Transmitter requirements for 40/100GBASE-CR4/10

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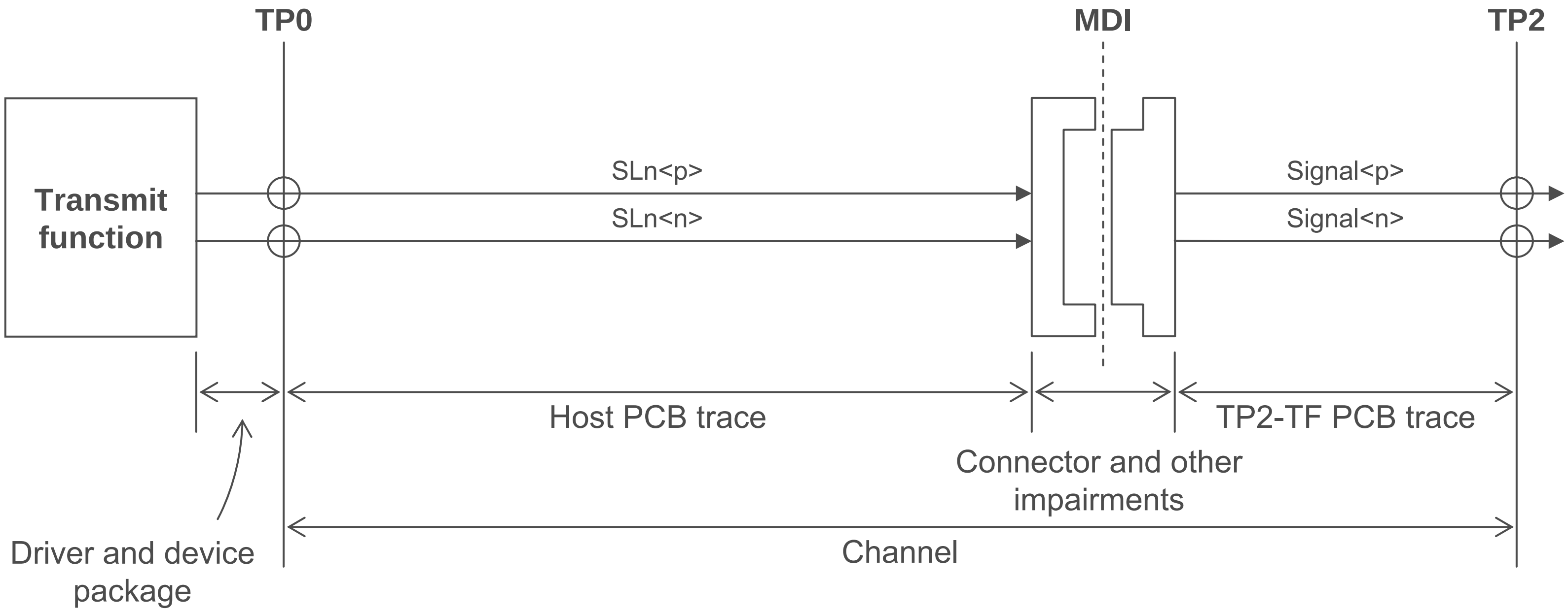
Stage setting

- 10GBASE-KR requirements for the transmit equalizer are based on the pre-shoot and overshoot measured on a square wave test pattern
- 10GBASE-KR transmit equalizer requirements are verified at TP1, which is “very close” to the device package
- 40GBASE-CR4 and 100GBASE-CR10 also seek to take advantage of adaptive transmitter techniques
- However, these proposed specifications define the compliance point (TP2) to be a separable connector, accessed via a test fixture, that is “far away” from the device package

