

Line Code Options for 10GBASE-T

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Outline

- Line Code Options
- ENOB Requirements
- Crest Factor
- DFE Requirements
- Constrained DFE
- Realistic Line Code options



Assumptions

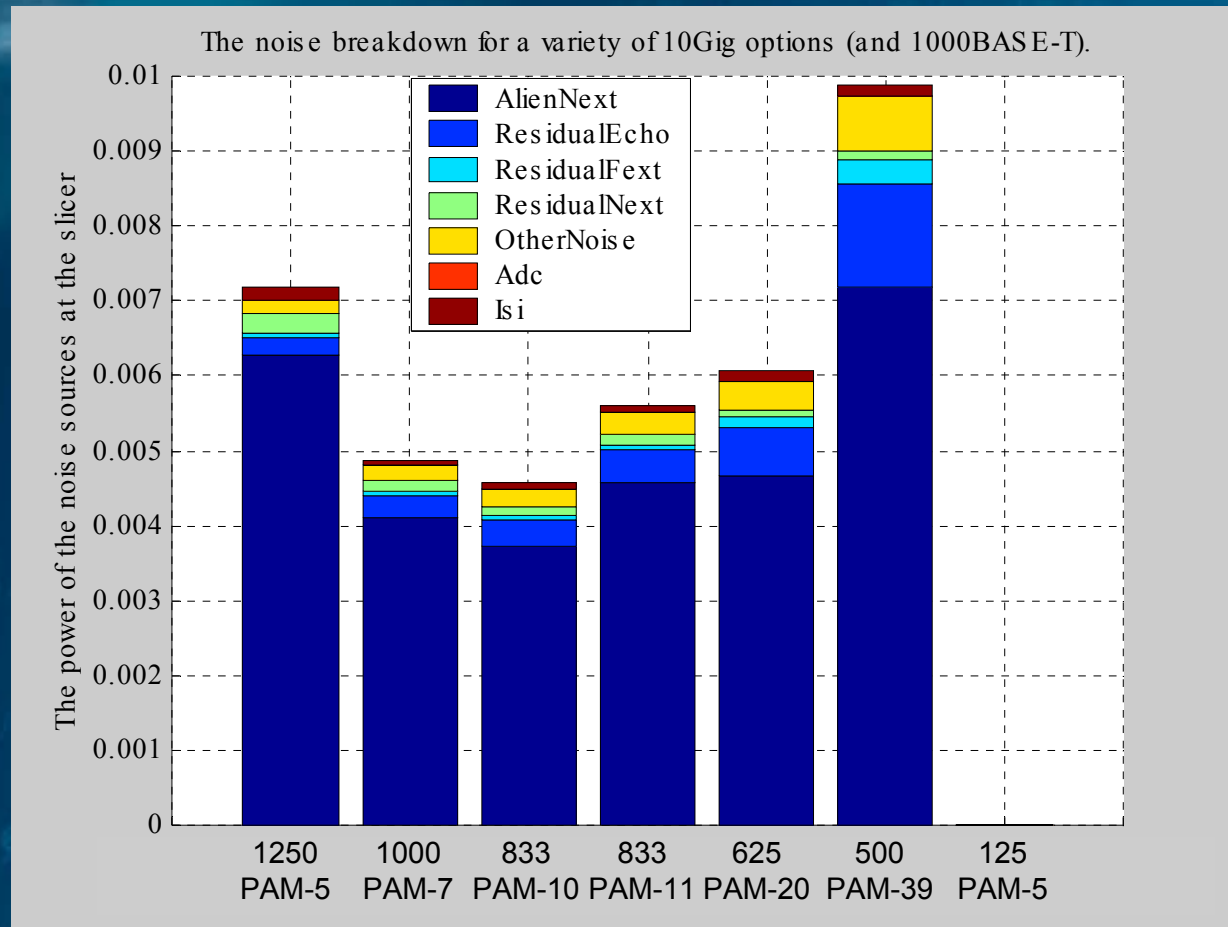
- -80dBm/Hz limit on transmit PSD to comply with FCC class A limits.
- Channel and noise models as per 10GE Tutorial November 2002
- Sample rate simulation with MMSE solution for large equalizer (FFE and DFE)
- -17dB noise power target assumed (about 5.5dB coding gain).

