DFE Bound Calculation for Line Code Alternatives -*Uncoded System*-

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Line Codes Studied

Line Code Alternatives

4PAM 1.25Gbaud

8PAM 833Mbaud

12PAM 697Mbaud

Transmit Power

6dBm, 10dBm, and 12dBm

1st order Low-pass filtered at 0.75 times of baud

Back Ground Noise

-150dBm/Hz to -130dBm/Hz

Optimal DFE Calculation

Salz formula[1]

Ideal implementation

MMS algorithm for FFE + DFE

BER 10(-12)**

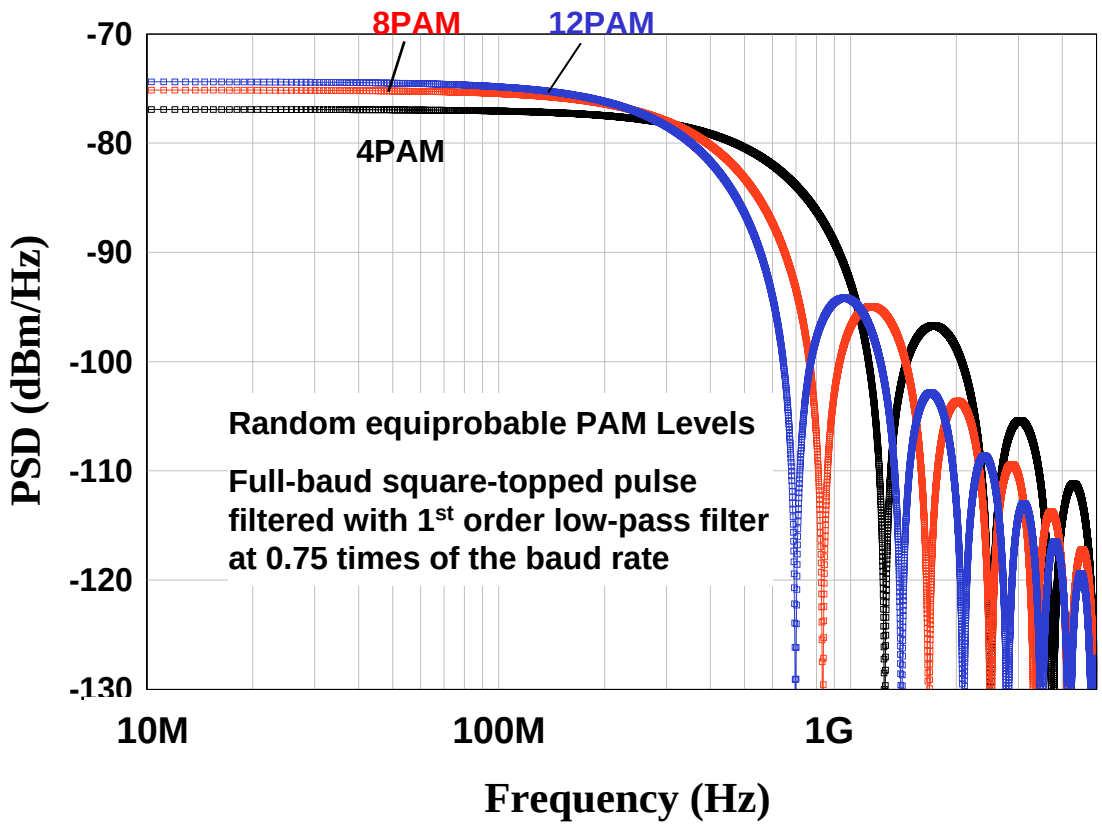
A-Cross Talk

Specified in 10GBase-T Channel Model Proposal March '04,

(1) J. Salz, "Optimum Mean-Squre Decision Feedback Equalization", BSTJ, Vol 52, No.8, October 1973, p.1341

Power Spectral Density (Single sided)

10dBm Power for all Line Codes



Launch voltage (peak to peak)

