VITESSE

06-206r2 SAS-2 Data Eyes vs. De-Emphasis

Serial Attached SCSI

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SAS-2 Phy Working Group

5/9/06

YOUR PARTNER FOR SUCCESS

Outline

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- Address the Concern that Fixed De-Emphasis on External Links Will Cause too Much Jitter for Short Links
  - Compare Fixed and Optimal De-Emphasis for Example External SAS-2 Links
  - Estimate the Jitter Penalty of Fixed vs. Adaptive De-Emphasis
  - Discuss Concerns with Optional Adaptive De-Emphasis Provisions
- Evaluate De-Emphasis on some Example T10 Chassis S-Parameters
  - Compare Results to 06-049r1
- Propose Recommendations for Discussion

Simulation Methodology

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- Convert S-Parameters to Frequency Response
  - Use Mellitz Capacitive Package Model RL~7dB @ 3GHz Combined with S-Parameter Model

$$H(f) = \frac{S_{21}\Gamma_L + S_{21}}{(1 - S_{22}\Gamma_L) + S_{11}(1 - S_{22}\Gamma_L) + S_{21}\Gamma_L S_{12}}$$

- Convert Frequency Response to an Impulse Response

$$h(t) = FFT^{-1}(H(f))$$

- Measure Transmitted Pulse Shape
- Compute the Optimal (ZF) De-Emphasis Tap Weights

$$y(t) = p(t) * h(t)$$

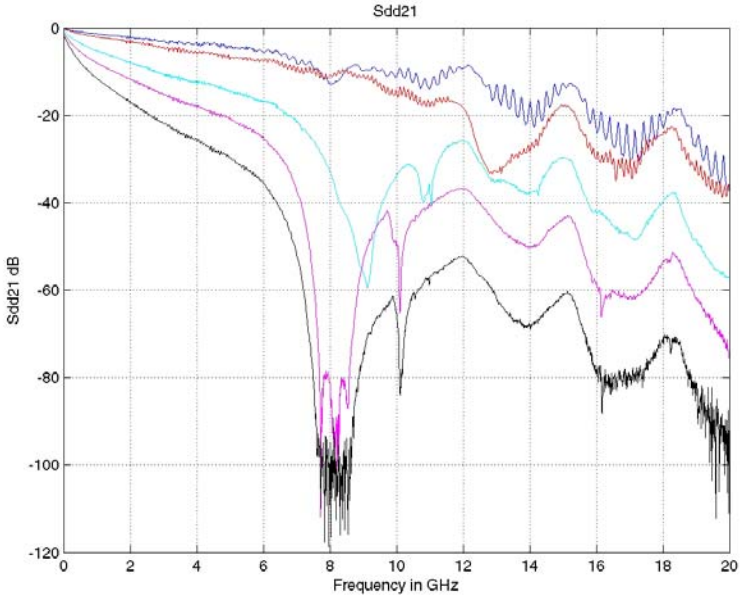
$$C_{zf} = \begin{bmatrix} y(\tau) & y(\tau - T) \\ y(\tau + T) & y(\tau) \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

- Filter the Measured & Estimated Channel Output with the De-Emphasis Filter

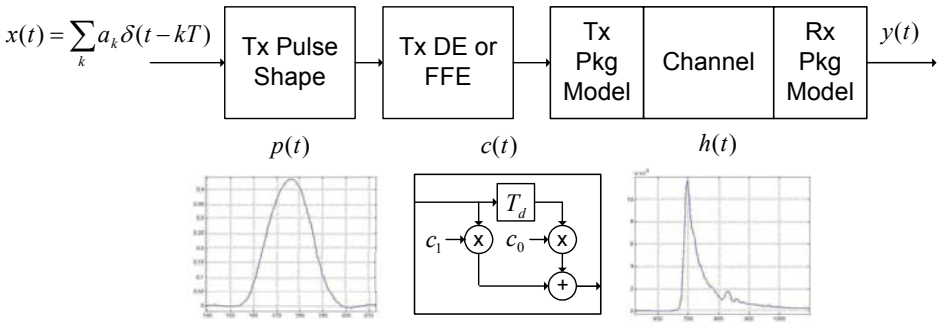
$$\hat{y}_m(t) = y_m(t) * c(t) \qquad \hat{y}(t) = x(t) * h(t) * c(t)$$

