# Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

**Submission Title:** Performance Evaluation of Channel Coding with Interleaver Based on TG6ma Channel Model for Some Classes of Coexistence

**Date Submitted:** July 30th, 2025

**Source:** Daisuke Anzai, Sho Asano, Kento Takabayashi, Takumi Kobayashi, Marco Hernadez, Ryuji Kohno

**Company:** Osaka Metropolitan University (OMU), Japan

**Address:** 1-1 Gakuen-cho, Naka-ku, Sakai, Osaka 599-8531, Japan

**Voice:** +81-72-254-9553, **E-Mail:** d.anzai@omu.ac.jp

**Re:** In response to call for technical contributions

**Abstract:** This provides a preliminary investigation of the effect of interleaving on channel coding defined in TG6ma under multiple BAN coexistence situations, and some simulation results are discussed.

**Purpose:** Material for discussion in P802.15.6a TG corresponding to comments in EC Meeting

# Performance Evaluation of Channel Coding with Interleaver Based on TG6ma Channel Model for Some Classes of Coexistence

Daisuke Anzai, Sho Asano, Takumi Kobayashi, Kento Takabayashi, Marco Hernandez, Ryuji Kohno

Osaka Metropolitan University (OMU)

Toyo University, YNU, YRP-IAI, CWC Oulu University

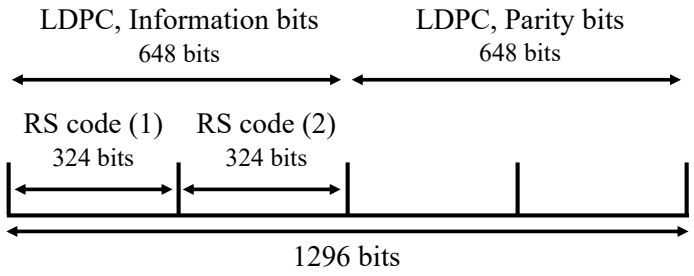
# Forward error correcting codes in TG6ma

| User priority | Inner code | Outer code | HARQ |
|---|---|---|---|
| 0 | 15.4ab LDPC or BCC (R=1/2) | | - |
| 1 | 15.4ab LDPC or BCC (R=1/2) | | - |
| 2 | 15.4ab LDPC or BCC (R=1/2) | | - |
| 3 | 15.4ab LDPC or BCC (R=1/2) | | - |
| 4 | 15.4ab LDPC or BCC (R=1/2) | (54, 46) shortened RS code | - |
| 5 | 15.4ab LDPC or BCC (R=1/2) | (54, 38) shortened RS code | - |
| 6 | 15.4ab LDPC or BCC (R=1/2) | (54, 28) shortened RS code | - |
| 7 | 15.4ab LDPC or BCC (R=1/2) | (54, 14) shortened RS code | - |

- As an outer code, shortened Reed-Solomon (RS) codes with N=54 (original code length N=63) will be selected to correct burst errors due to interference from other WBANs and the coding rates are changed according to each QoS and channel condition
- As an inner code, 15.4ab LDPC (K=324, 648, 972, R=1/2) or BCC will be selected for the coexistence of 15.6ma and 15.4ab
- This updated concept table is considered as the first priority

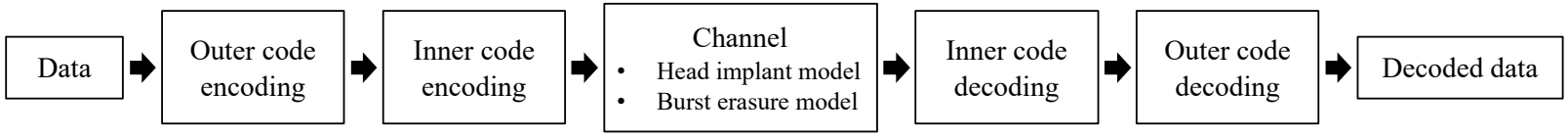
# Simulation settings

- Concatenated code
  - Outer code : Two shortened RS codes
  - Inner code : LDPC code
- BPSK modulated