Without transformer

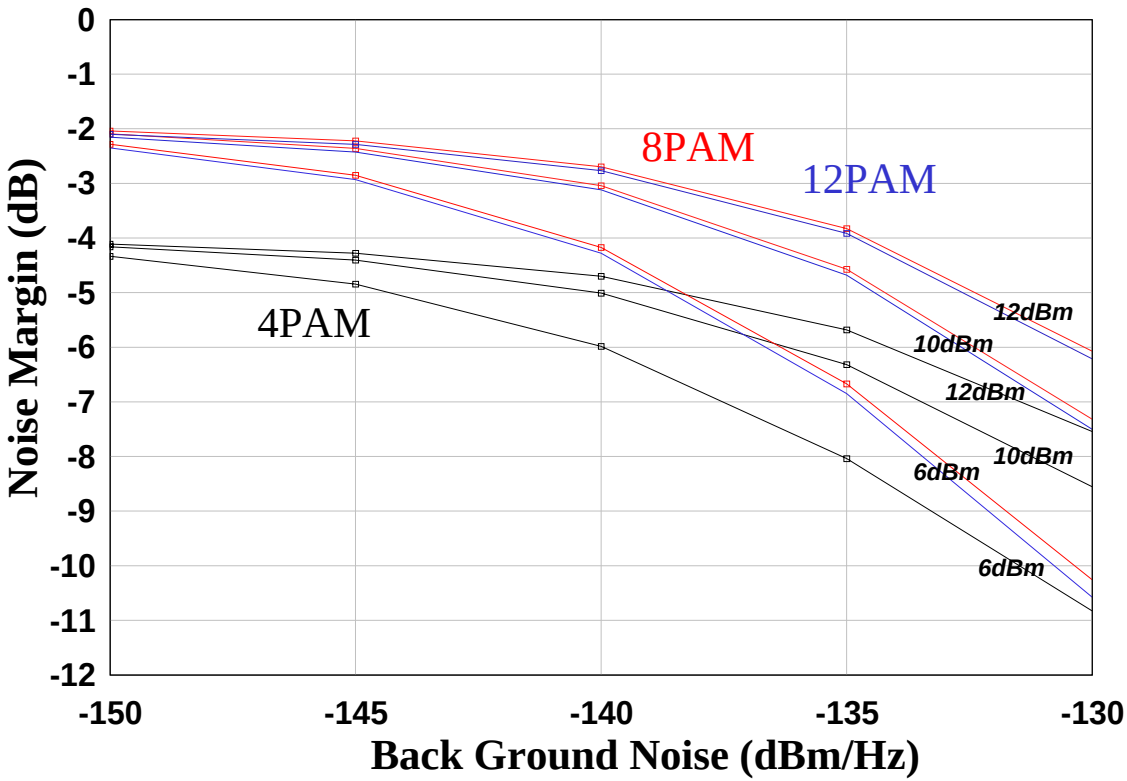
	4PAM	8PAM	12PAM
6dBm	1.88V	2.15V	2.23V
10dBm	2.99	3.41	3.55
12dBm	3.77	4.29	4.47

The values increase when DC wander Exists by DC cut characteristics due to transformers

Model 1: 100m, Class F

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12)**



Results: Noise margin

BGN	4PAM	8PAM	12PAM
-140dBm/Hz	-5.0dB	-3.0dB	-3.1dB
-150dBm/Hz	-4.2dB	-2.1dB	-2.2dB

10dBm TX Power

8 PAM is slightly better than 12PAM by 0.1dB.

4PAM shows obvious degradation.

Minor improvement with TX power increase above 10dBm.

