VITESSE

# *Duobinary Transmission over ATCA Backplanes*

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# Outline

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- Introduction
- Adaptive FSE + DFE for Duobinary Signaling
- ATCA Backplanes
  - Tyco
  - Intel
- Simulation Results
- Equalizer Requirements and Conclusion

# Duobinary, PR2 and NRZ Spectrums

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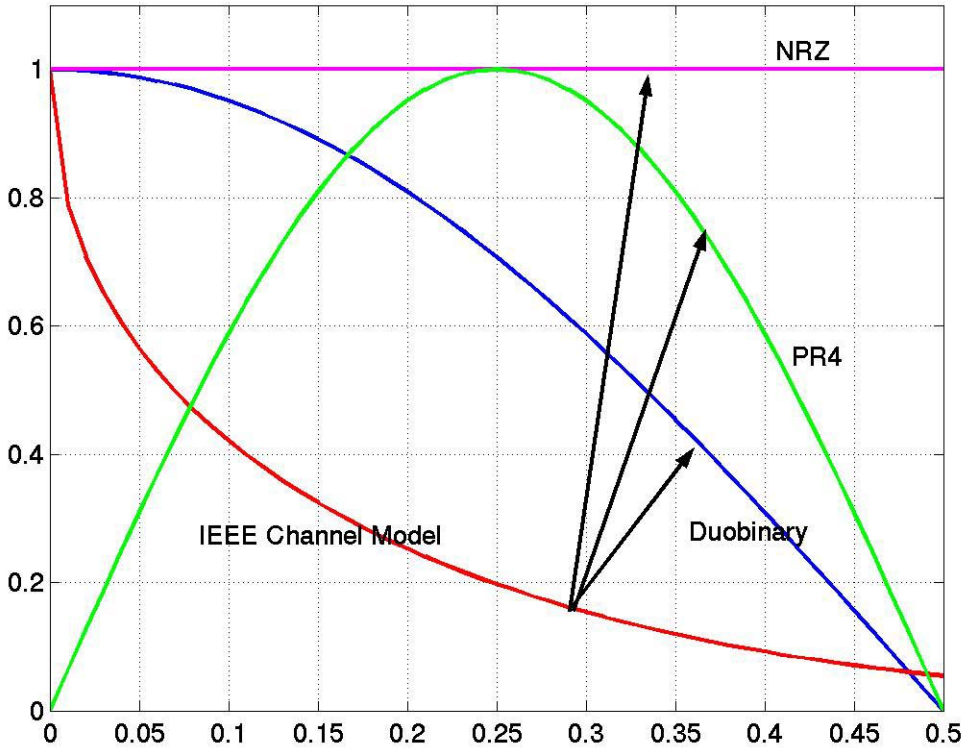


- Duobinary requires the least amount of boost at higher frequencies.

# Duobinary and PR2 Eye Diagrams

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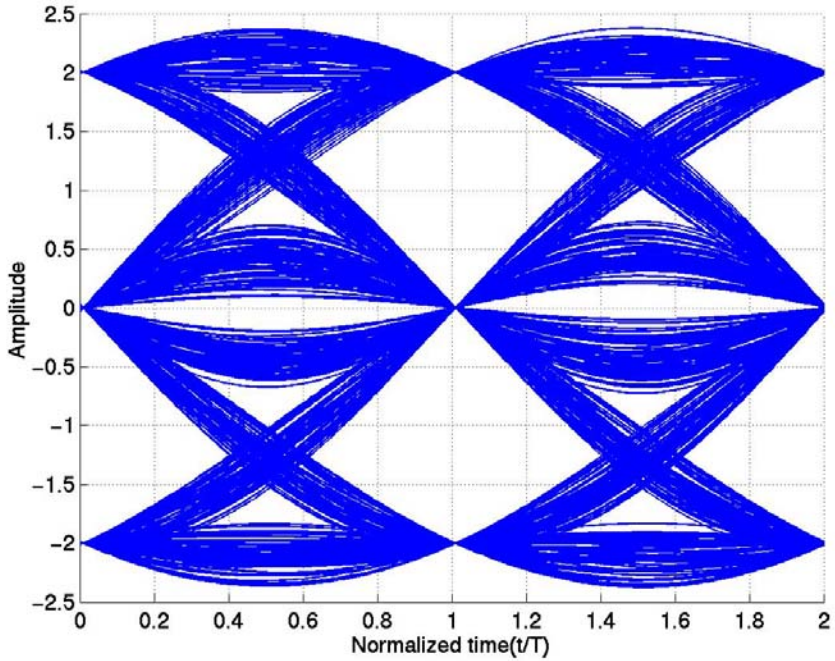


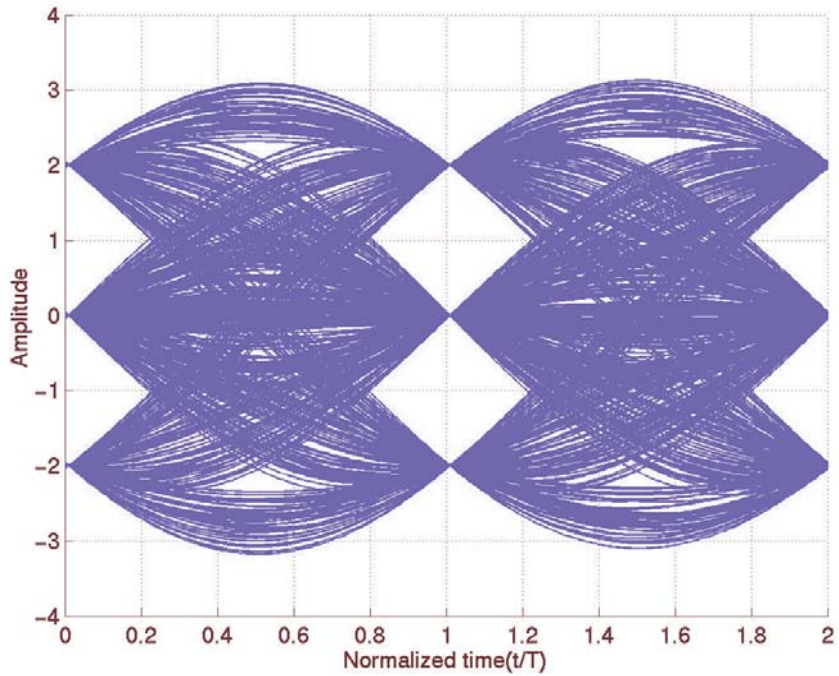


- In duobinary, Transition from 2 to –2 and –2 to 2 over one bit period is not allowed.
  - Low horizontal Jitter

# Adaptive FSE+DFE Block Diagram for Duobinary Signaling

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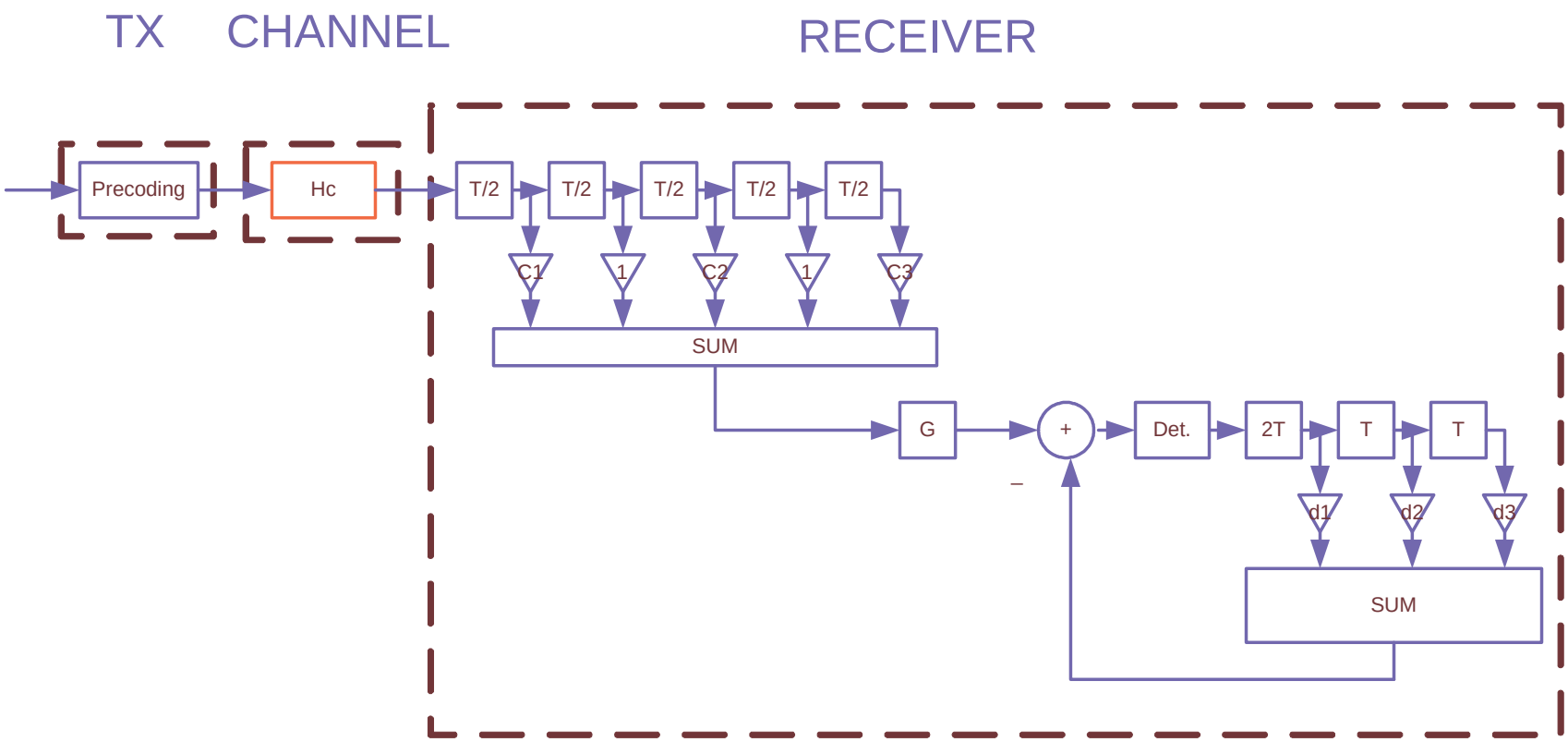

