IEEE802.3ca Tx and Rx Spec Proposal

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Tx Spec Host

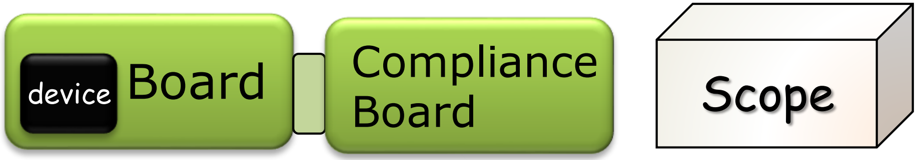
- Transmitted signal to noise distortion ratio (SNDR) and waveform parameters are from a fitted pulse from derived from a PRBS9 test pattern
- Jitter is determined from PRBS9 pattern

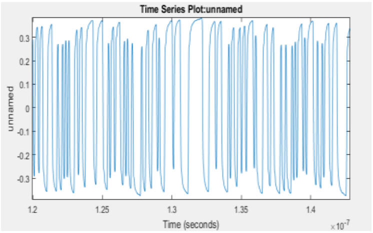
Table 92–6—Transmitter characteristics at TP2 summary

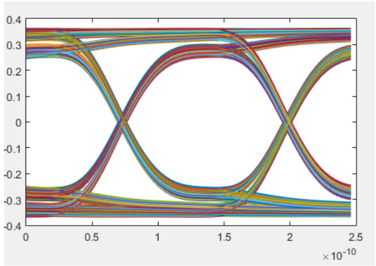
Parameter	Subclause reference	Value	Units
Differential peak-to-peak output voltage (max.) with Tx disabled	92.8.3.1		mV
DC common-mode voltage (max.)	92.8.3.1		V
AC common-mode output voltage, v_{cmi} (max., RMS)	92.8.3.1		mV
Differential peak-to-peak voltage, v_{di} (max.)	92.8.3.1		mV
Differential output return loss (min.)	92.8.3.2		dB
Common-mode to differential mode output return loss (min.)	92.8.3.3		dB
Common-mode to common-mode output return loss (min.)	92.8.3.4		dB
Transmitter steady-state voltage, v_f (min.) Transmitter steady-state voltage, v_f (max.)	92.8.3.5.		V
Linear fit pulse peak (min.)	92.8.3.5.	× v_f	V
Transmitted waveform abs coefficient step size (min.) abs coefficient step size (max.) minimum precursor full-scale ratio minimum post cursor full-scale ratio	 92.8.3.5. 92.8.3.5. 92.8.3.5. 92.8.3.5.		
Signal-to-noise-and-distortion ratio (min.)	92.8.3.7		dB
Output jitter (max.) Even-odd jitter, peak-to-peak Effective bounded uncorrelated jitter, peak-to-peak Effective total uncorrelated jitter, peak-to-peak	 92.8.3.8 92.8.3.8. 92.8.3.8.		 UI UI UI
Signaling rate, per lane	92.8.3.9		GBd
Unit interval nominal	92.8.3.9		ps

Transmitter Waveform

Questions often asked



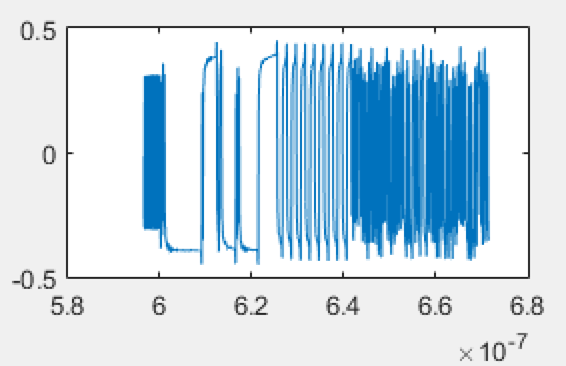




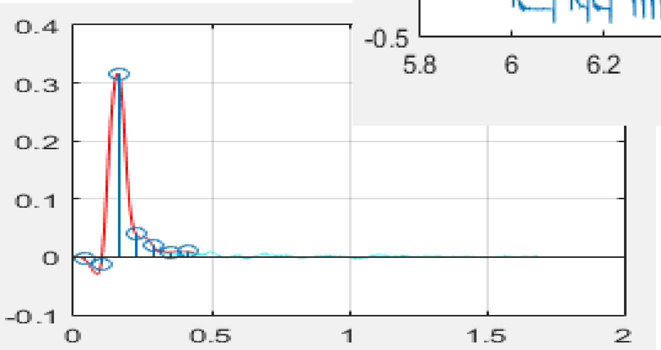
- What does the eye diagram or waveform mean to
  - The board
  - The device
- How much of the board ISI is compensated in the Device
- What is the affect of non linear devices
- How much noise is introduced outside of the lane under test?
- Its hard to tell

