# Analog Pre-emphasis and the Tx Template

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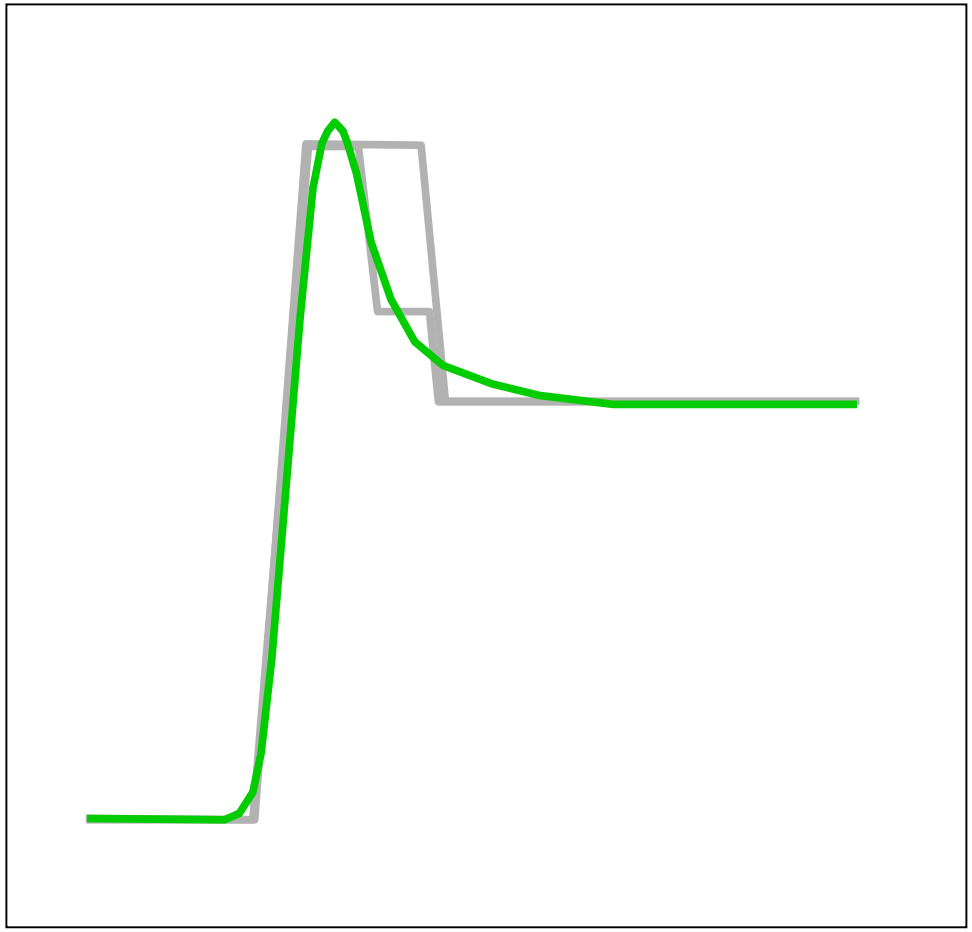
# Analog Pre-Emphasis

