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Technology to the Core

# Selecting a Robust TX Pre Emphasis For CX4

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# Motivation

• The current pre-emphasis value (50%) was derived theoretically using 2/3 of the worst-case cable assembly model under following conditions

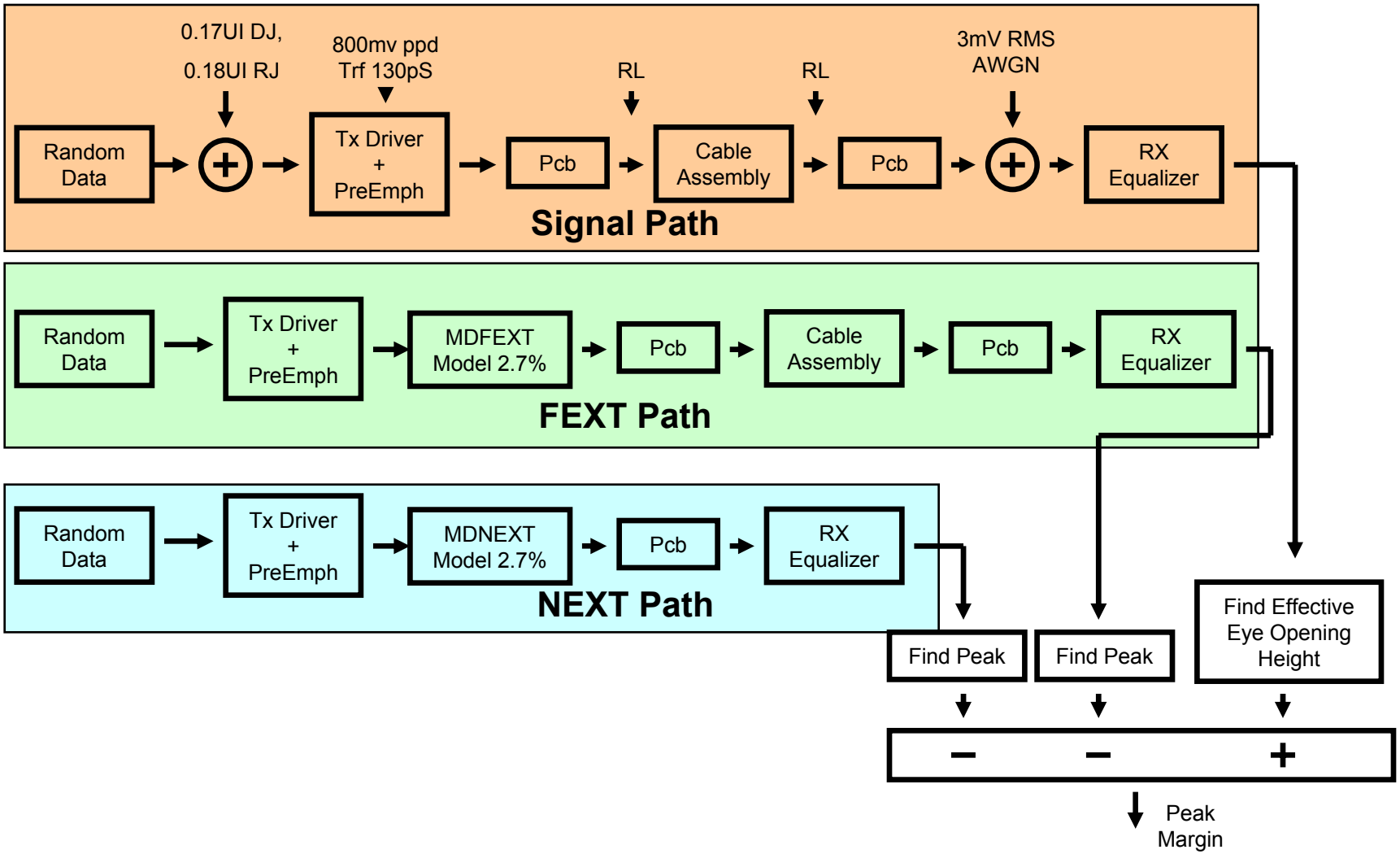
- No equalizer is used
- No NEXT/FEXT impairments
- No Return Loss
- No Jitter

•The real world is more complicated – for better and for worse…

# Motivation – Cont'd

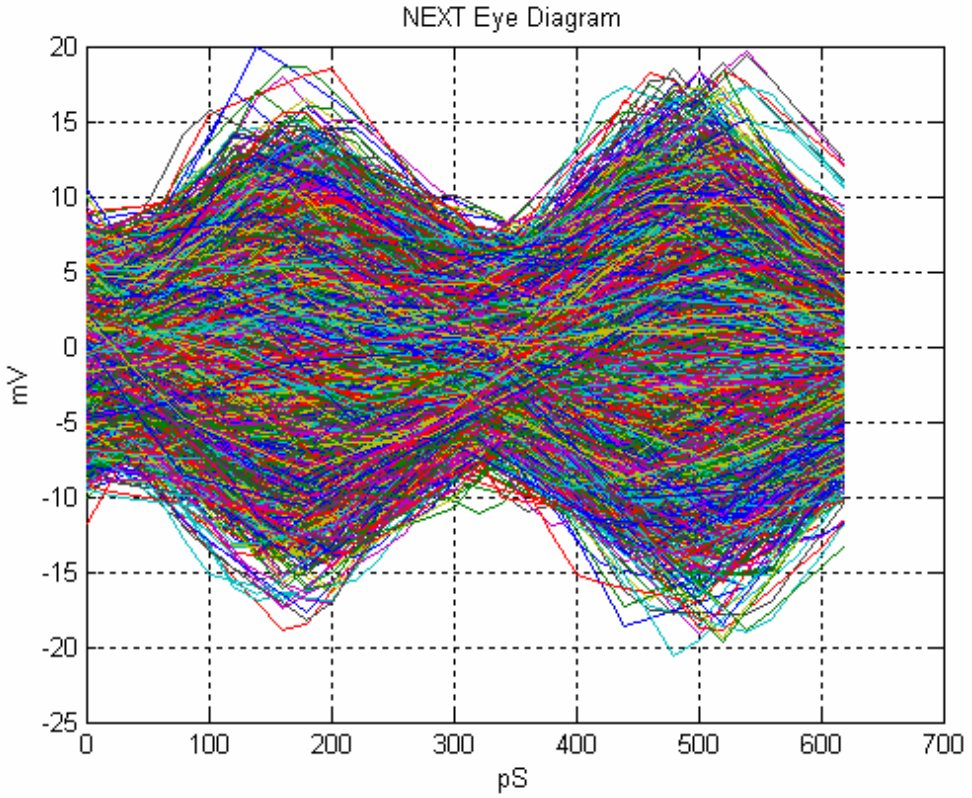
- When all impairments are taken into account, simulation results indicate very clearly that 50% pre-emphasis isn't optimal
  - It creates problem for both long-reach and short-reach cables
  - Verified by real silicon measurement
- The main reason is SNR (Signal-to-Noise Ratio) degradation
  - The pre-emphasis degrades the transmitted signal power more than it does the noise components
    ( NEXT/FEXT/Return Loss)

