IEEE 802.3ap Simulation Results for 10Gb Serial BP Links

IEEE 802.3ap Task Force
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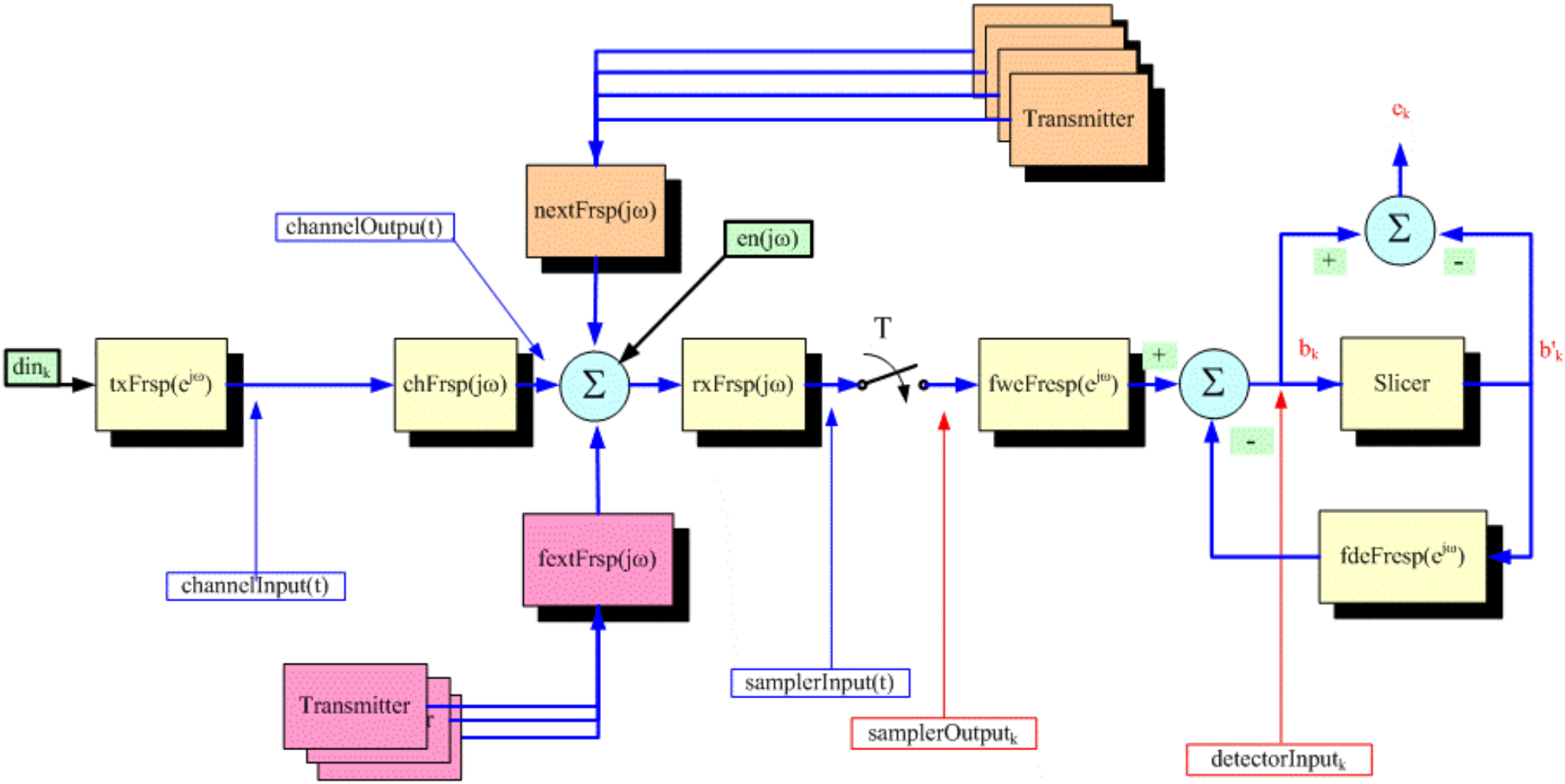
Objectives

- **Demonstrate:**
  - **Signaling results comparing NRZ, Duobinary and PR4 line codes**
  - **Effects of packaging and design variations on link SI**

Agenda

- Simulation model
- Simulation conditions
- Channel simulation results
  - NRZ, Duo & PR4 sim results for *good* and *bad* channels
  - Channel result summary
- Packaging effects
- Rx noise filter effects
- Summary & Conclusions

High Level Simulation Model



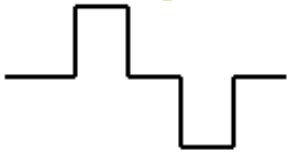
Simulation Conditions

- Data Pattern: PRBS15, 100kbit sim time
- NEXT/FEXT:
  - 2 aggressors, linearly summed, random phase
- Line Coding:

NRZ: Y=X

Duo: Y=(1+D)X

PR4: Y=(1-D^2)X



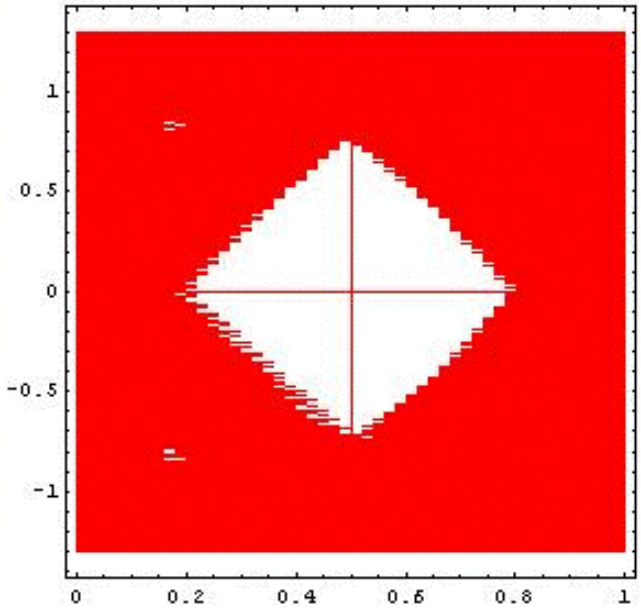
- Tx
  - Jitter: DCD=0.05UI_{p-p}, Tx R_J= 0.018UI_{RMS}
  - Amplitude: 1$V_{pk(diff'l)}$
- 2nd Order Rx noise filter:
  - $\omega_1=(2\pi)*7GHz$
  - $\omega_2=(2\pi)*10GHz$