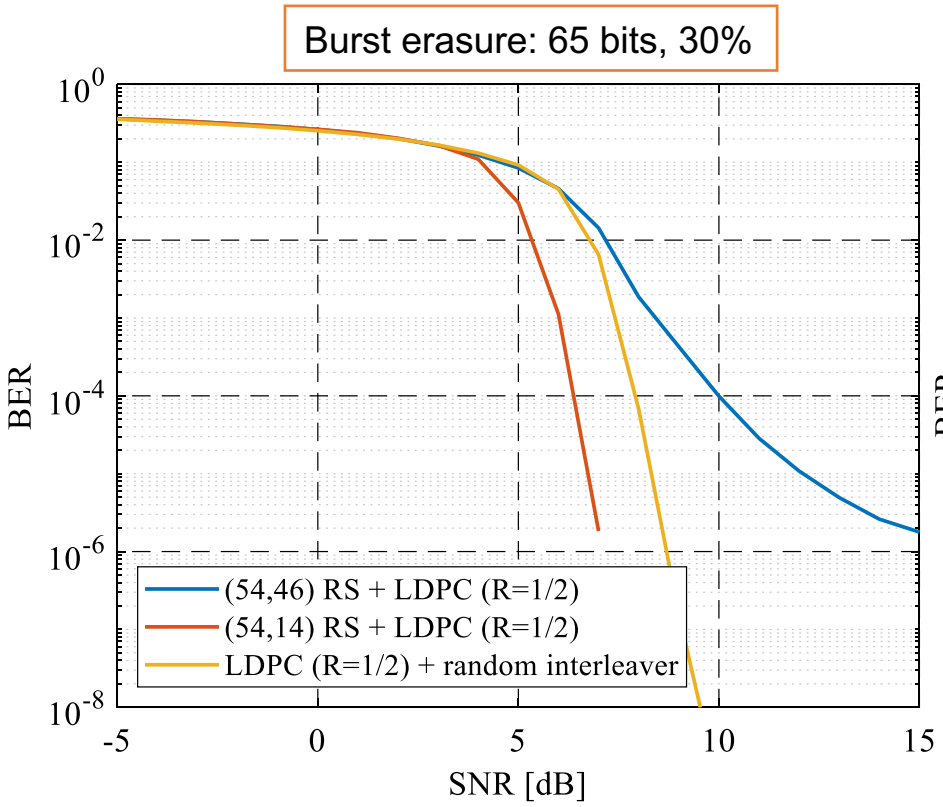

Configuration of concatenated code

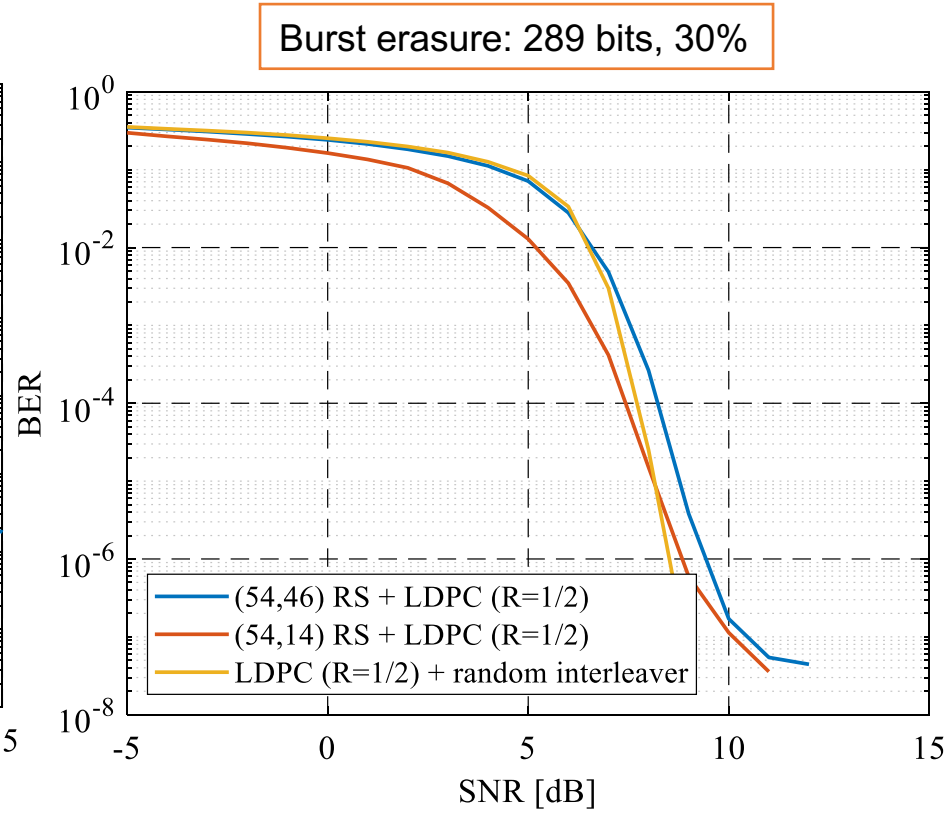
- Shortened RS code
  - 1 symbol = 6 bits
  - Codeword : 63 symbols
  - Shortened symbol : 9 symbols
  - Code length : $(63 - 9) \times 6 = 324$ bits
  - Coding rate : 46/54, 38/54, 28/54, 14/54
- LDPC code
  - Code length : 1296 bits
  - Coding rate : 1/2
  - Number of iteration : 30
  - Decoding algorithm : Min-sum algorithm