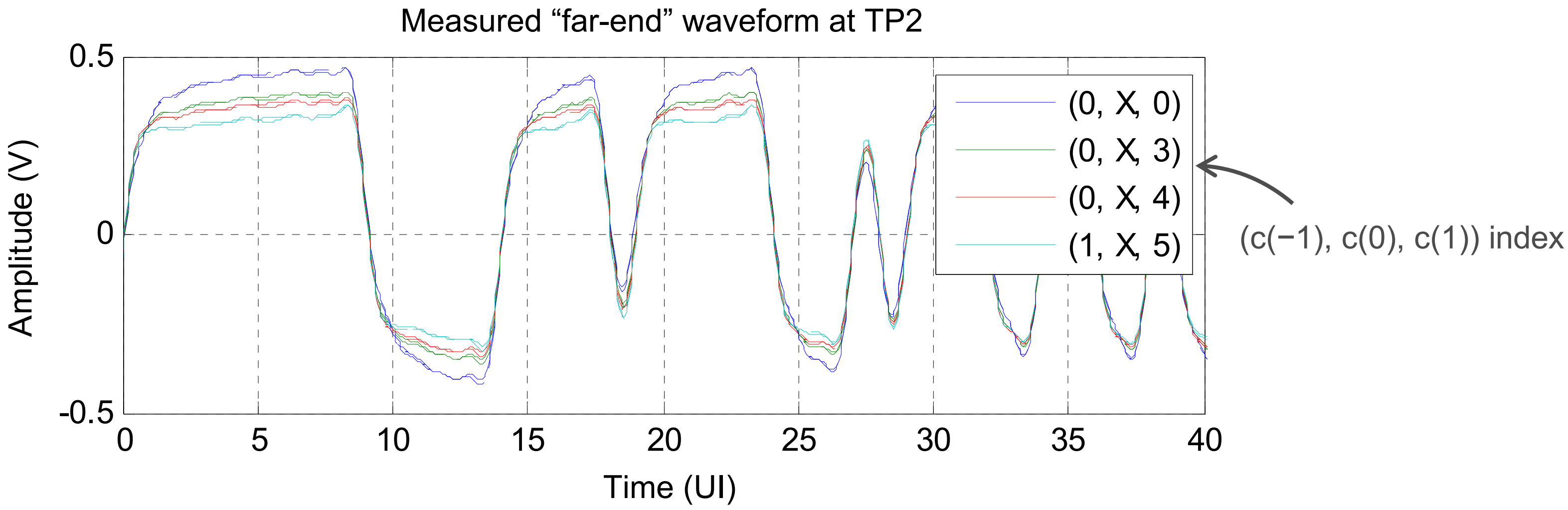
Loss budget from TP0 to TP2



NOTE – TP0 corresponds to 10GBASE-KR and 40GBASE-KR4 TP1

Channel component	Insertion loss at 5.15625 GHz, dB
Host printed circuit board (PCB) trace	2.37 – 3.50
Connector and other impairments	0.54 – 1.50
TP2 test fixture (TP2-TF) PCB trace	1.26
Total	**4.17 – 6.26**

Problem statement



- The transfer function of the channel between TP0 and TP2 distorts the signal making requirements based on pre-shoot and overshoot difficult to verify

- It is difficult to differentiate distortion that could be equalized (acceptable) from distortion that cannot (must be bounded) based on direct observation of the waveform

ILTP2 – Comments #135, #136, #140 (1 of 2)

- A method to derive the transfer function between the transmit function (behind TP0) and TP2 was adopted for inclusion in Draft 2.1

