DFE Error Performance Under 1000BASE-T1 Noise Environments

Xiaofeng Wang, Qualcomm Inc
wangxiao@qti.qualcomm.com

Supporters

- Sujan Pandey, NXP
- Benson Huang, Realtek
- Shaoan Dai, Marvell

Agenda

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Motivations

- Previous SNR results provide estimates of BER only when DFE error propagation is negligible.

- Actual error performance are required under 1000BASE-T1 noise environments and with realistic DFE taps for
  - evaluation of symbol mapping schemes.
  - finalization of Tx PSD mask.
  - design of FEC.

DFE Results Over 2m Channel

- First-order transmit filter to fit the agreed Tx-PSD mask with reduced DC level at 80.5dBm/Hz .
- Agreed Xtalk models and thermal noise @ -140dBm/Hz and receive HPF with fc=10 MHz.
- 10% overhead in addition to mapping, two mapping schemes: Map 1, 2D-PAM3 with out "00"; Map 2, 10 bits to 7 symbols mapping [xiaofeng_3bp_02_0314.pdf.]

Table - Results for 2m channel @ 125 ^{0}C, Infinite-length DFE.

	Eye Height (mV)	SNR (dB)	DFE Tap 1	DFE Tap 2
Map 1, SQNR=32.8 dB	270	30.16	0.67	0.13
Map 1, SQNR=29.8 dB	270	27.49	0.66	0.10
Map 2, SQNR=32.8 dB	275	30.35	0.61	0.07
Map 2, SQNR=29.8 dB	275	27.8	0.59	0.04

DFE Results Over 15m Channel

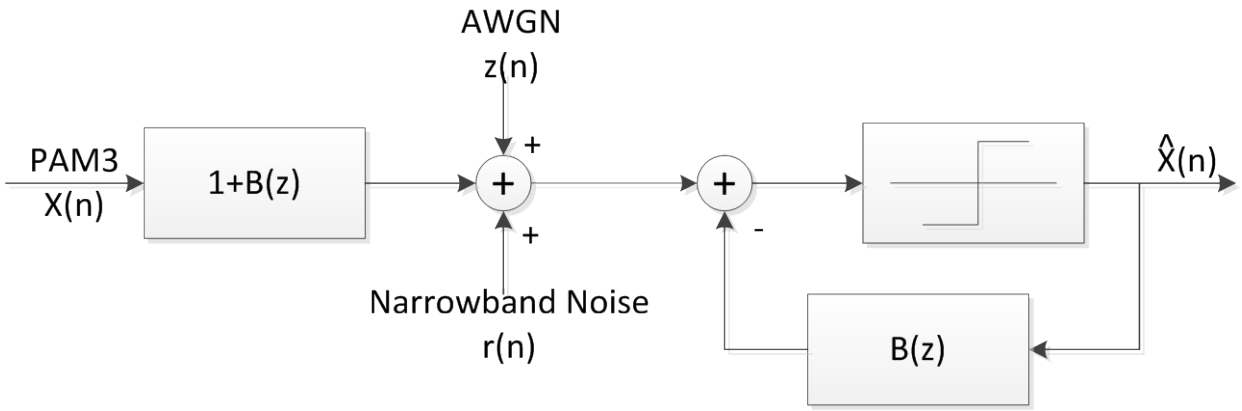
Table - Results for 15m channel @ 20^0C, Infinite-length DFE.

	Eye Height (mV)	SNR (dB)	DFE Tap 1	DFE Tap 2
Map 1, SQNR=32.8 dB	174	29.06	0.88	0.32
Map 1, SQNR=29.8 dB	174	26.4	0.87	0.30
Map 2, SQNR=32.8 dB	177	29.4	0.82	0.25
Map 2, SQNR=29.8 dB.	177	26.8	0.81	0.22

Discussions

- The first DFE feedback tap is greater than 0.5 in all cases.
- Finite-length implementation may lead to smaller DFE tap at the cost of reduced SNR and non-flat FFE gain.
- In the absence of narrowband noises, large SNR renders DFE error propagation a nonissue.
- Two worst-case scenarios need to be investigated
  - 2m channel with 200mVpp RFI.
  - ISO-7637-3 transient noise.
- To measure error propagation, number of error code symbols per codeword will be used. It is assumed that a codeword has 255 code symbols and a code symbol has 6 PAM-3 symbols (or 9 bits) for Map1 and 7 PAM-3 symbols (0r 10 bits) for Map 2.