# Equalizer and Source and Load parameters

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- Transmitter:
  - Transmitter pre-emphasis: For Long Channels (40”) one pre-emphasis tap at at most 0.4 was used at transmitter.

$$H_{pre}(z) = 1 - \alpha z^{-1}$$

  - Transmit amplitude: 800 mv  peak-to-peak differential
- Receiver Equalizer:
  - Fractionally Spaced Equalizer, 5 Taps (3 variable)
    - Low sensitivity to sampling time.
  - DFE: 3 Taps
- Receiver Input and Transmitter Output Models
  - Differential 100 ohms resistance
  - 0.5 pf of capacitance was used as a model for the effects via, package and chip capacitances.

# Simulations parameters

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- Optimum Coefficients are are obtained using adaptive LMS Algorithm.
- Simple Alexander timing recovery algorithm was used at the receiver.
- Floating point representation of coefficients
- No training pattern was used in the simulations.
- A wide variety of ATCA channels (provided by Intel and Tyco to IEEE 802.3 task force) were used for simulations.
- No Crosstalk.
- No TX or RX clock jitter.

# BER Calculation and Margin

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- Vertical and horizontal margins are defined to achieve BER of 1e-15.
- Vertical Margin
  - Subtract the effect of residual ISI after equalization
  - Subtract the effect of dc offset and slicer sensitivity (total value of 10 mv is assumed)
  - Margin is defined as the maximum standard deviation of residual Gaussian noise to achieve BER of 1e-15
- Horizontal margin
  - Subtract the effect of ISI on horizontal eye opening
  - Margin is defined as  maximum standard deviation of the residual clock jitter (Gaussian assumption) to achieve BER of 1e-15.

# Intel ATCA Channels SDD12

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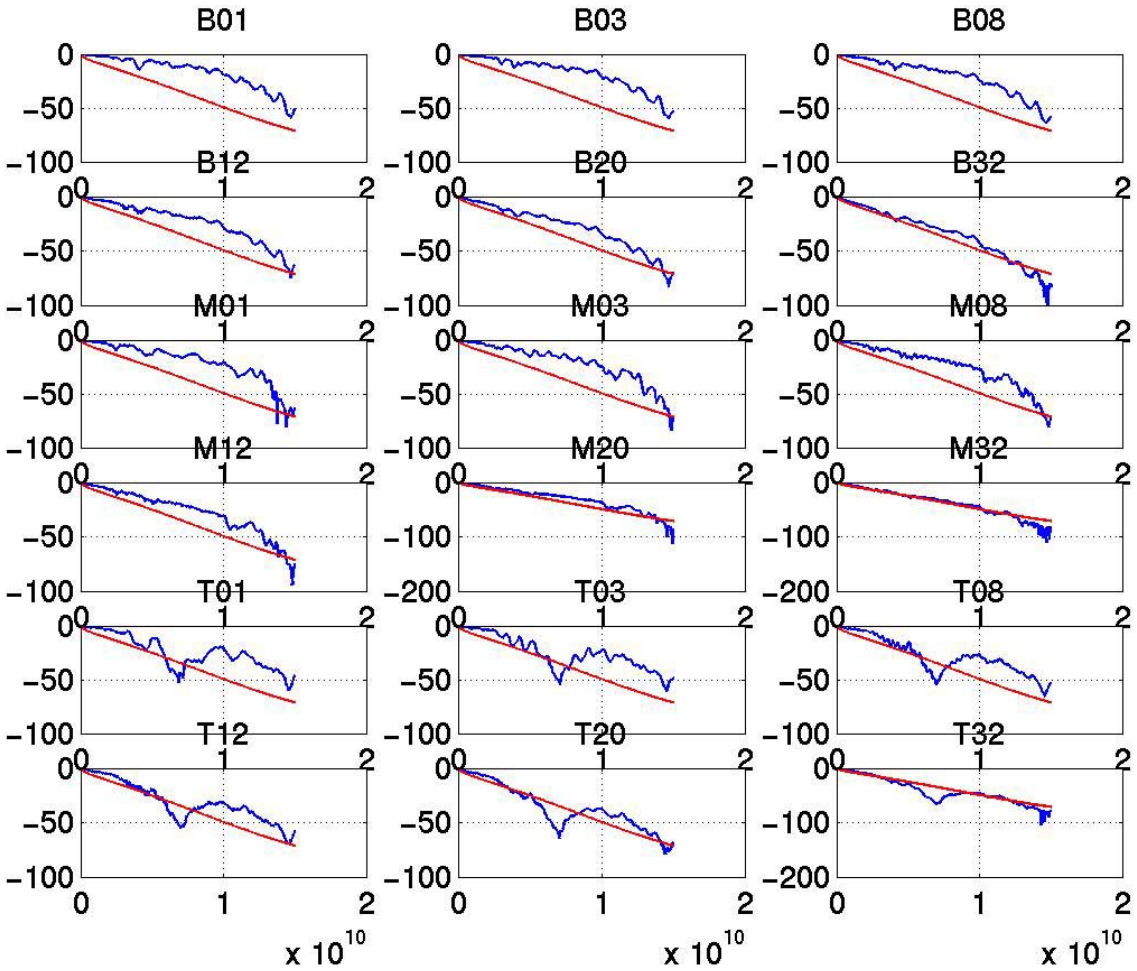


- Backplanes (B01, B03, B32, M32, T01, T20) were used in simulations.

# Intel ATCA Channels Impulse Responses

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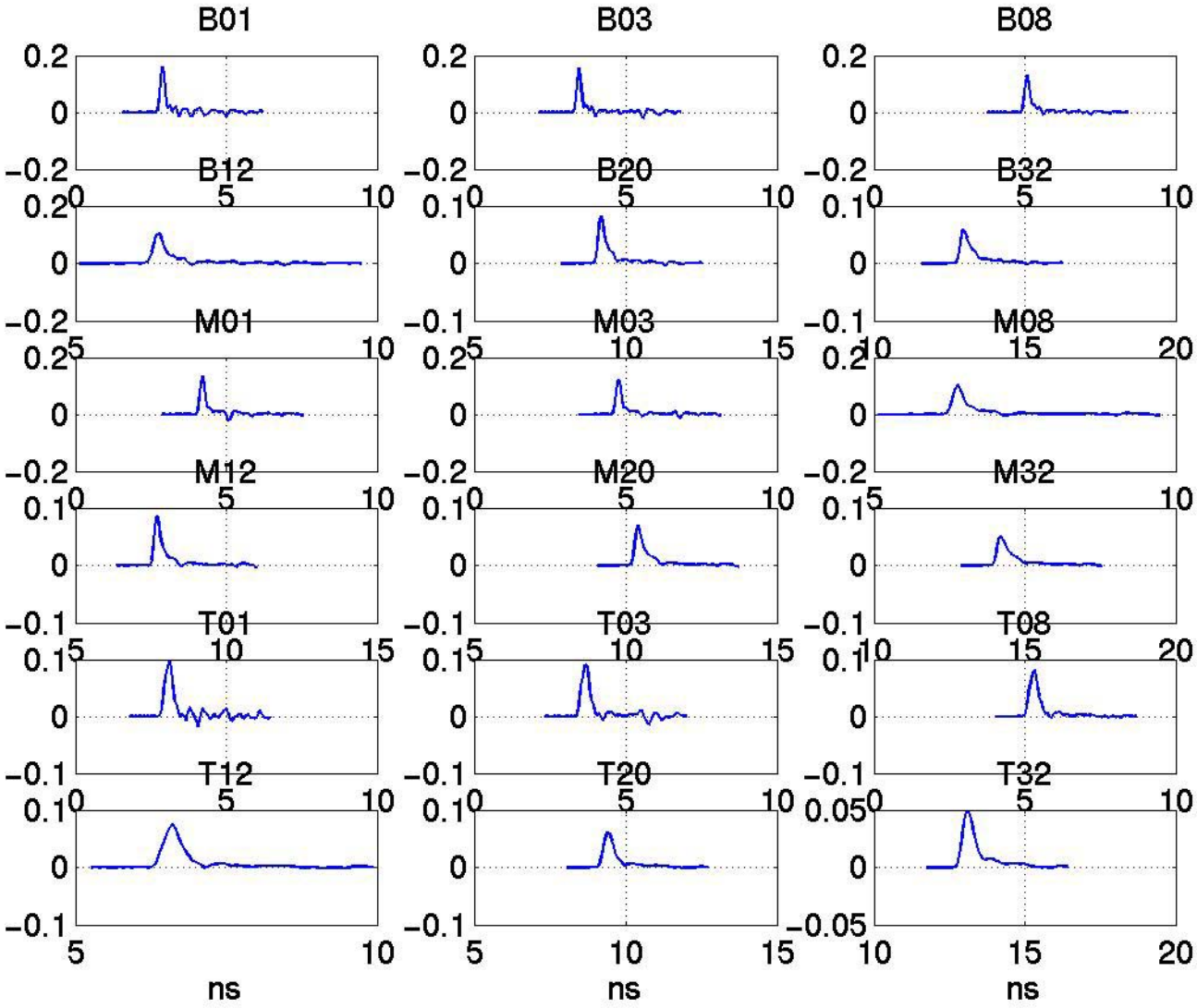