Line Code / Baud Rate Options

No.	Option	Baud Rate (M symbols/s)	PAM Levels (total)
1	1250-PAM5	1250	[-2:2] (5)
2	1000-PAM7	1000	[-3:3] (7)
3	833-PAM10	833	[-9/2:9/2] (10)
4	833-PAM11	833	[-5:5] (11)
5	625-PAM20	625	[-19/2:19/2] (20)
6	500-PAM39	500	[-19:19] (39)
7	125-PAM5	125	[-2:2] (5)

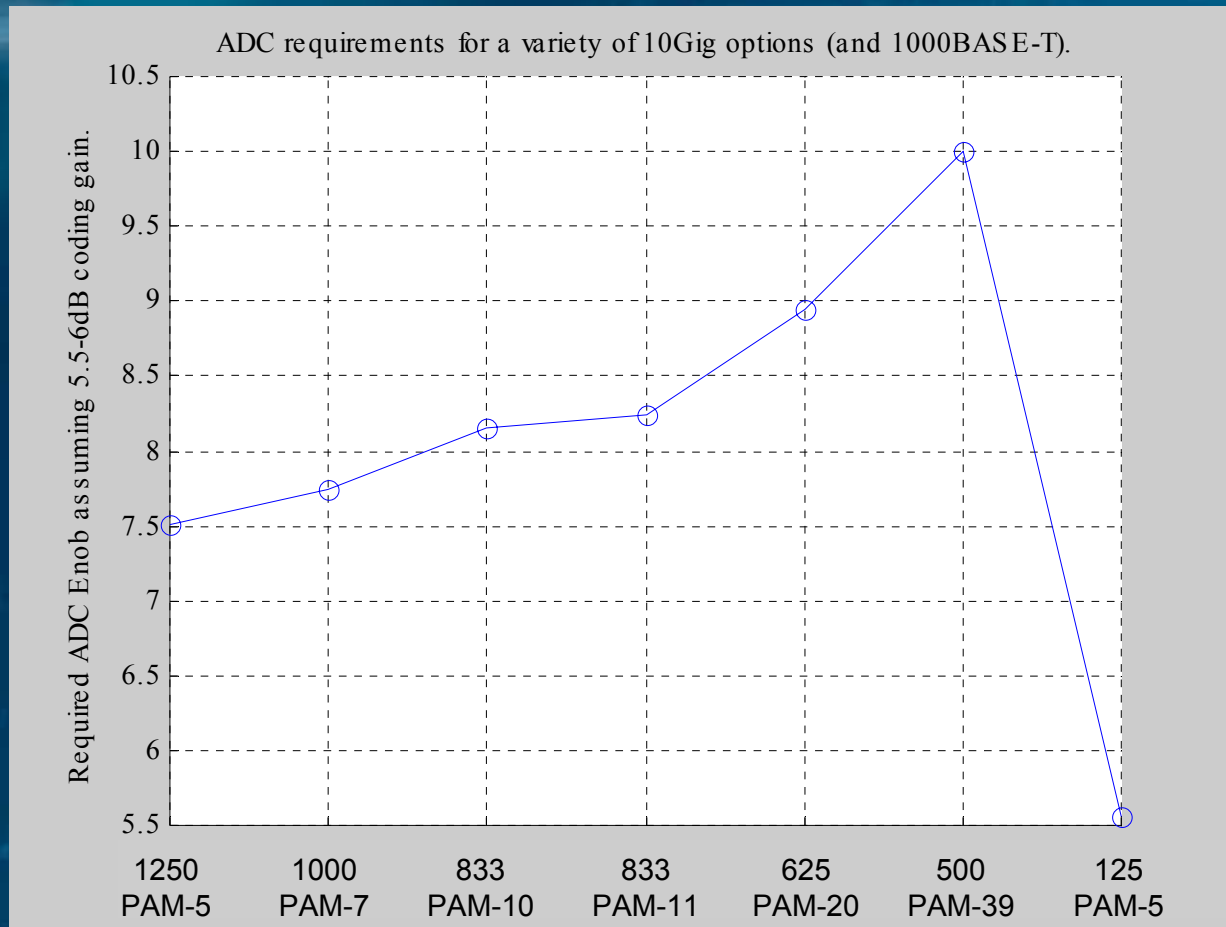
Noise Mix Excluding ADC