$$H(s)=\frac{1}{(s/\omega_1+1)\cdot(s/\omega_2+1)}$$

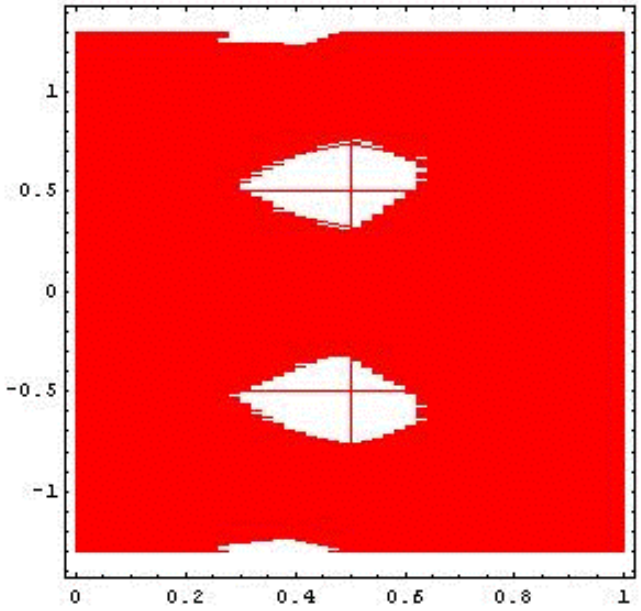
- Equalization
  - Tx Eq= 4Tap, τ-spaced FIR
  - Rx Eq= 5Tap, τ-spaced DFE
- Equalizer Adaption
  - LMS optimization in presence of Noise
  - Adaption target: 1$V_{pk(diff'l)}$, limited at 1.25$V_{pk(diff'l)}$
- Eye diagrams hold Eq^{n} constant