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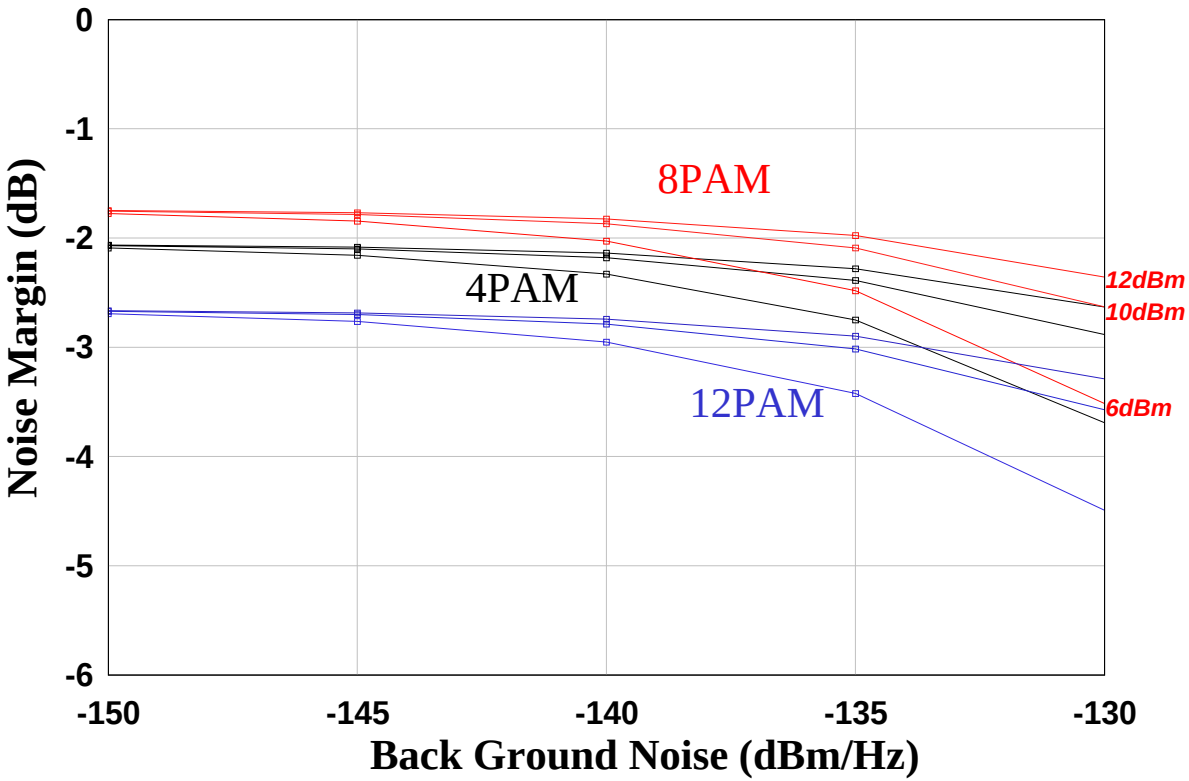
Model 2: 55m, Class E

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12)**



Results: Noise Margin

BGN	4PAM	8PAM	12PAM
-140dBm/Hz	-2.2dB	-1.9dB	-2.8dB
-150dBm/Hz	-2.1dB	-1.8dB	-2.7dB

10dBm TX Power

8 PAM is slightly better than 4PAM by 0.3dB.

8PAM is better than 12PAM by 0.9dB.

No improvement with TX power increase above 10dBm.