- Noise break-down for line code options



Receiver ENOB Requirements

- ENOB required to meet SNR target at the slicer

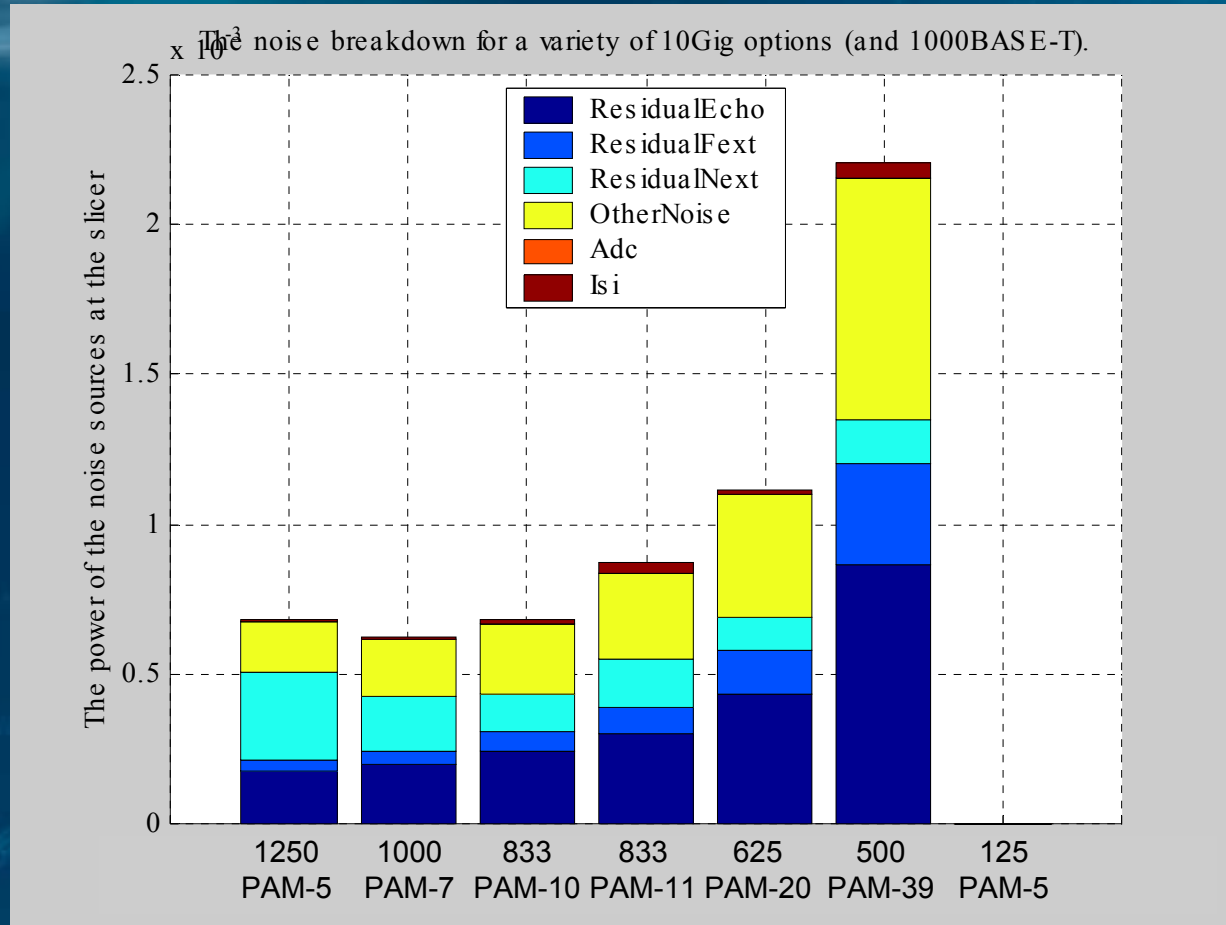


Comments

- Alien NEXT is dominant in all 10 Gig cases
- Optimum from a noise power perspective is at 833 MHz
- ADC requirements fall as baud rate is increased
- Below 500 MHz channel capacity becomes less than 10 Gigabits/s