- Estimate the Jitter from the Data Eye $\{\hat{y}_m(t), \hat{y}(t)\}$
- Compare to Measured Results

0.5, 1, 6, 10 & 15m iPASS



Simulation Model



Optimal De-Emphasis for iPASS Cables

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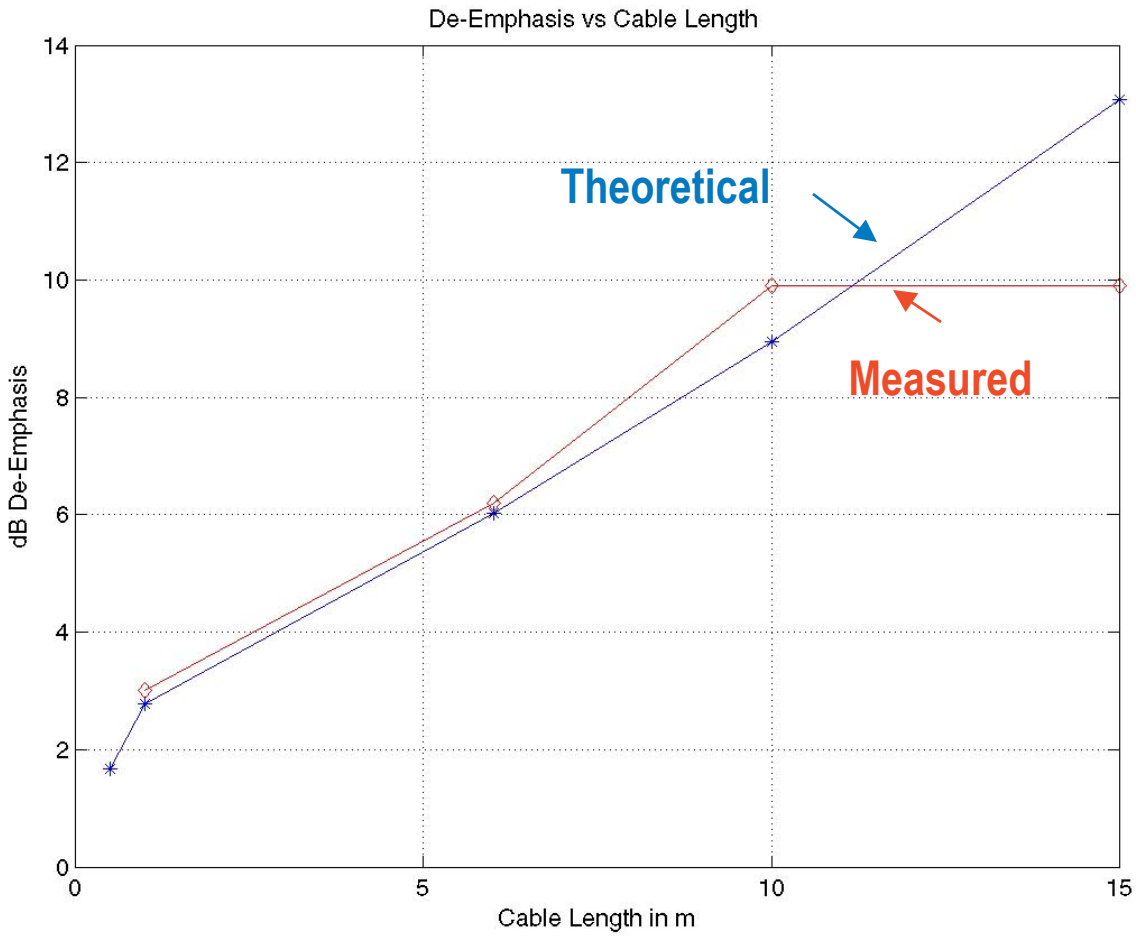
- Computed Optimal and Laboratory Optimization De-Emphasis



Limited by 9.9dB Max DE

6dB Max for EMI?