Common language

- Pulse response
  - AKA single bit response (SBR)
- Intuitive perspective
- Can we take a measurement something like this



- And get this?
  - Ref Circa 2010 in IEEE specifications



Baseline Understanding of Superposition: Start with the Response to Single Bit

- A measured response may be generated for and arbitrary bit pattern
  - Using a shifted version of that pulse
  - And adjusting for whether the bit corresponding to the shift is a zero or 1
- Its just superposition

Spread Sheet Example: Superposition Review

(M = 1 sample per UI)

Single bit response samples							
1	2	3	5	6	7	8	9
0	-0.1	0.75	-0.05	-0.1			
	0	-0.1	0.75	-0.05	-0.1		
		0	-0.1	0.75	-0.05	-0.1	
			0	-0.1	0.75	-0.05	-0.1

Bit stream
1
-1
1
1

Interim bit response samples							
1	2	3	5	6	7	8	9
0	-0.1	0.75	-0.05	-0.1	0	0	0
0	0	0.1	-0.75	0.05	0.1	0	0
0	0	0	-0.1	0.75	-0.05	-0.1	0
0	0	0	0	-0.1	0.75	-0.05	-0.1
0	-0.1	0.85	-0.9	0.6	0.8	-0.15	-0.1

Σ

P
```
[ 0, p1, p2, p3, p4, p5,  0,  0,  0]
[ 0,  0, p1, p2, p3, p4, p5,  0,  0]
[ 0,  0,  0, p1, p2, p3, p4, p5,  0]
[ 0,  0,  0,  0, p1, p2, p3, p4, p5]
```

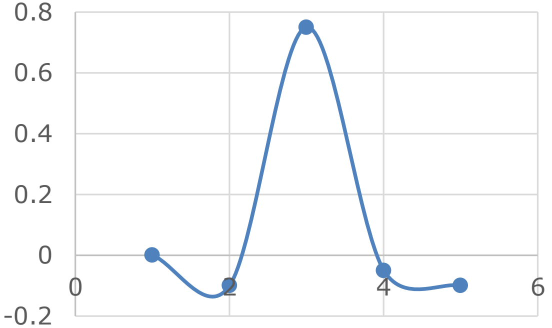
X
```
x1
x2
x3
x4
```

$$y = [P^T * X]^T$$

```
[ 0, p1*x1, p1*x2 + p2*x1, p1*x3 + p2*x2 + p3*x1, p1*x4 + p2*x3 + p3*x2 + p4*x1, p2*x4 + p3*x3 + p4*x2 +
p5*x1, p3*x4 + p4*x3 + p5*x2, p4*x4 + p5*x3, p5*x4]
```

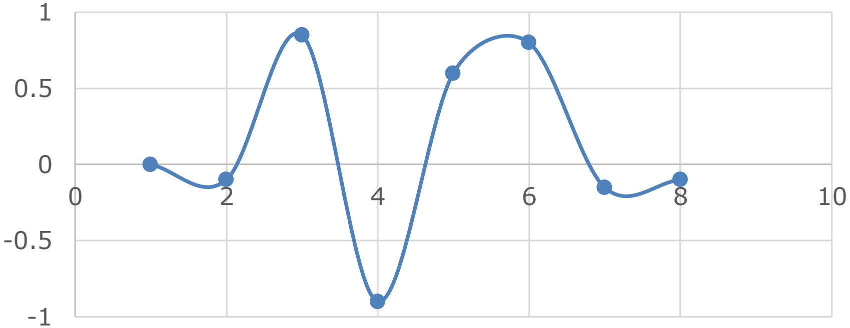
Single Bit Response

[0, p1, p2, p3, p4, p5, 0, 0, 0]