Channel coding

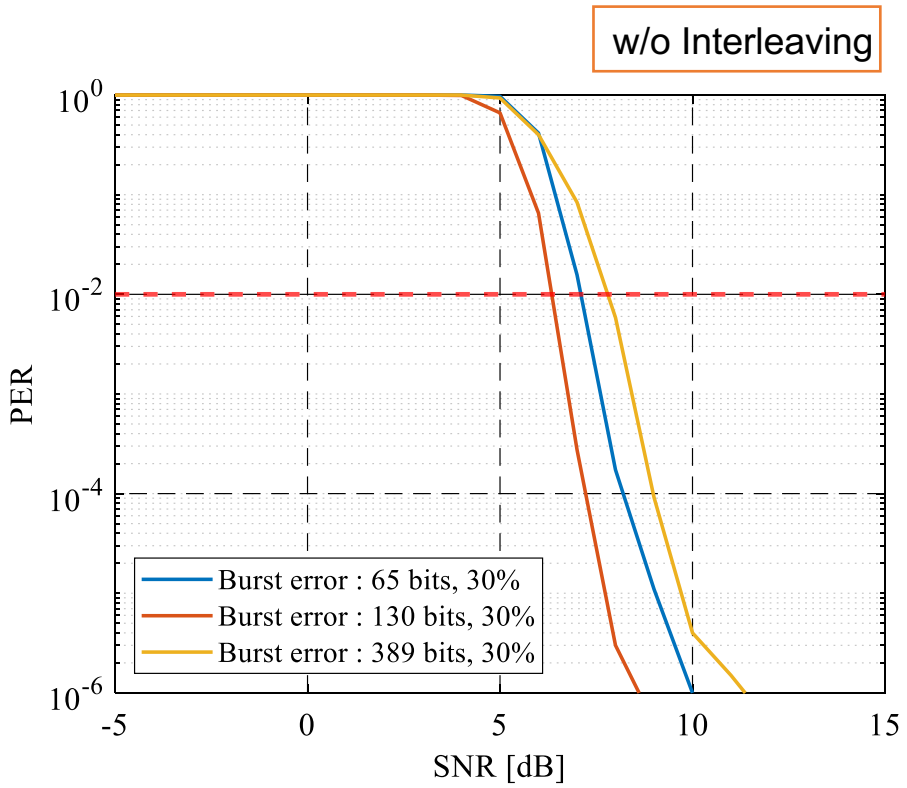
# Effect of interleaving on BER performance