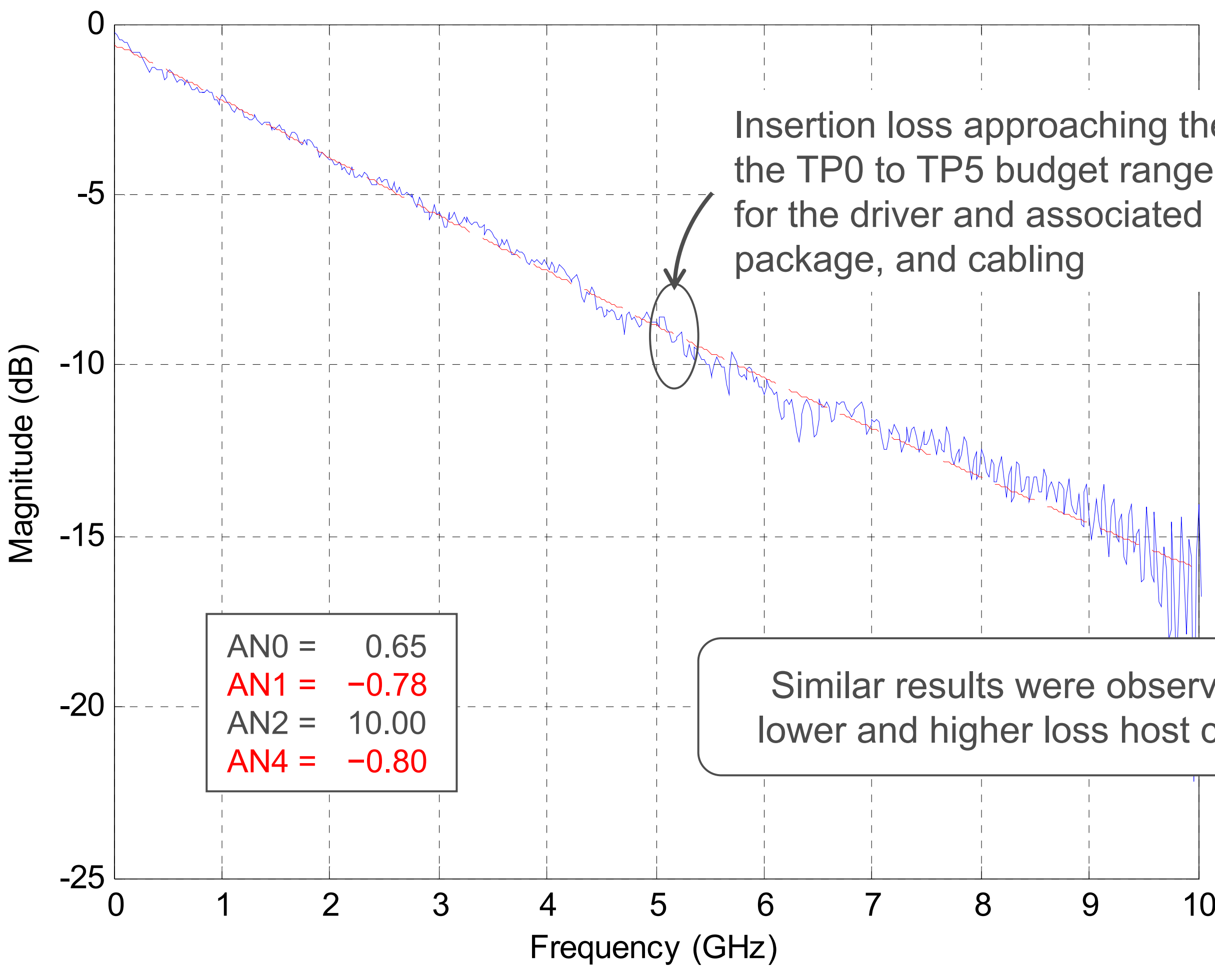
- This transfer function is bounded in terms of a linear least mean squares fit of the extracted transfer function to a polynomial model
  – The coefficients of the best fit polynomial are bounded
  – However, the deviation of the fit from the extracted transfer function is not bounded

- Attempts to execute this fit on a compliant 10GBASE-KR transmitter has yielded unexpected behavior
  – Negative polynomial coefficients which are not allowed per Draft 2.1
  – This may be due to the fact that the f^2 term in the polynomial, which is intended to represent the rise time of the driver, may not be an appropriate model for all implementations
  – Perhaps, in an effort to minimize the mean squared error, the fit yields “non-physical” coefficients

ILTP2 – Comments #135, #136, #140 (2 of 2)

- The transfer function is used as the basis for an equalizing filter that is employed to "de-embed" impact of the transfer function from the measurement of specific characteristics
  - Equalization voltages and ratios for example
  - Very little guidance on how to compute this equalizing filter is provided making the standard difficult to use and possibly leading to inconsistency in measurement
  - Distortion that cannot be equalized is not explicitly bounded; it simply interferes with other measurements, possibly causing them to fail