# Tyco ATCA Channels SDD12

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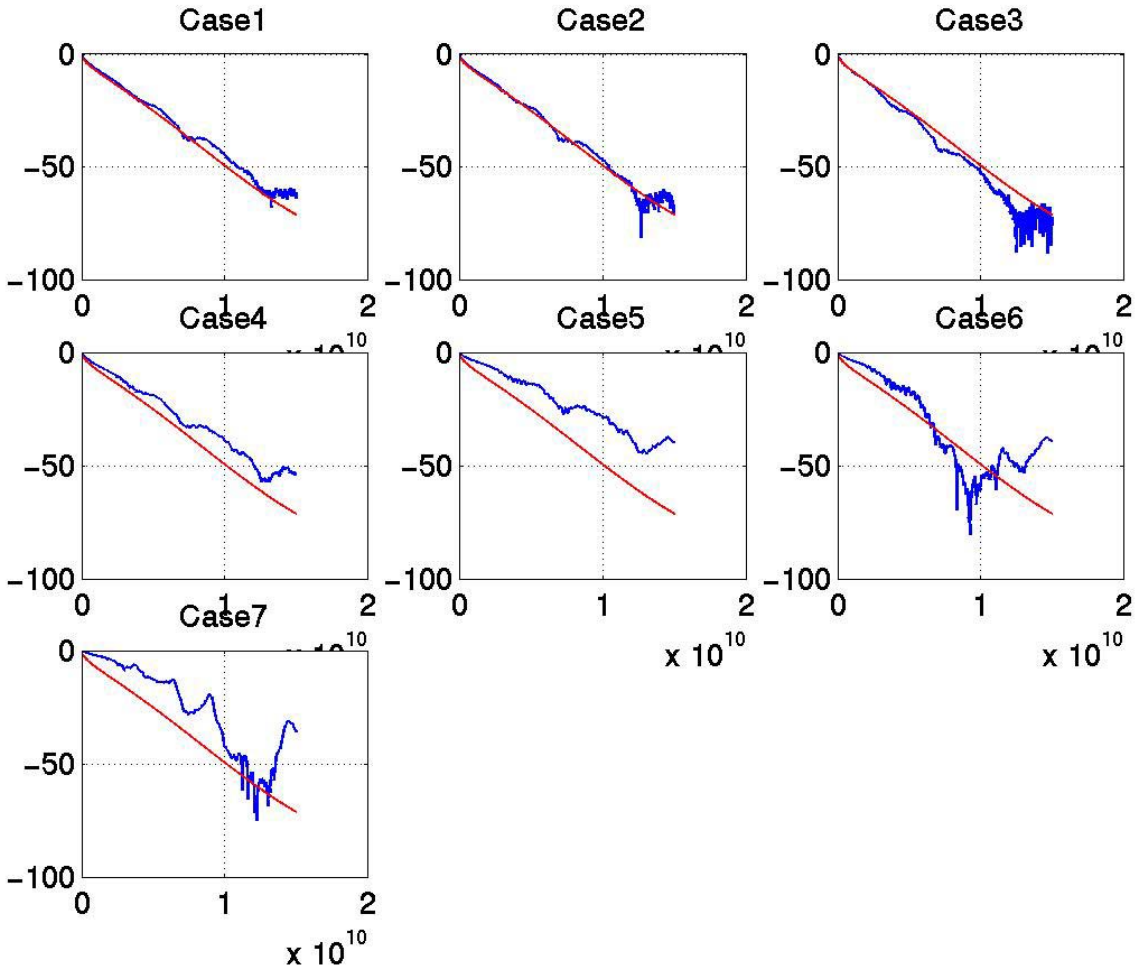


- Backplanes (Case1, Case3, Case4, Case6, Case7) were used in simulations.

# Tyco ATCA Channels Impulse Responses

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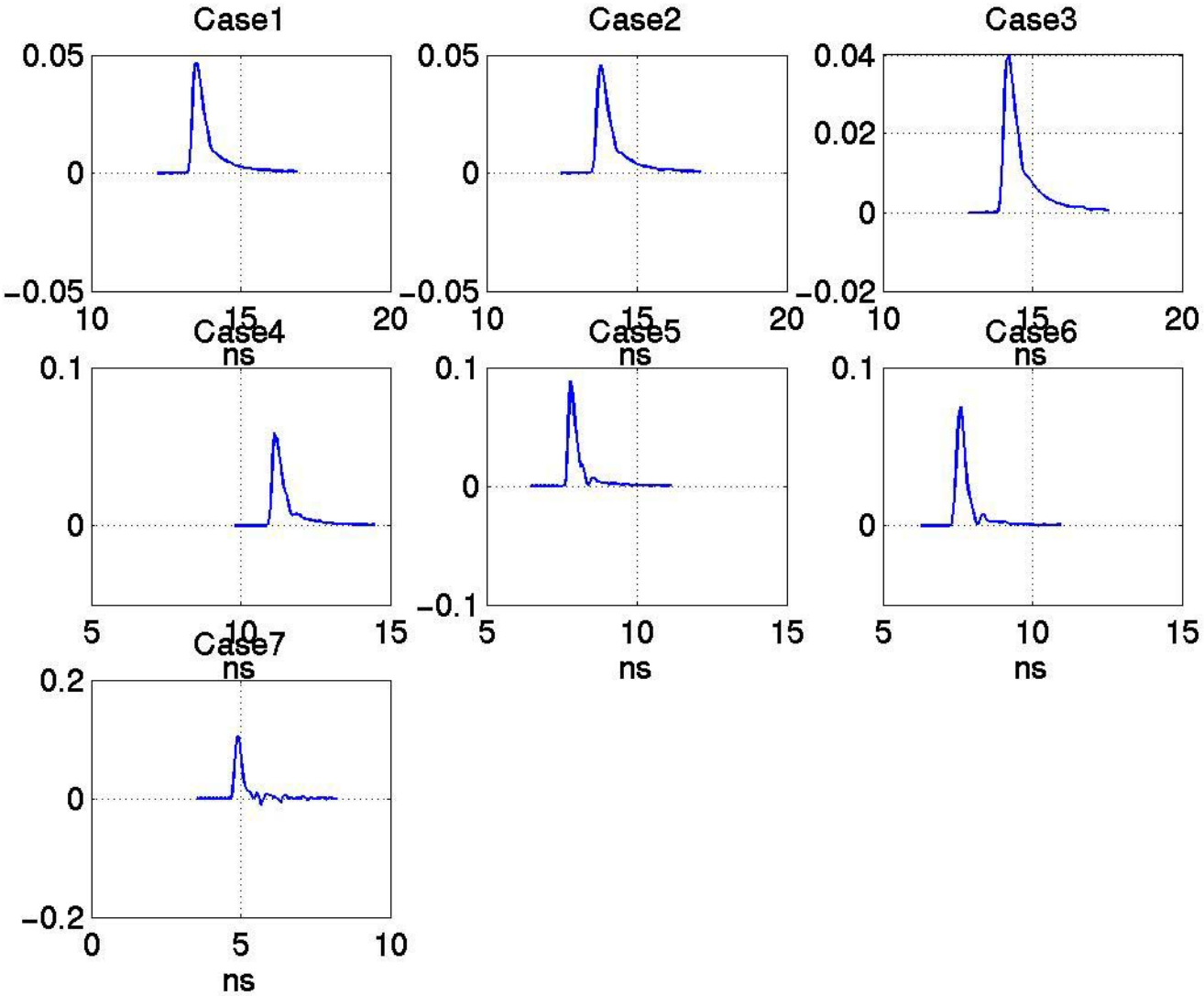