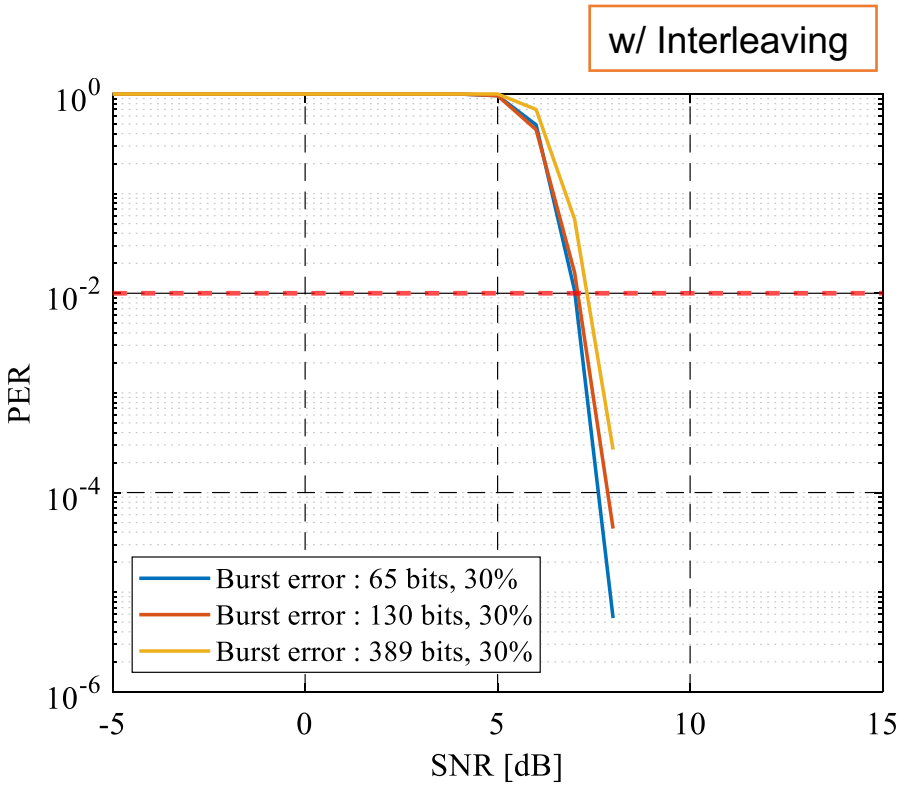



- Modulation: BPSK
- Interleaver type: Random
- Channel: AWGN + burst erasure channel

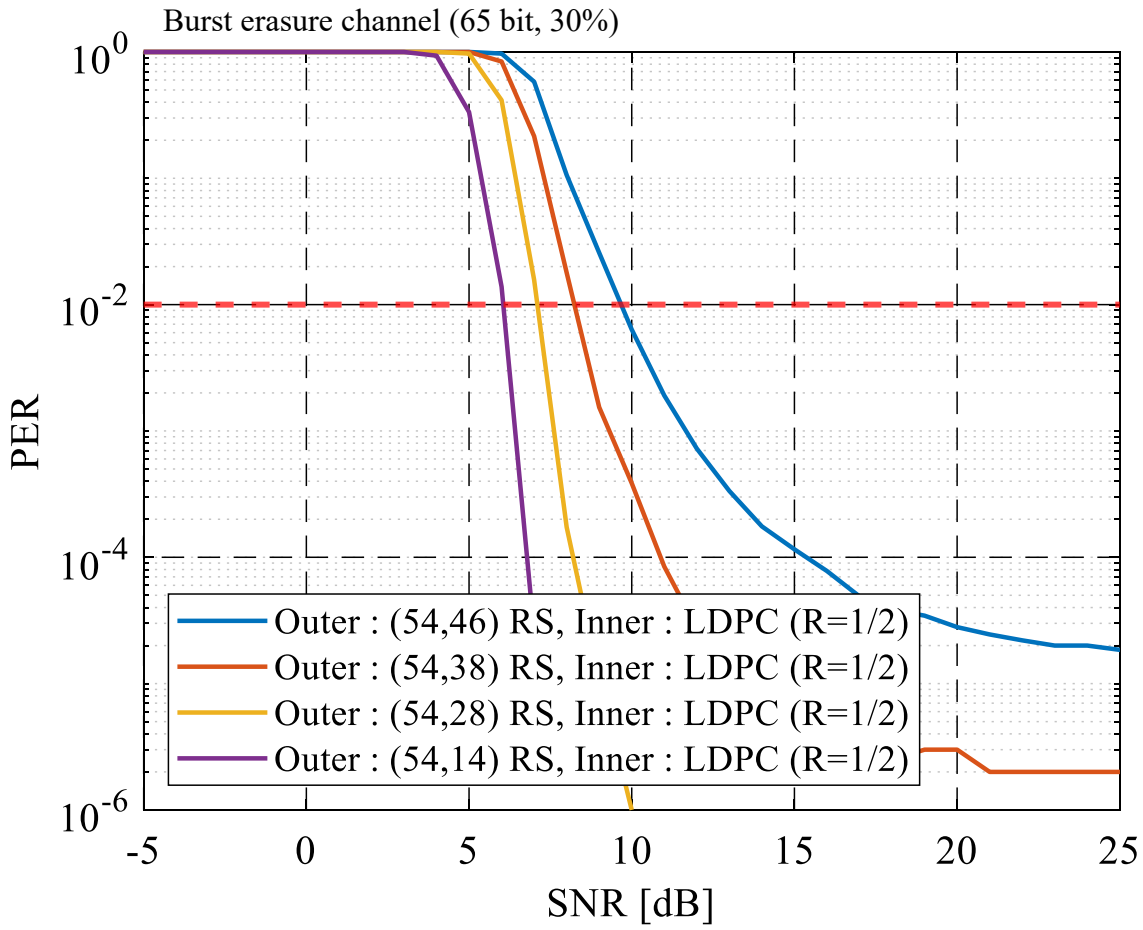
# Effect of interleaving on BER performance