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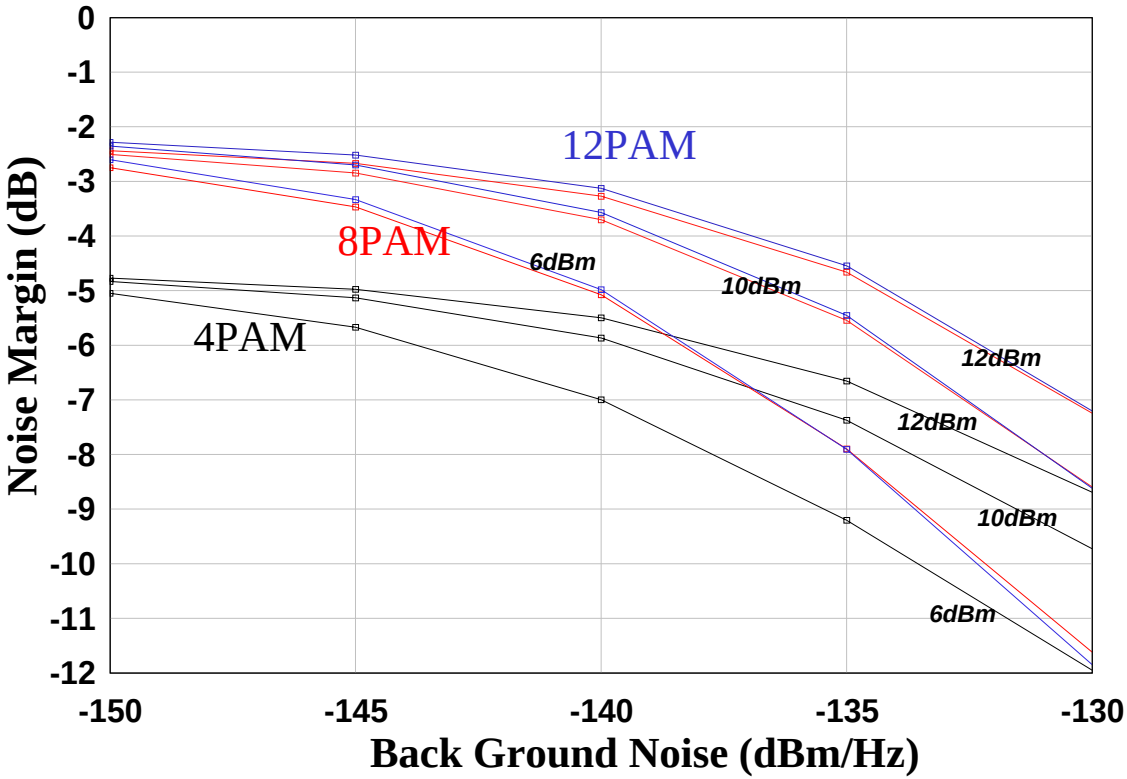
Model 3: 100m, Class E

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12)**



Results: Noise Margin

BGN	4PAM	8PAM	12PAM
-140dBm/Hz	-5.9dB	-3.7dB	-3.6dB
-150dBm/Hz	-4.8dB	-2.5dB	-2.4dB

10dBm TX Power

12 PAM is slightly better than 8PAM by 0.1dB.

4PAM showed obvious degradation.

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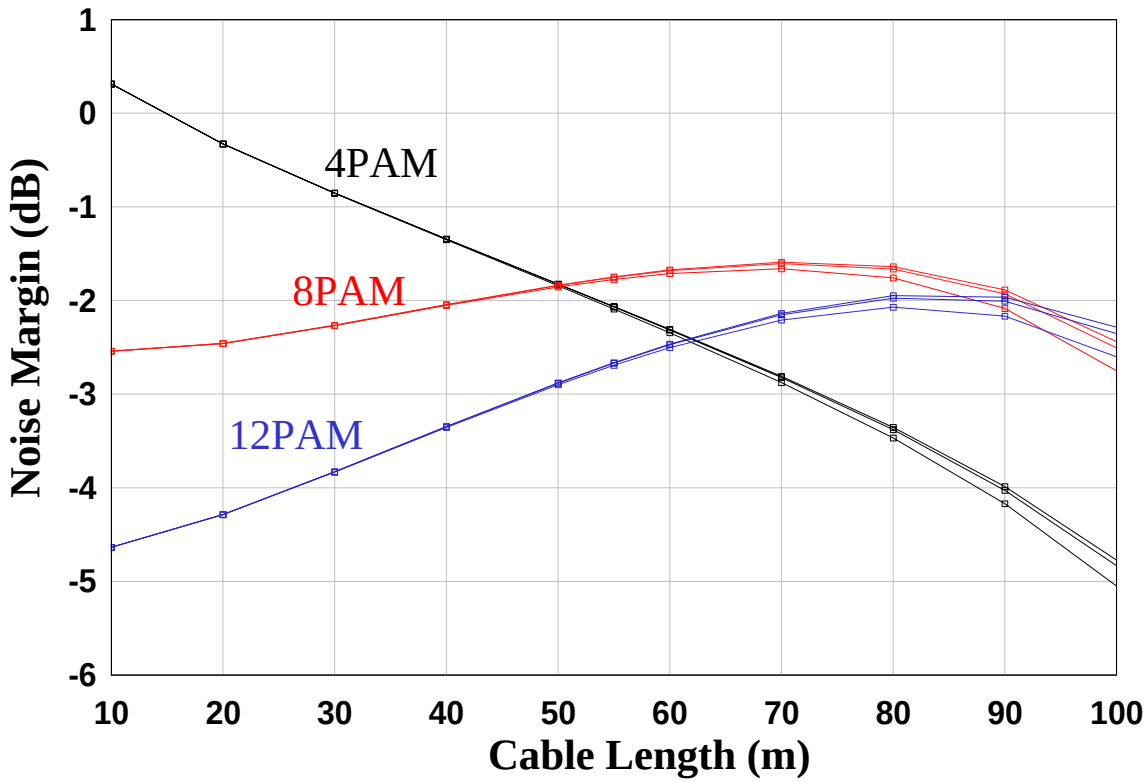
Model 4: 55~100m, Class E

