Worst Case Impulse Responses for Various EDC Architectures

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Outline

• Channel Model
• Impulse Responses Considered
• Equalizer Architectures
• Simulation Results
• Conclusions
Channel Model

\[ \text{Data} \xrightarrow{\text{Laser Driver}} \text{Laser} \xrightarrow{\text{Fiber}} \text{Photodetector/TIA} \xrightarrow{\text{Received Signal}} \]

\[ \{x_k\} \xrightarrow{p(t)} h_t(t) \xrightarrow{h_f(t)} h_r(t) \xrightarrow{\oplus} y(t) \]

Transmitted Data: Ideal Rectangular NRZ Pulse

2\textsuperscript{nd} Order Critically Damped, 10\%-90\%
RT=72.9 psec

Selected Impulse Response

BT filter, BW = 7.725 GHz

White Gaussian Noise

\[ n(t) \]

ClariPhy Communications, Inc.
Impulse Responses Considered
Fiber Impulse Responses

• Five impulse responses simulated
  – Three impulse responses from the 802.3z National Lab set of measurements
    • “Split Pulse”, “Stair-Step”, “Smooth Pulse”
  – Ideal Gaussian Pulse
  – Ideal Split Pulse
    • Two delta functions with separation set to give correct modal BW
• All impulse responses normalized to give -3dB Optical BW (-6dB Electrical BW) of 1.67 GHz at 300m
  – Corresponds to 500 MHz-km modal BW at 300m
“Split-Pulse” Impulse Response

Impulse Response: LG011105L1p.dat
“Stair-Step” Impulse Response
“Smooth Pulse” Impulse Response
Gaussian Impulse Response
Comparison of Gaussian and “Smooth Pulse”
Equalizer Architectures
Linear Equalizer

- 4-Tap equalizer shown
- Ideal infinite-length equalizer simulated
### Decision Feedback Equalizer

![Diagram of a Decision Feedback Equalizer]

- 4 feed-forward taps, 3 feedback taps shown
- Ideal infinite-length equalizer simulated
Simulation Results
Frequency Responses @ 300m

Frequency (GHz) vs. Frequency Response (dBe) graph showing different pulse shapes:
- **Gaussian**
- **IDEAL**
- **SPLIT PULSE**
- **SMOOTH PULSE**
- **STAIR-STEP**

Data files used:
- 72b10000L3c.dat
- LG011105L1p.dat
- 72900000L3p.dat

L3c, L1p, and L3p are likely code numbers or identifiers for different data sets or versions.
Optical Power Penalties

- Next two slides give optical power penalties with respect to -12.6 dBm LR nominal sensitivity
- MMSE criterion used to compute performance
- Performance for infinite length ideal equalizers
Optical Power Penalty vs Distance, Linear Eq

![Graph showing Optical Power Penalty vs Distance with various pulse shapes and fiber types.](image)
Conclusions
Conclusions

• Worst-case shape of impulse response, for a given modal-bandwidth, depends on distance

• Performance does not necessarily degrade monotonically with distance
  – Consider ideal split pulse and linear equalizer
  – Performs worst when delay is integer number of bit periods

• For distances exceeding ~185m of 500 Mhz-km fiber, Gaussian performed worse than all other impulse responses considered
  – True for linear equalizer and DFE
  – Attributed to sharp rolloff of Gaussian at high frequencies

• Gaussian is candidate model for worst case impulse response for 500 MHz-km fiber at distances of interest (220m-300m)
  – May be conservative