

COM update 4.1

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Background

- ❑ COM direction on RXFFE clarified in July 2023

Straw Poll #1

I would support the direction of the RXFFE changes to Annex 93A (COM) in mellitz_3dj_01a_2307 slides 6, 7, and 8

Results (all): Y: 61, N: 0, NMI: 7, A: 19

Straw Poll #9

I would support the direction of a RXFFE based reference RX to the 200G/lane AUI C2M and AUI C2C

Results (all): Y: 61, N: 0, NMI: 10, A: 26

https://www.ieee802.org/3/dj/public/23_07/motions_3cwdfdj_2307.pdf

Progress Report

Key Changes for Rx_{FFE} in Annex 93A (COM)

- ✓ ☐ Consider an update to the COM reference model, figure 93A-1
 - See slide 6
- ✗ ☐ Provide for implementation noise, η_1
- ✓ ☐ Include another term, $H_{rxffe}(f)$, the receiver FFE response, into the voltage transfer function, $H^{(k)}(f)$
 - $H^{(k)}(f) = H_{ffe}(f) H_t(f) H_{21}^{(k)}(f) H_r(f) H_{ctf}(f) H_{rxffe}(f)$
- ✓ ☐ Provide a receiver equalizer description like the transmitter equalizer in sub-section 93A.1.4.2 .
- ✓ ☐ Reuse the specified COM FOM for the determination of the variable equalizer parameters settings

https://www.ieee802.org/3/dj/public/23_07/mellitz_3dj_01a_2307.pdf

COM 4.1 Update Agenda

For .3dj project work

- ☐ Changes from COM 4.0
- ☐ Block Diagram
- ☐ COM flow
- ☐ COM Keyword update
- ☐ Tx anchor for Rx_{FFE}
- ☐ Rx_{ffe} determination

Changes from 4.0 → 4.1

1. Rx_{ffe} – suggested in mellitz_3dj_01a_0723
 - a) COM 4.0 and earlier used first zero crossing to reference T_s one UI later for Rx_{ffe} tap determination
 - a) After determination, Mueller-Muller (MM) is used for T_s
 - b) COM 4.1 determines initial T_s anchor uses pulse response (PR) peak for Rx_{FFE} tap determination
 - a) The oversampled offset away from the anchor is determined using in the specified over sampled range.
 - b) T_s is determined for the best FOM of all specified oversamples in combination with all CTF and Tx FFE combinations.
2. PDF & CDF correction as suggested in kirkland_3dj_elec_01_230406
 - a) Tends to offset the COM impact when sample adjustment is set to 0 in 1b
3. Renormalize inputted s-parameters. 50 ohms reference no longer required.
4. Removed RL data from reports unless bread_crumbs is set (memory saving)
5. S_{21}^2 changed to $s_{12} * s_{21}$ in s21_pkg. Corrected VTF needed for non-passive s-parameters