Poorly behaved fit – Example



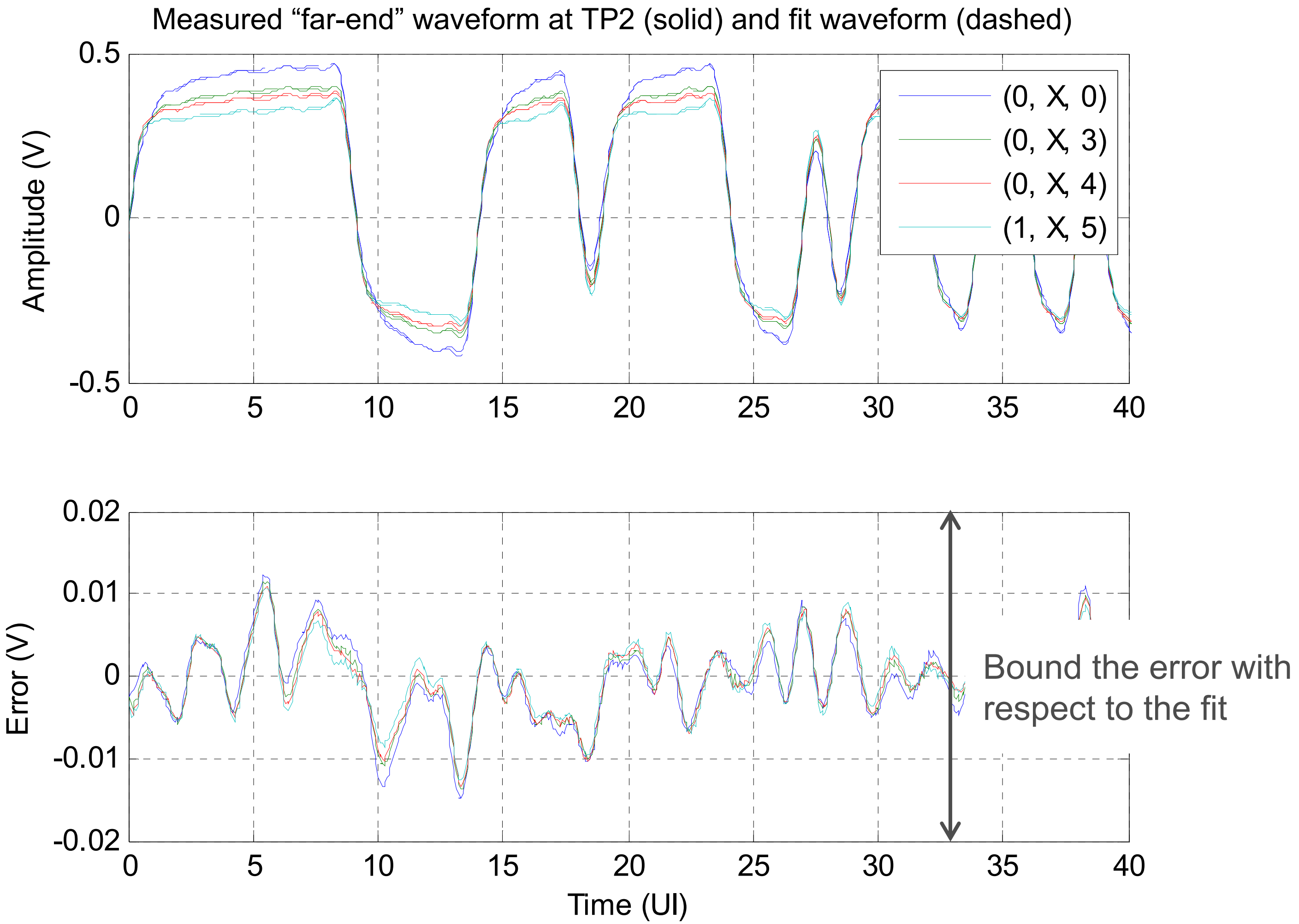
Insertion loss approaching the upper end of the TP0 to TP5 budget range with allowances for the driver and associated loading, device package, and cabling

