reed-Solomon Based Quasi-

Cyclic LDPC Codes Based on Protograph

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- 1. Construction of RS based Quasi-Cyclic LDPC Codes using Protograph
 - RS based QC-LDPC Codes
 - Introducing the construction of QC-LDPC codes using the parity-check matrix of Reed-Solomon codes with girth more than 8[1]
 - Parity-check matrix of RS codes over *GF*(2^s)

$$B_{RS}(d,n) = \begin{bmatrix} 1 & \beta & \cdots & \beta^{n-1} \\ 1 & \beta^2 & \cdots & (\beta^2)^{n-1} \\ \vdots & \vdots & \ddots & \cdots \\ 1 & \beta^d & \cdots & (\beta^d)^{n-1} \end{bmatrix}$$

• Parity-check matrix of RS based QC-LDPC codes

$$H_{RS}(d,n) = \begin{bmatrix} H_{0,0} & H_{0,1} & \cdots & H_{0,n-1} \\ H_{1,0} & H_{1,1} & \cdots & H_{1,n-1} \\ \vdots & \vdots & \ddots & \vdots \\ H_{d-1,0} & H_{d-1,1} & \cdots & H_{d-1,n-1} \end{bmatrix}$$

- $H_{i,j}$ is $r \times r$ Identity matrix cyclically shifted by the elements of $B_{RS}(i,j)$
- This RS based QC-LDPC codes has girth at least 6[1].
- Construction of RS based QC-LDPC with girth 8[1]
 - Make $B_{RS}(d, t)$ by choosing t columns of $B_{RS}(d, n)$
 - $\Lambda_t = \{l_1, l_2, \dots, l_t\}$: Index set of selected t columns and satisfying following equations

2. Experiment analysis and conclusion

- For simulation, experiment BER performance of RS based QC-LDPC codes using protograph compared with RS base QC-LDPC codes[1]
- RS parity-check matrix $B_{RS}(4,85)$ over $GF(2^8)$ and Index set $\Lambda_8 = \{2, 5, 7, 13, 20, 32, 54, 60\}$ ->Submatrix $B_{RS}(4,8)$
- Parity-check matrix $H_{RS}(4,8)$ with constructed protograph is RS based QC-LDPC codes with length 2040 and rate $\frac{1}{2}$
- 3 weight matrices of constructed protograph



 $l_{i_3} \neq 2l_{i_2} - l_{i_1}, \ l_{i_3} \neq 3l_{i_2} - 2l_{i_1}, \ l_{i_3} \neq \frac{3l_{i_3} - l_{i_1}}{2},$ $n \nmid l_{i_2} + l_{i_3} - 2l_{i_1}, n \nmid l_{i_2} + 2l_{i_3} - 3l_{i_1}, n \nmid 2\overline{l}_{i_2} + l_{i_3} - 3l_{i_1},$ $n \nmid 2l_{i_3} - l_{i_1} - l_{i_2}, n \nmid 3l_{i_3} - 2l_{i_1} - l_{i_2}, n \nmid 3l_{i_3} - l_{i_1} - 2l_{i_2},$

QC-LDPC Codes based on Protograph

- Protograph : allow more than 2 edges b/w check and variable nodes
- Copy small Tanner graph and lift the edges to copied graph
- Calculate upper bound of minimum Hamming distance of QC-LDPC codes based on protograph[2]



 Propose the construction of QC-LDPC codes combining RS based QC-LDPC codes with girth 8 and protograph with makes increasing minimum Hamming distance





- Protographs which increase the upper bound of minimum Hamming distance attain coding gain 0.05dB in sense of BER compared with RS based QC-LDPC codes [1]
- To attain more coding gain, we will focus on the construction strategy for protographs with their upper bounds of minimum Hamming distance

Reference

[1] X. Xiao, W.E.Ryan, B.Vasic, S.Lin and K.Abdel-Ghaffar, "Reed-Solomon-Based Quasi-Cyclic LDPC Codes: Designs, Cycle Structure and Erasure Correction," Information Theory and its Application(ITA2018), Catamaran Resort, San Diego, Feb. 21-26, 2018.

[2] R.Smarandache and P.O.Vontobel, "Quasi-Cyclic LDPC Codes: Influence of Proto- and Tanner-Graph Structure on Minimum Hamming Distance Upper Bounds," *IEEE Trans. on Information Theory*, vol. 58, no.2, Feb. 2012.