# Simulation Results for Intel ATCA B1

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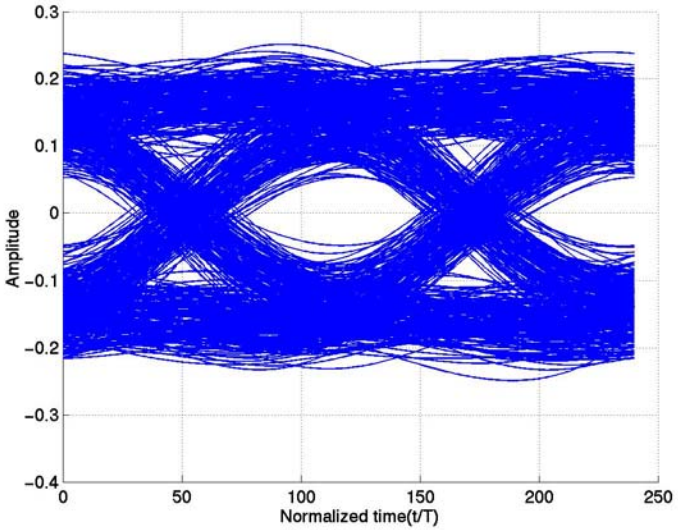
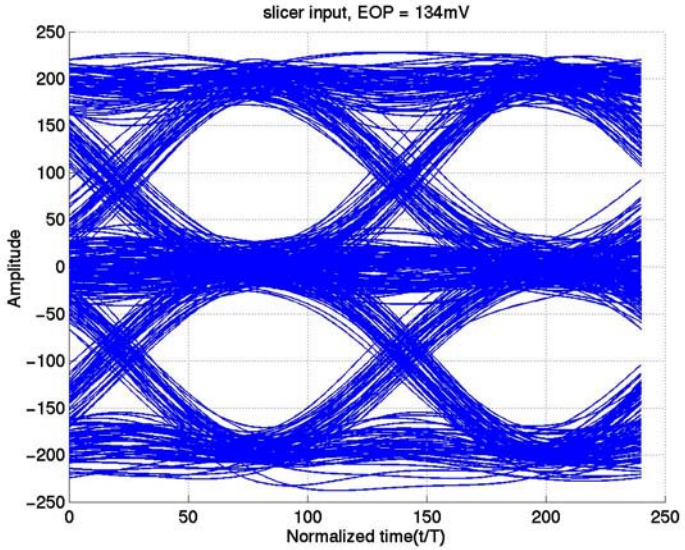
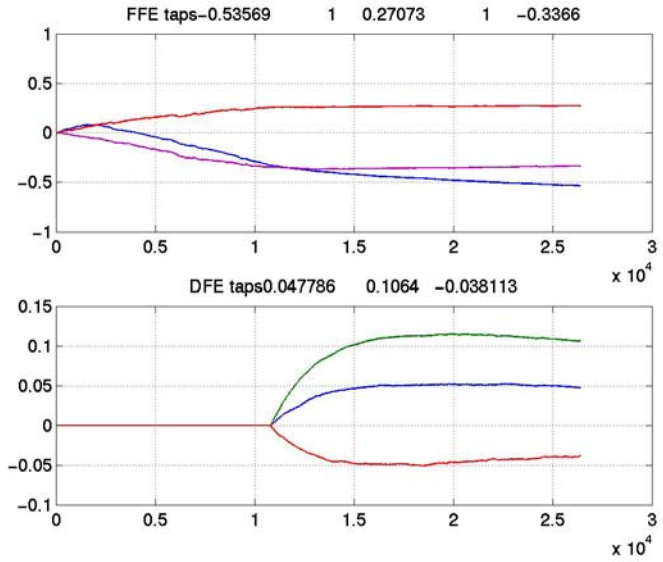



- Length: 2.25”+1.25”+2.97”
- Eye opening: 1
  - Vertical: 134 mv, (margin= 7.12 mv)
  - Horizontal: 85 ps (margin = 5.3 ps)
- Pre-emphasis: 0



# Simulation Results for Intel ATCA B3

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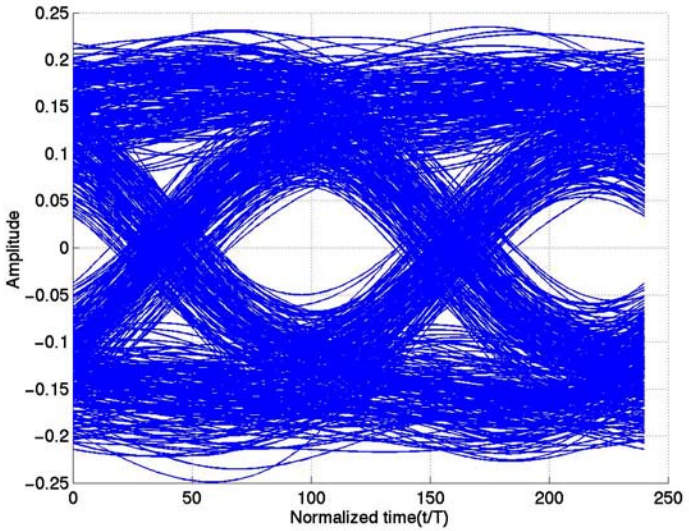


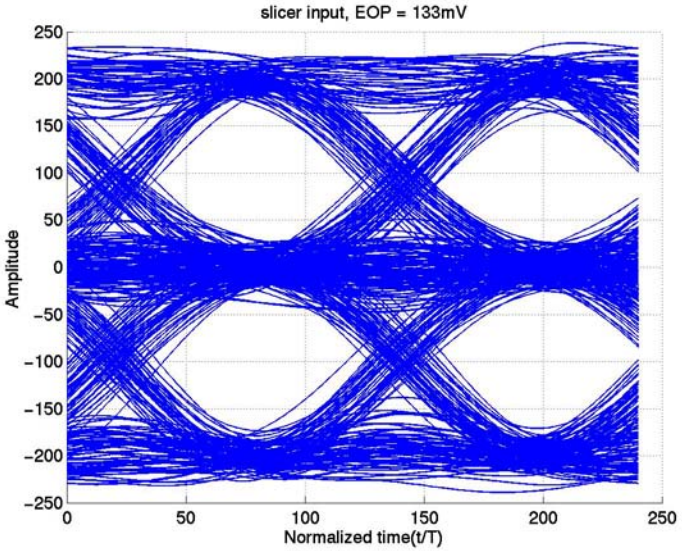


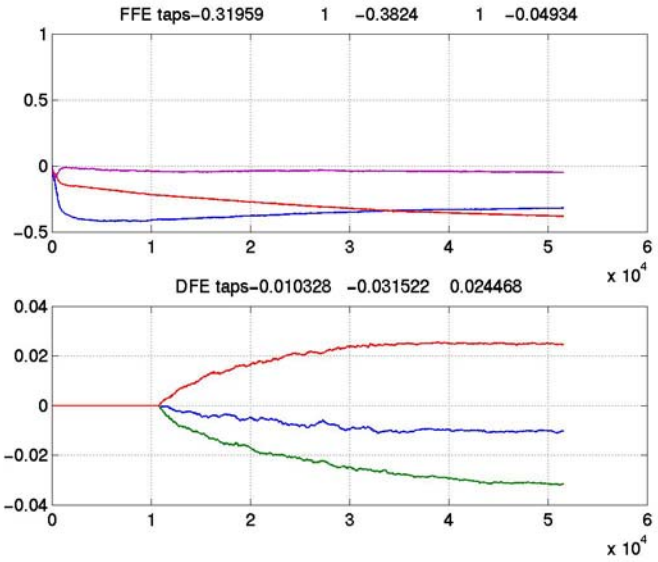


- Length: 2.25”+3”+2.97”
- Eye opening:
  - Vertical: 133 mv (margin= 7 mv)
  - Horizontal : 80 ps (margin = 5 ps)
- Pre-emphasis: 0