Optimal De-Emphasis iPASS Cables

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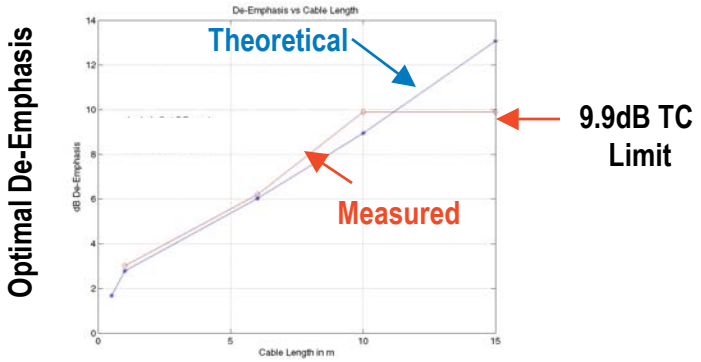
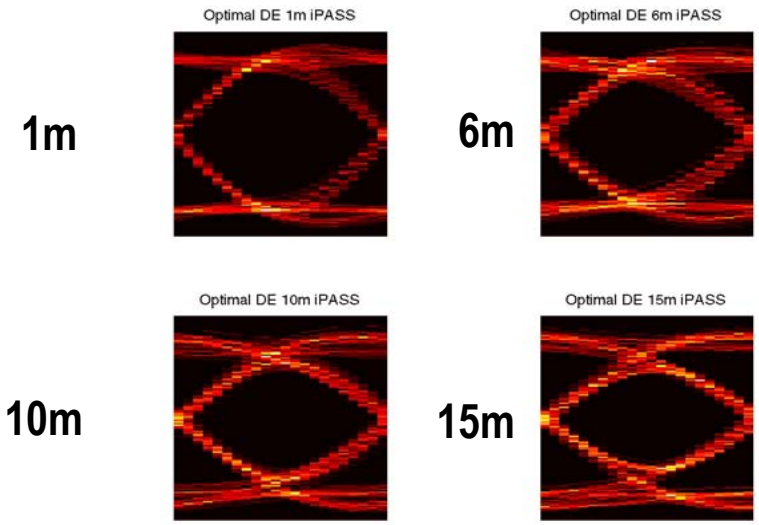
Simulation vs Measured

- 6 Gbps Output Driver Test Chip
  - 2 Tap De-Emphasis
  - 0 → 9.9 dB De-Emphasis Capability

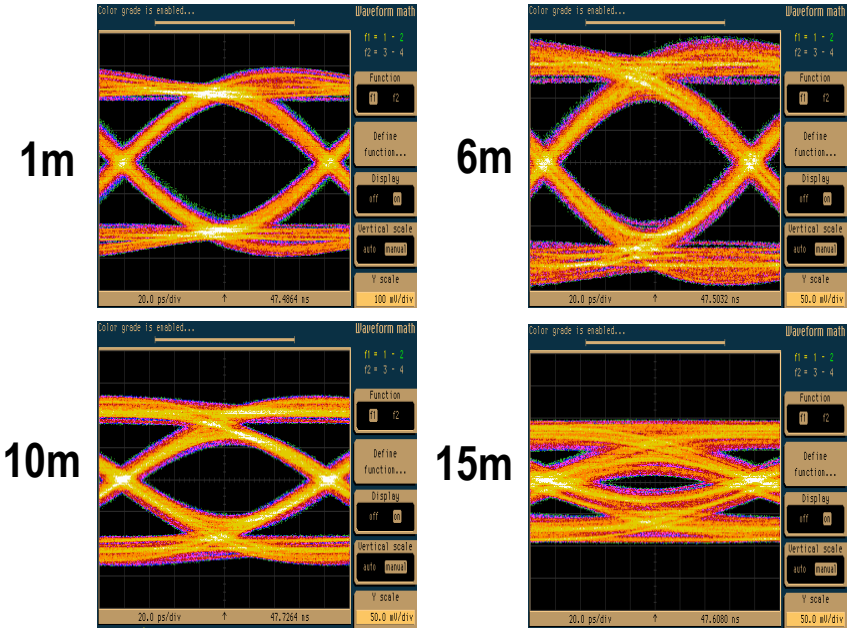
Optimal De-Emphasis vs Length iPASS Cables