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12), Back Ground Noise=-150dBm/Hz**



Results:

4PAM showed obvious advantage for shorter cable up to 50~55m.

However, 8 and 12 PAM show strange behavior for reach performance.

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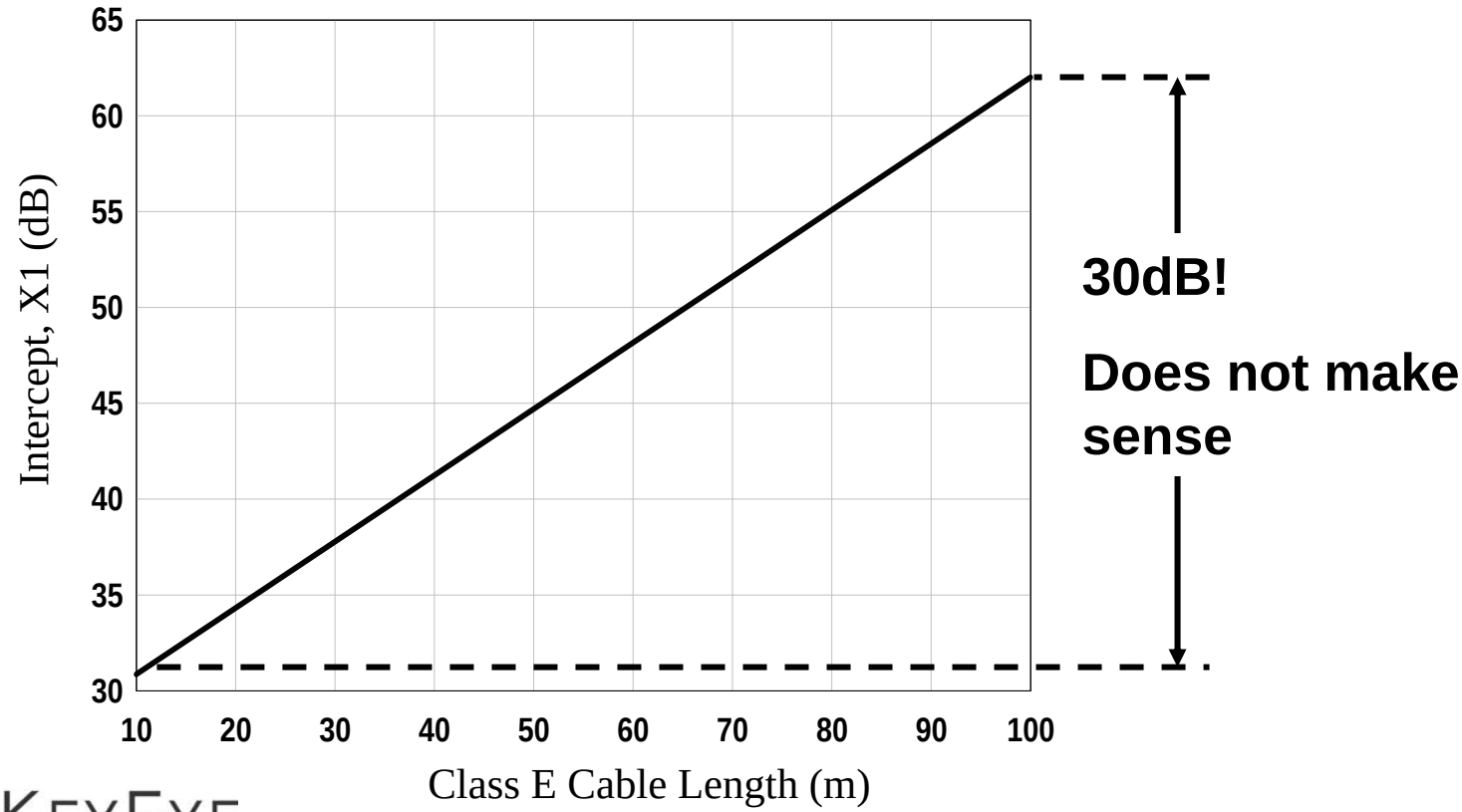
ANEXT Intercept (X1) Model Correct?