Similar results were observed with lower and higher loss host channels

Proposed test procedure

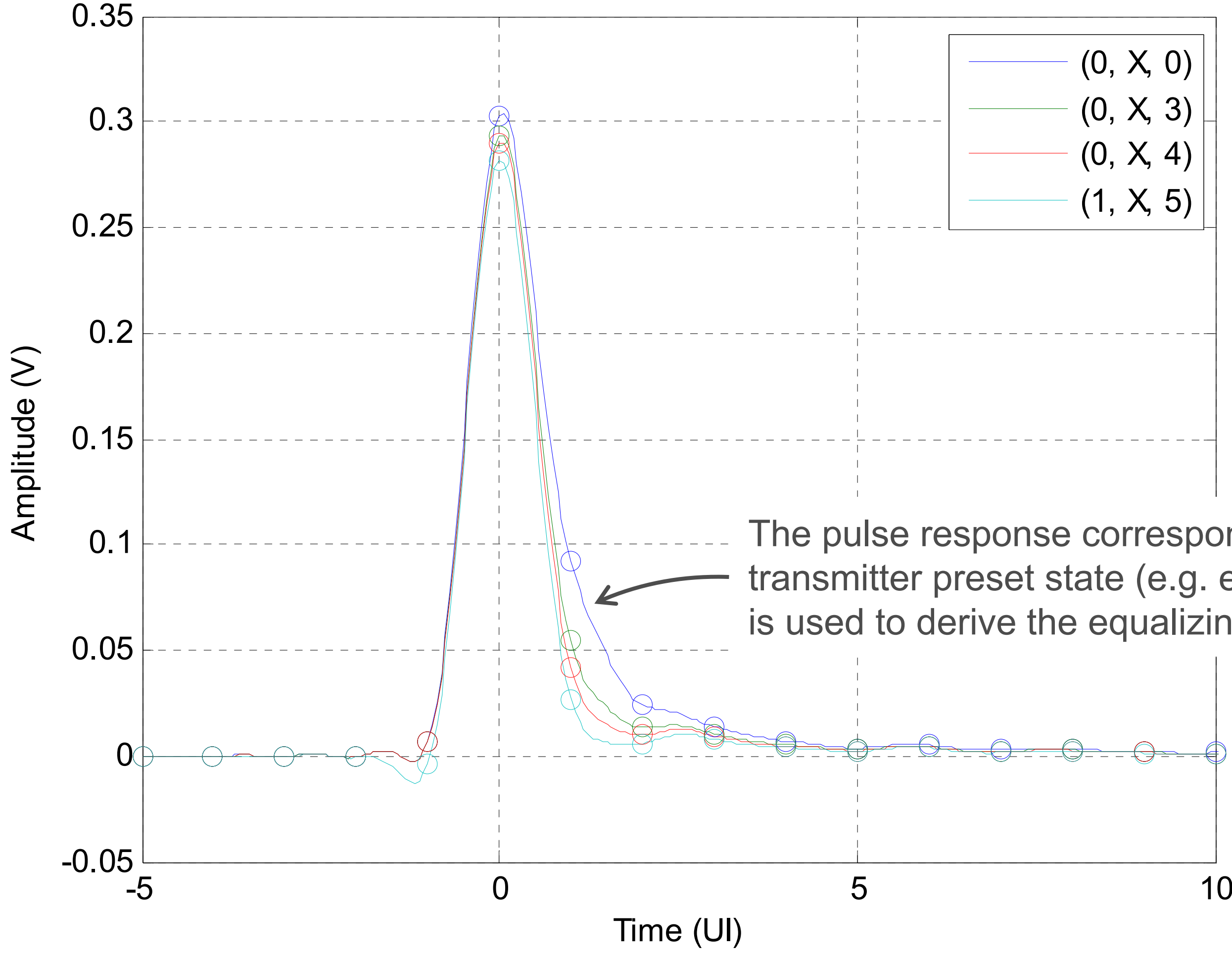
- Refer to companion document (healey_04_0709.pdf)…