Optimal De-Emphasis Simulated Eyes



Optimal De-Emphasis Measured Eyes



Non-Optimal DE 9.9dB Limit

Fixed 6dB De-Emphasis

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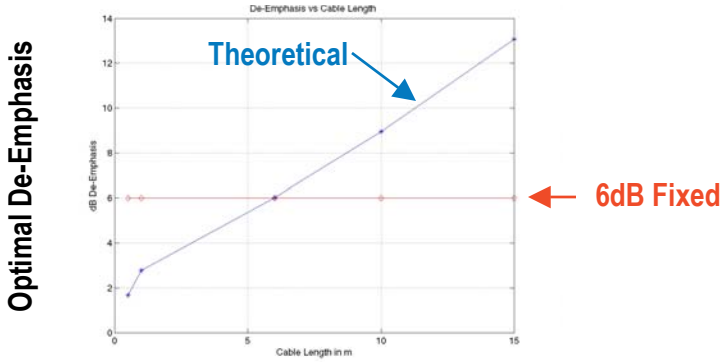
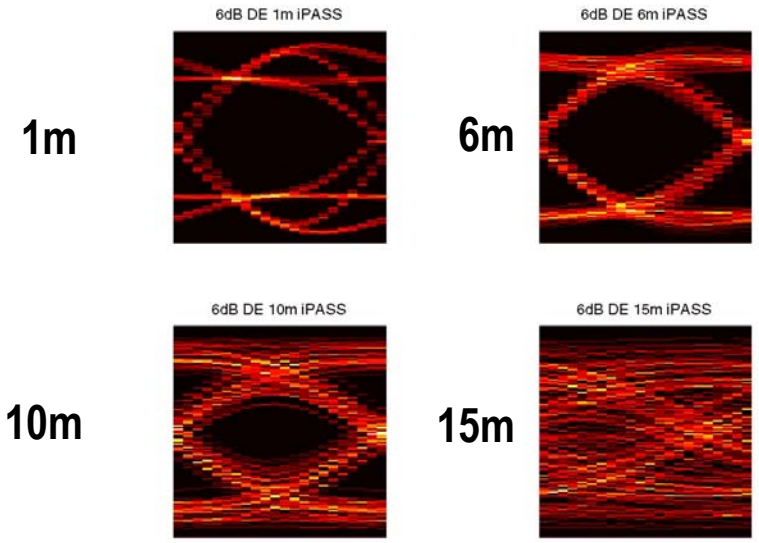
- Simulation vs Measured
  - 6 Gbps Output Driver Test Chip
    - 2 Tap De-Emphasis
    - 0 → 9.9 dB De-Emphasis Capability

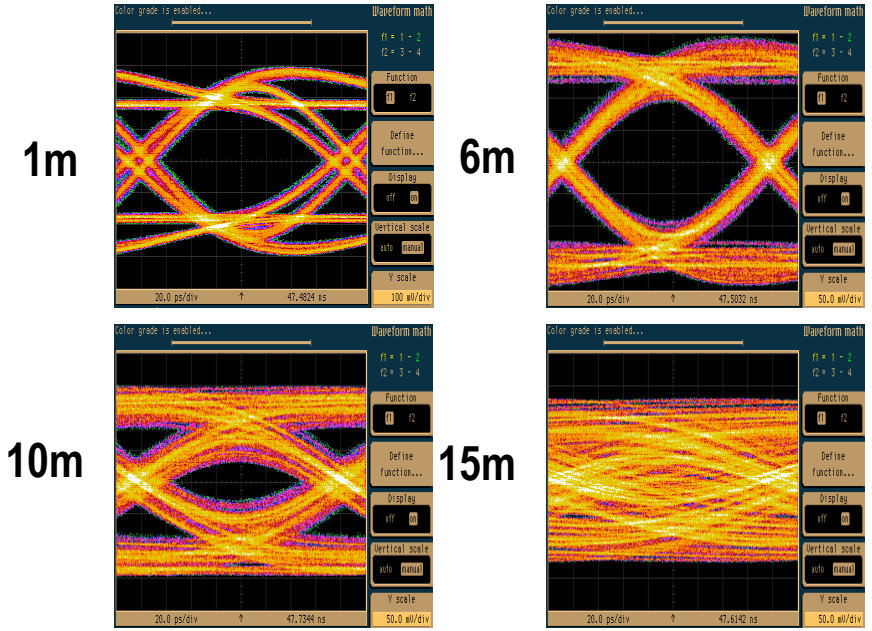
Optimal De-Emphasis vs Length iPASS Cables