Equalization Sim (good channel) – Tyco#1

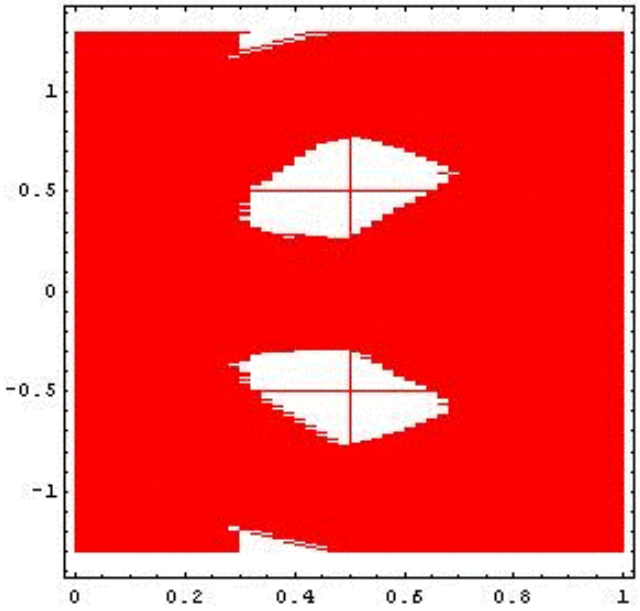
NRZ



Duobinary

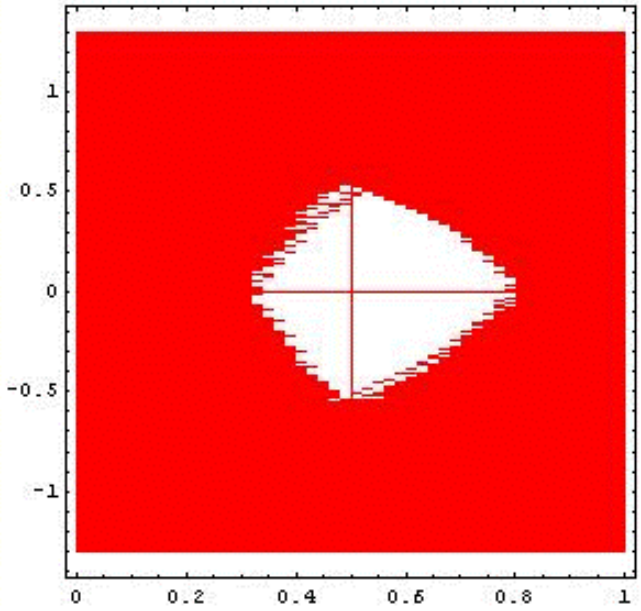


PR-4

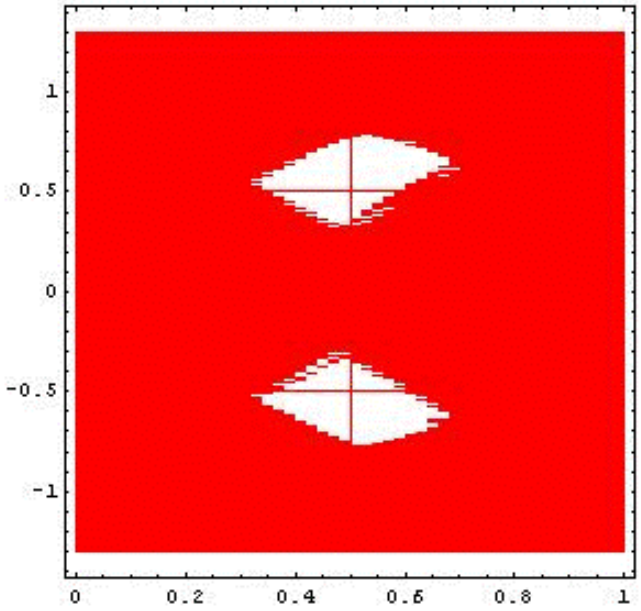


Equalization Sim (good channel) – Intel B12

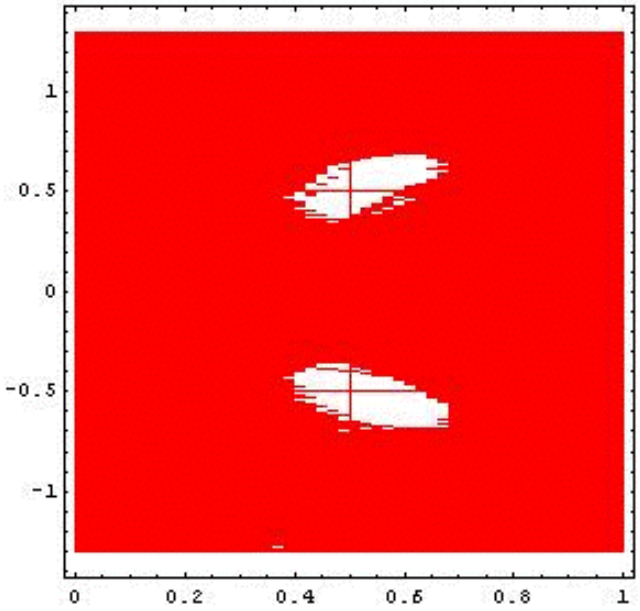
NRZ



Duobinary

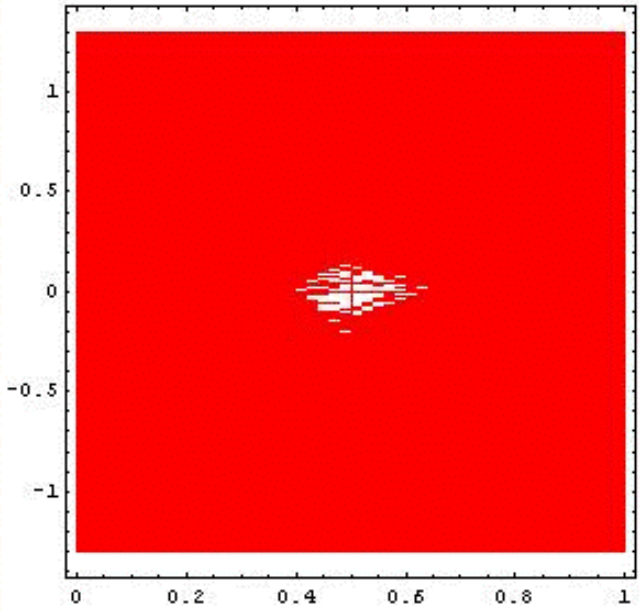


PR-4

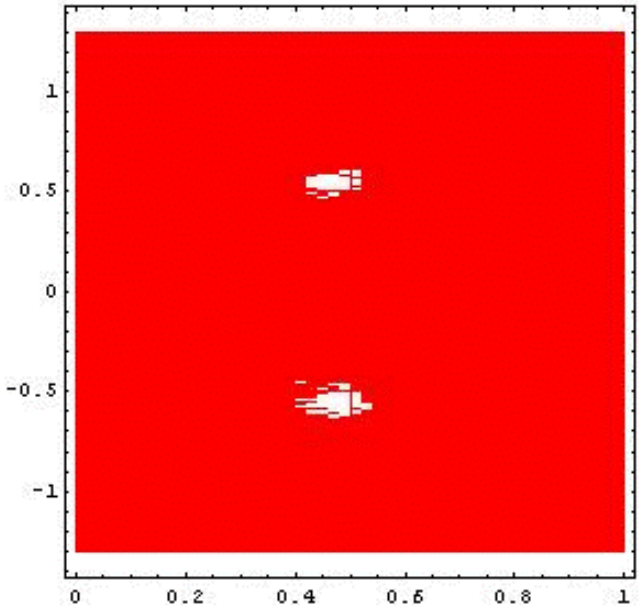


Equalization Sim (bad channel) – Intel T1

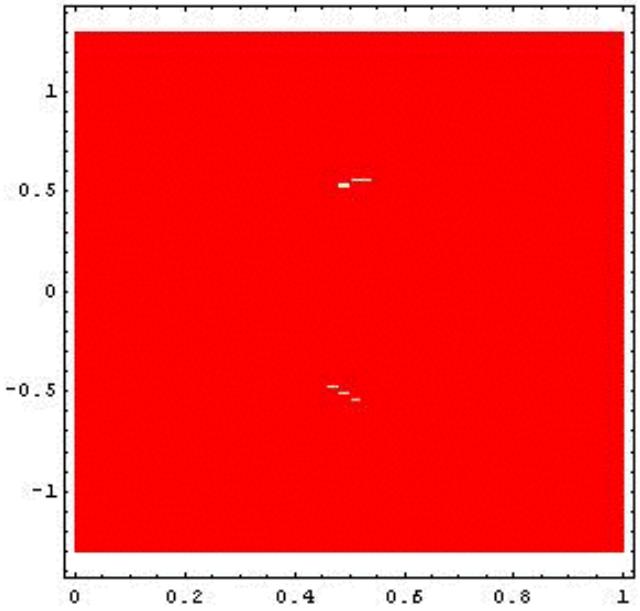
NRZ



Duobinary



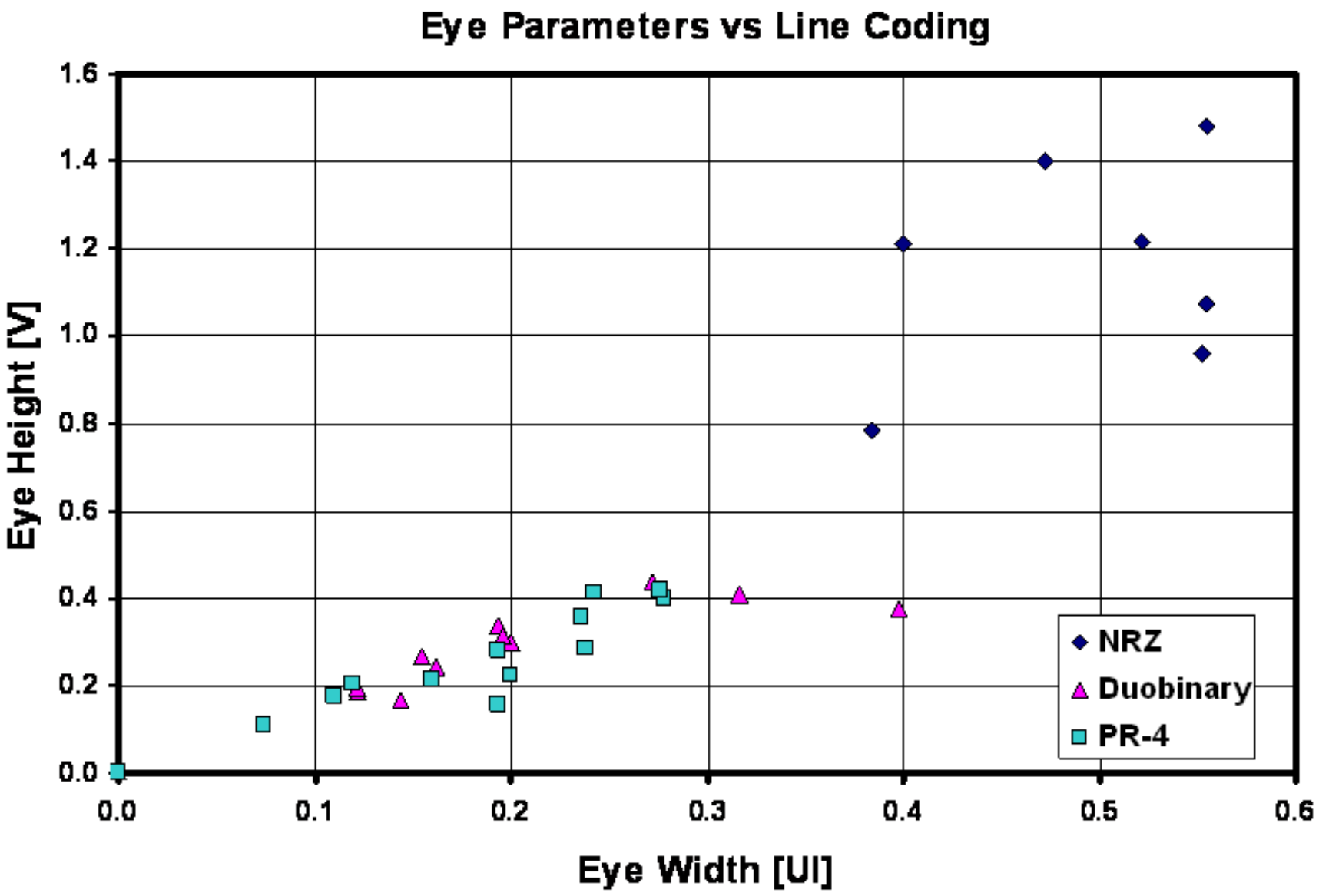
PR-4



Simulation Result Summary – Eye Parameters

Channel	NRZ		Duobinary		PR-4	
	Width [UI]	Height [V]	Width [UI]	Height [V]	Width [UI]	Height [V]
Intel B1	0.430	1.060	0.144	0.164	0.110	0.174
Intel B12	0.320	0.860	0.162	0.242	0.120	0.204
Intel B20	0.440	1.100	0.2	0.3	0.194	0.278
Intel M1	0.282	1.002	-	-	0.194	0.156
Intel M20	0.522	0.906	0.194	0.338	0.236	0.358
Intel T1	-	-	-	-	-	-
Tyco #1	0.554	1.482	0.196	0.314	0.278	0.4
Tyco #2	0.472	1.4	0.122	0.186	0.238	0.284
Tyco #3	0.4	1.210	0.122	0.194	0.160	0.216
Tyco #4	0.554	1.072	0.272	0.436	0.242	0.414
Tyco #5	0.522	1.216	0.398	0.376	0.276	0.420
Tyco #6	0.384	0.784	0.154	0.268	0.074	0.110
Tyco #7	0.552	0.958	0.316	0.406	0.2	0.224