# Simulation Results for Intel ATCA B32

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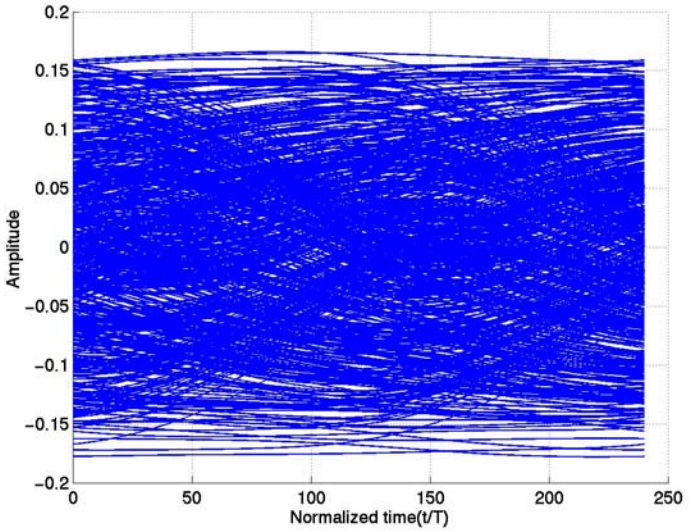


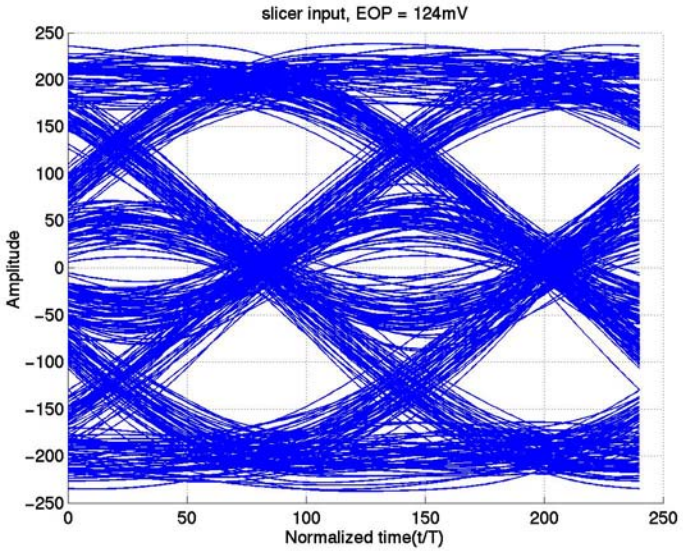


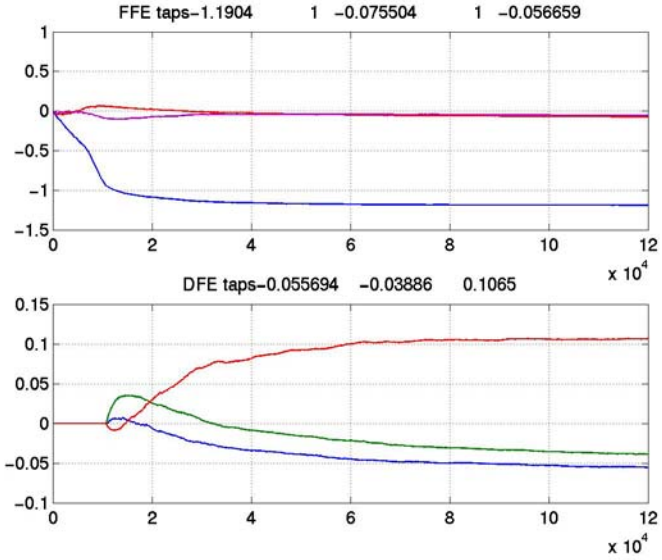


- Length: 2.25”+32”+2.97”
- ) Eye opening:
  - Vertical: 124 mv (margin= 6.5 mv)
  - Horizontal: 71 ps (margin = 4.4 ps)
- Pre-emphasis: 0

# Simulation Results for Intel ATCA M32

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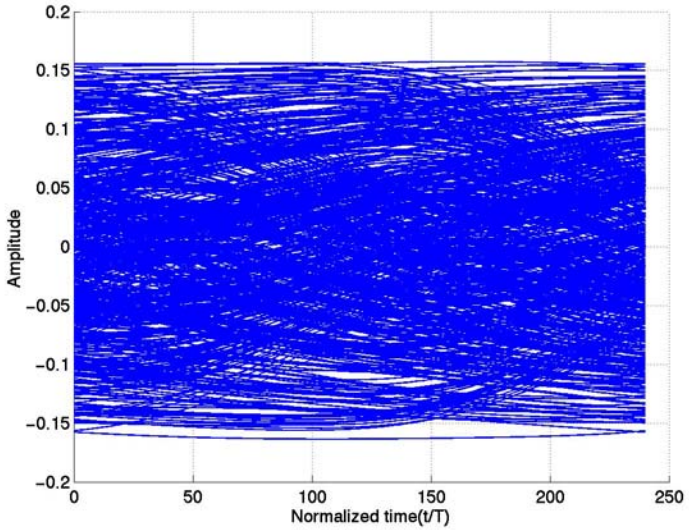
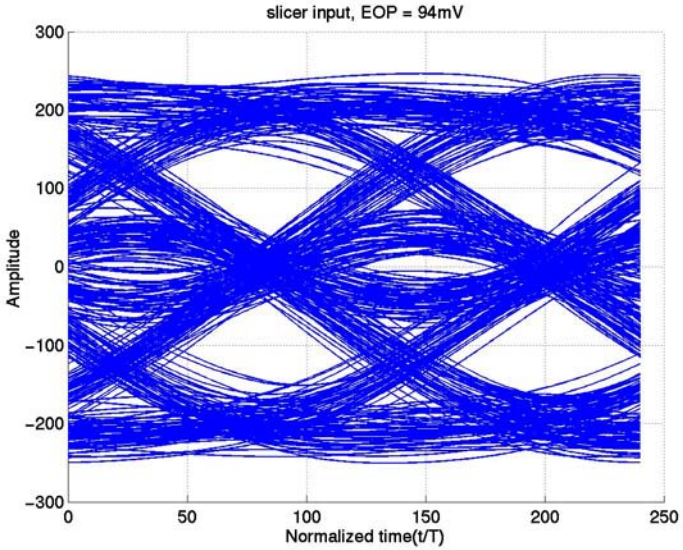
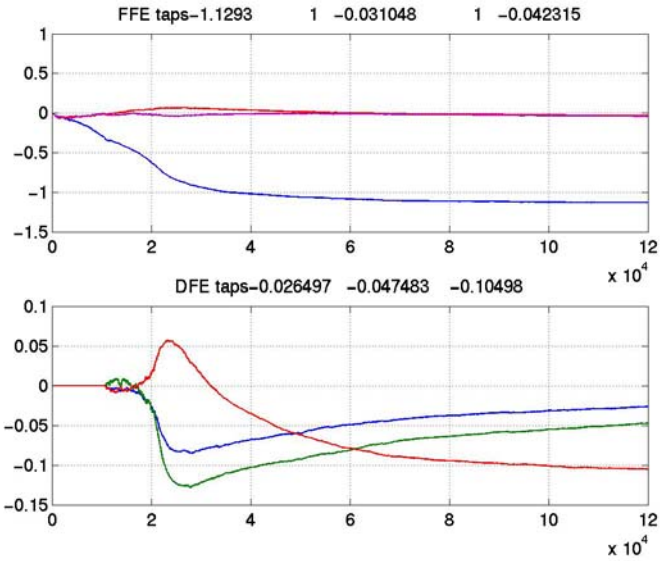