'p' is pulse response
'x' are the bits
'y' is the measured response

Bit stream response



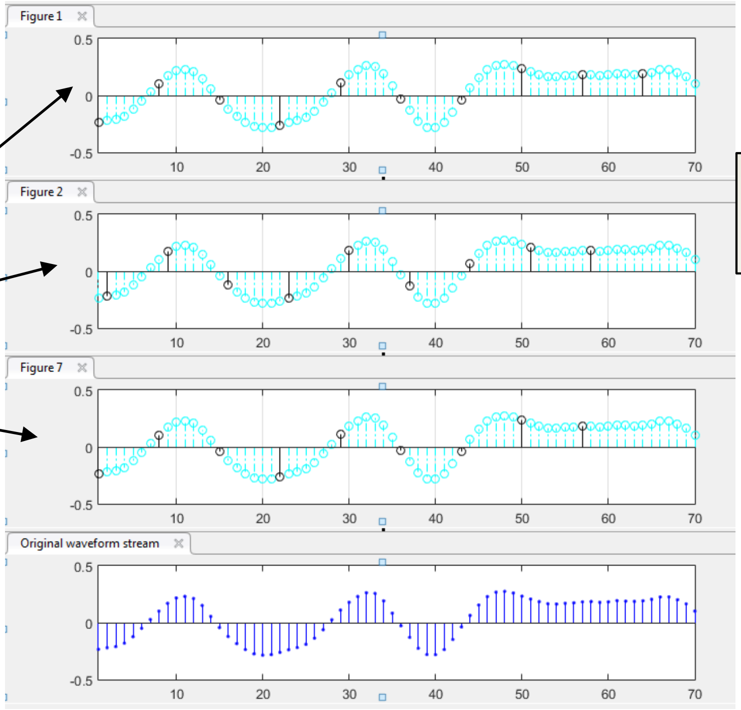
M samples per UI

- Perform for each sample $y = [P^T X]^T$
- That suggest we can have M equations for linear fitting
- y is what we measure.
  - It has M samples per UI
  - Y is the collection of y's for each sample
- We can solve for P
  - $P = YX^T(XX^T)^{-1}$
  - The first row of P is single bit response

Clause 85 example: Create matrix Y for each sample

Eq. 85-4

$$Y = \begin{bmatrix} y(1) & y(M+1) & \dots & y(M(N-1)+1) \\ y(2) & y(M+2) & \dots & y(M(N-1)+2) \\ \dots & \dots & \dots & \dots \\ y(M) & y(2M) & \dots & y(MN) \end{bmatrix}$$



One for each sample in the UI

Clause 85 example: for bit vector, x for Dp=2 and Np=5

Eq 85-5: Shifted bits bit d_p

$$x_r = \left[x(D_p+1)\ \ x(D_p+2)\dots\ x(N)\ x(1)\ \dots\ x(N-D_p)\right]$$

Eq 85-6: Matrix of circular shifted bits

$$X = \begin{bmatrix} x_r(1) & x_r(2) & \dots & x_r(N) \\ x_r(N) & x_r(1) & \dots & x_r(N-1) \\ \dots & \dots & \dots & \dots \\ x_r(2) & x_r(3) & \dots & x_r(1) \end{bmatrix}$$

Dp

x	1	-1	-1	1	-1	1	1	1	1	-1

dp=2

xr	-1	1	-1	1	1	1	1	-1	1	-1

X	-1	1	-1	1	1	1	1	-1	1	-1
	-1	-1	1	-1	1	1	1	1	-1	1
	1	-1	-1	1	-1	1	1	1	1	-1
	-1	1	-1	-1	1	-1	1	1	1	1
	1	-1	1	-1	-1	1	-1	1	1	1
	1	1	-1	1	-1	-1	1	-1	1	1
	1	1	1	-1	1	-1	-1	1	-1	1
	1	1	1	1	-1	1	-1	-1	1	-1
	-1	1	1	1	1	-1	1	-1	-1	1
	1	-1	1	1	1	1	-1	1	-1	-1

N

N

For IEEE802.3ca Recommendation: Dp=2, Np=40, fit is Np+Dp+1 bits

X

-1	1	-1	1	1	1	1	-1	1	-1
-1	-1	1	-1	1	1	1	1	-1	1
1	-1	-1	1	-1	1	1	1	1	-1
-1	1	-1	-1	1	-1	1	1	1	1
1	-1	1	-1	-1	1	-1	1	1	1
1	1	-1	1	-1	-1	1	-1	1	1
1	1	1	-1	1	-1	-1	1	-1	1
1	1	1	1	-1	1	-1	-1	1	-1
-1	1	1	1	1	-1	1	-1	-1	1
1	-1	1	1	1	1	-1	1	-1	-1