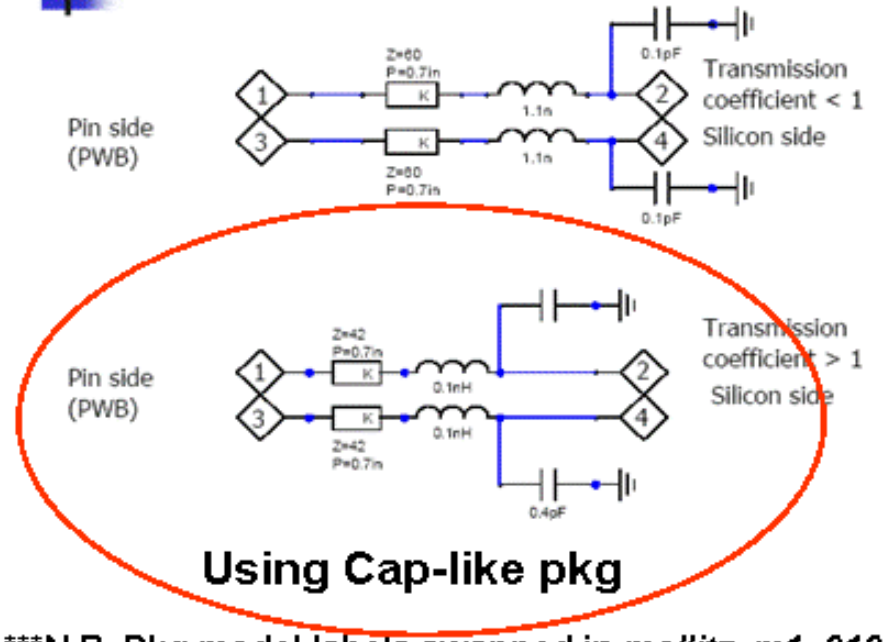
Simulation Result Summary – Eye Parameters



Package Effects

- **Adding a package model affects**
  - **Affects pulse response**
  - **Affects adaption algorithm stability**
- **Package model – from *mellitz_01_0105.pdf***

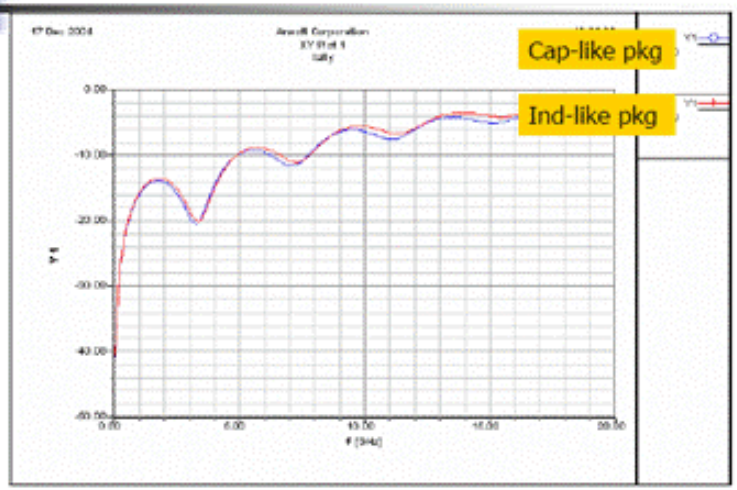
PKG models -10 dB @ 5GHz



Using Cap-like pkg

2

RL for two pkgs



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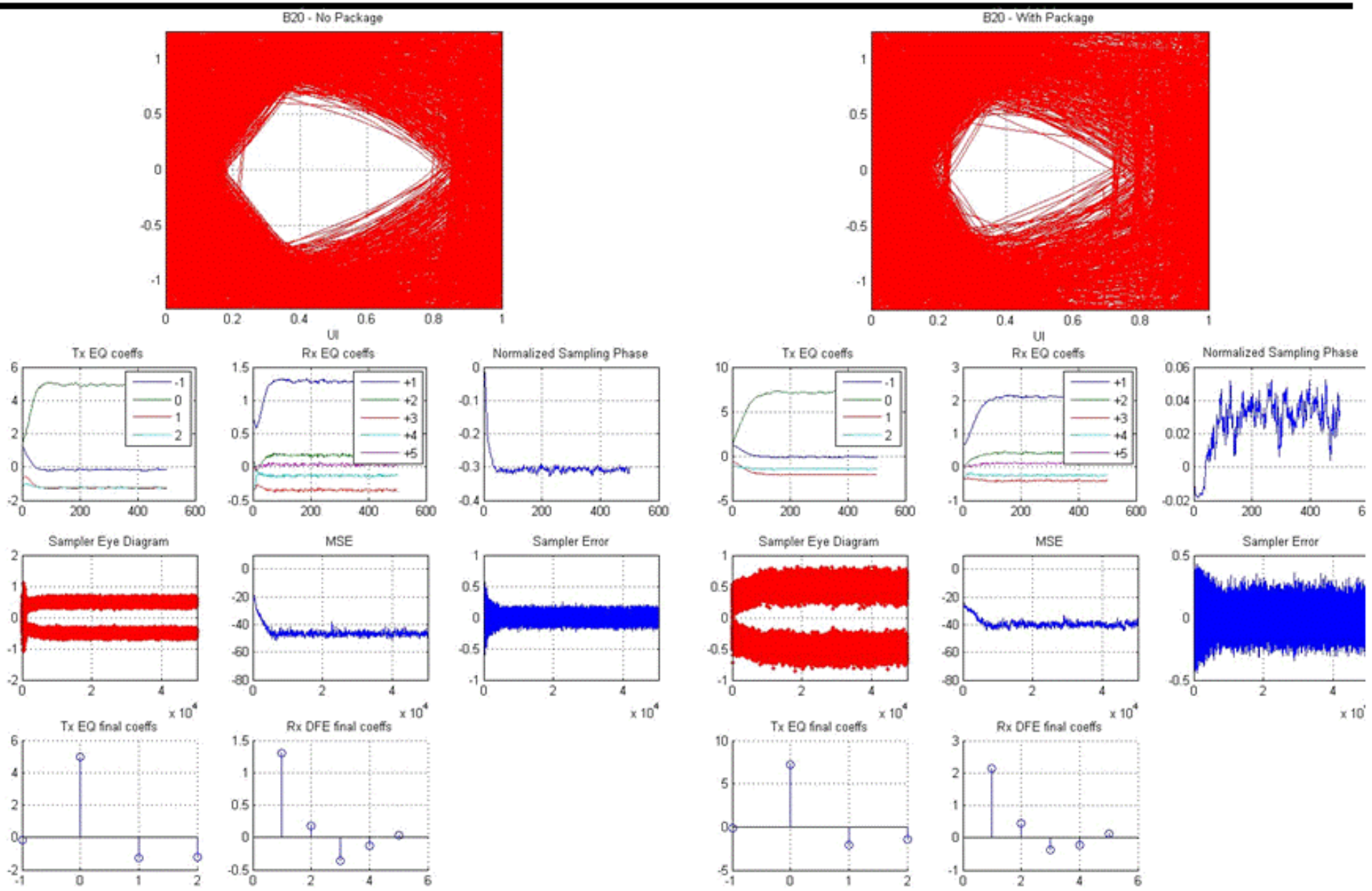
N.B. Pkg model labels swapped in *mellitz_m1_0105.pdf

