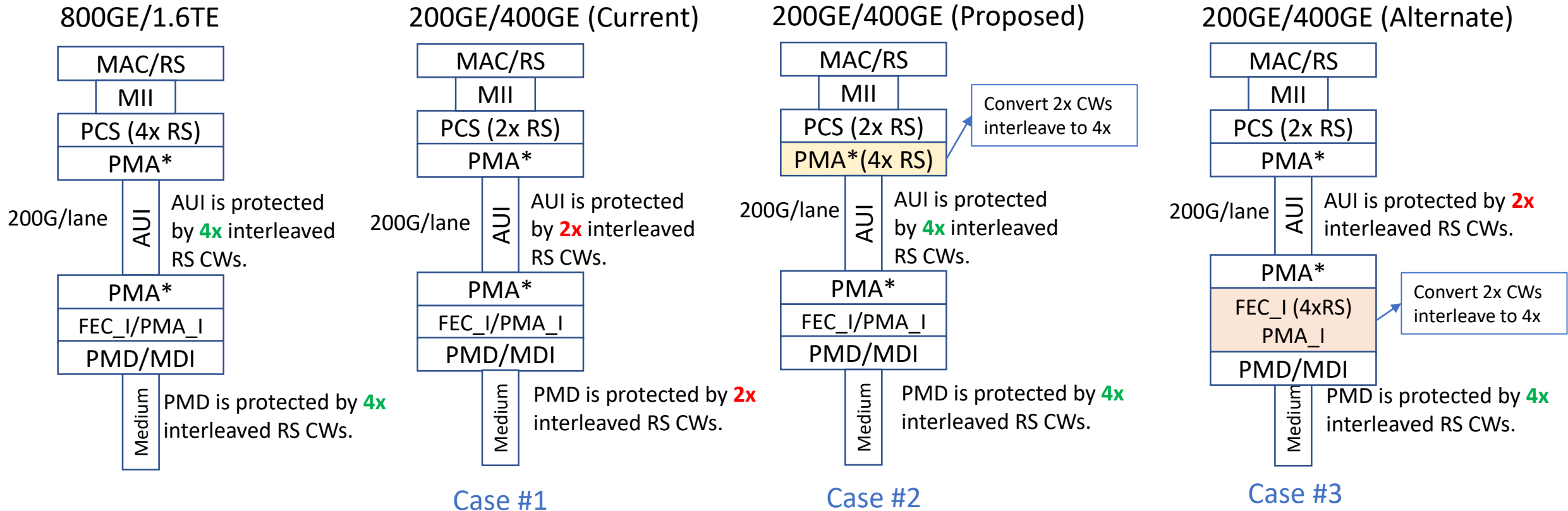# RS Codeword Interleaving for 200 GbE and 400 GbE

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Introduction

- P802.3dj covers various Ethernet rates for 200GE, 400GE, 800GE and 1.6TE.
  - Each rate needs to support 200Gb/s per lane AUIs and PMDs.

- For short reach PHYs, lower latency is preferred.
  - 4x codewords rather than 12x codewords interleaving may be preferred.

- All PCS designs for the above rates have been determined in the Task Force.
  - 200GE and 400GE both interleave 2x RS codewords in the PCS.
  - 800GE and 1.6TE both interleave 4x RS codewords in the PCS/PMA.

- Symbol-pair muxing PMA has been adopted for 200G/lane AUIs.
  - Please see ran_3dj_01a_2303.

- This presentation is a preliminary analysis on the performance difference due to different number of RS codewords for Type 2 PHY scheme.
  - This analysis is specific for Type 2 optical links with up to 2 AUIs at each end.
  - Type 1 PHY scheme needs to be addressed as well, but not covered in this presentation.

Interleaving Depth vs AUI Burst Protection

800GE/1.6TE

MAC/RS
MII
PCS (4x RS)
PMA*

200G/lane — AUI

AUI is protected by **4x** interleaved RS CWs.

PMA*
FEC_I/PMA_I
PMD/MDI

Medium

PMD is protected by **4x** interleaved RS CWs.

200GE/400GE (Current)

MAC/RS
MII
PCS (2x RS)
PMA*

200G/lane — AUI

AUI is protected by **2x** interleaved RS CWs.

PMA*
FEC_I/PMA_I
PMD/MDI

Medium

PMD is protected by **2x** interleaved RS CWs.

Case #1

200GE/400GE (Proposed)

MAC/RS
MII
PCS (2x RS)
PMA*(4x RS) → Convert 2x CWs interleave to 4x

200G/lane — AUI

AUI is protected by **4x** interleaved RS CWs.

PMA*
FEC_I/PMA_I
PMD/MDI

Medium

PMD is protected by **4x** interleaved RS CWs.

Case #2

200GE/400GE (Alternate)

MAC/RS
MII
PCS (2x RS)
PMA*

200G/lane — AUI

AUI is protected by **2x** interleaved RS CWs.

PMA*
FEC_I (4xRS) PMA_I → Convert 2x CWs interleave to 4x
PMD/MDI

Medium

PMD is protected by **4x** interleaved RS CWs.