Linear fit – Example



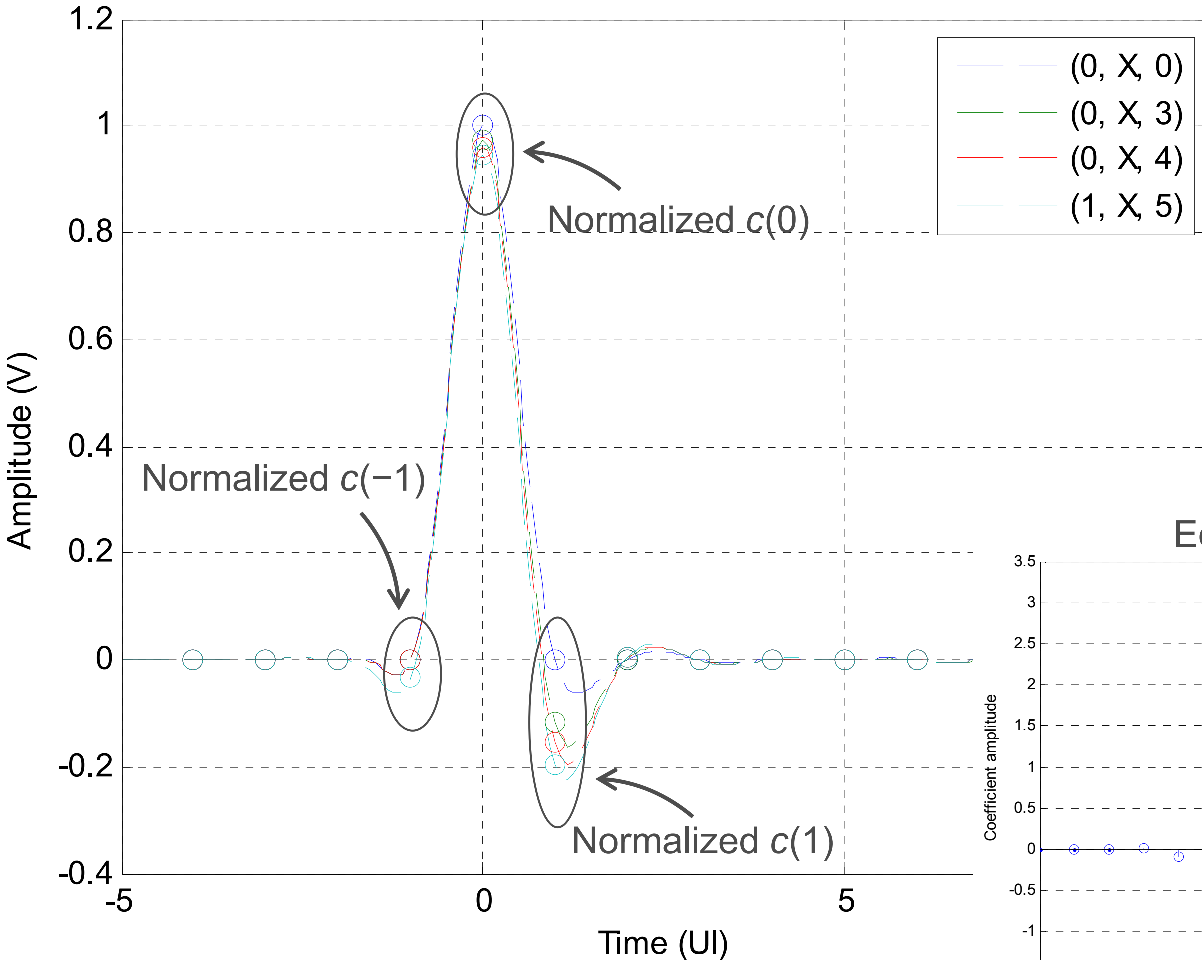
NOTE – Linear fit parameters were N_p = 46, D_p = 5.

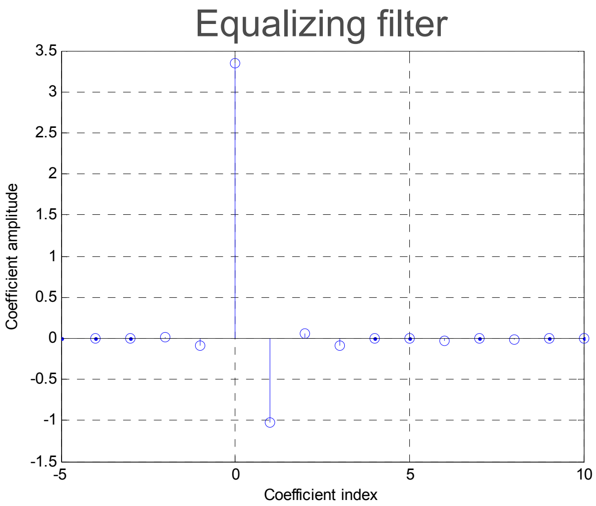
Linear fit pulse responses – Example



The pulse response corresponding to the transmitter preset state (e.g. equalizer off) is used to derive the equalizing filter

