MLSE ΔCOM Equation U1.c for L-level PAM

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Supporters

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U1.c Applied to PAM4

- The underlying analysis for calculating the MLSE COM improvement (ΔCOM) was presented in several contributions:
  - shakiba_3dj_elec_02_230504.pdf
  - shakiba_3dj_elec_01a_230504.pdf
  - shakiba_3dj_elec_02_230420.pdf
  - shakiba_3dj_elec_01_230420.pdf
  - shakiba_3dj_elec_01_230223.pdf
  - shakiba_3dj_01_230116.pdf
- The analysis was not limited to PAM4 and always assumed PAM modulation with L levels (see any of the above contributions)
- In the January 2024 Interim meeting, the analysis result equation U1.c was adopted to calculate and represent MLSE effect in COM reference receivers
- However, in the supporting contribution (shakiba_3dj_01b_2401.pdf), equation U1.c was provided for L = 4 (PAM4)

U1.c Applied to PAM-L

$$\Delta COM \approx 20\log_{10}\left(\frac{1}{A_s}CDF_{noise}^{-1}\left(1-\frac{2}{3}DER_{MLSE}\right)\right)-IP$$

$$DER_{MLSE} \approx 2\sum_{j=1}^{\infty}\left(\frac{3}{4}\right)^j\left(1-CDF_{noise,jEE}\left(A_s\frac{\left(\mathrm{trace}\left(\rho_{noise,jEE}\right)\right)^{\frac{3}{2}}}{\sqrt{\sum_{vertical}\sum_{horizental}\left(\rho_{noise,jEE}\right)}}\right)\right)$$

U1.c for $L = 4$

- In the above equation, constants $\frac{2}{3}$ and $\frac{3}{4}$ and are numerical evaluations of the general parameters $\frac{L}{2(L-1)}$ and $\frac{L-1}{L}$, for $L = 4$ (PAM4) (see analysis from the list on previous slide)
- This contribution suggests to replace these numerical values with their parameterized expressions so U1.c can be applied to general L-level PAM (PAM-L)

$$\Delta COM \approx 20\log_{10}\left(\frac{1}{A_s}CDF_{noise}^{-1}\left(1-\frac{L}{2(L-1)}DER_{MLSE}\right)\right)-IP$$

$$DER_{MLSE} \approx 2\sum_{j=1}^{\infty}\left(\frac{L-1}{L}\right)^j\left(1-CDF_{noise,jEE}\left(A_s\frac{\left(\mathrm{trace}\left(\rho_{noise,jEE}\right)\right)^{\frac{3}{2}}}{\sqrt{\sum_{vertical}\sum_{horizental}\left(\rho_{noise,jEE}\right)}}\right)\right)$$

U1.c for Parametrized L

U1.C Rewritten in Terms of 802.3 Standard DER Definition

- In its current format, and as equations (178A-36) and (178A-37) in the IEEE P802.3dj D1.0 draft, equation U1.c uses DER to denote error event rate
- If equation U1.c is to be rewritten in terms of the 802.3 standard DER definition (as per contribution lim_3dj_02_2405.pdf), it is suggested to consider this parameterization to the rewritten U1.c equation as well:

U1.c Rewritten in terms of 802.3 Standard DER Definition

U1.c for $L = 4$:

$$\Delta COM \approx 20\log_{10}\left(\frac{1}{A_s} CDF_{noise}^{-1}(1 - DER_{MLSE})\right) - IP$$

$$DER_{MLSE} \approx \sum_{j=1}^{\infty}\left(\frac{3}{4}\right)^{j-1}\left(1 - CDF_{noise,jEE}\left(A_s \frac{\left(\mathrm{trace}\left(\rho_{noise,jEE}\right)\right)^{\frac{3}{2}}}{\sqrt{\sum_{vertical}\sum_{horizental}\left(\rho_{noise,jEE}\right)}}\right)\right)$$

U1.c for Parametrized L:

$$\Delta COM \approx 20\log_{10}\left(\frac{1}{A_s} CDF_{noise}^{-1}(1 - DER_{MLSE})\right) - IP$$

$$DER_{MLSE} \approx \sum_{j=1}^{\infty}\left(\frac{L-1}{L}\right)^{j-1}\left(1 - CDF_{noise,jEE}\left(A_s \frac{\left(\mathrm{trace}\left(\rho_{noise,jEE}\right)\right)^{\frac{3}{2}}}{\sqrt{\sum_{vertical}\sum_{horizental}\left(\rho_{noise,jEE}\right)}}\right)\right)$$