Agenda

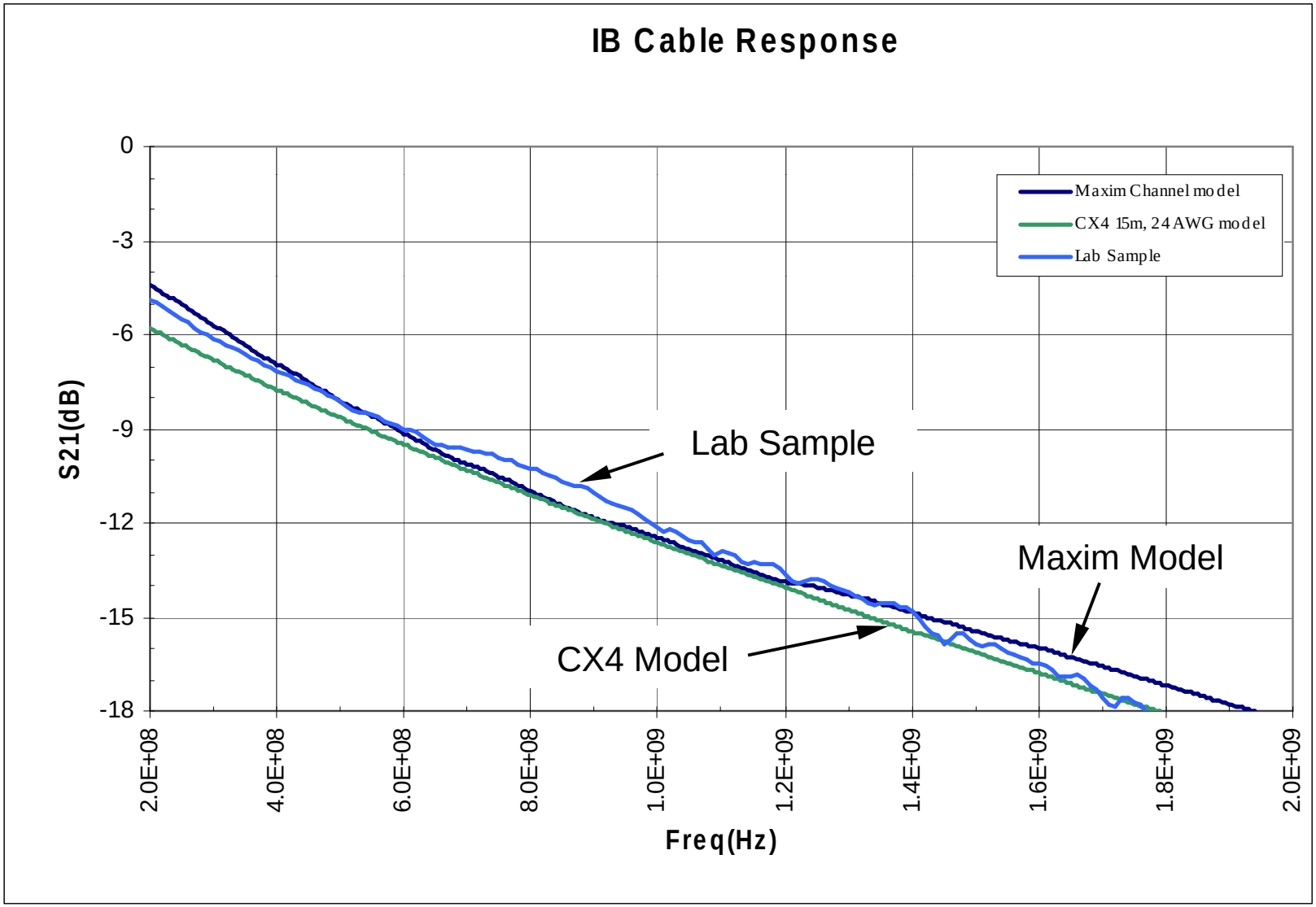
- Types of PE
- Demonstration of Analog filter for PE
- Comparison of Tx output to Tx template
- Recommendation

# Generating Pre-Emphasis

- 1-bit wide FIR
  - easy to implement
  - crude approximation
- Fractional or Sub-bit interval/multi-bit FIR
  - better approximation
  - more complex
- Analog Filter
  - accurate transfer function
  - not an approximation
  - simple