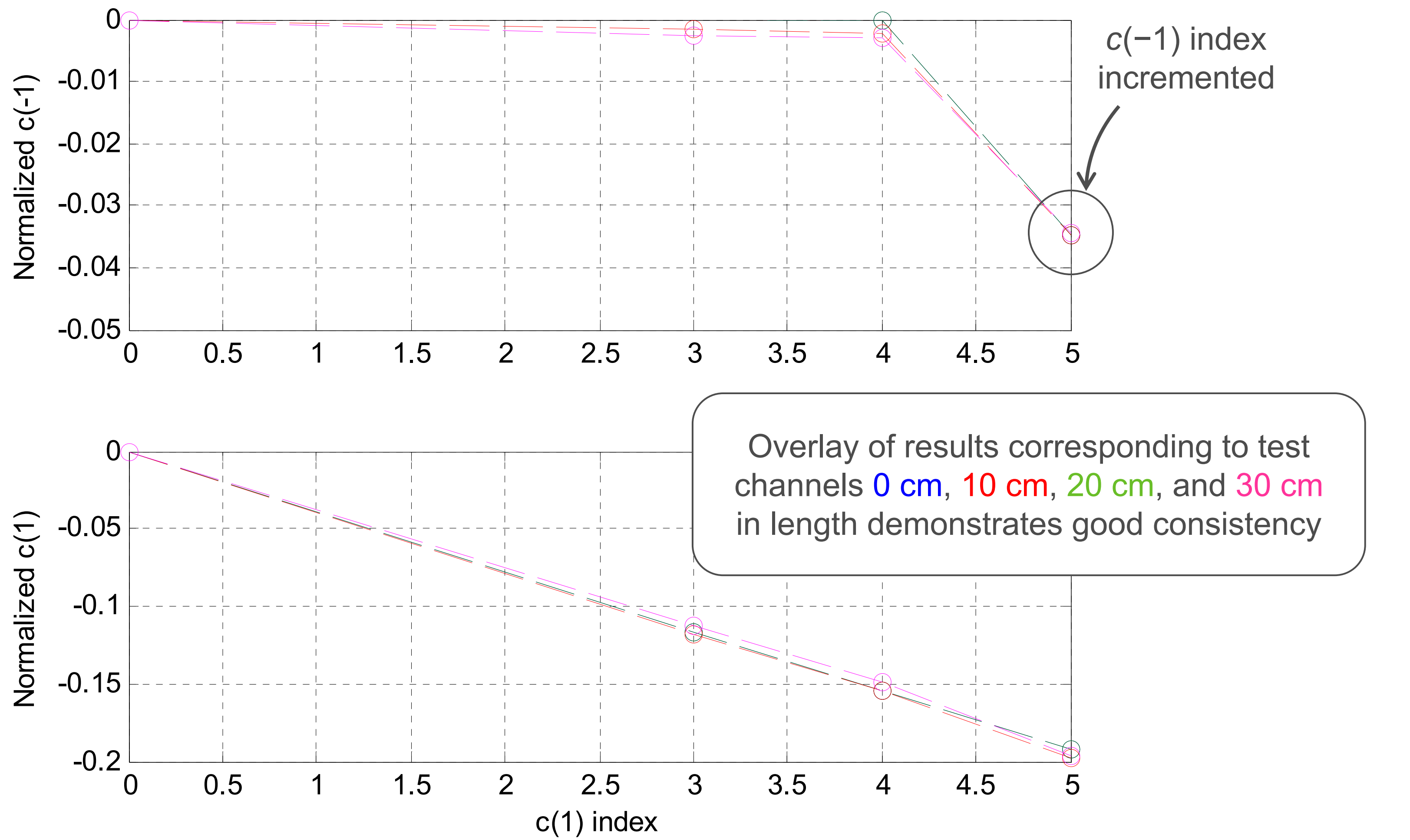
Equalized pulse responses – Example





NOTE – Equalizer parameters were N_w = 46, D_w = 5.

Consistency check



Observations

- The proposed methodology identifies non-linear distortion and noise in the transmitter output
- The proposed methodology identifies linear distortion via the linear fit pulse response
- The proposed methodology identifies the coefficients of the transmit equalizer consistently across a broad range of intervening host channels
- These waveform properties may be bounded separately and used as a diagnostic to pinpoint the cause of failure

Summary

- A complete definition of an equalizing transmitter whose output is observed at some "far-end" compliance point includes…
- A bound on the linear fit pulse response to constrain the inter-symbol interference contributed by the channel to that point
- A bound on the difference between the linear fit waveform and the measured waveform to constrain sources of un-cancellable distortion or noise
- A bound on the normalized coefficients of the equalizer