Np

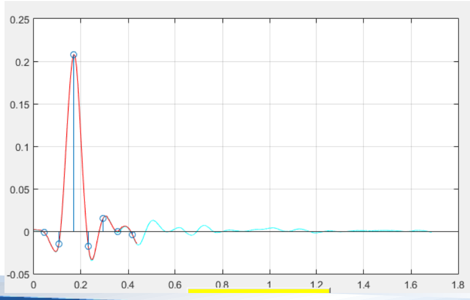
X1

-1	1	-1	1	1	1	1	-1	1	-1
-1	-1	1	-1	1	1	1	1	-1	1
1	-1	-1	1	-1	1	1	1	1	-1
-1	1	-1	-1	1	-1	1	1	1	1
1	-1	1	-1	-1	1	-1	1	1	1
1	1	-1	1	-1	-1	1	-1	1	1
1	1	1	1	1	1	1	1	1	1

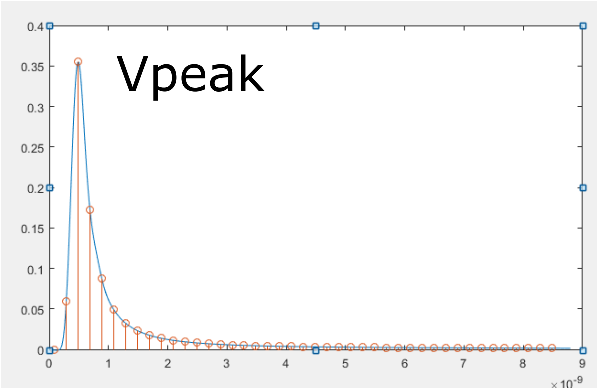
N

$$P = YX_1^T(X_1X_1^T)^{-1}$$

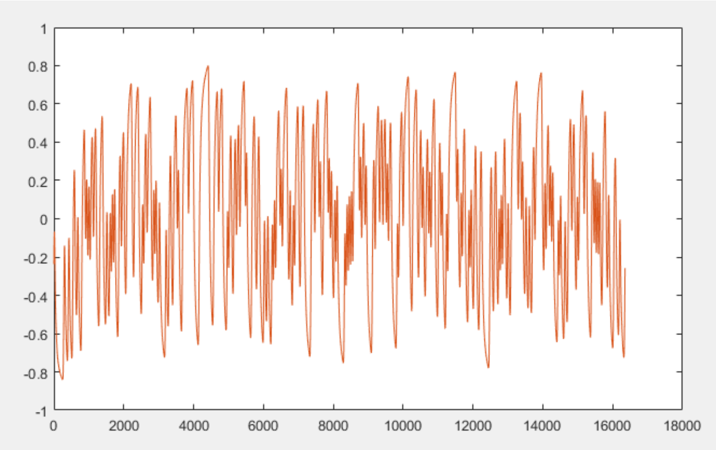
First Column of P



Reconstructed waveform out of fit pulse and data bits



$$\otimes \; X_1 =$$

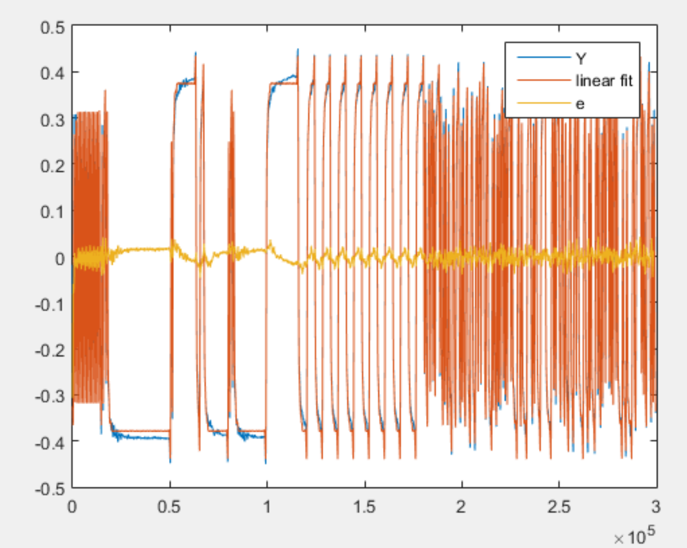


Errors per sample point outside the receiver's DFE reach

Eq 85-8: Errors are the Matrix of column E

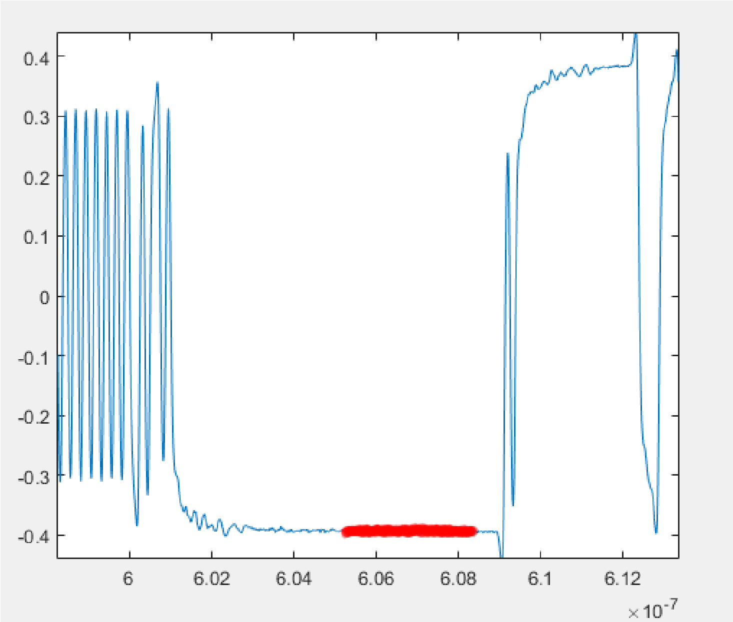