Case #3

*Symbol-pair muxing PMA as in ran_3dj_01a_2303.

- Assuming same AUI BER threshold for all Ethernet rates using 200G/lane AUIs, the current 200GE/400GE will have lower performance due to 2x RS CWs interleaving compared to 4x of 800GE/1.6TE.

Two-part Link Simulation for 2x and 4x RS Codewords Interleave

- Case #1: 2x RS

- Case #2: 4x RS(host)
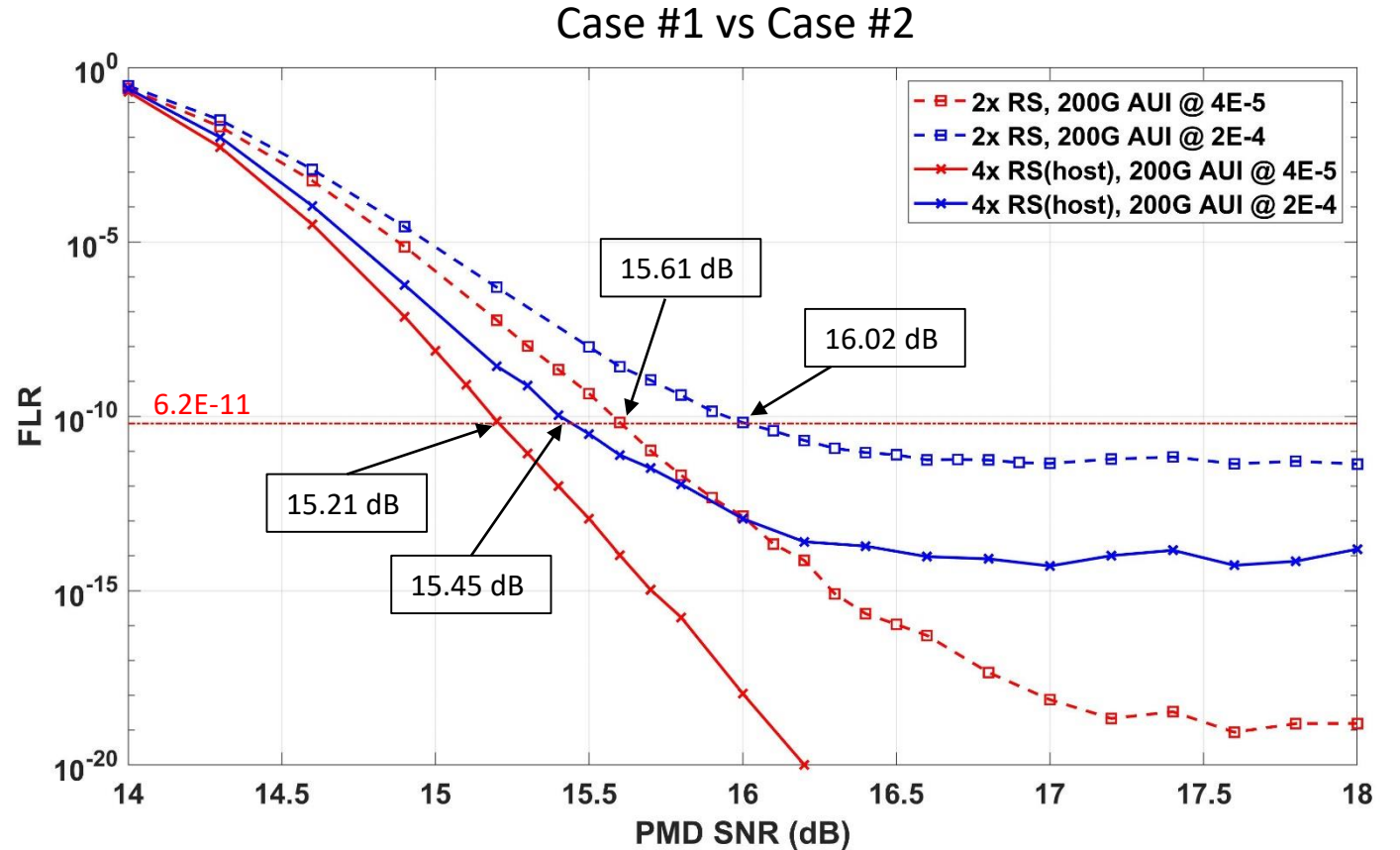
Case #1 vs Case #2

- Simulation configuration:

AUI: 200G/lane, symbol-pair muxing.
Error propagation probability "a" = 0.75, pre-coding ON.

PMD: Pure AWGN.

FEC_I: Hamming(128,120), w/o convolutional interleaver.

Total AUI BER	PMD BER Threshold	
	Case #1	Case #2
4E-5	2.62E-3	3.74E-3
2E-4	1.76E-3	3.03E-3

# Alternative Location to Convert 2x Codewords Interleave to 4x

- Case #2: 4x RS(host)

- Case #3: 2x RS(host), 4x RS(module)

- Case #3 has very little margin below the FLR target when the total AUI BER is 2E-4.
  - Case #2 improves this margin by ~3 orders.