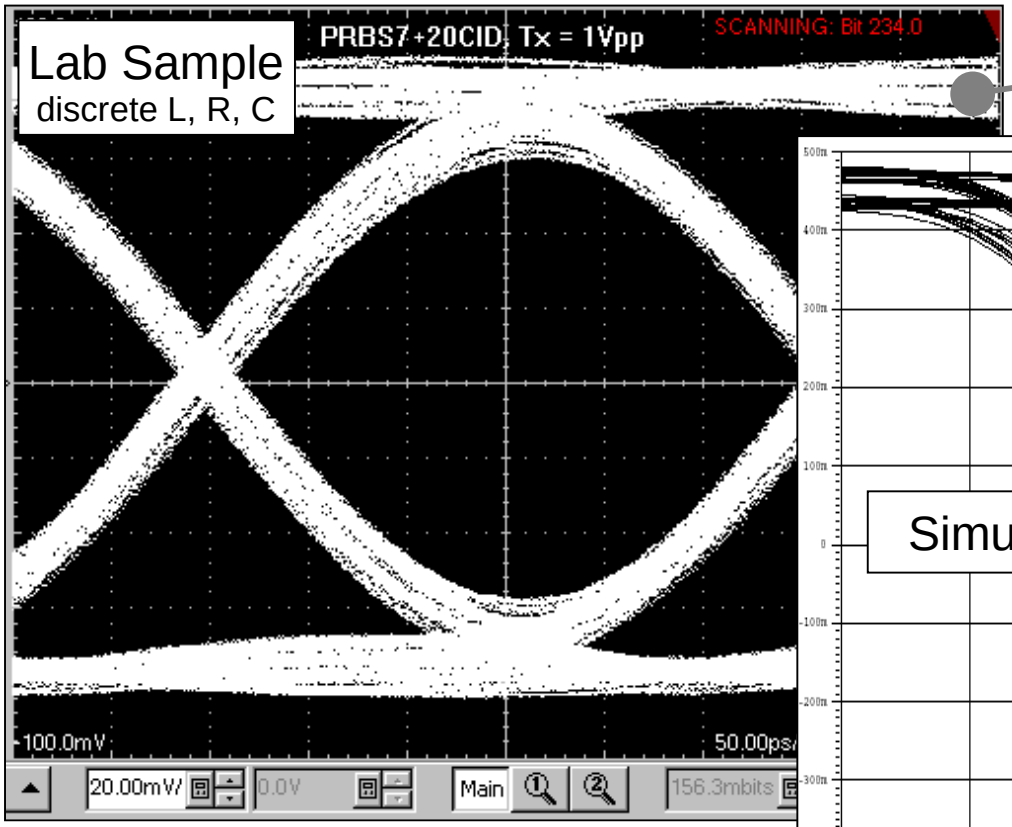


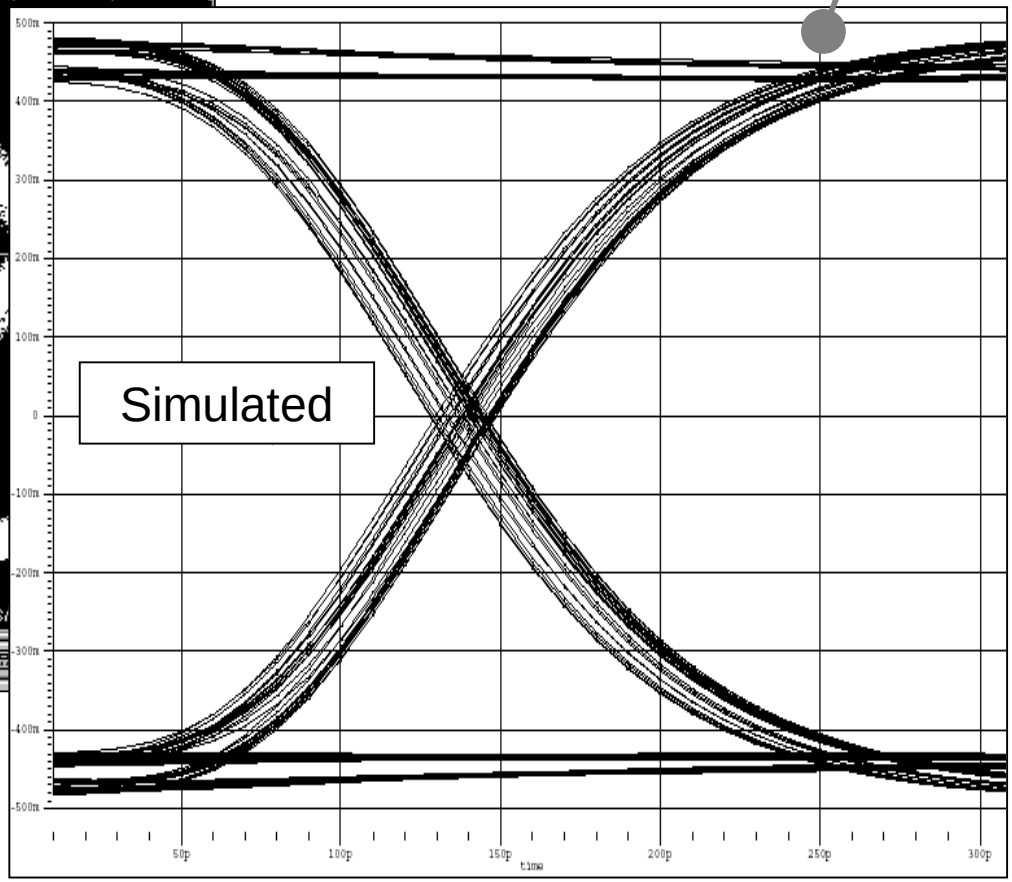
# Modeling the Channel



# End-to-End Compensation