The error waveform, $e(k)$, is then read column-wise from the elements of E as shown in Equation (85–8).

$$E = PX_1 - Y = \begin{bmatrix} e(1) & e(M+1) & \dots & e(M(N-1)+1) \\ e(2) & e(M+2) & \dots & e(M(N-1)+2) \\ \dots & \dots & \dots & \dots \\ e(M) & e(2M) & \dots & e(MN) \end{bmatrix} \quad (85\text{–}8)$$



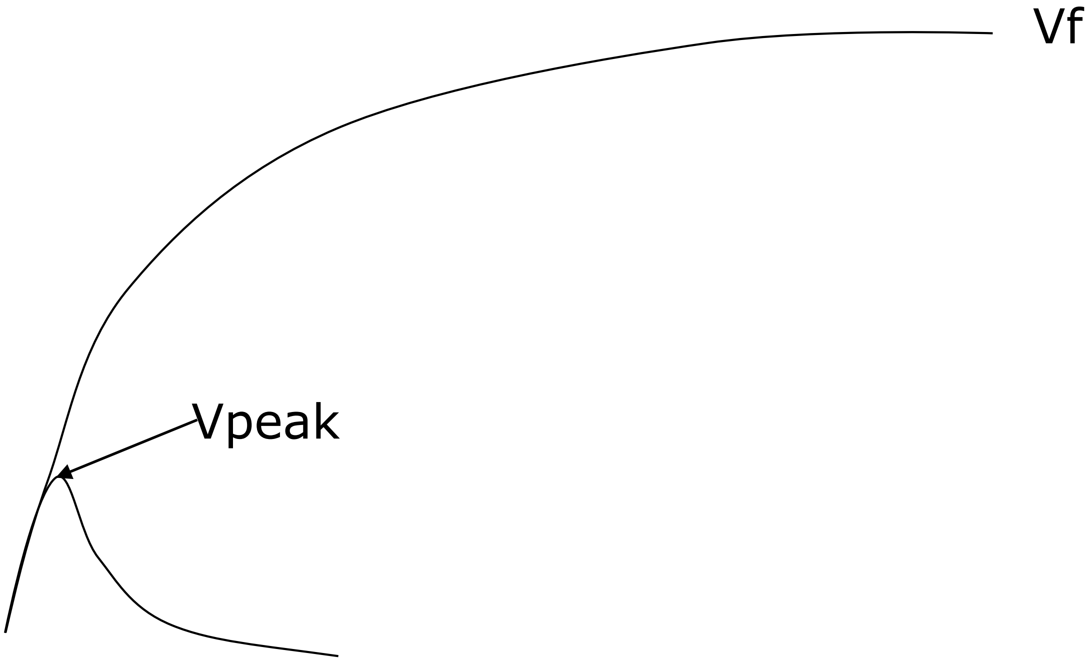
- May be use to justify just how many taps of DFE are required.
- The rms of "E" is basically noise that receiver will see,
  - Lets call that σ_e
- It is in relation to the peak of the pulse
- So the SNR might be 20*log10(Vpeak/ σ_e)
- But there is more noise to consider