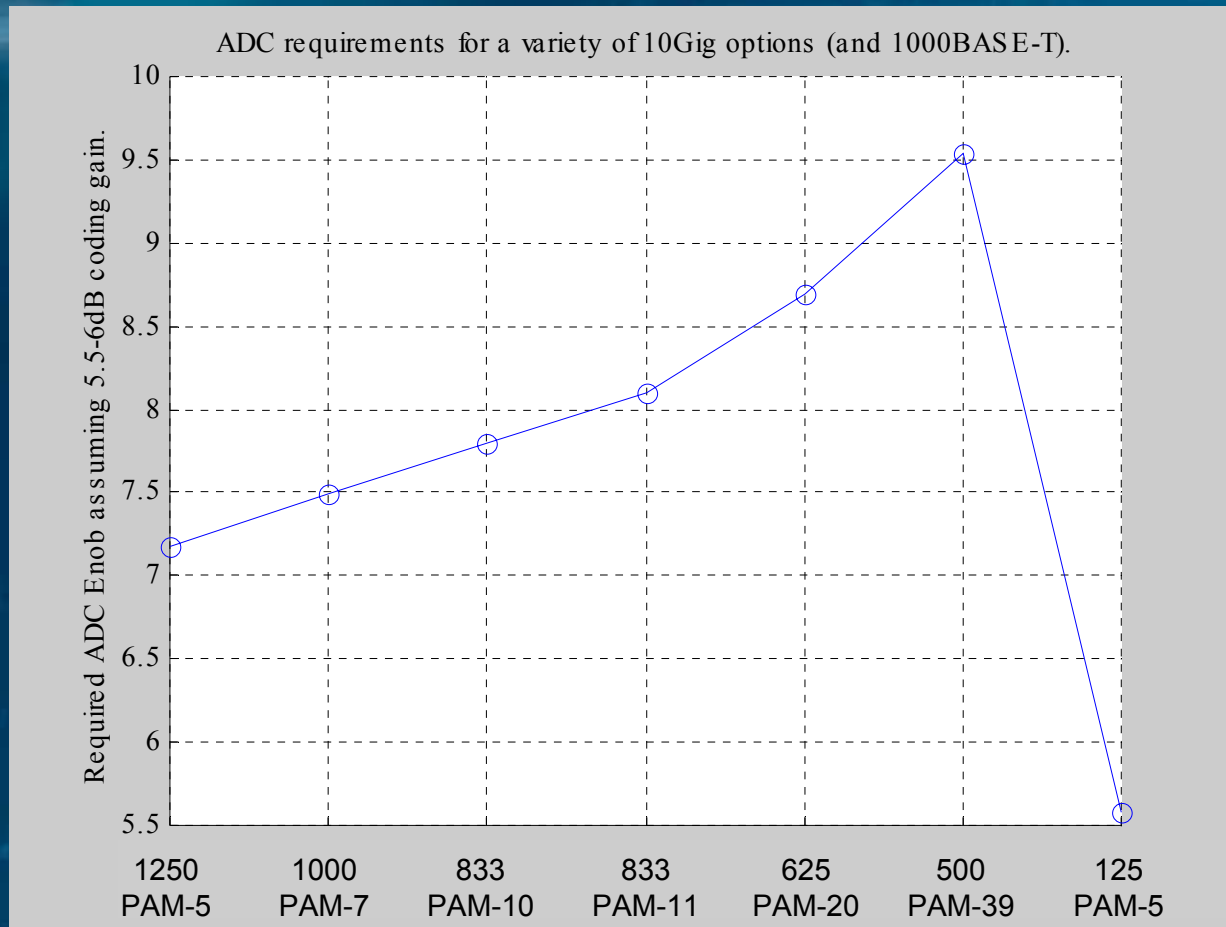
Noise mix with no Alien NEXT

- What are the benefits if Alien NEXT is reduced



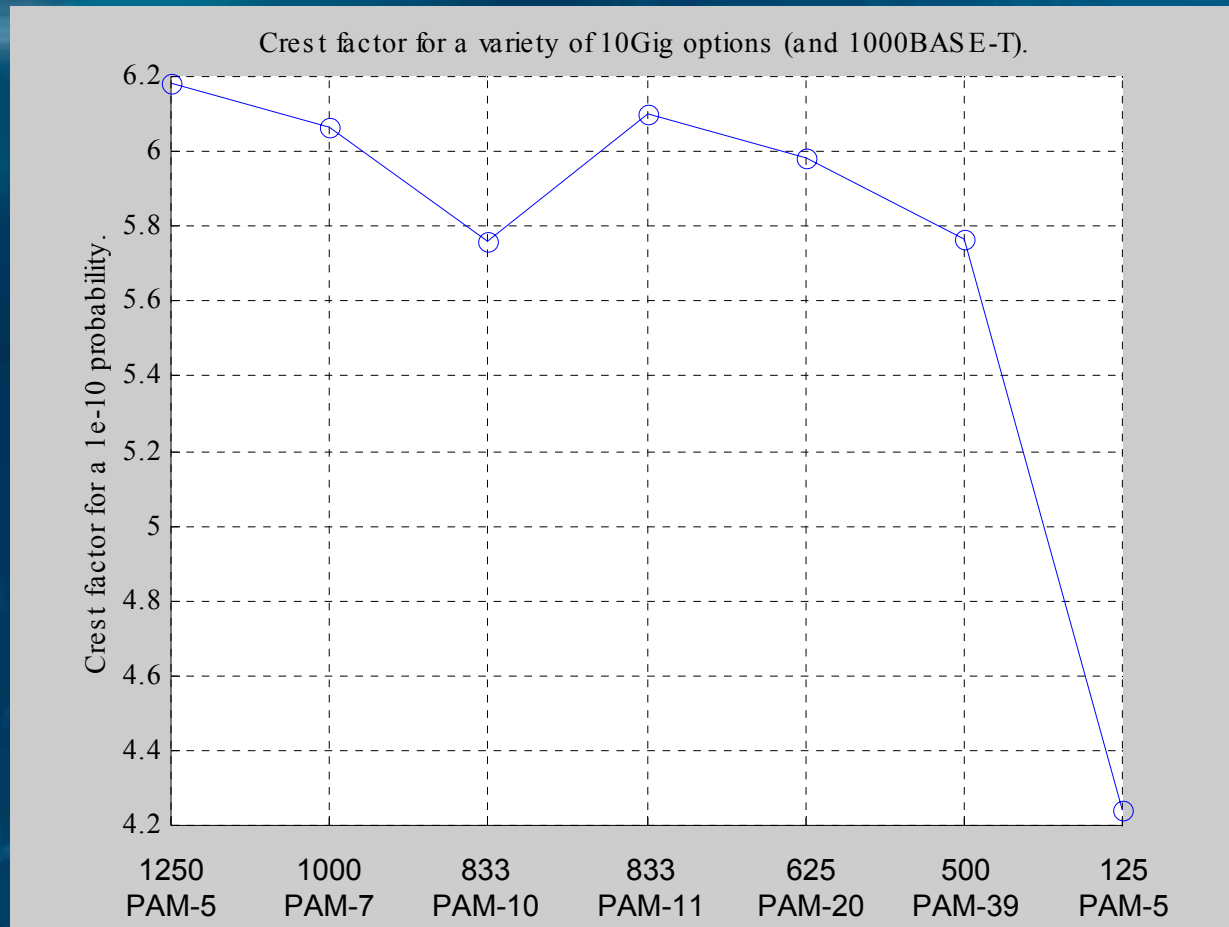
Receiver ENOB with no Alien NEXT

- ADC ENOB requirement is only reduce by 0.5