Package Effects – Intel B20



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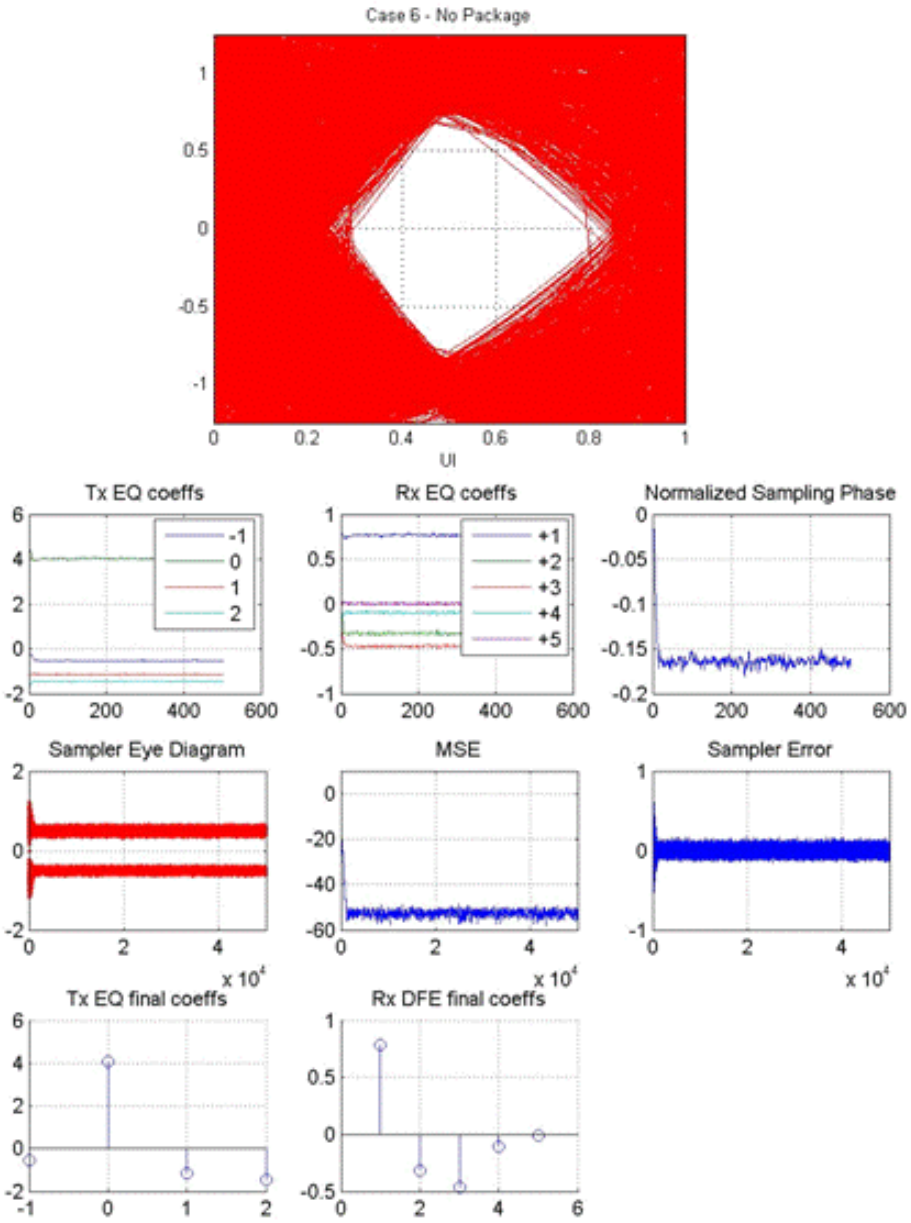
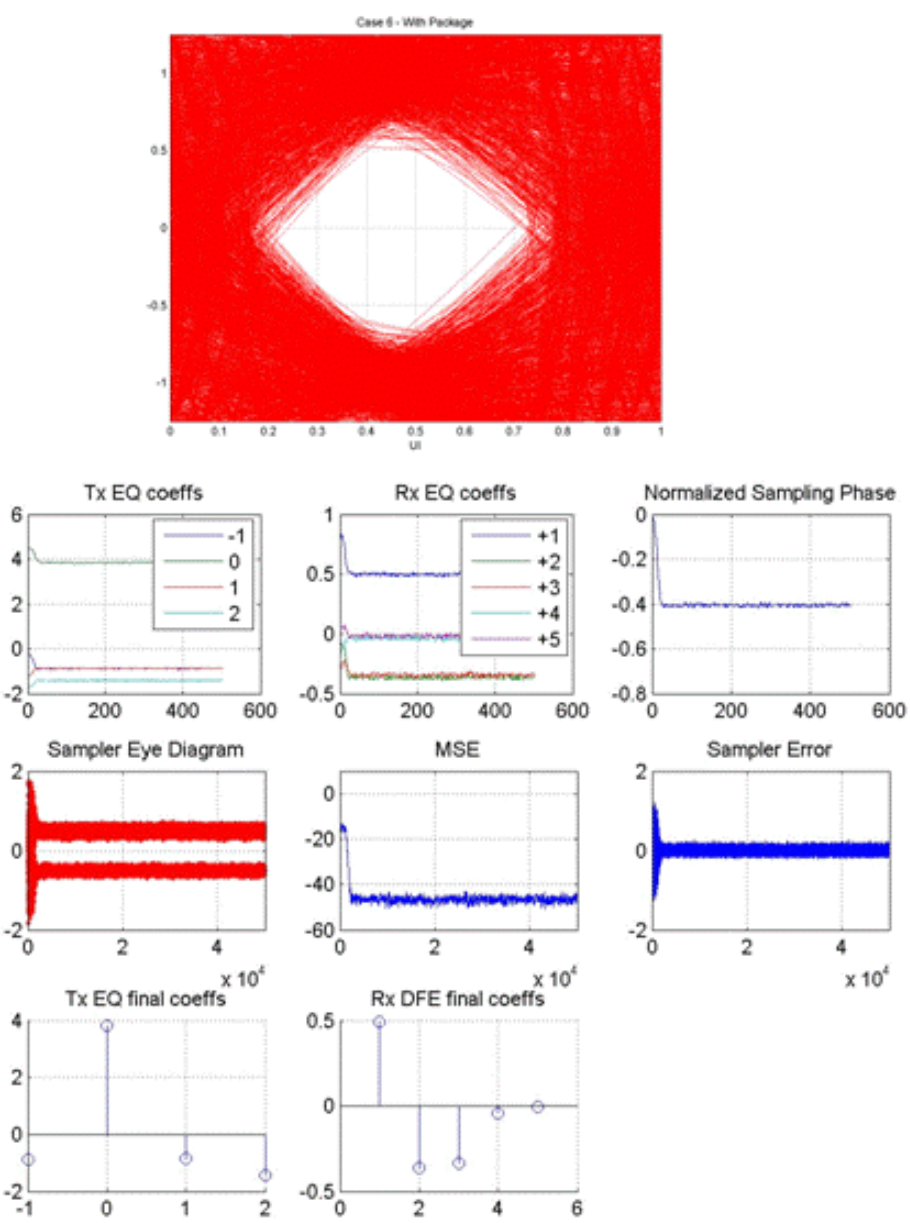
Package Effects – Tyco #6