# Worst Case Margin Simulation Environment



# Creating Worst Case Scenario

- The NEXT, FEXT and reflection effects depend strongly on their relative phase with the received data signal
- We align FEXT, NEXT and reflections to create worse possible scenario
  - difficult to encounter in random simulation



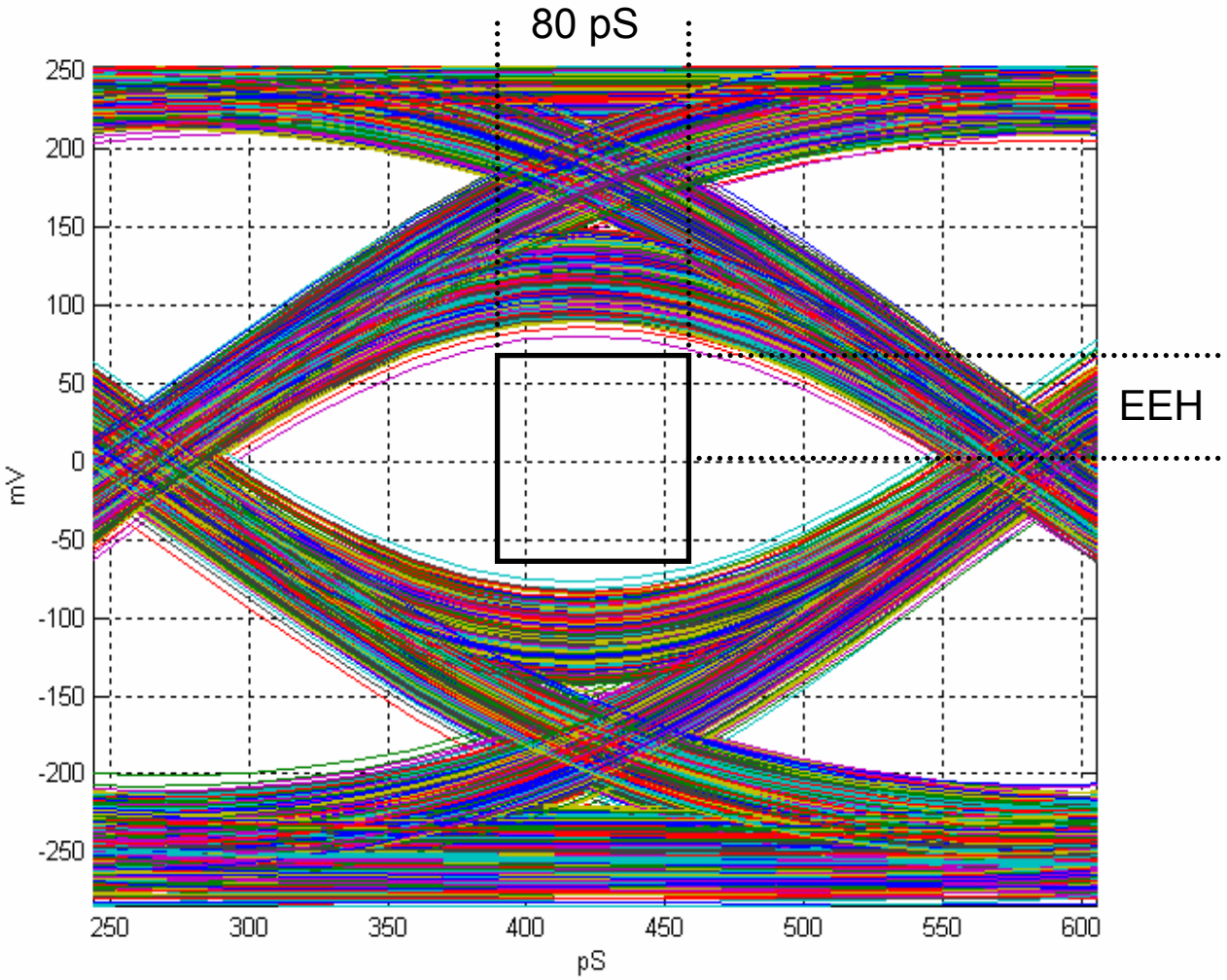
# Creating Worst Case Scenario – Cont'd

- We factorize the RJ RMS such that in the simulation period (1e4 symbols) the peak-to-peak value will match 0.18UI
- We factorize the AWGN RMS such that in the simulation period the peak-to-peak value will match $14*\sigma=42mv$
  - 42mV is the expected peak to peak of 3mv RMS in 1e12 samples.
  - The AWGN was band-limited to 2.0GHz

# Evaluating Noise Margin

- 3 Levels of pre emphasis were checked: 25%, 33% and 50%.
- 4 types of equalizers were checked.
- Cables in length of 1 to 20 meters.
- Effective Eye Height (EEH) was defined as the maximal rectangle height with 80pS (0.25UI) width which can be fit inside the RX Eye without violations.
- Noise peak margin was defined as Effective Eye Height – MDNext peak – MDFext peak - RL peak as seen by the receiver after the cable and the equalization (TP6).