6dB De-Emphasis Simulated Eyes



6dB De-Emphasis Measured Eyes



Jitter Generation vs. De-Emphasis

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Jitter vs Length with Fixed and Optimal De-Emphasis

- Measurement is 2000 hit Histogram

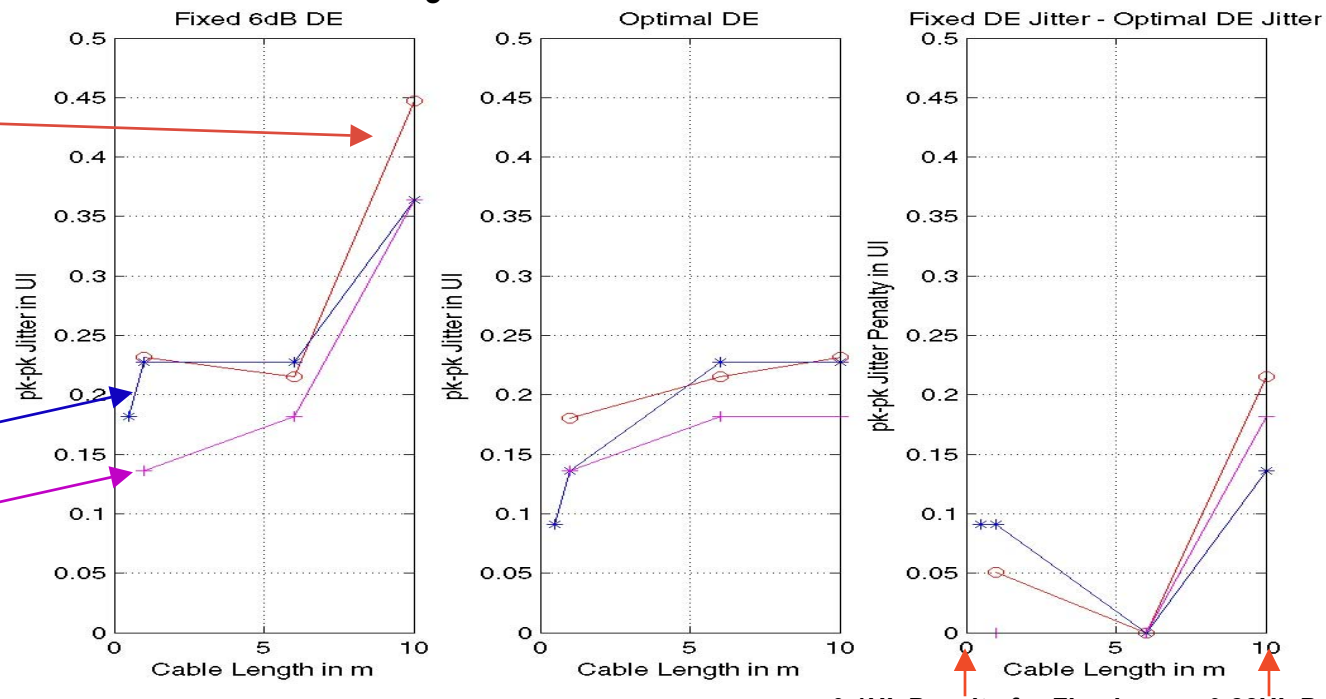
Measured

Filtered Estimated Channel Output

$$\hat{y}(t) = x(t) * h(t) * c(t)$$

Filtered Measured Channel Output

$$\hat{y}_m(t) = y_m(t) * c(t)$$



< 0.1UI Penalty for Fixed vs Optimal DE at 0.5 & 1m

< 0.22UI Penalty for Fixed vs Optimal DE at 10m