X1 = 62 – (IL(100m) – IL(Lm))*15/15.6

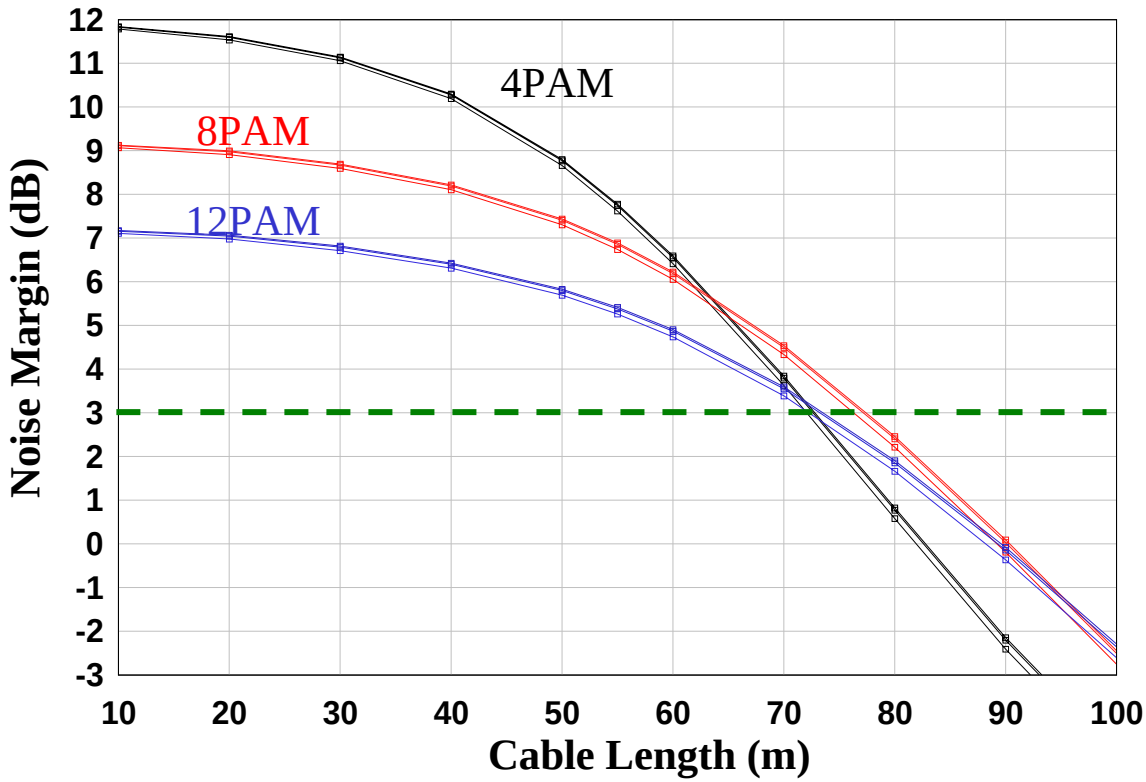
@ 250MHz



Model 4': 55~100m, Class E, X1=62dB fixed

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12), Back Ground Noise=-150dBm/Hz**