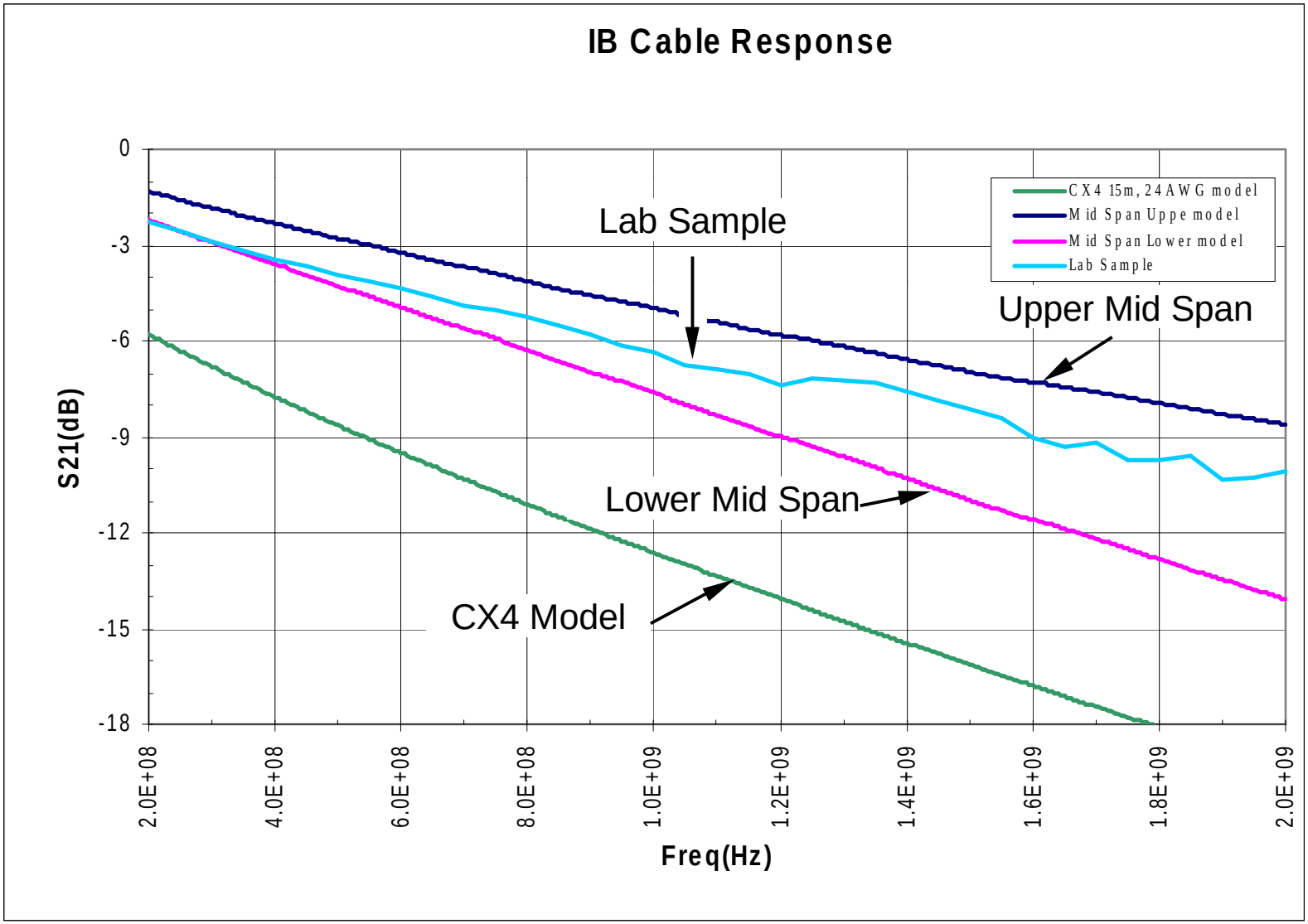
using analog filter



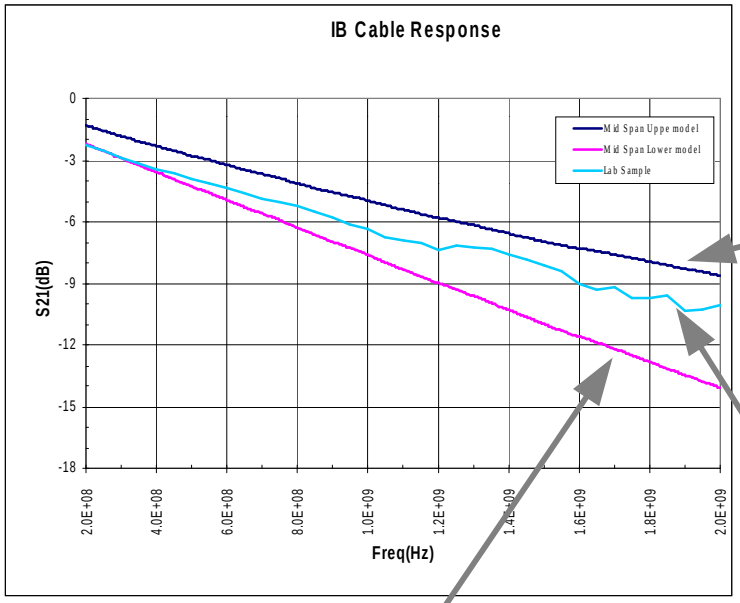

***Fully restored signal without retiming***