- Minimum Length External Channel 0.5m Jitter is Simulated Only
- Jitter Penalty at 10m is higher than at 1m length
- The data to date does not support the need for adaptive Tx De-Emphasis. 6dB of Fixed Tx De-Emphasis for external links does not appear to cause too much jitter when the short links are used.

HP Chassis Simulation Comparison

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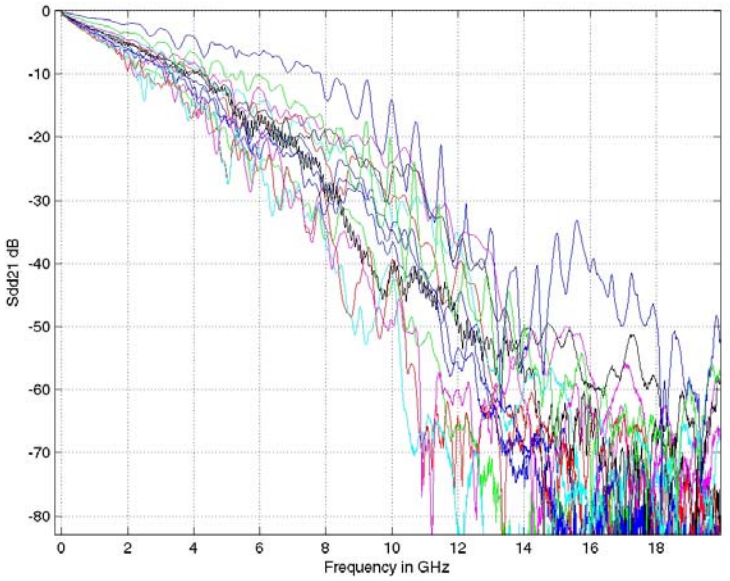
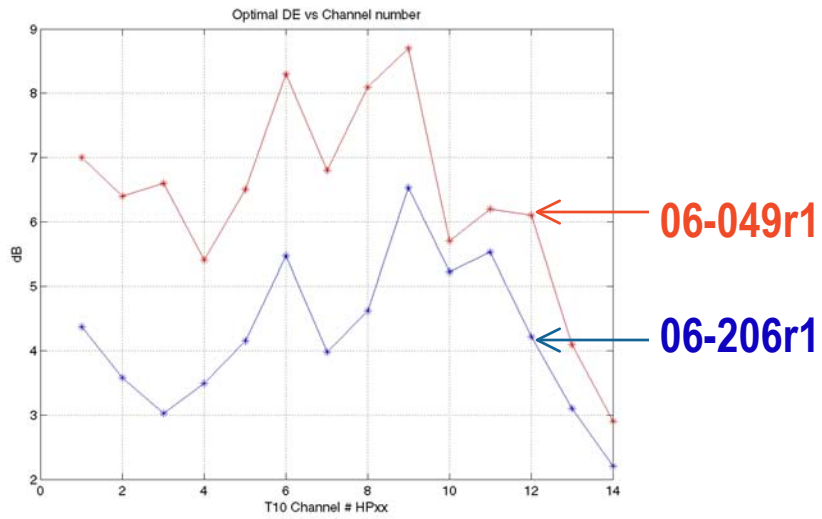
Simulation Comparison