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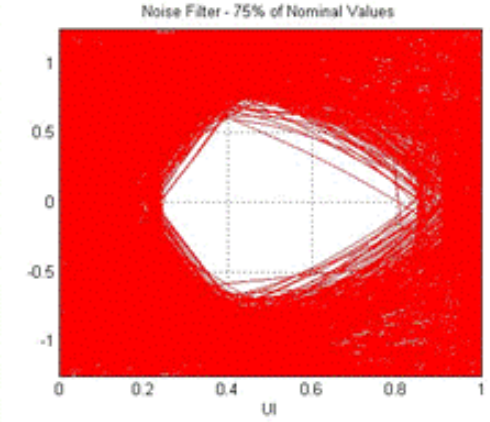
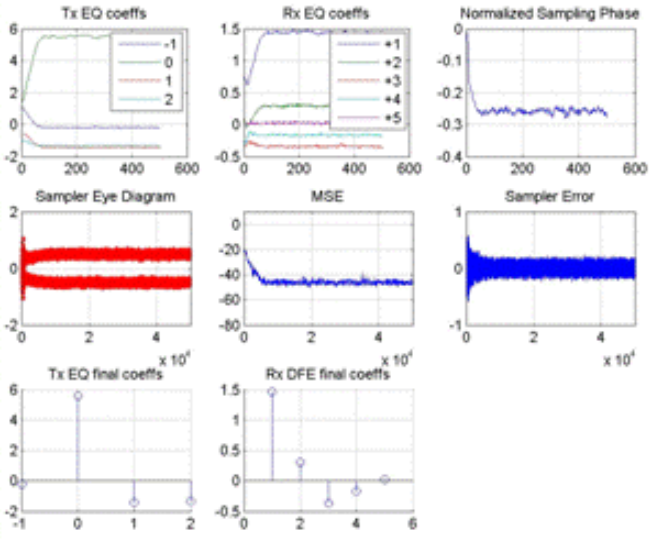
Rx Noise filter Effects

- Investigated Rx front end variations on simulated response
- Varied Rx input amplifier BW, modeled as a 2 real pole response:
  - Both poles changed to track proportionally
  - -25% / nom / +25% variations
- Estimate effects of typical manufacturing control