feature

Bug

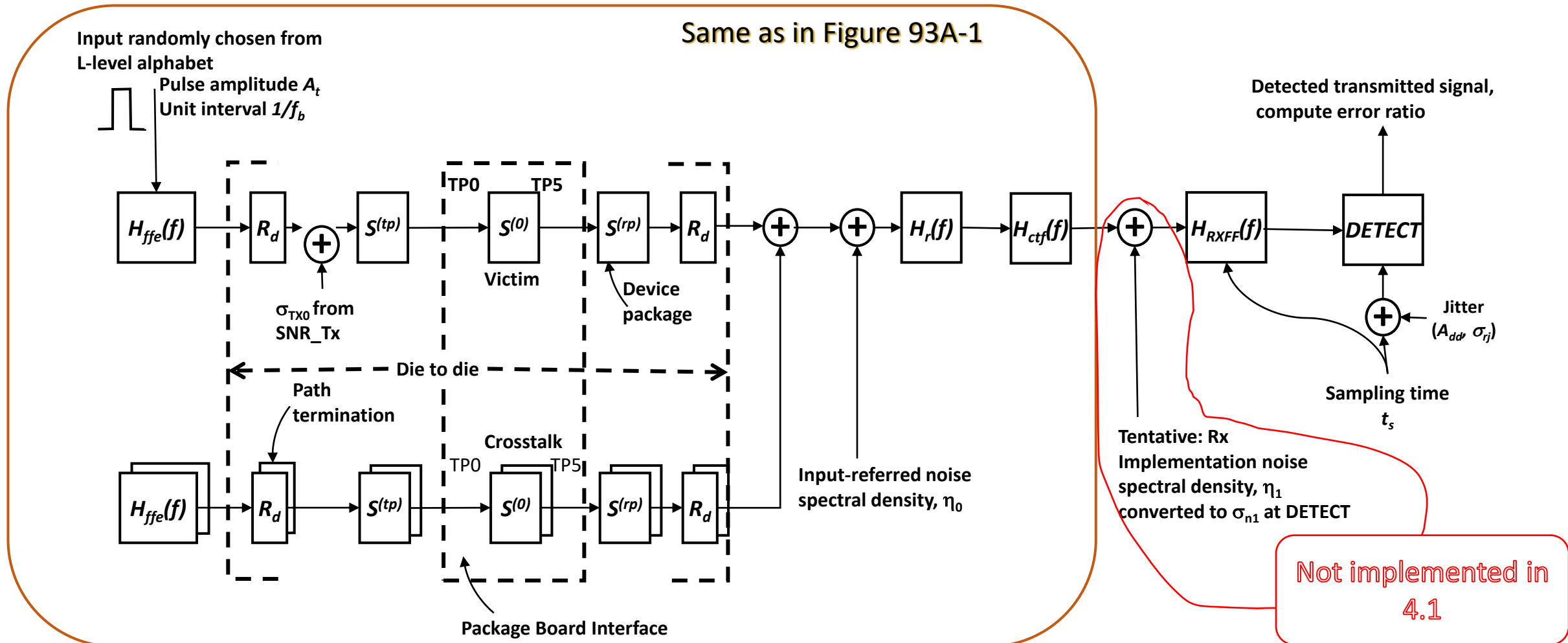
feature

Bug

Bug

COM reference model proposal

WITH RX FFE



Rx_{FFE} is within the Full Grid Optimization Loop and includes T_s sweep

Added COM parameter	Example value	Default	information	notes
sample_adjustment	[-32 32]	0	Min max sample offset range from ts anchor	Integer related to M
ts_anchor	1	0	Ts anchor for sample adjustment (0,1)	See next slides

Full grid loop hierarchy

1. CTF
 - for each G_{DC} and G_{DC2}
2. Tx_{ffe}
 - for each C(n)
3. For Rx_{FFE} only (new for COM 4.1)
 - Determine T_s (like a CDR)
 - Initial T_s anchor uses Mueller-Muller (MM), PR peak, or max dv/UI and then continue for each oversample step in “sample_adjustment”