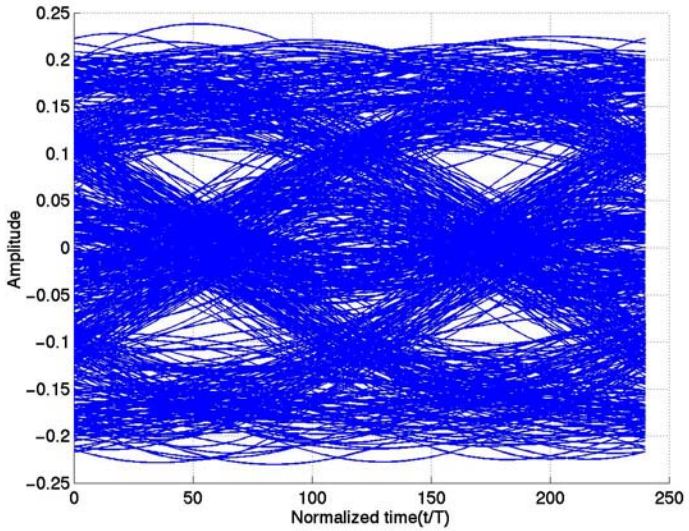



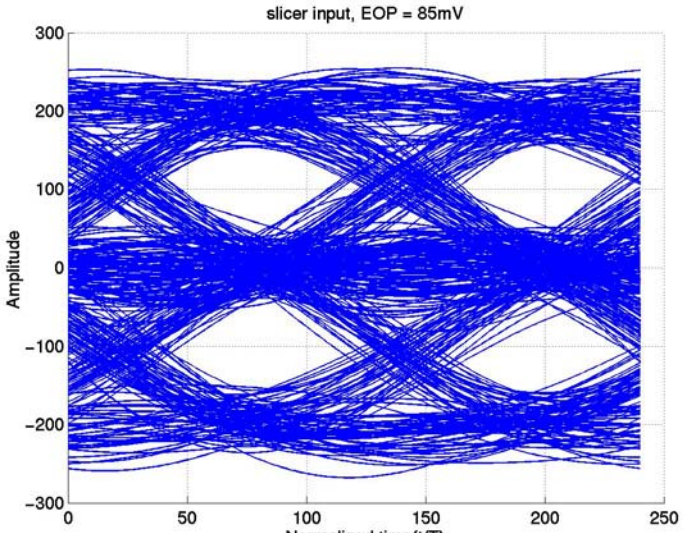



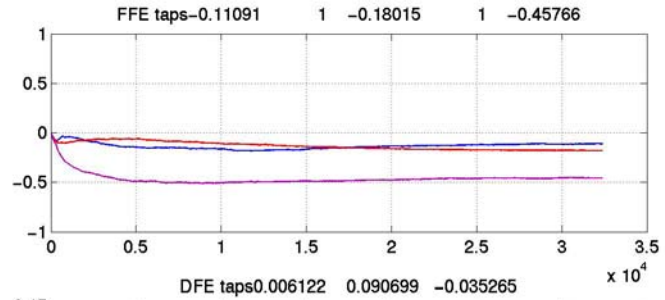

- Length: 4.75”+32”+3.79”
- ) Eye opening:
  - Vertical: 94 mv (margin = 4.6 mv)
  - Horizontal: 71 ps (margin = 4.4 ps)
- Pre-emphasis: 0

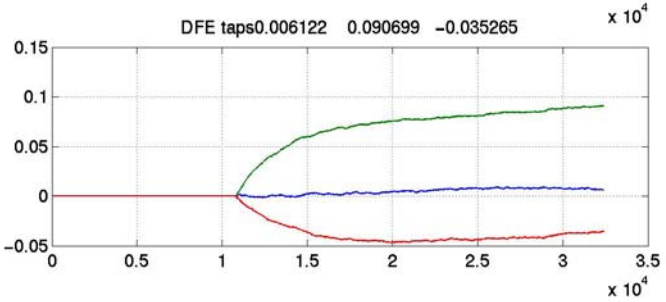
# Simulation Results for Intel ATCA T1

VITESSE



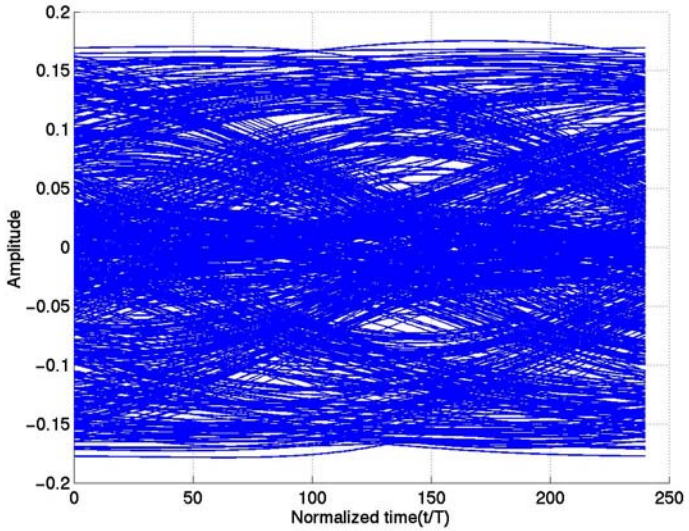



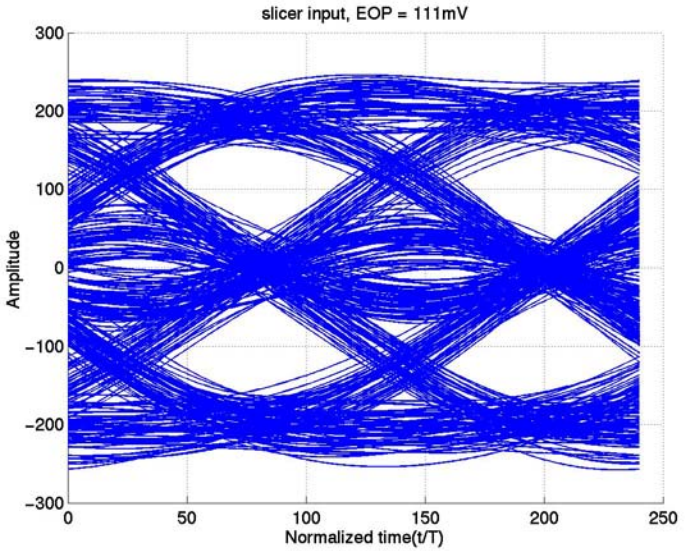




- Length: 2.73”+1.25”+3.18”
- ) Eye opening:
  - Vertical 85 mv (margin = 4 mv)
  - Horizontal: 71 (margin = 4.4 ps)
- Pre-emphasis: 0

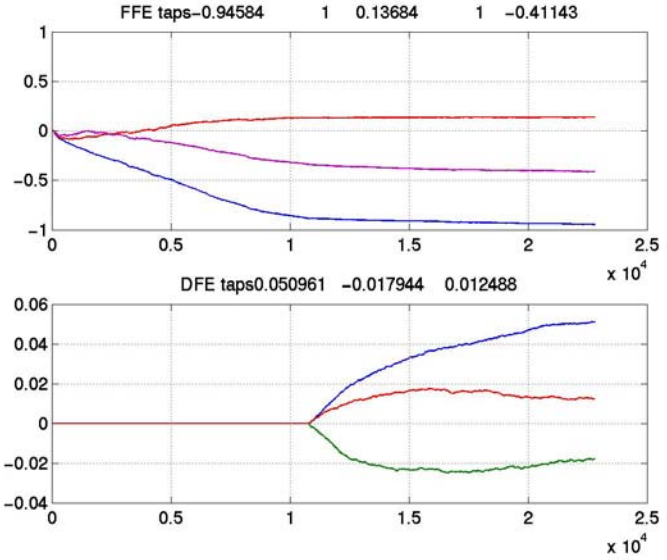
# Simulation Results for Intel ATCA T20

VITESSE



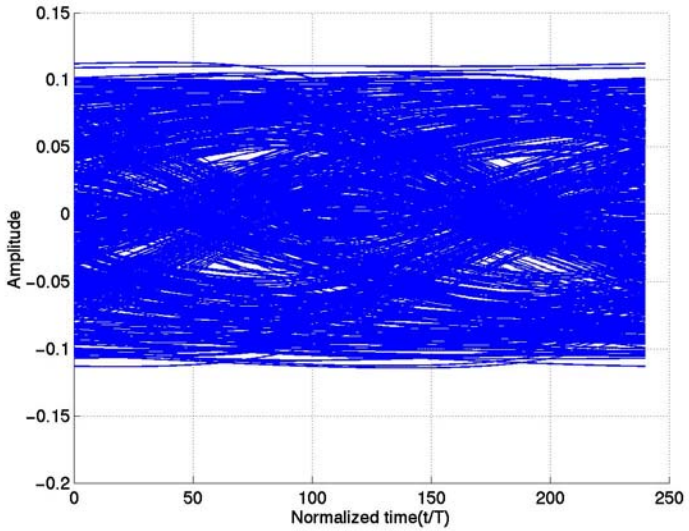



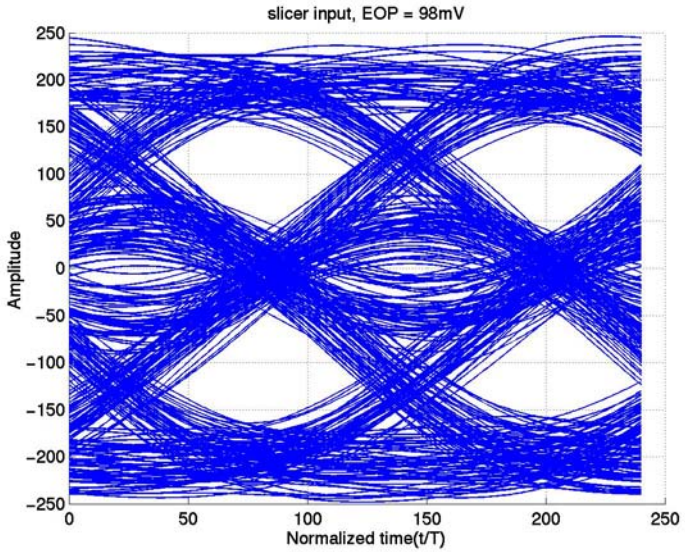

- Length: 2.73”+12”+3.18”
- ) Eye opening:
  - Vertical 111 mv (margin = 5.7 mv)
  - Horizontal: 70 ps (margin = 4.4 ps)
- Pre-emphasis: 0