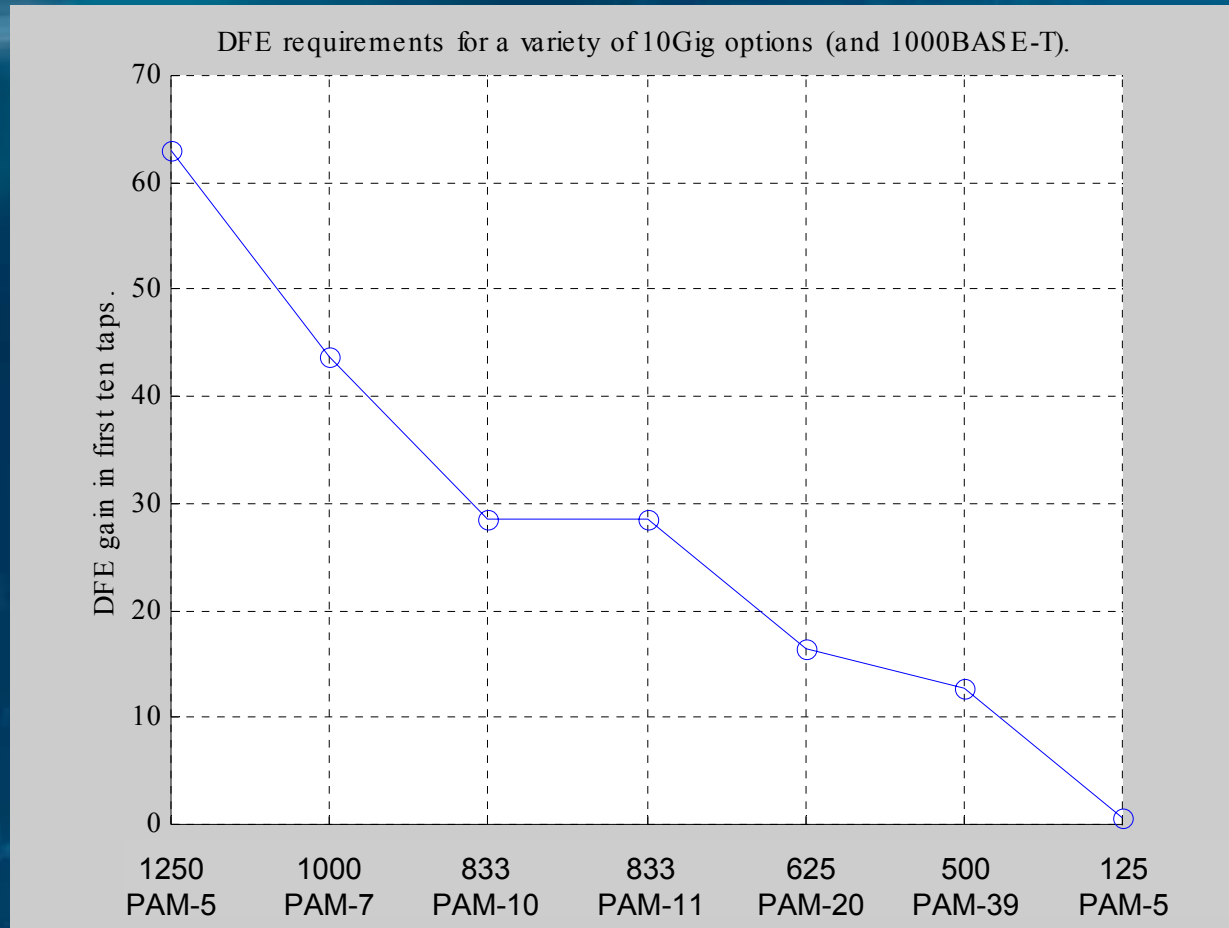
Crest Factor

- Little difference in Crest Factor



DFE Requirements

- Large DFE taps required for MMSE solution



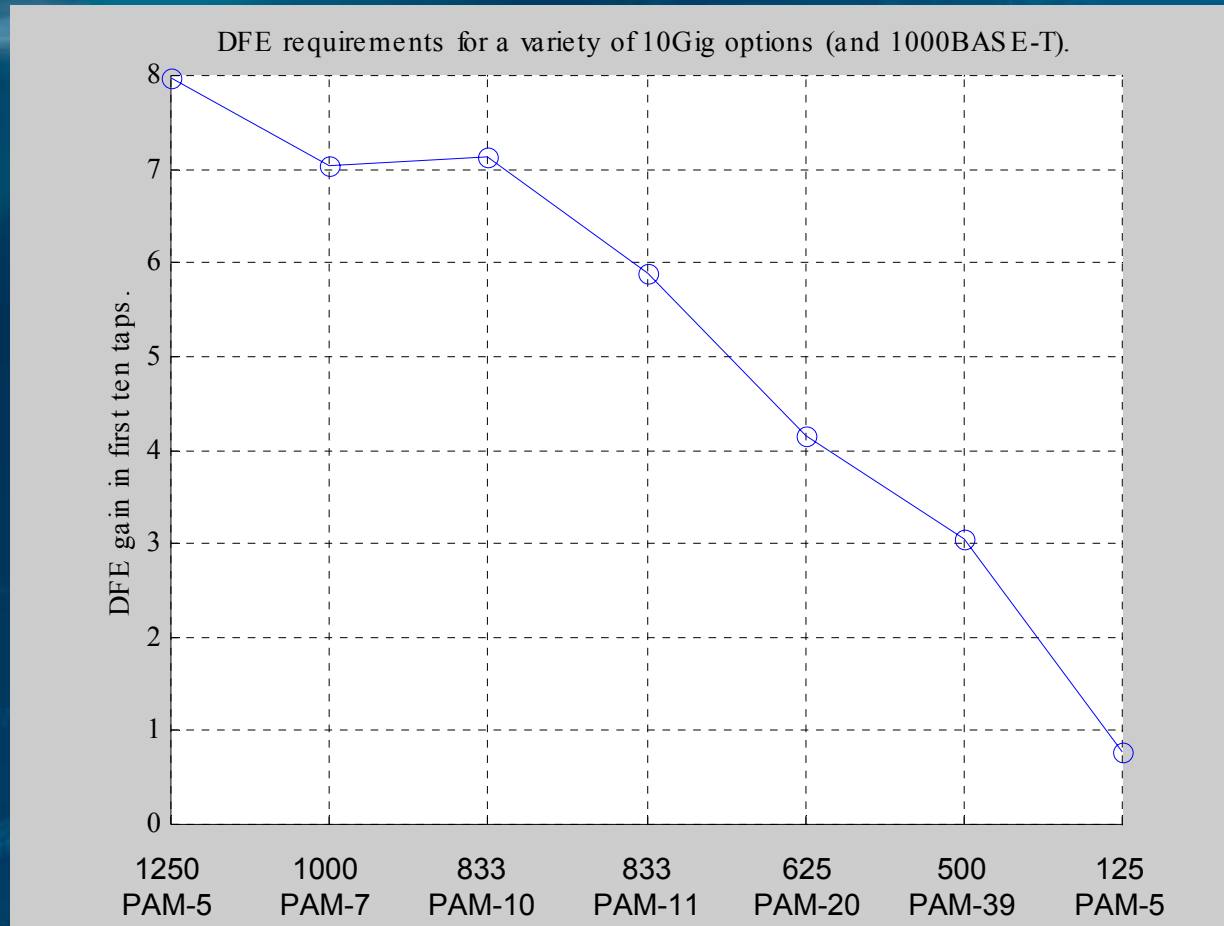
DFE Requirements

- To achieve MMSE large DFE taps are required for line code schemes
- Major implications for signal recovery
- Major implications for code design
- Major implications for error propagation
- Can the DFE be constrained