 - If sample_adjustment= 0 then only MM is used for T_s and thus Rx_{ffe}
 - Sample adjustment
 - Find Rx_{FFE} taps C_{rx}(n) and apply
4. For Rx_{FFE} with sample_adjustment=0 or no Rx_{FFE}
 - T_s is determined from Mueller-Muller (MM), equation 93A–25
5. Compute FOM for steps [1 2 3 4]
6. Determine variable equalizer settings for best FOM

COM 4.1 Configuration Keyword Update

ADDED, REVISED, AND RETIRED

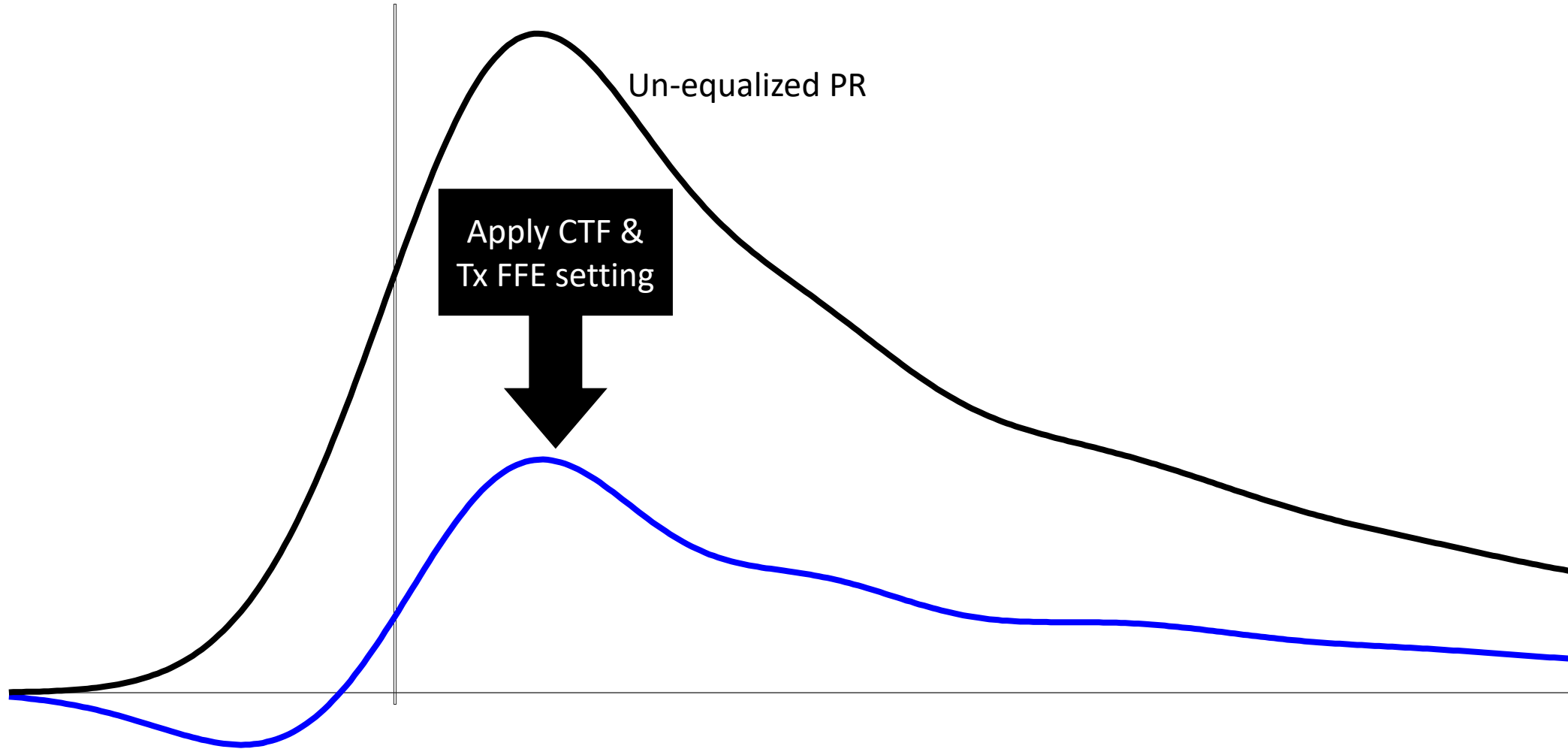
<i>Added COM parameter</i>	<i>Example value</i>	<i>Default</i>	<i>information</i>	<i>notes</i>
sample_adjustment	[-32 32]	0	Min max sample offset range from ts anchor	Integer related to M
ts_anchor	1	0	Ts anchor for sample adjustment (0,1)	See next slides