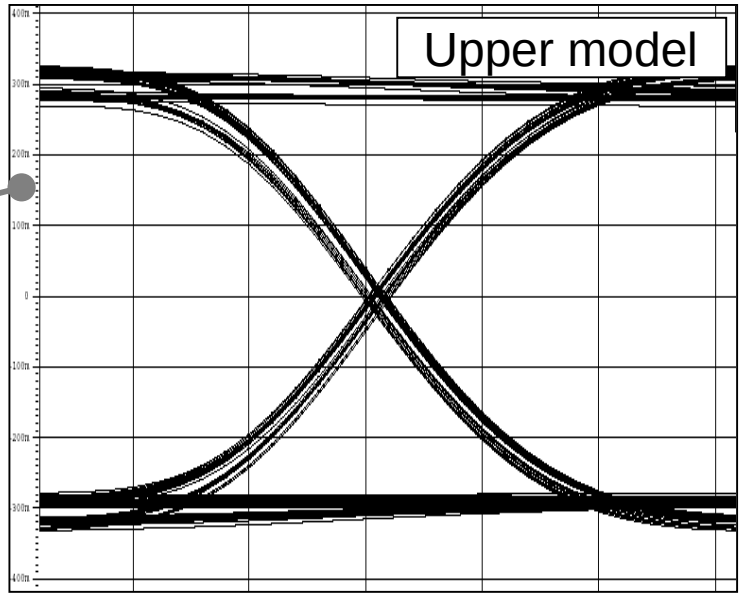
# Mid-Span Compensation

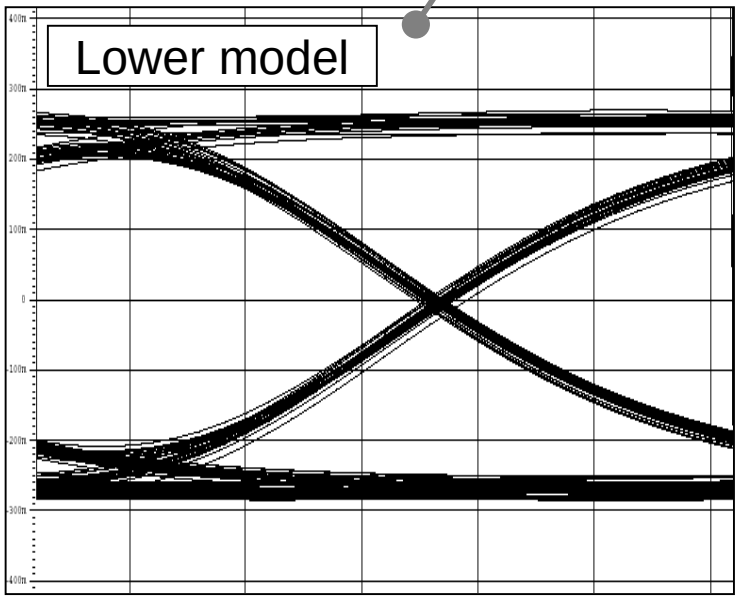


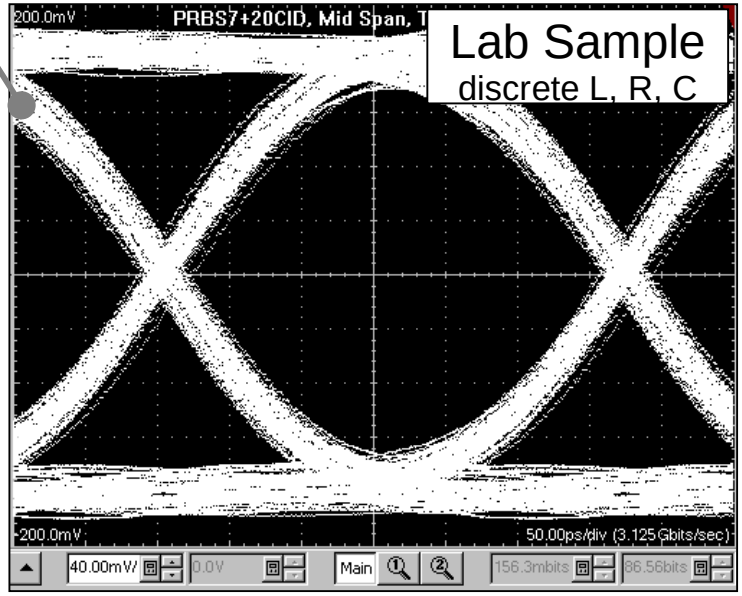