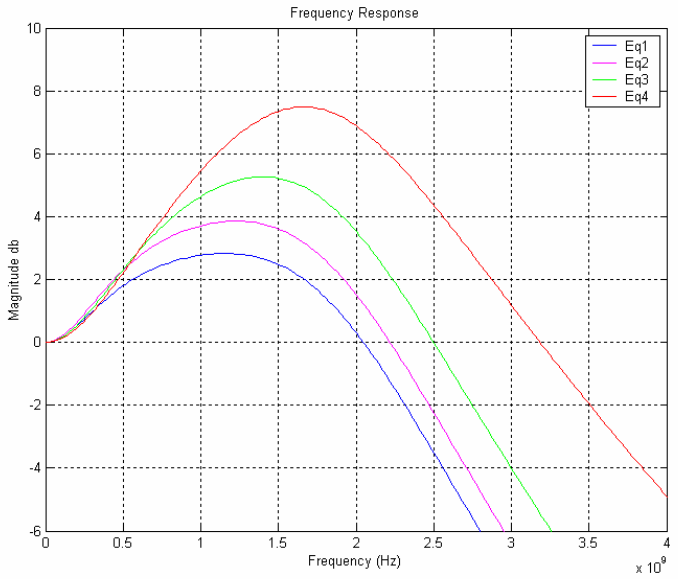
# Effective Eye Height



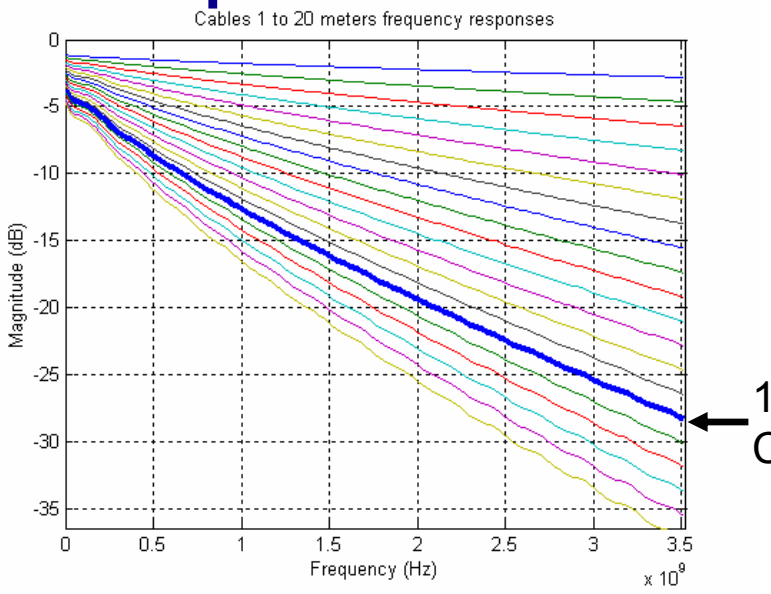

Noise Margin= EEH – MDNext peak – MDFext peak - RL peak

# The Equalizers Family and Cables F.R.

## The Equalizers Family




## The Cables Frequency Responses

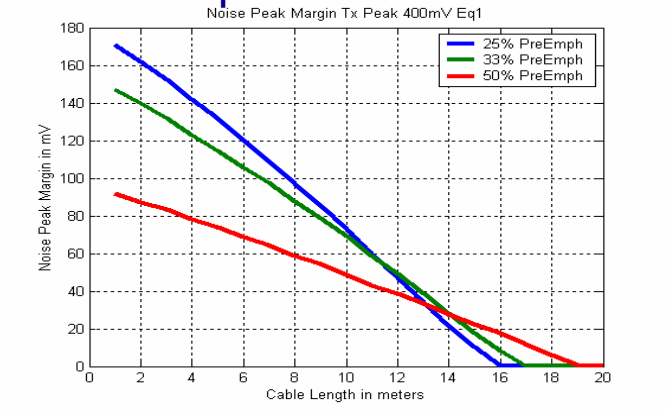


# Tested Scenarios Outline

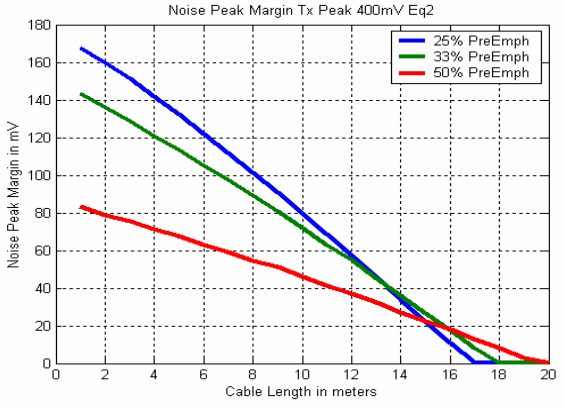
| Scenario # | Trf – Rise/Fall Time [psec] | Jitter (On/Off) | RL (On/Off) |
|---|---|---|---|
| 1 | 130 | OFF | OFF |
| 2 | 130 | ON | OFF |
| 3 | 60 | ON | OFF |
| 4 | 60 | ON | ON |
| 5 | 130 | ON | ON |