<i>Revised COM parameter</i>	<i>Example value</i>	<i>Default</i>	<i>information</i>	<i>notes</i>
Local Search	2	0	Distance length for coordinate decent 0 disables	Sample_adjustment incorporated for COM 4.1
ffe_main_cursor_min	1		Minimum value for the $C_{RX}(0)$	All taps are normalized such that $C_{rx}(0)=1$
ffe_pre_tap_len	5	0	Number of pre taps	if both are 0, Rx_FFE and eta1 is not used
ffe_post_tap_len	24	0	Number of post taps	
ffe_pre_tap1_max	1	1	Maximum value for $C_{RX}(1)$	
ffe_post_tap1_max	1	1	Maximum value for $C_{RX}(-1)$	
ffe_tapn_max	1	1	Maximum value of all other taps	
ffe_tap_step_size		0	Step size (normalized)	May be revisited

<i>Retired COM parameters</i>	<i>Default</i>	<i>information</i>	<i>Notes. Defaulted in COM script</i>
ffe_backoff	0		

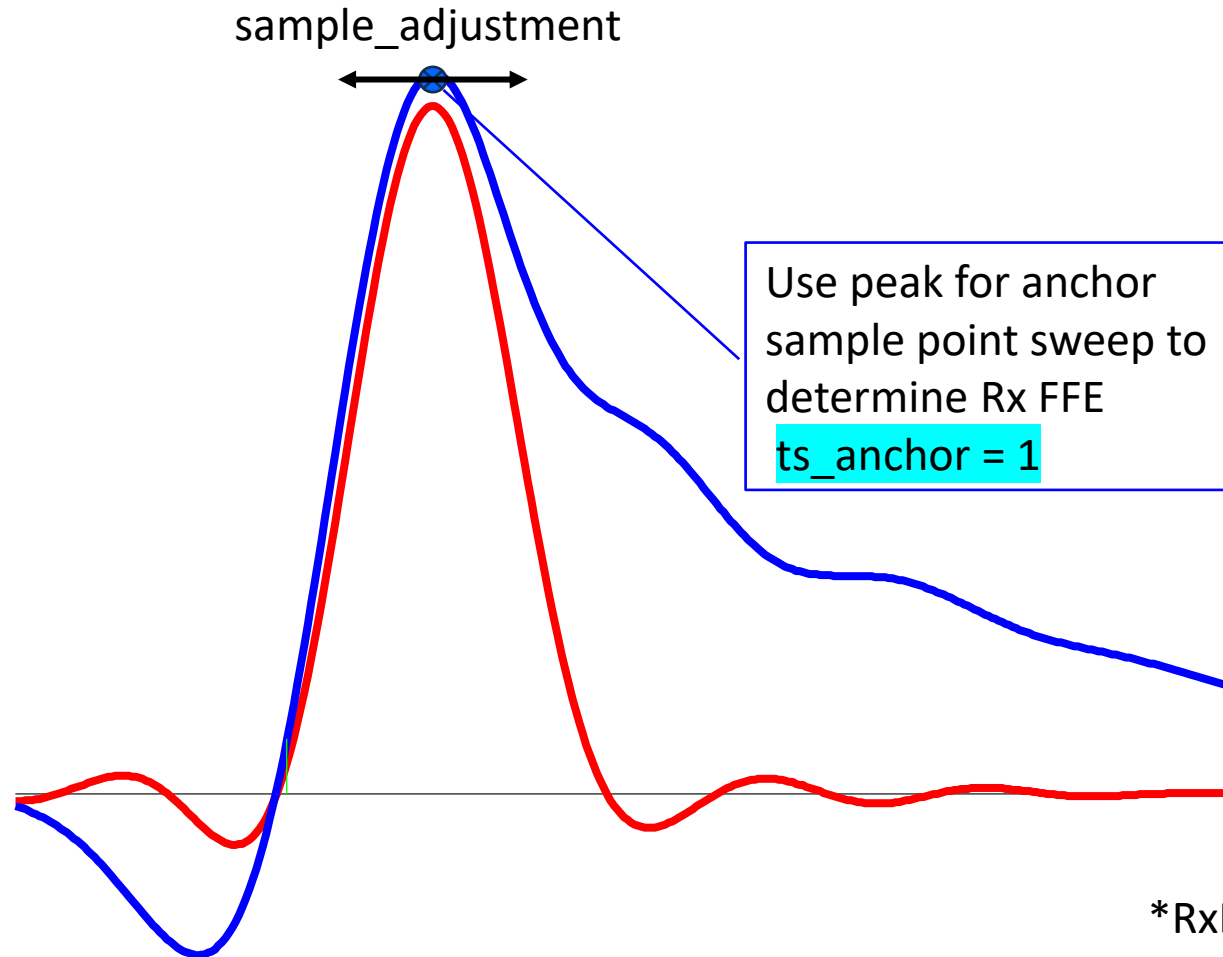
For each Tx_{ffe} and CTF setting

STEPS 1 AND 2



COM 4.1 T_s over sample sweep

*TS_ANCHOR = 1 FOR RX_FFE



*RxDFE still uses MM (T_s _anchor = 0)

Rx FFE Determination

mellitz_3ck_adhoc_01a_100318 (COM 2.51 with RX_{FFE} updates)

- ❑ Rx FFE tap determination is within the inner loop for the Tx, CTF, and T_s sweeps
- ❑ More information on the vector forcing algorithm is per [mellitz_3ck_adhoc_01a_100318.pdf](#)
- ❑ Rx FFE taps, C_{rx} , is a least squares solution for the following equation
 - $\overline{FV} = [HH]\overline{C_{RX}}$, where
 - HH the convolution matrix derived from the sampled pulse response
 - FV is a forcing vector zero everywhere except
 - FV(0) corresponds to the sample point
 - FV(1) is set to the pre-RX_{FFE} postcursor DFE value (up to $b_{max}(1)$).
 - Solve for C_{RX}
 - $C_{RX} = \left((HH^T HH)^{-1} HH^T \right)^T FV^T$
 - A partial response is embodied in the forcing vector FV

Next Steps

Determine what is good enough for 200 Gbps PAM4 COM?

- ❑ Test COM 4.1 more broadly across industry with provided channels and investigate reference EQ needs for baseline proposals
- ❑ Refine COM 4.1 as needed for RXFFE functionality and accuracy
- ❑ Expand COM for MLSE feature (CR/KR applications)

Thank You!

back up slides – extra information

Determining FFE taps, C within the inside loop

FROM: MELLITZ_3CK_ADHOC_01A_100318.PDF SLIDE 9

- ❑ $C = ((HH^T * HH^{-1} * HH^T)^T * FV^T$
 - C are the Rx FFE taps
 - HH is derived from $h^{(0)}(t)$
 - HH is shifted sampled ISI matrix
- ❑ FV is the forcing vector ,
- ❑ $FV = [\dots 0, 0, FV0, FV1, 0, 0, 0, 0 \dots]$
- ❑ FV for the cursor tap is
 - $FV0 = h^{(0)}(t_s)$
 - This forces the cursor tap to 1
- ☞ Modified from mellitz_3ck_01_0718:
FV for the post cursor tap (2.5T update)
 - $FV1 = \text{sign}(h^{(0)}(t_s + T_b)) \min(|h^{(0)}(t_s + T_b)|, |b_1 h^{(0)}(t_s)|)$
 - This makes sure the b_1 is not violated for the DFE
- ❑ $h_{\text{fferx}}(f)$ is computed from the C found as in eq 93A-21