Results: 3dB Reach

BGN	4PAM	8PAM	12PAM
-150dBm/Hz	72m	77m	73m

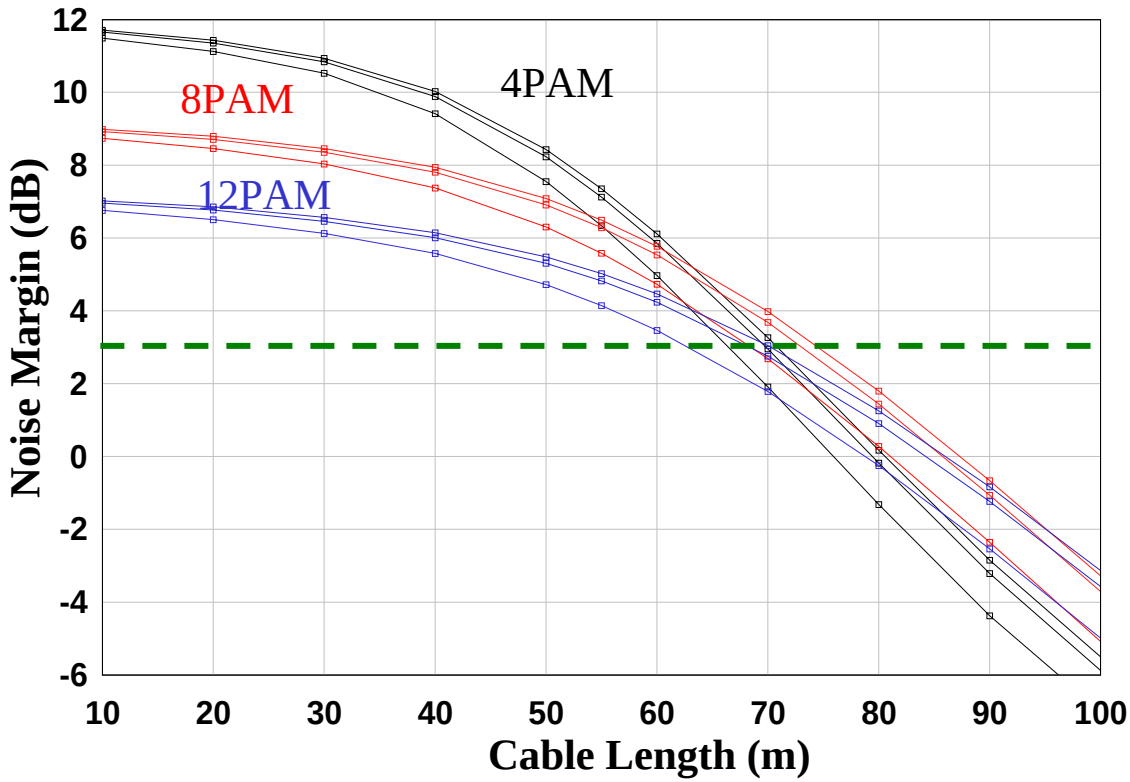
10dBm TX Power

8PAM can reach longest.

Model 4': 55~100m, Class E, X1=62dB fixed

Uncoded Noise Margin 4, 8, and 12PAM

BER=10(-12), Back Ground Noise=-140dBm/Hz**



Results: 3dB Reach

BGN	4PAM	8PAM	12PAM
-150dBm/Hz	70m	73m	70m

10dBm TX Power

8PAM can reach longest.

Summary

Theoretical performance analysis is made assuming ideal DFE structure. Noise margins of the uncoded 4, 8, and 12PAM are compared with different TX-Power and Back Ground Noise conditions. Fixed X1 value (ANEXT Intercept) of 62dB is used for the model 4.

[Results] **8 PAM is the best solution to meet both 55m and 100m criteria.**

8 PAM (uncoded) noise margins are, -2 ~-3dB for Model 1 and 2

-2~-4dB for Model 3.

6~7dB coding gain is necessary to achieve 3dB margin for all models.

In practice, another a few dBs of further improvement of coding gain is strongly recommend to allow the non-ideal implementation.

8 PAM attains a longest among three PAM alternatives.

[Conclusion]

1. 8PAM is the choice for the 10GBase-T Line Code.

2. 8~9dB of real coding gain is necessary to achieve 3dB margin with the implementation loss of 2dB.

3. 10dBm TX power (nominal) is recommended.