# Scenario 1 – No Jitter/No Return Loss/Trf=130ns

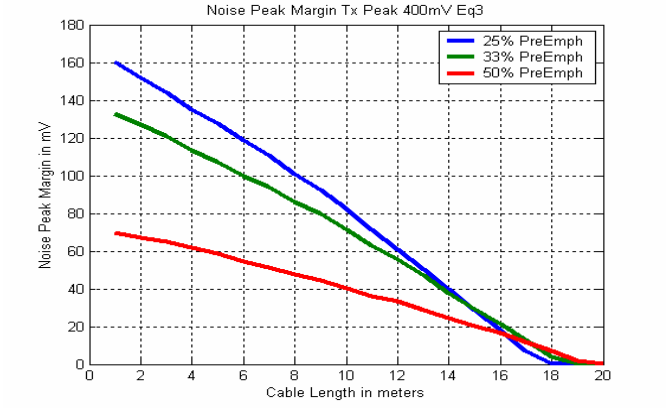
## Equalizer 1



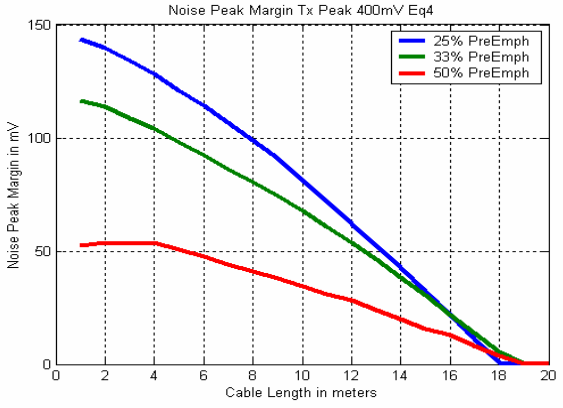

## Equalizer 2




## Equalizer 3




## Equalizer 4

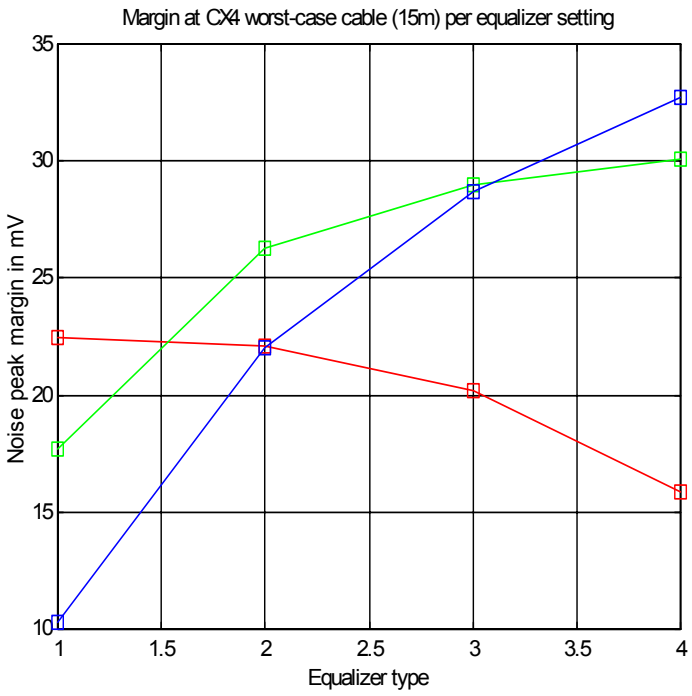


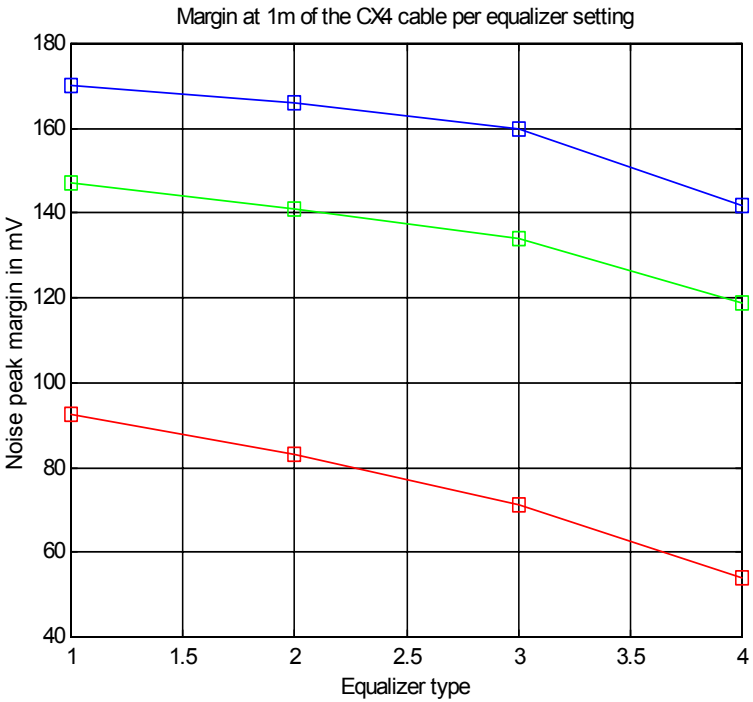
# Margin Summary for Scenario 1

Blue – 25% Pre-emphasis @ TP2

Green - 33% Pre-emphasis @ TP2

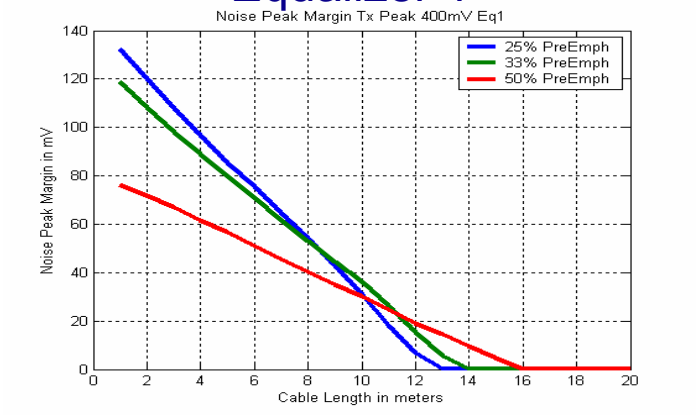
Red – 50% Pre-emphasis @ TP2



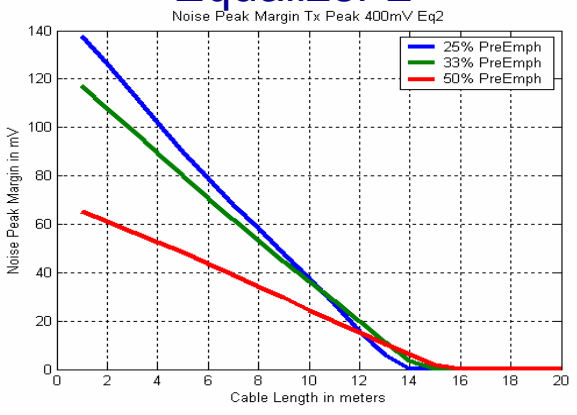



# Scenario 2 – With Jitter/No Return Loss/Trf=130ns

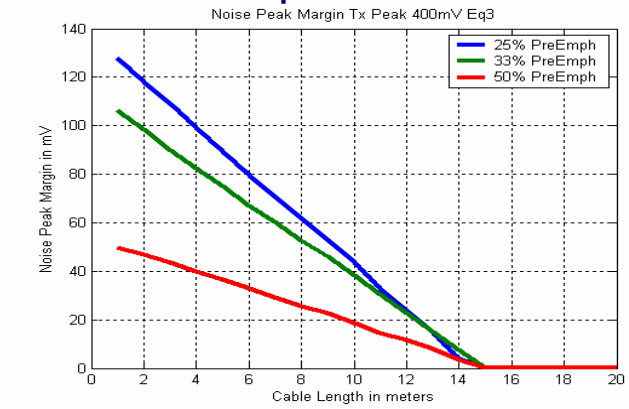