DFE Simulation Model



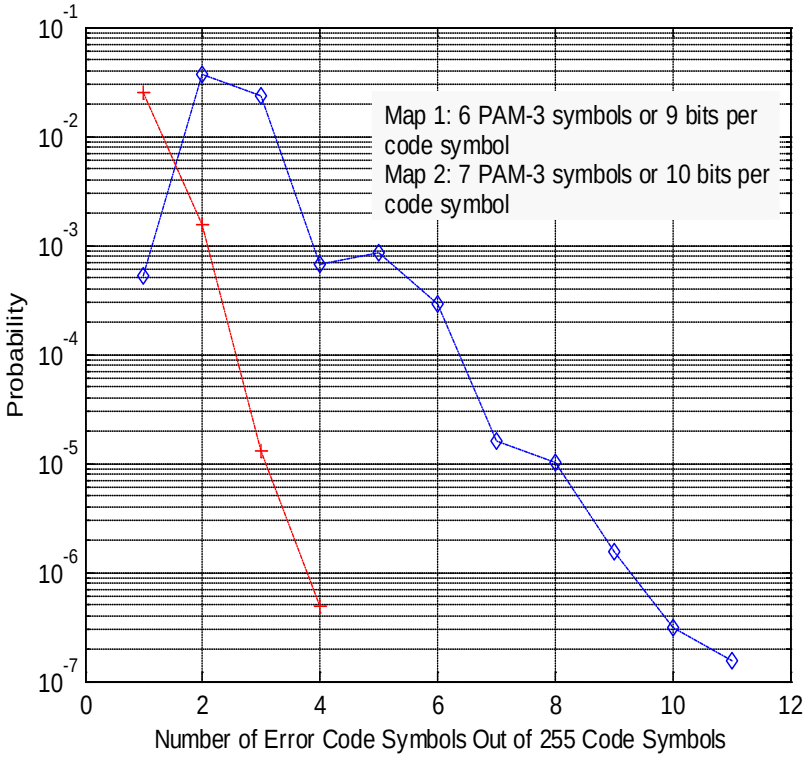
- B(z) with two taps.
- When a decision error happens, the signal before decision is:

  x(n)+r(n)+z(n)-b(1)e(n-1)-b(2)e(n-2)
- Observations:
  - Error propagation can happen even when b(1) <0.5 and b(2)=0 because the effect of r(n).
  - When r(n) and r(n-1) have the same sign, error propagation unlikely occurs. This indicates that error propagation will happen more likely when RFI frequency is over fb/4 and less likely in transient noise and RFI with frequency less than fb/4. The worst case happens when RFI with frequency fb/2 and e(n-1) and r(n) always push the error toward the same direction.

Error Performance Under RFI

- $B(z)=0.67z^{-1}+0.13z^{-2}$
- RFI peak to peak amplitude =0.70 vs. eye height =1.
- RFI frequency at 0.47fb with fb as symbol rate.
- If RS code, Map 1 needs t=11 and Map 2 needs t=4.

Mapping Scheme	SER
Map 1	3.7e-4
Map 2	5.6e-5



Error Performance Under Transient Noise I

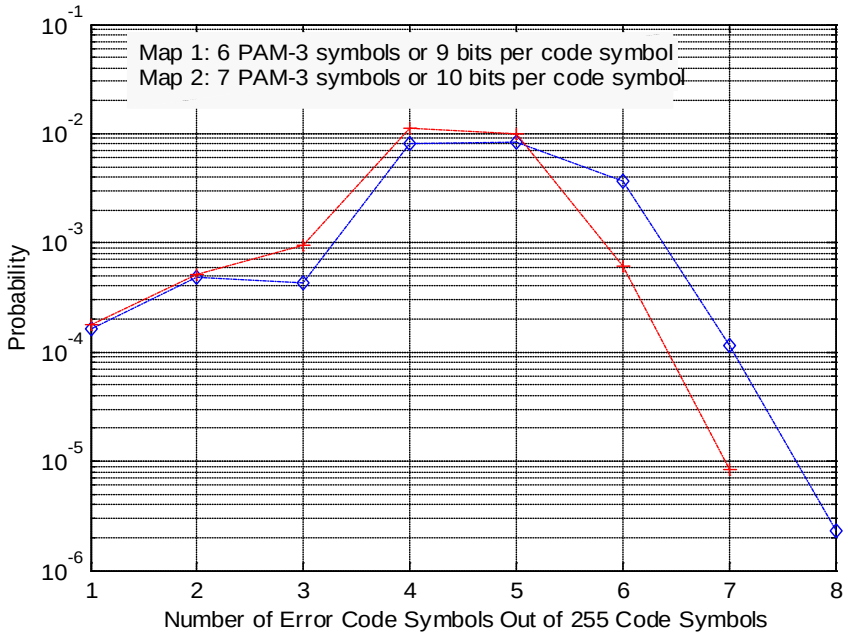
- 2m channel
  - $B(z)=0.67z^{-1}+0.13z^{-2}$
  - Transient noise modeled as a cycle of sine wave with duration 80ns and peak to peak amplitude =0.70 vs. eye height =1.
  - SNR = 26 dB.
- No error propagation observed and hence RS code with t=1 is sufficient.

Mapping Schemes	SER
Map 1	3.4e-8
Map 2	1.36e-8

Performance Under Transient Noise II

- 15m channel
  - $B(z)=0.88z^{-1}+0.32z^{-2}$
  - Transient noise a cycle of sine wave with duration 80ns and peak to peak amplitude =1.14 vs. eye height =1.
  - SNR = 26 dB.
  - RS code with t=8 for Map 1 and RS code with t=7 for Map 2.

Mapping Scheme	SER
Map 1	1.02e-4
Map 2	9.2e-5



Conclusions

- HPF significantly reduce DFE tap gains.
- Even with HPF in 2m channel, the first DFE feedback tap tends to be large.
- Severe error propagation occurs in the presence of high-frequency RFI.
  - RFI with frequency at half of symbol rate causes error propagation that is un-decodable.
- Because ISO-7637 transient noise primarily consists of components of frequency far lower than half of the symbol rate, error propagation is not an issue.
- Appropriate line coding can significantly reduces the required coding overhead.
  - With the proposed 10 bits to 7 symbol mapping scheme, RS code with t=4 or 5 is sufficient.