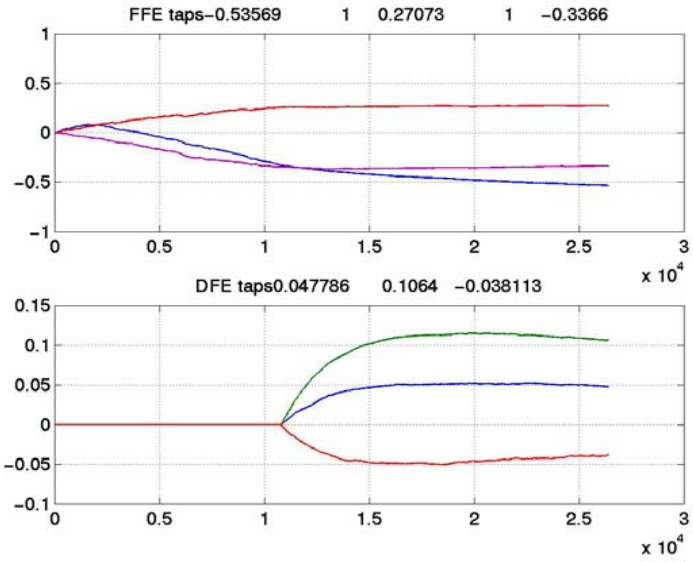
# Simulation Results for Tyco ATCA Case1

VITESSE



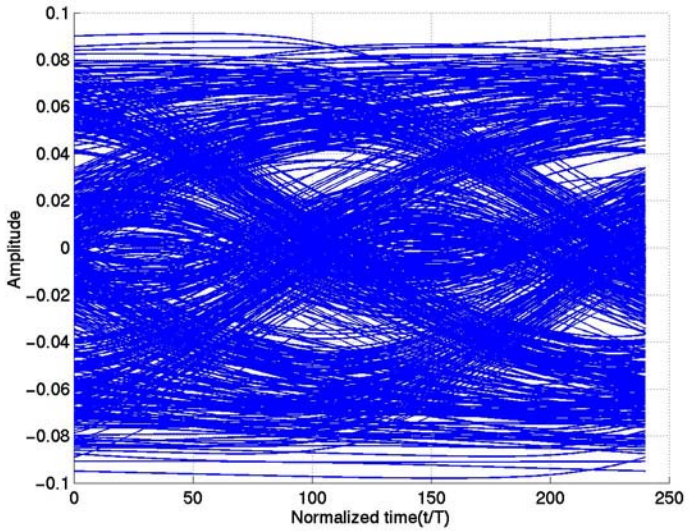



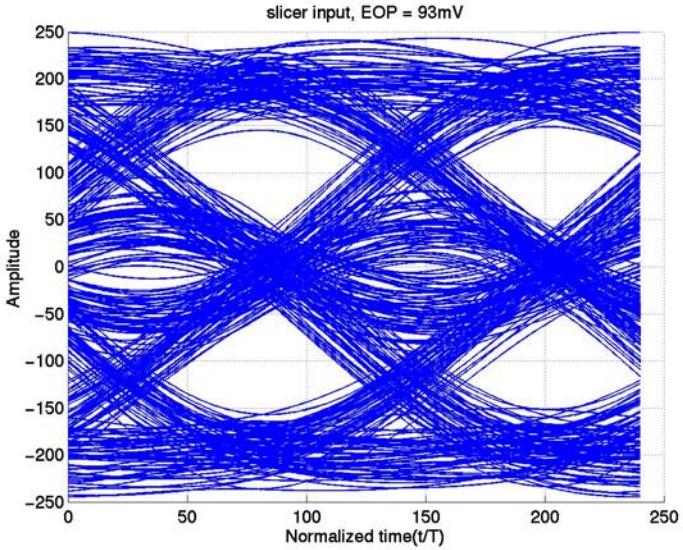

- Length: 10”+20”+10”
- Stub Bottom (or counter boring)
- Eye opening:
  - Vertical: 98  mv (margin = 4.87 mv)
  - Horizontal: 70 ps (margin = 4.4 ps)
- Pre-emphasis: 0.3



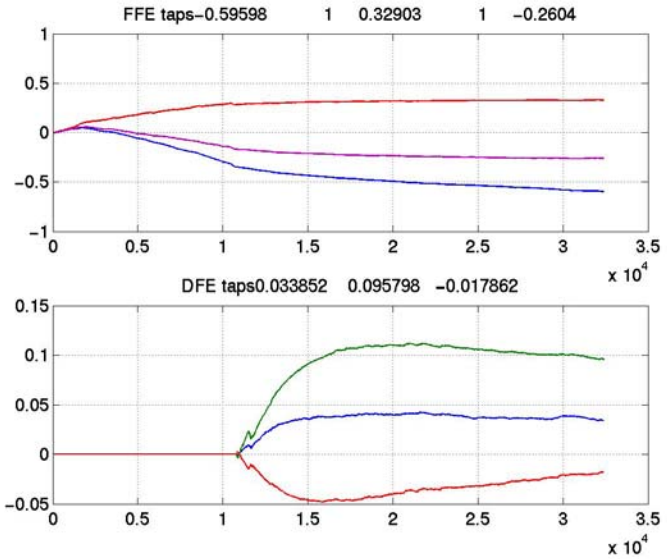
# Simulation Results for Tyco ATCA Case3

VITESSE



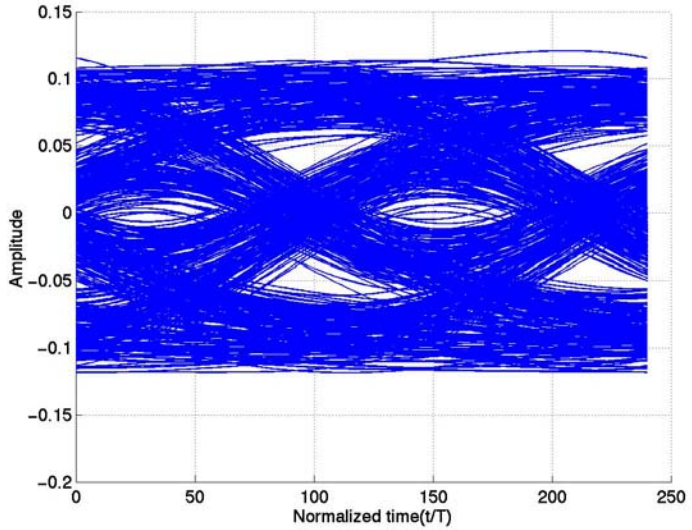



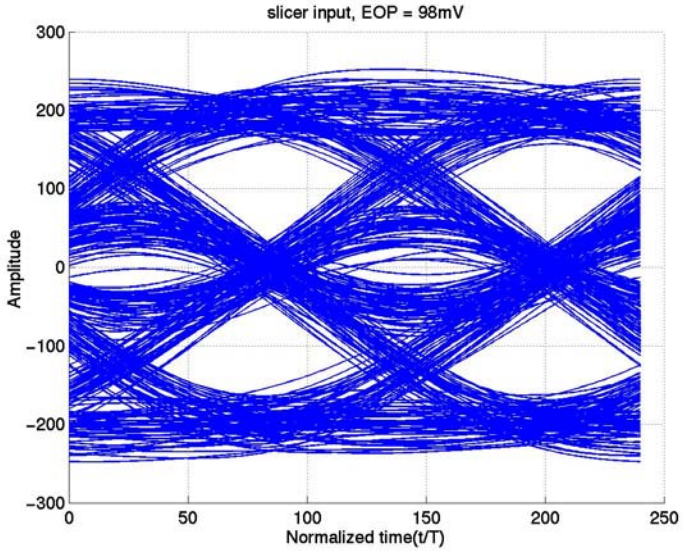

- Length: 10”+20”+10”
- Stub Bottom (or counter boring)
- Eye opening:
  - Vertical : 93 mv (margin = 4.56 mv)
  - Horizontal: 70 ps (4.4 ps)
- Pre-emphasis: 0.4



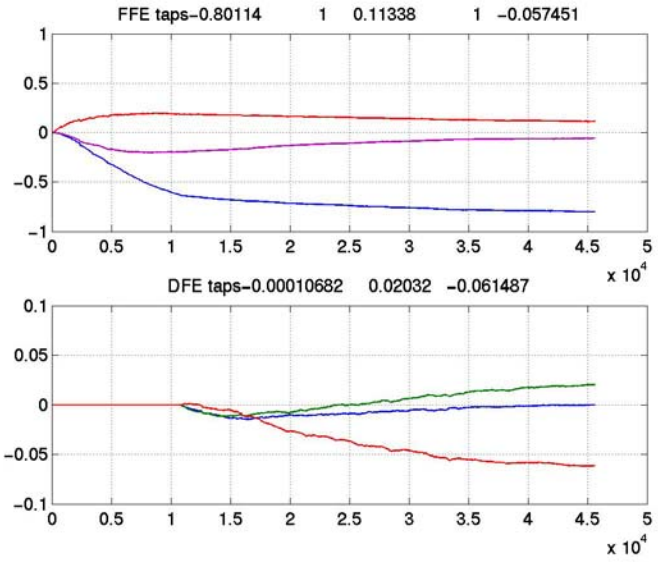
# Simulation Results for Tyco ATCA Case4