## Equalizer 1



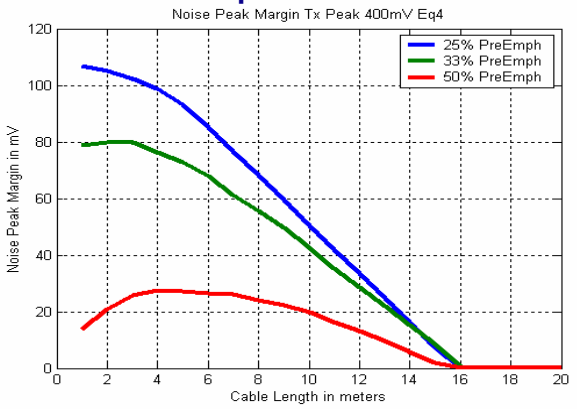

## Equalizer 2




## Equalizer 3




## Equalizer 4

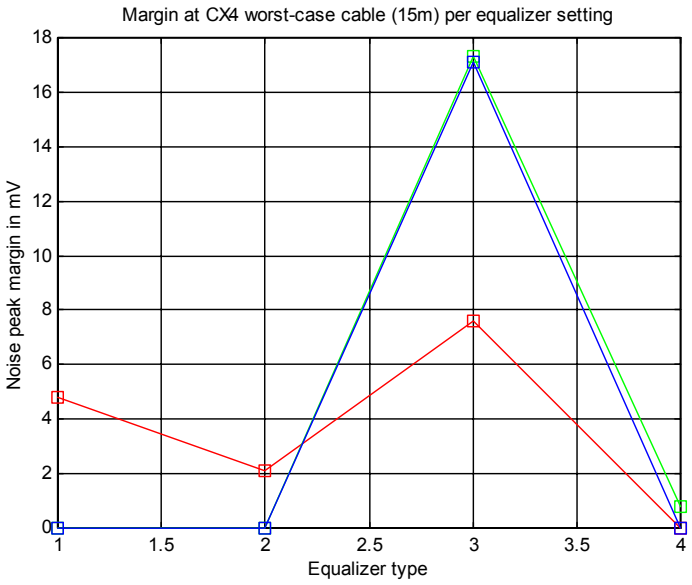


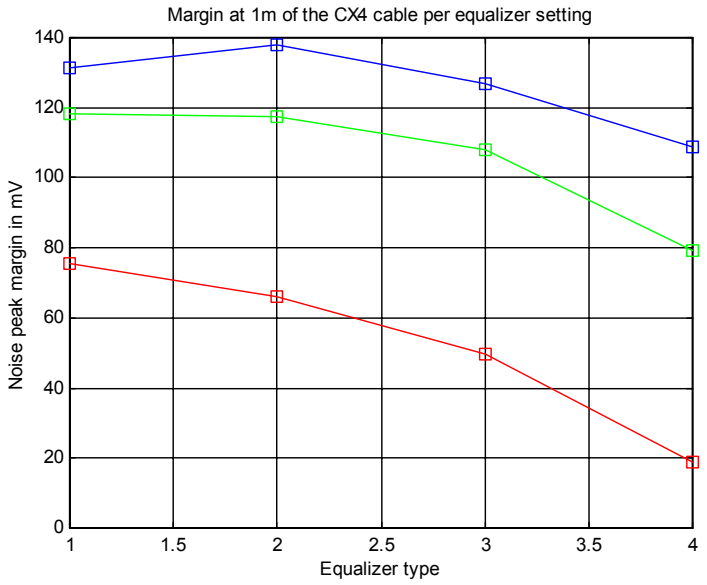
# Margin Summary for Scenario 2

Blue – 25% Pre-emphasis @ TP2

Green - 33% Pre-emphasis @ TP2

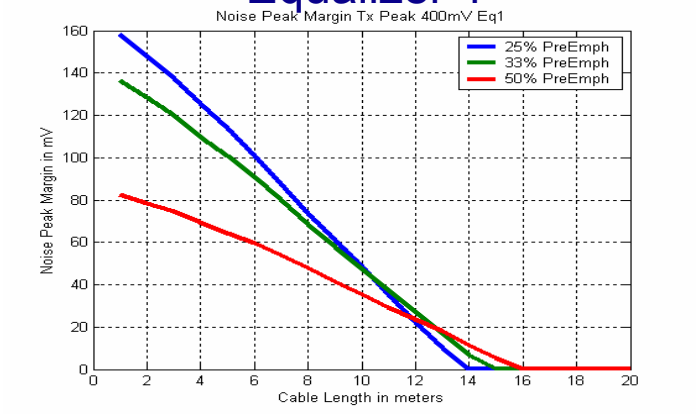
Red – 50% Pre-emphasis @ TP2



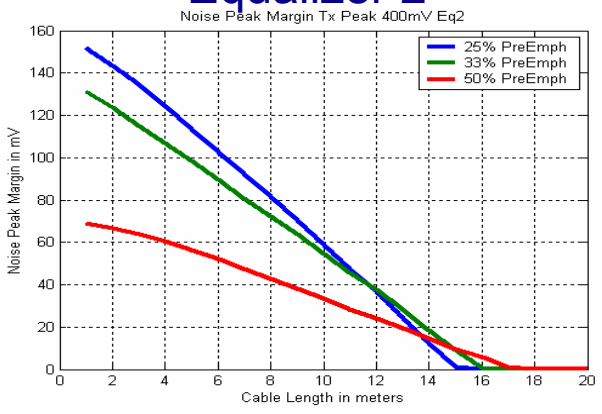



# Scenario 3 – With Jitter/No Return Loss/Trf=60ns

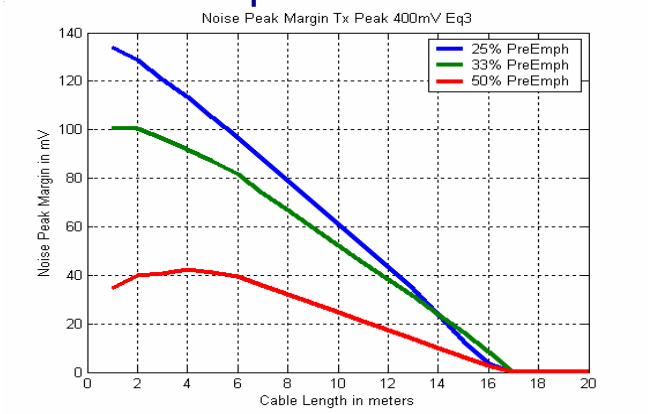
## Equalizer 1



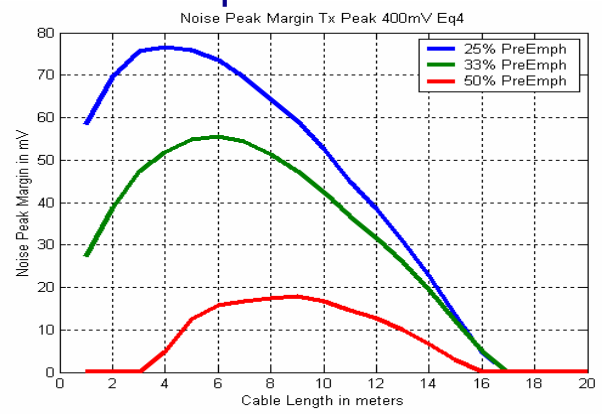