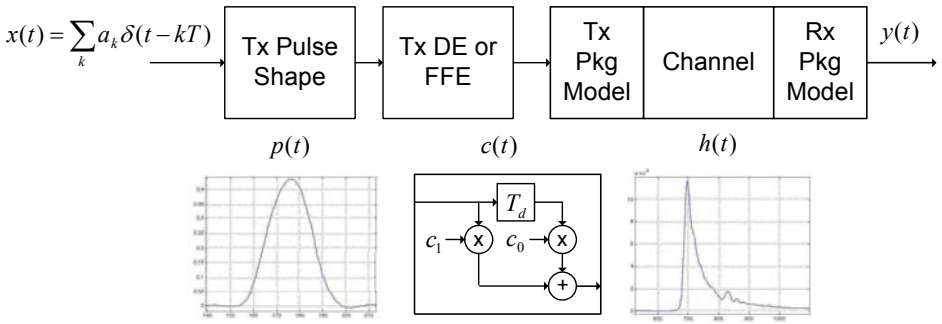
	06-049r0		06-206r1
	# DFE	dB DE	ZF DE
HP01	0	7.0 dB	4.37 dB
HP02	0	6.4 dB	3.58 dB
HP03	0	6.6 dB	3.03 dB
HP04	0	5.4dB	3.49 dB
HP05	0	6.5 dB	4.16 dB
HP06	0	8.3dB	5.47 dB
HP07	0	6.8 dB	3.90 dB
HP08	0	8.1 dB	4.62 dB
HP09	0	8.7 dB	6.53 dB
HP10	1	5.7 dB	5.20 dB
HP11	1	6.2 dB	5.53 dB
HP12	0	6.1 dB	4.22 dB
HP13	0	4.1 dB	3.11 dB
HP14	0	2.9 dB	2.21 dB

Chassis HP1→14





Simulation Model



HP Chassis Simulation Comparison

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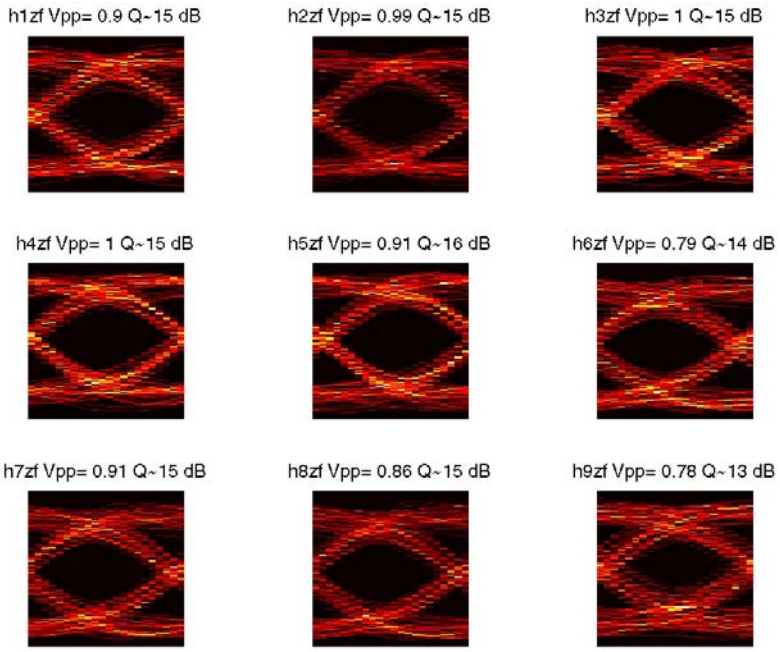
HP Chassis 1→9 Optimal DE