VITESSE




- Length: 10”+20”+10”
- Stub Bottom (or counter boring)
- Eye opening:
  - Vertical: 98 mv (margin = 4.87 mv)
  - Horizontal: 70 ps (margin = 4.4 ps)
- Pre-emphasis: 0.3



# Simulation Results for Tyco ATCA case6

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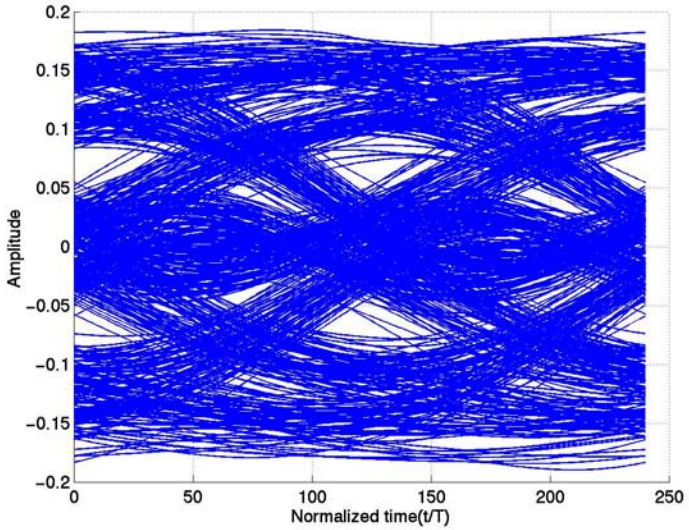
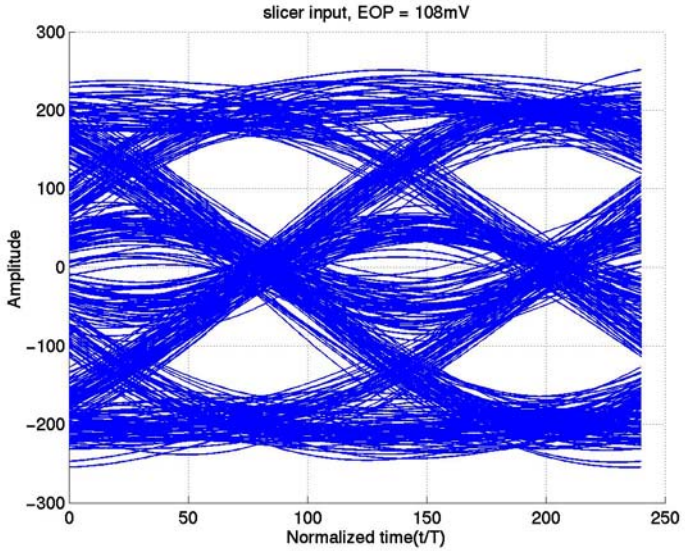
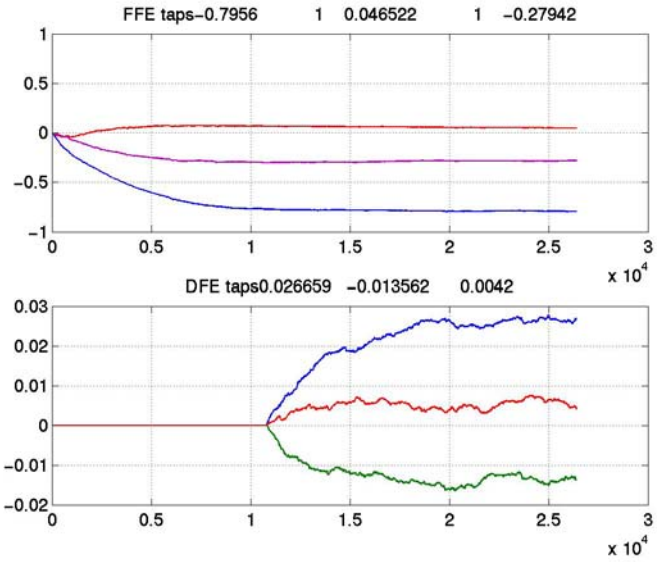


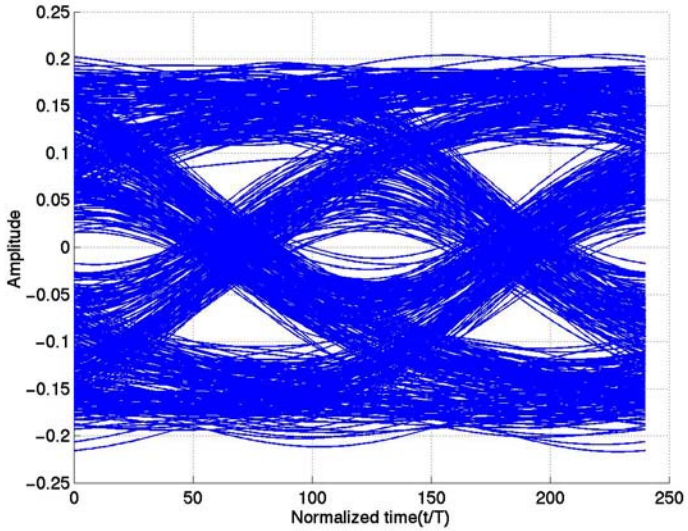



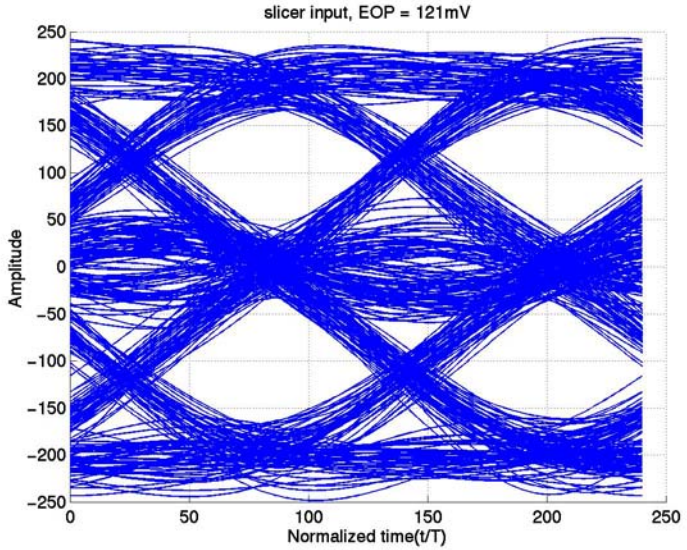

- Length: 6”+10”+6”
- Top Layer (with stub)
- Eye opening:
  - Vertical: 108 mv (margin = 5.5 mv)
  - Horizontal: 70 ps (margin = 4.4 ps)
- Pre-emphasis: 0



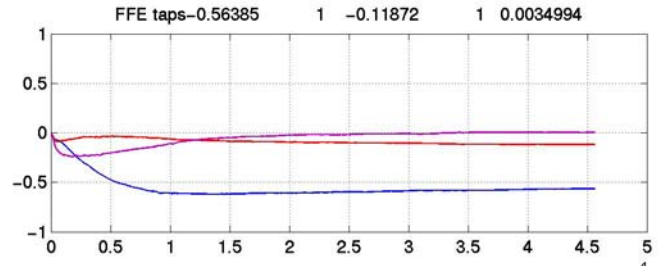
# Simulation Results for Tyco ATCA case7

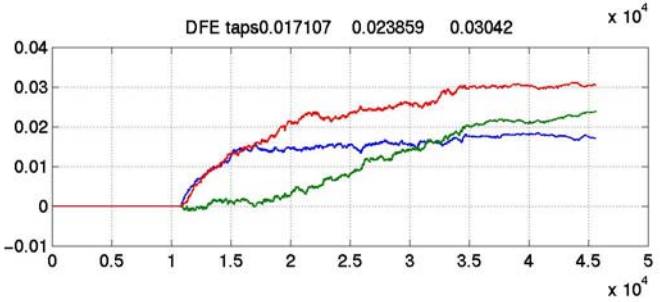
VITESSE




- Length: 6”+1”+6”
- Near Top layer (with stub)
- Eye opening:
  - Vertical: 121 mv (margin = 6.3 mv)
  - Horizontal : 75 (margin = 4.7 ps)
- Pre-emphasis: 0



# Equalizer Requirements and Conclusion

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- ATCA Backplanes provided by Intel and Tyco can be equalized with reasonable complexity, using duobinary modulation to achieve BER of 1e-15.
- A 5-tap feed-forward equalizer cascaded with 3-tap DFE can be used at the receiver to achieve good performance.
- To support long channels (40”), a simple one-tap pre-emphasis at transmitter is required.