## Equalizer 2




## Equalizer 3




## Equalizer 4

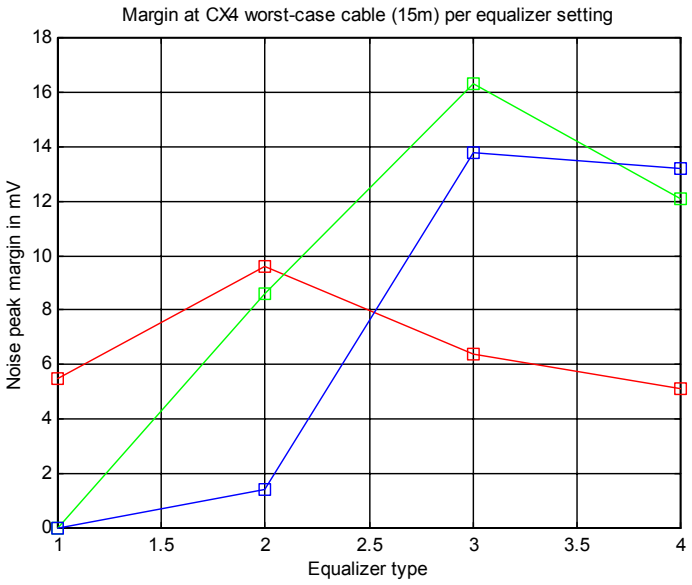


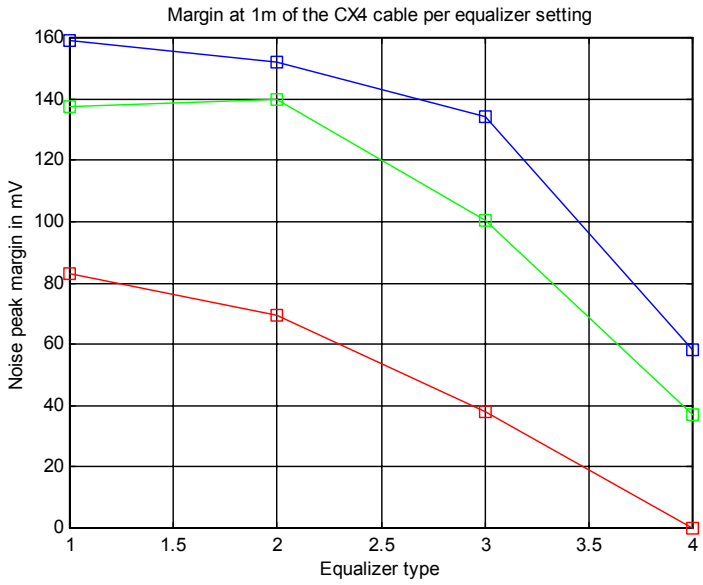
# Margin Summary for Scenario 3

Blue – 25% Pre-emphasis @ TP2

Green - 33% Pre-emphasis @ TP2

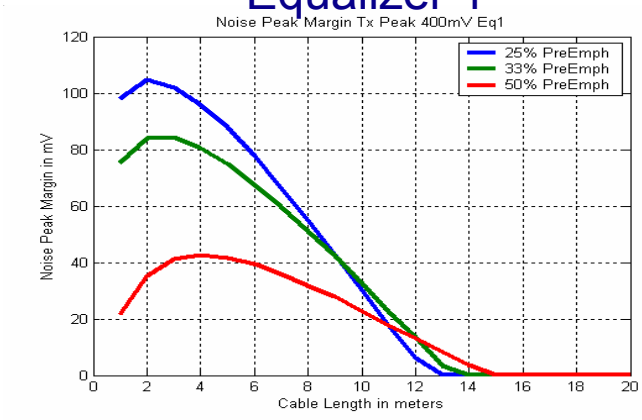
Red – 50% Pre-emphasis @ TP2



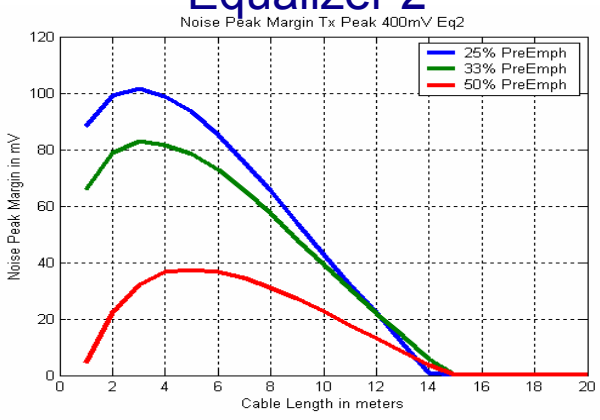



# Scenario 4 – With Jitter/With Return Loss/Trf=60ns

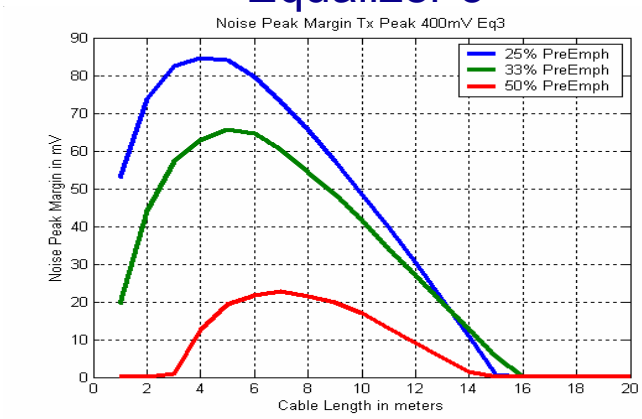
## Equalizer 1



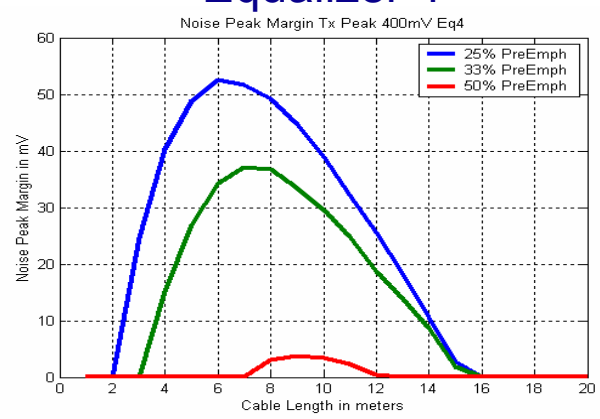

## Equalizer 2




## Equalizer 3




## Equalizer 4

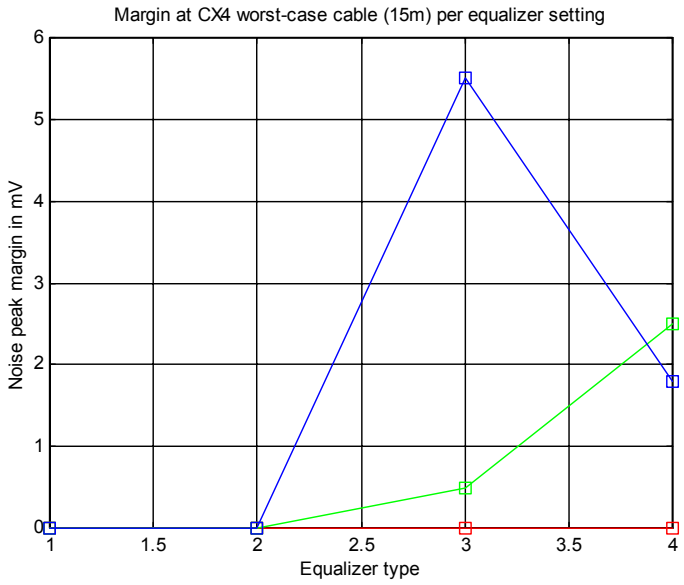