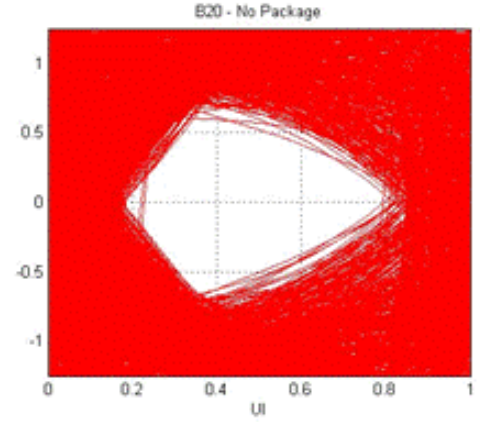
Rx Noise Filter Simulations – Intel B20

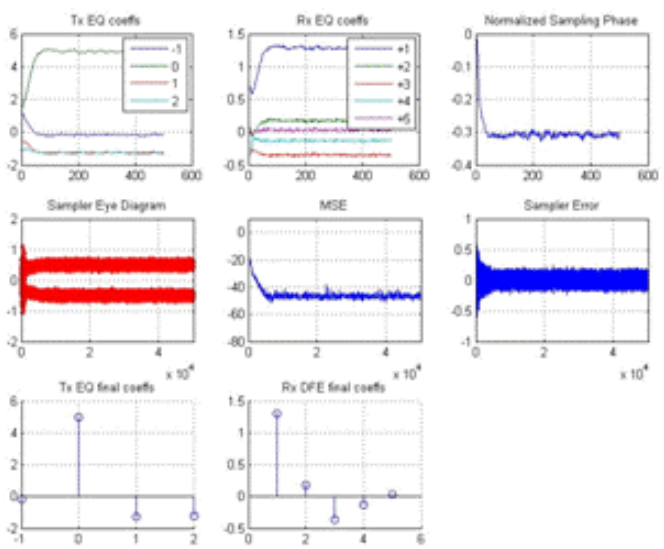
-25%



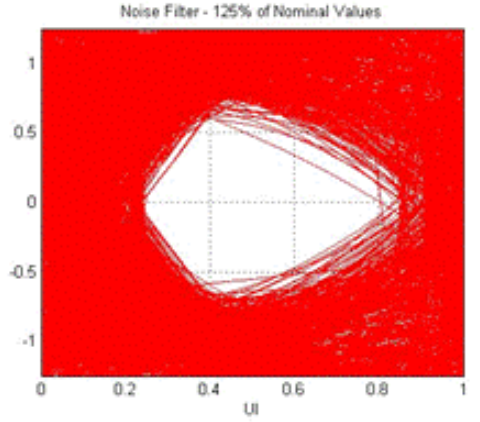


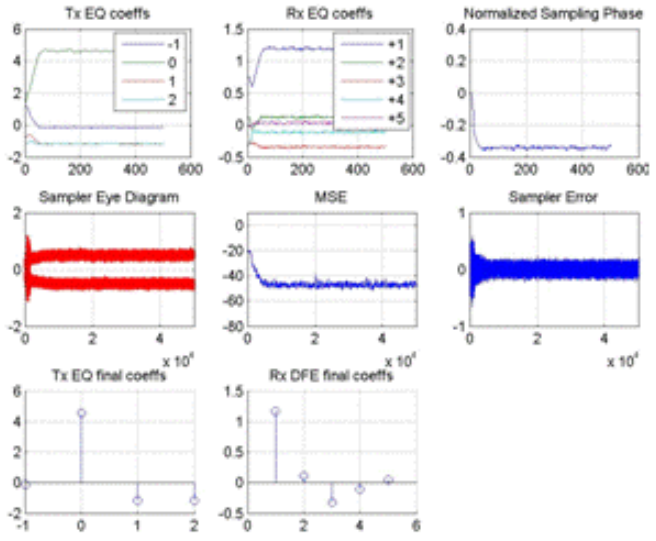
Nominal





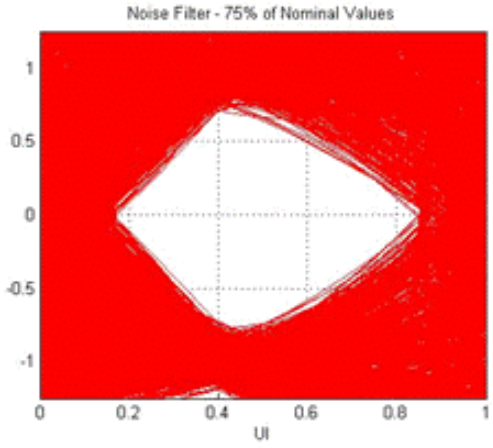
+25%



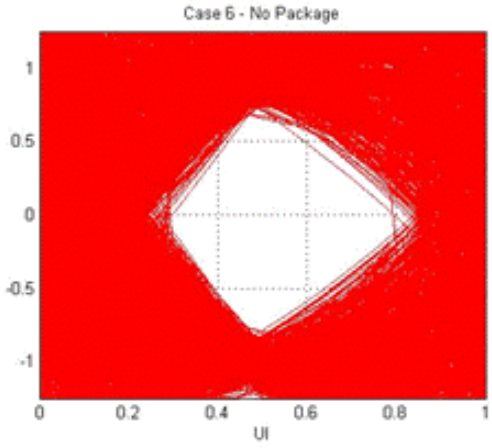


Rx Noise Filter Simulations – Tyco Case#6

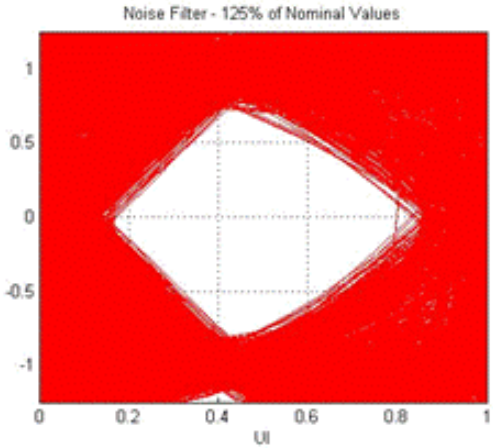
-25%



Nominal



+25%



Summary

- Presented a summary of NRZ, Duobinary and PR4 simulation results
- Partial Response vs. NRZ performance
  - DB and PR-4 channel coverage no better than NRZ
  - Most NRZ data eye diagrams better than PR-x data eyes
- Equalization not successful for all channels
  - Top-routed channels not successful for any line code
  - Sensitivity to stubs still clear for short equalizers
- Package and noise filtering have effect on adaption and final eye shape
  - Asymmetry in data eyes can easily result, reducing BER
- Improvement paths for unsuccessful channels
  - PR signaling allows option of MLSE detector
    - NOT considered here, but generally +3dB SNR
  - NRZ allows few improvements
    - Added overhead for Error Correcting Encoding
    - Added equalizer complexity – more taps, etc.