- Case #2 has 0.2dB higher coding gain than Case #3.

- Simulation configuration:

AUI: 200G/lane, symbol-pair muxing.
          Error propagation probability "a" = 0.75, pre-coding ON.

PMD: Pure AWGN.

FEC_I: Hamming(128,120), w/o convolutional interleaver.

Case #2 vs Case #3
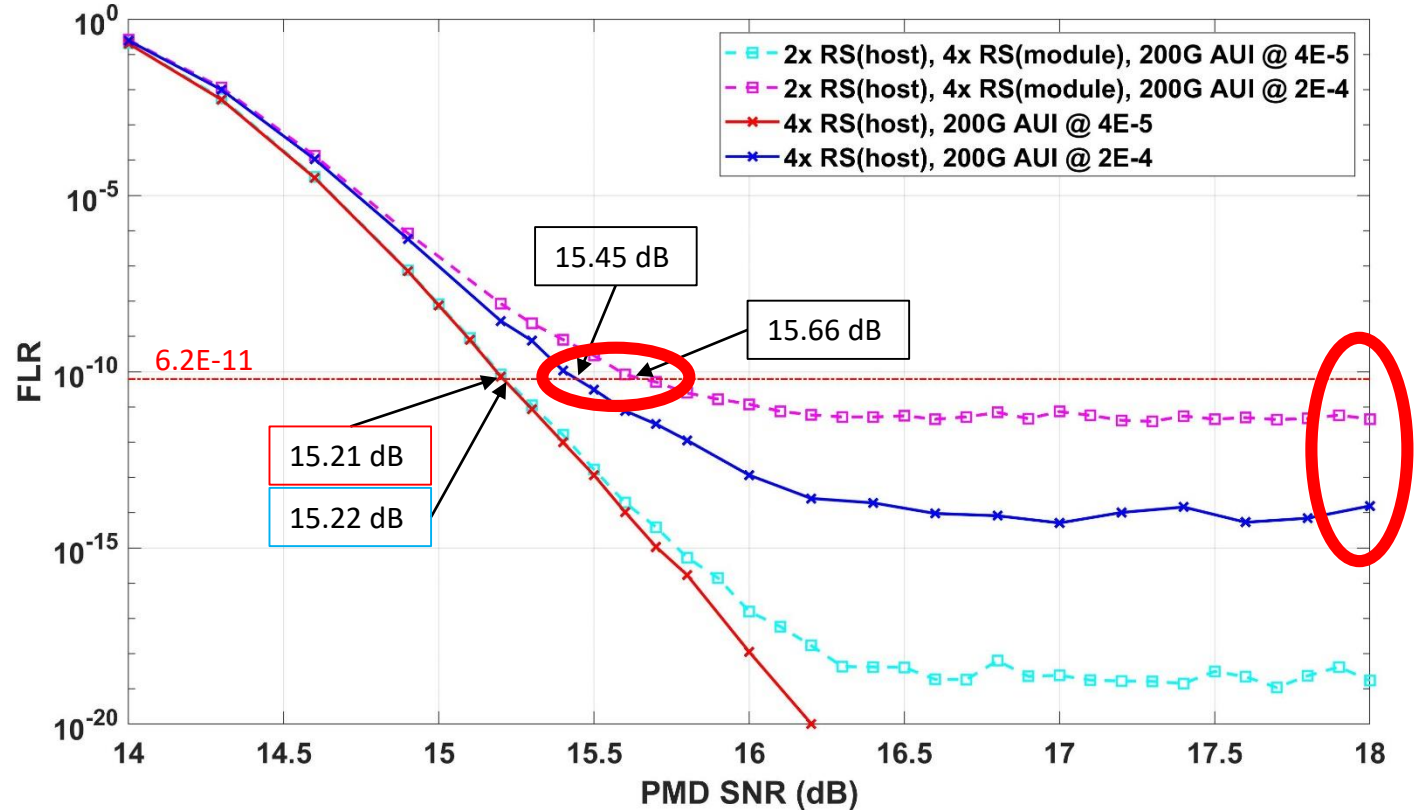
Total AUI BER	PMD BER Threshold	
	Case #2	Case #3
4E-5	3.74E-3	3.71E-3
2E-4	3.03E-3	2.50E-3

Summary

- Increasing interleaving depth from 2x codewords to 4x for 200GE and 400GE could improve overall coding gain by 0.57dB, if total AUI BER is 1E-4 on each side.

  - 2x codewords interleaving on AUI leads to error floor around 1E-11 FLR.

  - Increasing the interleaving depth in the host rather than in the module is preferred.

  - Latency impact is 51.2ns for 200GE, and 25.6ns for 400GE.

- If AUI BER is at 1E-5 per segment, increasing interleaving depth from 2x to 4x for 200GE and 400GE could improve overall coding gain by 0.4dB.

  - Increasing the interleaving depth in the host or module are both OK.

Thank you!

IEEE 802.3dj Task Force