- Modulation: BPSK
- RS(54, 28) + LDPC(R=1/2)
- Channel: AWGN + burst erasure channel

# Effect of channel coding parameters





D. Anzai, S. Asano, T. Kobayashi (OMU), K. Takabayashi (Toyo Univ.) M. Hernandez (CWC Oulu Univ.) R. Kohno(YNU/YRP-IAI)

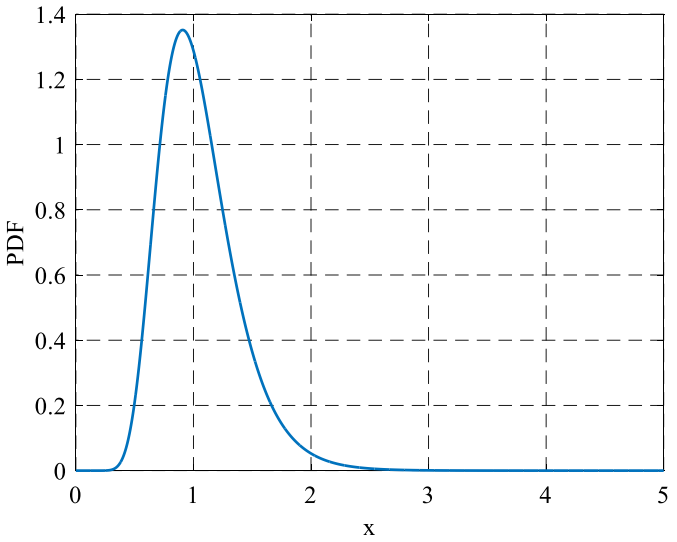
# FEC performance evaluation under TG6ma channel model

- The PDF of shadowing in path-loss is as follows:

$$g(y) = \frac{1}{\sqrt{2\pi\sigma_s^2}} \exp\left(-\frac{(y-\mu_s)^2}{2\sigma_s^2}\right)$$

- From the above, the voltage amplitude ratio follows a log-normal distribution, and the PDF is as follows:

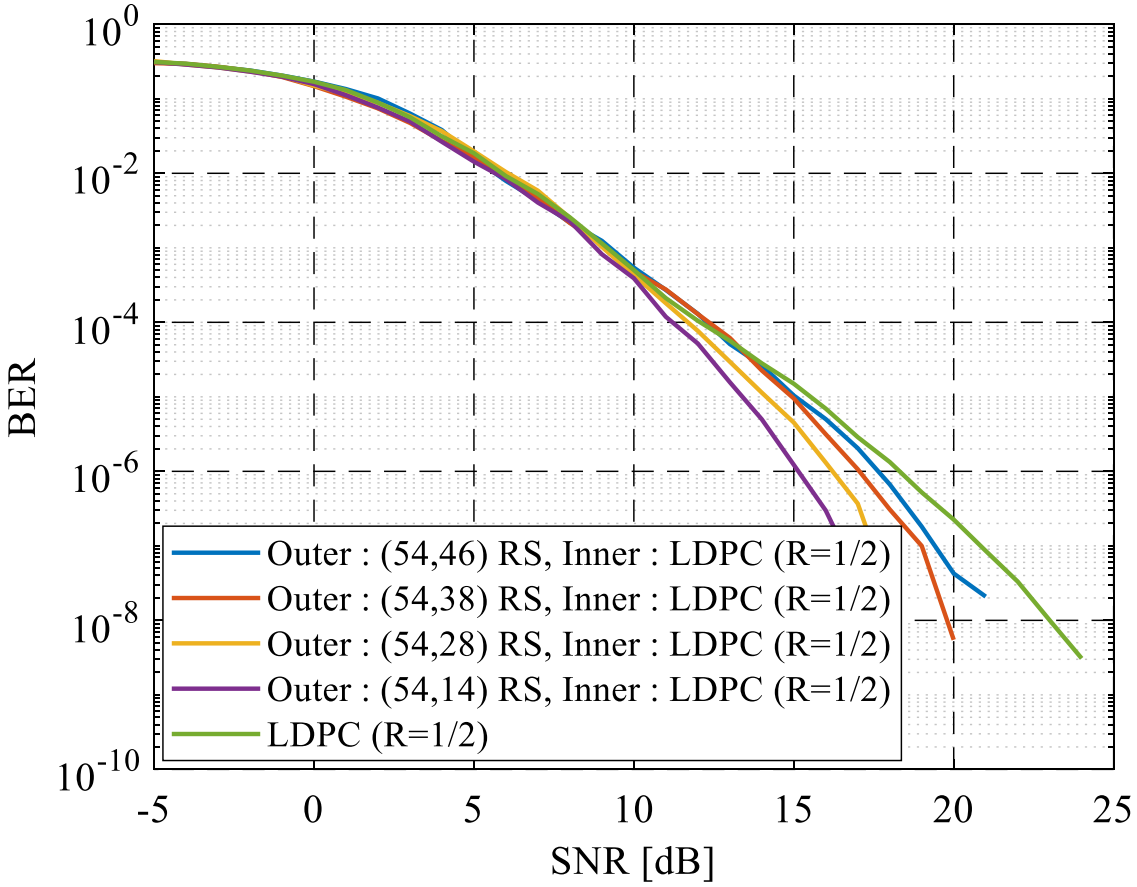
$$f(x) = \frac{1}{\sqrt{2\pi\left(\frac{\sigma_s}{a}\right)^2}\,x} \exp\left(-\frac{\left(\ln x - \frac{\mu_s}{a}\right)^2}{2\left(\frac{\sigma_s}{a}\right)^2}\right)$$




PDF of log-normal distribution ($\mu = 0, \sigma = 0.31$)

$\mu_s$: mean of shadowing [dB]
$\sigma_s$: standard deviation of shadowing [dB]
$\mu = \frac{\mu_s}{a}$: mean of logarithmic amplitude ratio
$\sigma = \frac{\sigma_s}{a}$: standard deviation of logarithmic amplitude ratio

# Evaluation results in shadow fading




BPSK modulation

AWGN and Shadowing

- LDPC
- Outer: RS, Inner: LDPC

RS parameter
Code length: 324 bits

LDPC parameter
Code length: 1296 bits

Fading parameter
Variance: 2.69 [dB]

# References


1. D. Anzai, I. Balasingham, G. Fischer, J. Wang, “Reliable and High-Speed Implant Ultra-Wideband Communications with Transmit–Receive Diversity,” EAI/Springer Innovations in Communication and Computing, pp. 27-32, March 2020.
2. Y. Shimizu, D. Anzai, R. C-Santiago, P. A. Floor, I. Balasingham, and J. Wang, “Performance evaluation of an ultra-wideband transmit diversity in a living animal experiment” IEEE Trans. Microw. Theory Tech., vol. 65, no. 7, pp. 2596-2606, July 2017.
3. D. Anzai, K. Katsu, R. Chavez-Santiago, Q. Wang, D. Plettemeier, J. Wang, and I. Balasingham, “Experimental evaluation of implant UWB-IR transmission with living animal for body area networks,” IEEE Trans. Microw. Theory Tech., vol. 62, no. 1, pp. 183-192, Jan. 2014.
4. J. Shi, D. Anzai, and J. Wang, “Channel modeling and performance analysis of diversity reception for implant UWB wireless link,” IEICE Trans. Commun., no. E95-B, vol. 10, pp. 3197-3205, Oct. 2012.