Other noise



- Now the measure waveform not averaged but pattern triggered so we look a that same run of zeroes or ones in the data pattern
- The rms of this noise is introduced outside the lane
  - Lets call this σ_n
  - We RSS σ_n's from the run of ones and the run of zeroes to and aggregate σ_n
- Combing the two rms values results in a Signal to noise and distortion ratio of SNDR
  - SNDR=$\frac{V_{peak}}{\sqrt{\sigma_n^2+\sigma_e^2}}$

Spec Vf and Vpeak/Vf (it is related to loss)

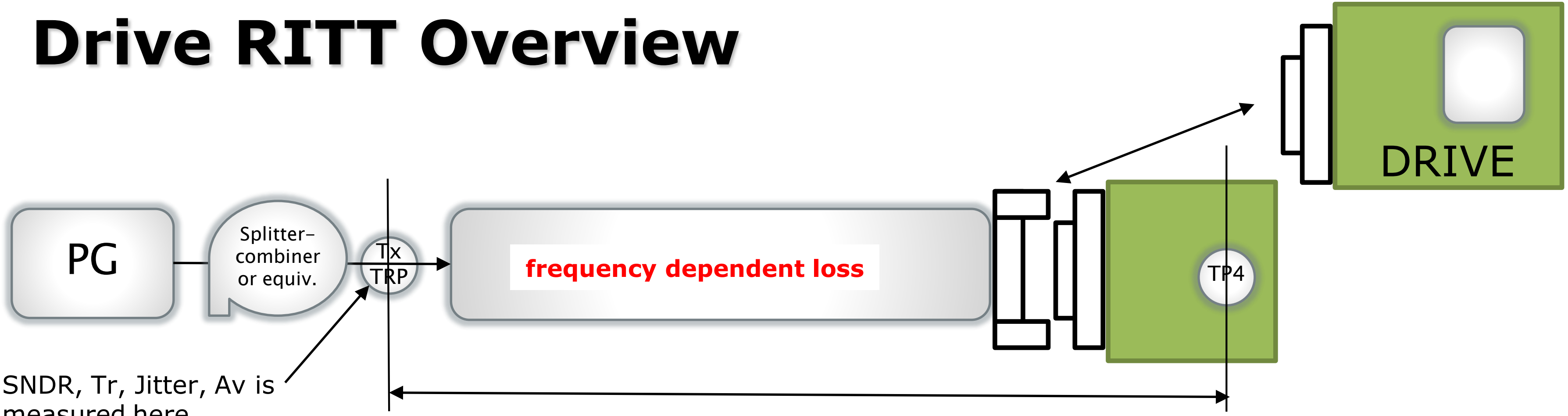


Extracting FFE Tap Coefficients if required

- 2 measurement waveforms required
  - Without equalization
  - With equalization
- Extracted to fitted pulse responses IEEE802.3 Clause 92.8.3.5.1
  - Without equalization, R
  - With equalization, P
- $P = R * C$
  - Where C is the tap coefficient vector
- $C = (R^T * R)^{-1} * R^T * P$ for each sample
- The values of C are used where the error P-R(for each sample) is minimum.

Receiver tests

Drive RITT Overview



SNDR, Tr, Jitter, Av is
measured here
Data for COM

Test channel= ([16.5dB and 8dB] – max drive board loss + test fixture loss) @ 2.5781GHz

- Measure s-parameter for Test Channel
- Set PG Tr, Av, and Jitter
- Measure PG SNDR and use in COM
- COM Tx Parameters are for reference chip spec
- Add board loss parameter in COM equivalent to max drive board loss - test fixture loss
- Determine what value of SNDR (SNR_TX) makes COM fail
- Sent noise to in to produce SNDR at TxTRP indicated by SNR_TX in last step.
- Determine DER using a test reference pattern
- Jitter tolerance use same setup except no noise is added and COM is not used.

Host RITT has its own table of losses

CHIP TO CHIP specs

- Borrow from IEEE802.3bj CL 93
- TX (Remove adaptive TX eq)
- RX
- Channel
  - Adopt reference package and ref equalizer developed in future adhoc work.