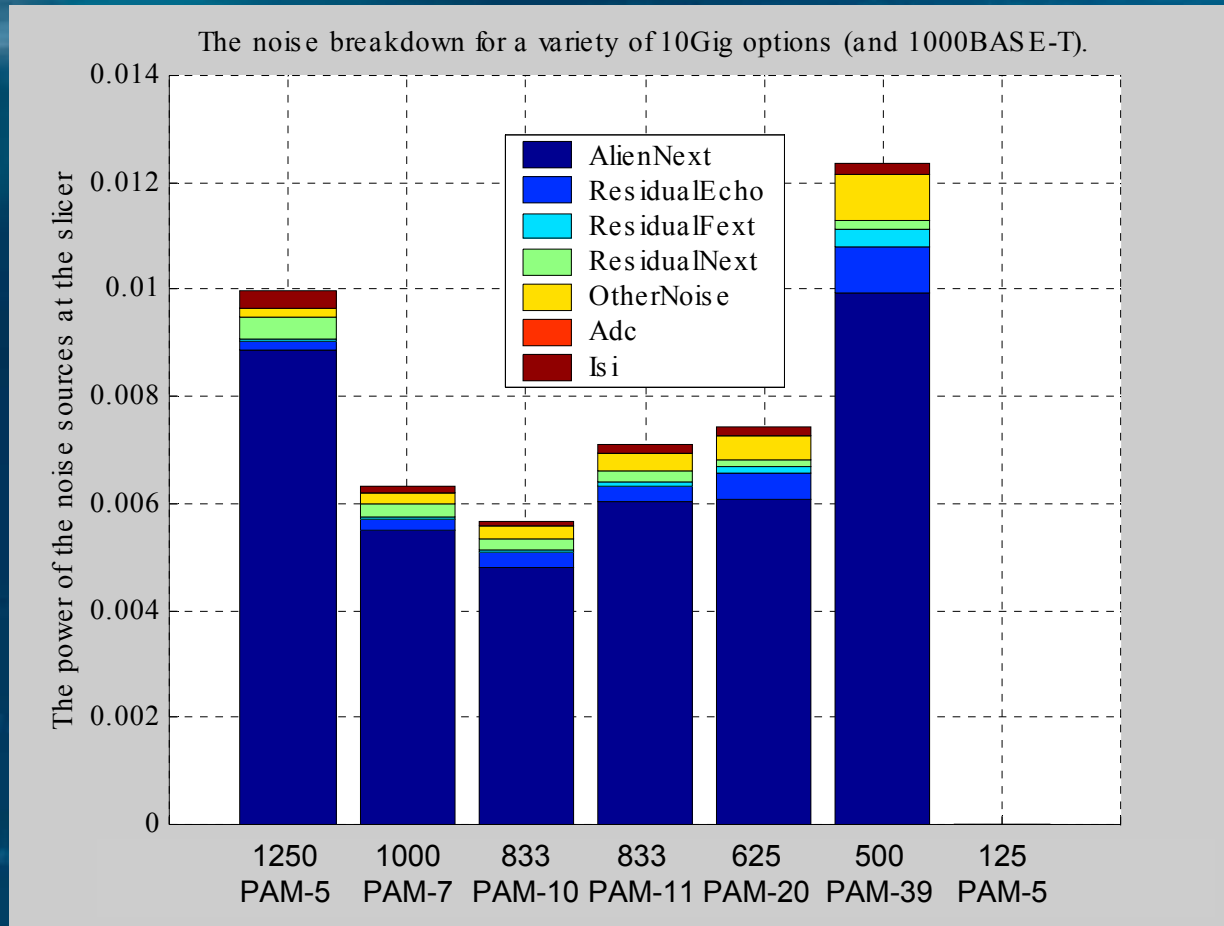
DFE with Constrained Taps

- Constrain first tap to 0.75



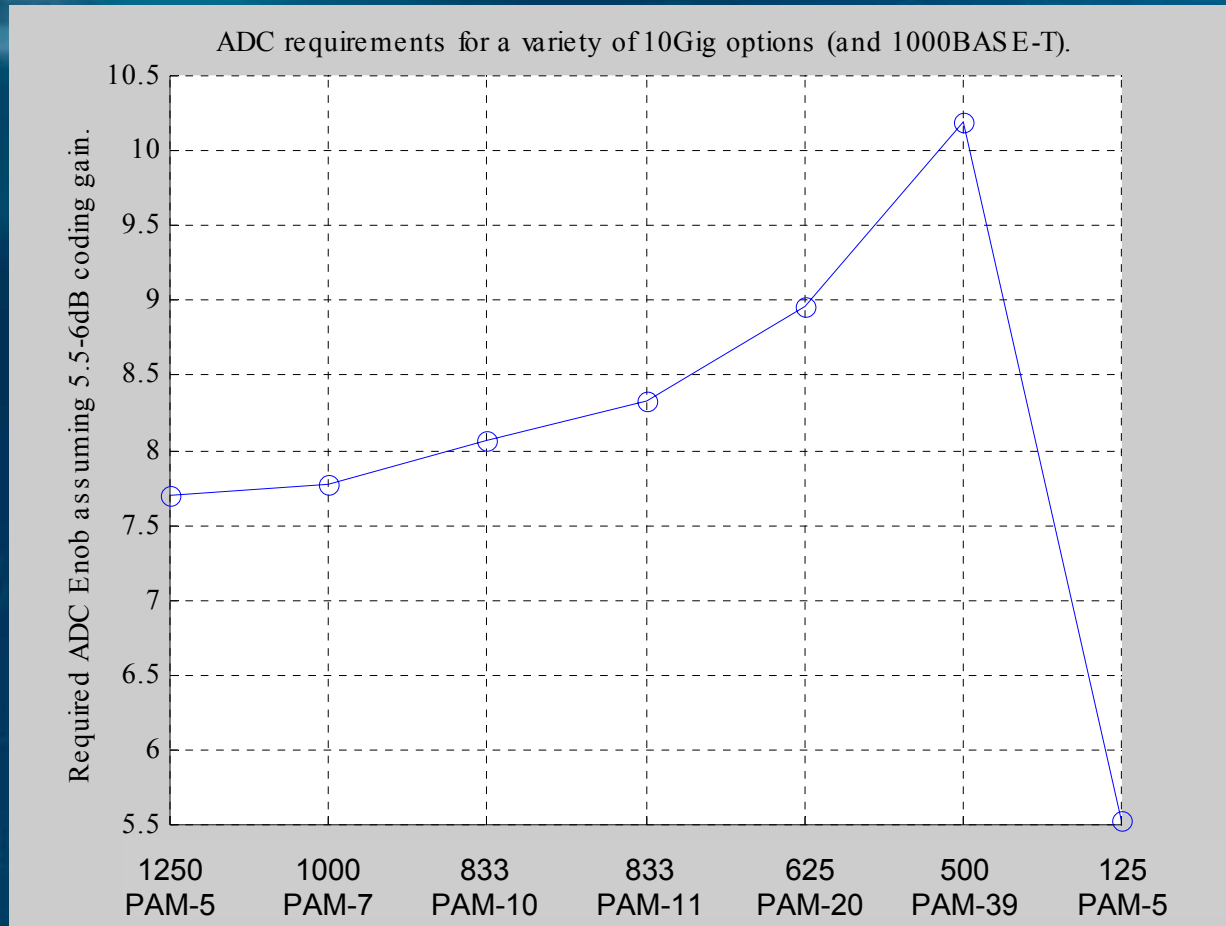
Noise Mix for Constrained DFE

- ISI increased only slightly



ENOB Requirements

- ENOB increased by about 0.5



Comments

- Energy in taps reduced by up to a factor of 10
- ISI is now a much larger impairment
- Clearly shows pre-coding could be very advantageous

Realistic Line Code Options

- Line code options from 1250PAM-5 to 500PAM-39 are all possible
 - In practice 9-11 bit ADC required
 - Implementation constraints will affect choice
- Constrained DFSE or Pre-coding will be needed
 - Pre-coding will have to be defined within the standard
- Use existing 1000BASE-T code
 - Extra coding gain (9dB or 12dB) to shift design complexity into digital domain is an option