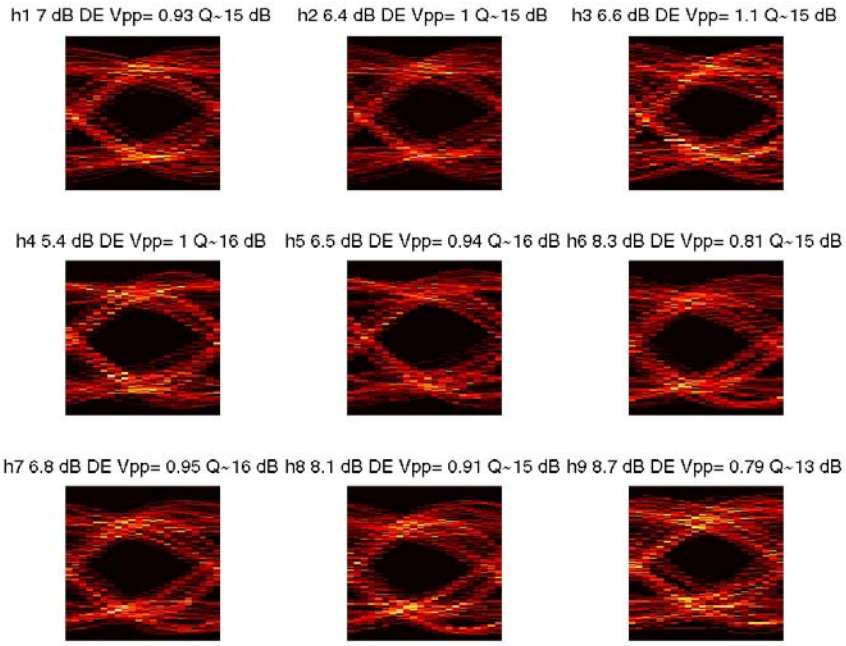
Based on Test Chip Tx Pulse



Simulations Consistent with 06-049r1 and Support the Assertion that 2 tap DE Adequate for these Channels

HP Chassis 1→ 9 Fixed DE

DE Levels Based on 06-049r1



Note: DE level based on assumed pulse shape in 06-049r0 not optimal for Simulated Pulse Shape

HP Chassis Simulation Comparison

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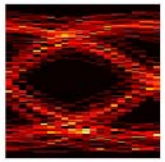
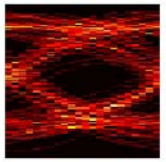
HP Chassis 10→14 Optimal DE

Based on Test Chip Tx Pulse

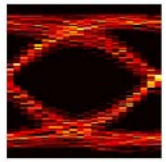
h10zf Vpp= 0.83 Q~13 dB



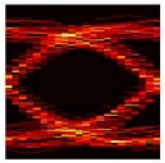
h11zf Vpp= 0.89 Q~13 dB



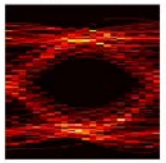
h12zf Vpp= 0.84 Q~17 dB



h13zf Vpp= 1 Q~17 dB



h14zf Vpp= 1.3 Q~16 dB

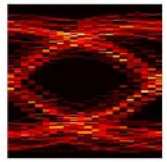


Simulations Consistent with 06-049r1 and Support the Assertion that 2 tap / 1 tap DFE DE Adequate for these Channels

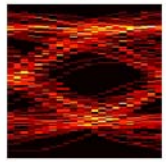
HP Chassis 10→ 14 Fixed DE

DE Levels Based on 06-049r1

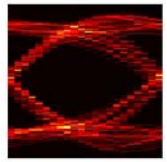
h10 5.7 dB DE Vpp= 0.84 Q~14 dB



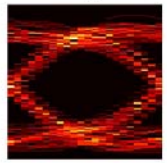
h11 6.2 dB DE Vpp= 0.9 Q~13 dB



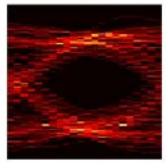
h12 6.1 dB DE Vpp= 0.86 Q~19 dB



h13 4.1 dB DE Vpp= 1 Q~18 dB



h14 2.9 dB DE Vpp= 1.3 Q~16 dB



Note: DE level based on assumed pulse shape in 06-049r0
HP10,11 expected to need 1 tap DFE

Summary and Recommendations

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- Optimal and Fixed De-Emphasis for External Links has been Investigated
  - Simulated and Measured Results Match Well
  - Fixed 6dB De-Emphasis Does not Cause Excessive Jitter for Short Links
- Simulations Consistent with 06-049r1
- Recommendations
  - Do not define “optional” primitives for adaptive De-Emphasis in the Training Sequence unless technical need determined.
  - Do Specify a Fixed 6dB Fixed De-Emphasis for External Links.
  - Do Provide Adjustable De-Emphasis for Internal Links.
  - Do Assume a Maximum of 6dB De-Emphasis for Link Analysis and Specification.
  - Determine a Compliance Test Methodology for External Links.