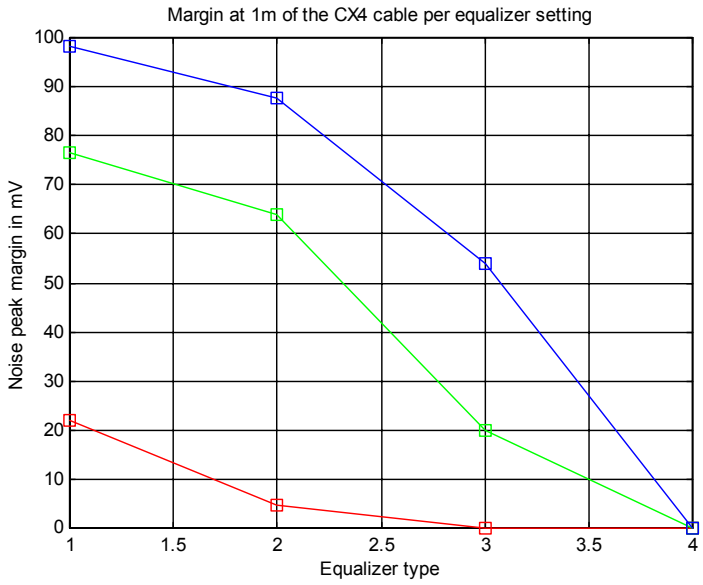
# Margin Summary for Scenario 4

Blue – 25% Pre-emphasis @ TP2

Green - 33% Pre-emphasis @ TP2

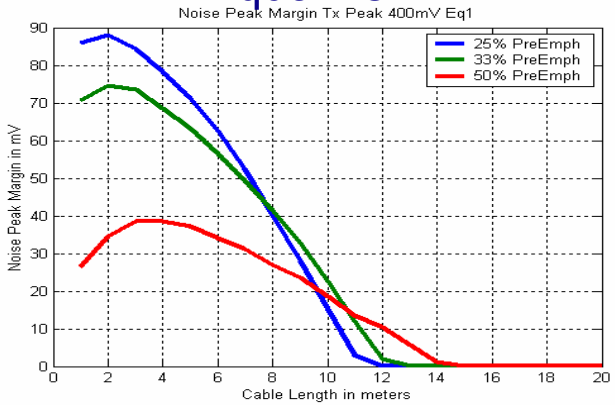
Red – 50% Pre-emphasis @ TP2



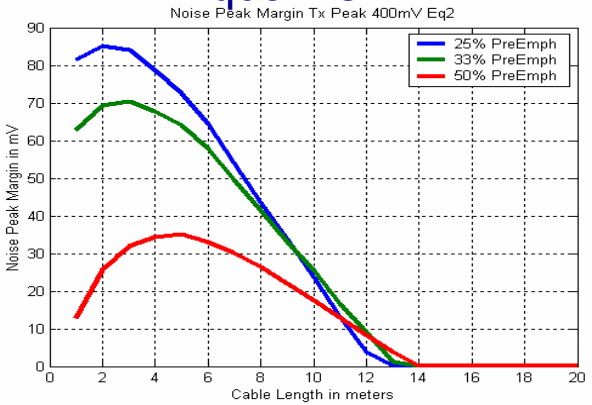



# Scenario 5 – With Jitter/With Return Loss/Trf=130ns

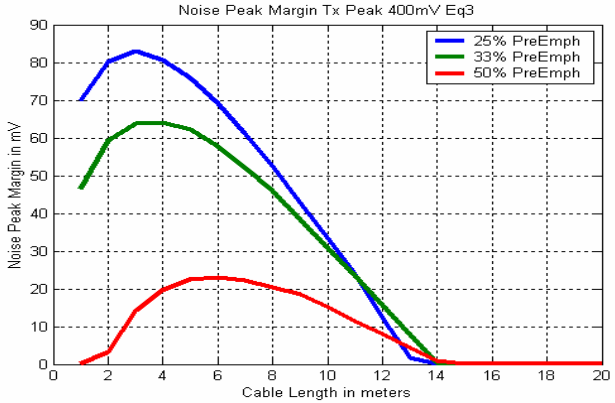
## Equalizer 1



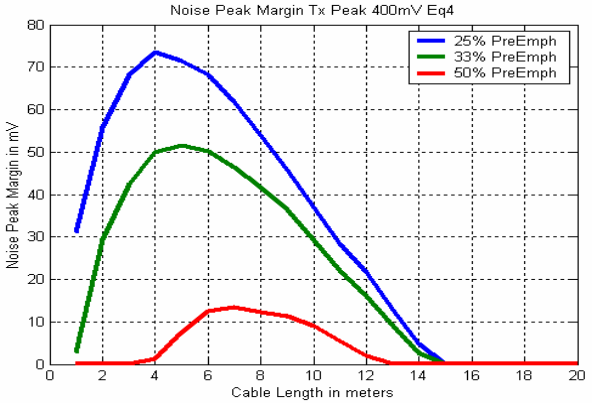

## Equalizer 2




## Equalizer 3




## Equalizer 4

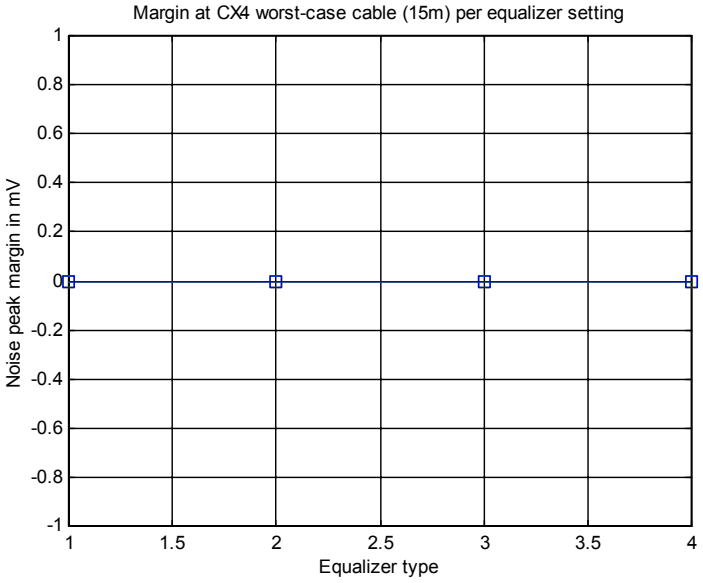


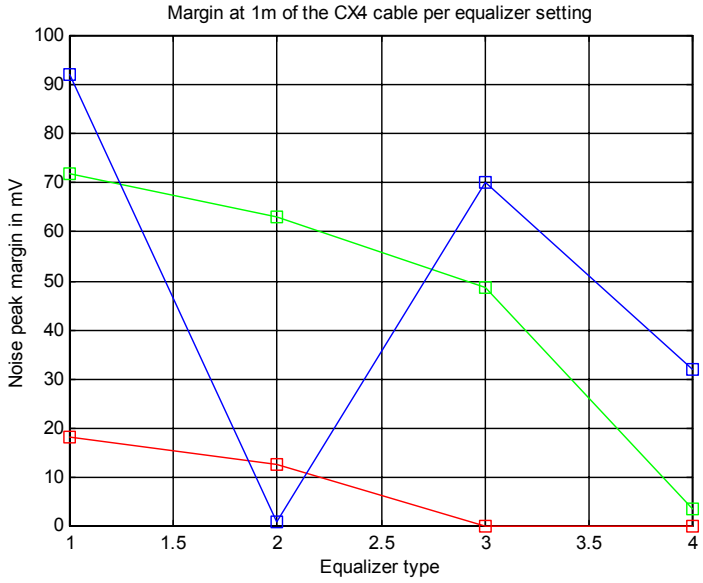
# Margin Summary for Scenario 5

Blue – 25% Pre-emphasis @ TP2

Green - 33% Pre-emphasis @ TP2

Red – 50% Pre-emphasis @ TP2



# Conclusions

•25%-33% pre emphasis nominal value show better margin over variety of equalizers and cable lengths compare to the 50% pre-emphasis.

• The 50% pre-emphasis is more sensitive to cross talk and RL on short cables and will not allow relaxing of NEXT/FEXT/RL requirements from short jumper cables

- •Some existing jumper cable assemblies will not work robustly – even one would think that short cable is very easy to drive

•We recommend to lower the pre-emphasis value to be between 24% - 38%.