# Mid-Span Compensation

## using analog filter



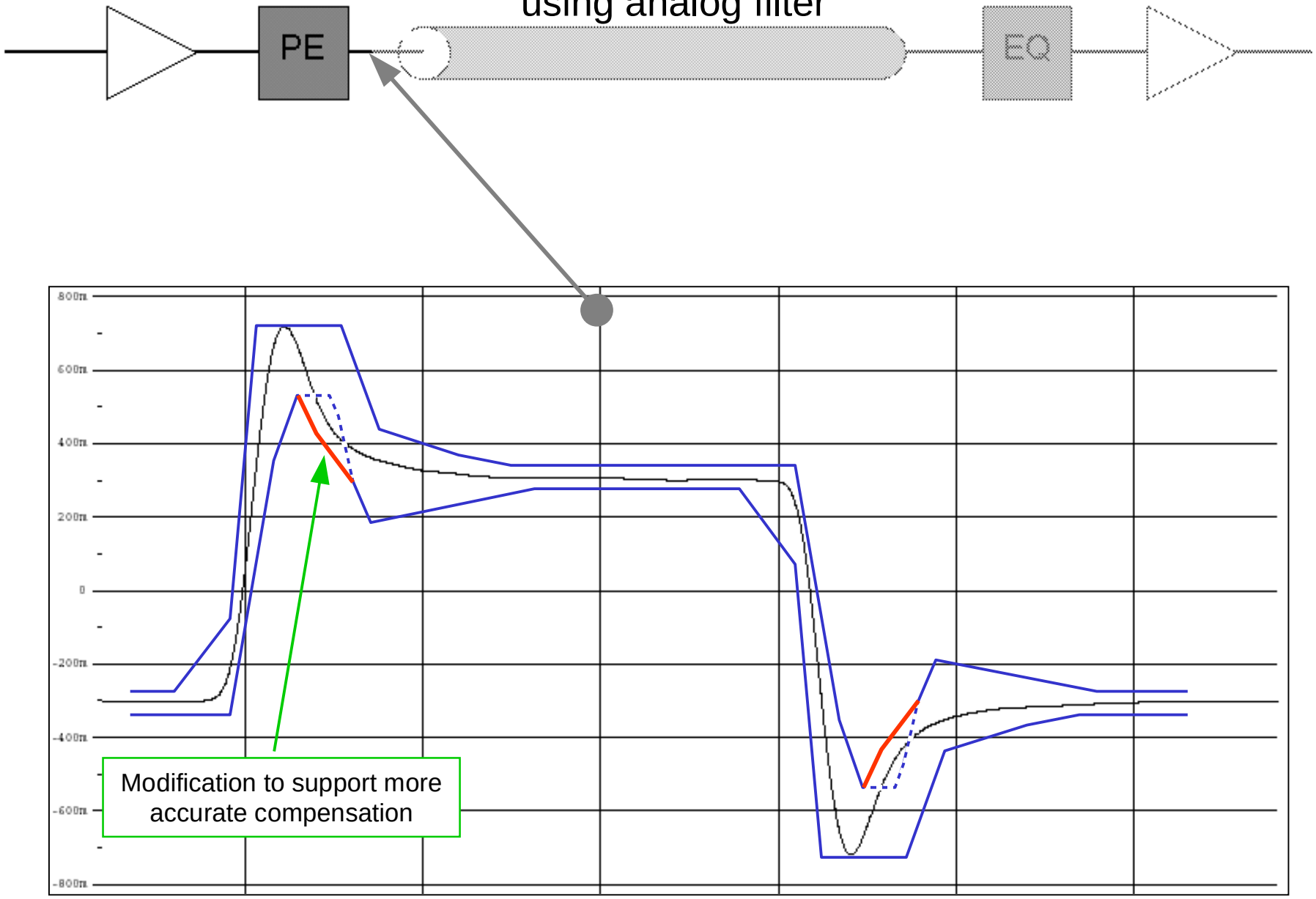



# Transmit Pre-Emphasis

## using analog filter



# Tx Template Concerns

Existing Tx Template is crafted for 1-bit wide pre-emphasis and it is implementation specific.

This excludes more accurate solutions:

Fractional delay/sub-bit timing

Analog filter

# Tx Template Modification

## Existing CX4 Tx Template

| time(ps) | Upper | | time(ps) | Lower |
|---|---|---|---|---|
| 0 | -0.4500 | | 0 | -0.5500 |
| 131 | -0.4500 | | 189 | -0.5500 |
| 283 | -0.1250 | | 287 | -0.5500 |
| 283 | -0.1250 | | 319 | -0.2660 |
| 291 | 0.0000 | | 349 | 0.0000 |
| 343 | 0.8500 | | 414 | 0.5860 |
| 363 | 1.1750 | | 477 | 0.8700 |
| 451 | 1.1750 | | 509 | 0.8700 |
| 602 | 1.1750 | | 565 | 0.8700 |
| 629 | 1.0600 | | 591 | 0.7760 |
| 669 | 0.8880 | | 611 | 0.6350 |
| 709 | 0.7150 | | 631 | 0.4940 |
| 709 | 0.7150 | | 685 | 0.3060 |
| 931 | 0.6000 | | 989 | 0.4000 |
| 1091 | 0.5500 | | 1149 | 0.4500 |
| 1789 | 0.5500 | | 1731 | 0.4500 |
| 1887 | 0.5500 | | 1883 | 0.1250 |
| 1919 | 0.2660 | | 1883 | 0.1250 |
| 1949 | 0.0000 | | 1891 | 0.0000 |
| 2014 | -0.5860 | | 1943 | -0.8500 |
| 2077 | -0.8700 | | 1963 | -1.1750 |
| 2109 | -0.8700 | | 2051 | -1.1750 |
| 2165 | -0.8700 | | 2202 | -1.1750 |
| 2191 | -0.7760 | | 2229 | -1.0600 |
| 2211 | -0.6350 | | 2269 | -0.8880 |
| 2231 | -0.4940 | | 2309 | -0.7150 |
| 2285 | -0.3060 | | 2309 | -0.7150 |
| 2589 | -0.4000 | | 2531 | -0.6000 |
| 2749 | -0.4500 | | 2691 | -0.5500 |
| 3200 | -0.4500 | | 3200 | -0.5500 |
| 3360 | -0.4500 | | 3360 | -0.5500 |

## Proposed Modification

| time(ps) | Upper | | time(ps) | Lower |
|---|---|---|---|---|
| 0 | -0.4500 | | 0 | -0.5500 |
| 131 | -0.4500 | | 189 | -0.5500 |
| 283 | -0.1250 | | 287 | -0.5500 |
| 283 | -0.1250 | | 319 | -0.2660 |
| 291 | 0.0000 | | 349 | 0.0000 |
| 343 | 0.8500 | | 414 | 0.5860 |
| 363 | 1.1750 | | 477 | 0.8700 |
| 451 | 1.1750 | | 503 | 0.7700 |
| 602 | 1.1750 | | 530 | 0.6700 |
| 629 | 1.0600 | | 581 | 0.5820 |
| 669 | 0.8880 | | 606 | 0.5380 |
| 709 | 0.7150 | | 631 | 0.4940 |
| 709 | 0.7150 | | 685 | 0.3060 |
| 931 | 0.6000 | | 989 | 0.4000 |
| 1091 | 0.5500 | | 1149 | 0.4500 |
| 1789 | 0.5500 | | 1731 | 0.4500 |
| 1887 | 0.5500 | | 1883 | 0.1250 |
| 1919 | 0.2660 | | 1883 | 0.1250 |
| 1949 | 0.0000 | | 1891 | 0.0000 |
| 2014 | -0.5860 | | 1943 | -0.8500 |
| 2077 | -0.8700 | | 1963 | -1.1750 |
| 2103 | -0.7700 | | 2051 | -1.1750 |
| 2130 | -0.6700 | | 2202 | -1.1750 |
| 2181 | -0.5820 | | 2229 | -1.0600 |
| 2206 | -0.5380 | | 2269 | -0.8880 |
| 2231 | -0.4940 | | 2309 | -0.7150 |
| 2285 | -0.3060 | | 2309 | -0.7150 |
| 2589 | -0.4000 | | 2531 | -0.6000 |
| 2749 | -0.4500 | | 2691 | -0.5500 |
| 3200 | -0.4500 | | 3200 | -0.5500 |
| 3360 | -0.4500 | | 3360 | -0.5500 |

## Conclusion:

An analog filter, or a good approximation, will deliver excellent compensation without retiming.

## Recommendation:

Modify the Tx Template to accommodate analog filters and sub-bit interval/multi-bit FIR.

- Use analog filter as the target transient response for sub-bit interval/multi-bit FIR
- 1-bit FIR will still fit the template