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, $H^{(k)}(f)$
  - $H^{(k)}(f) = Hffe(f)\, H_t(f)\, H_{21}{}^{(k)}(f)\, Hr(f)\, Hctf(f)\, H_{rxffe}(f)$
- ✓ 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

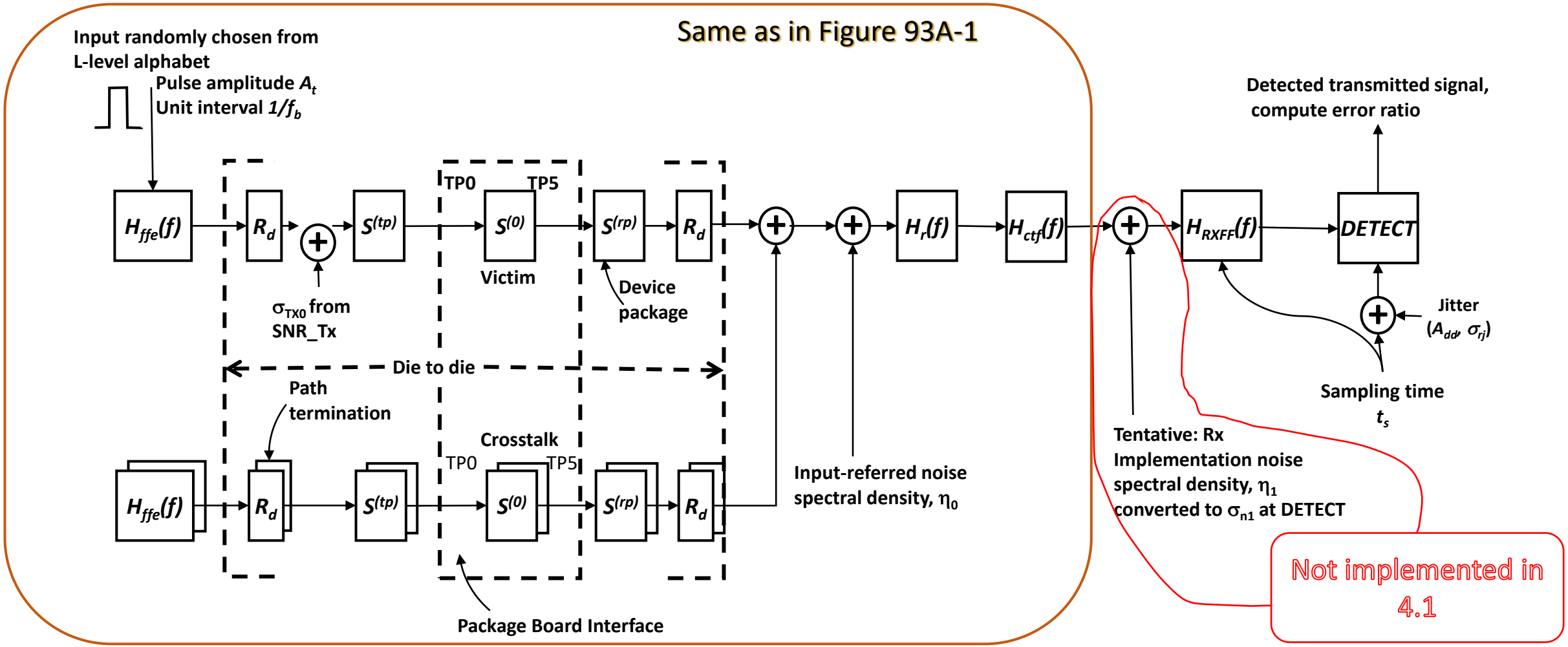
- ❑ Changes from COM 4.0
- ❑ Block Diagram
- ❑ COM flow
- ❑ COM Keyword update
- ❑ Tx anchor for Rx_{FFE}
- ❑ Rx_{ffe} determination

Changes from 4.0 → 4.1

1. Rx_{ffe} – suggested in mellitz_3dj_01a_0723 — feature
   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 form the anchor is determined using in the specified over sampled range.
      b) Ts 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 — Bug
   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. — feature
4. Removed RL data from reports unless bread_crumbs is set (memory saving) — Bug
5. S21.^2 changed to s12.*s21 in s21_pkg. Corrected VTF needed for non-passive s-parameters — 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 RxFFE 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

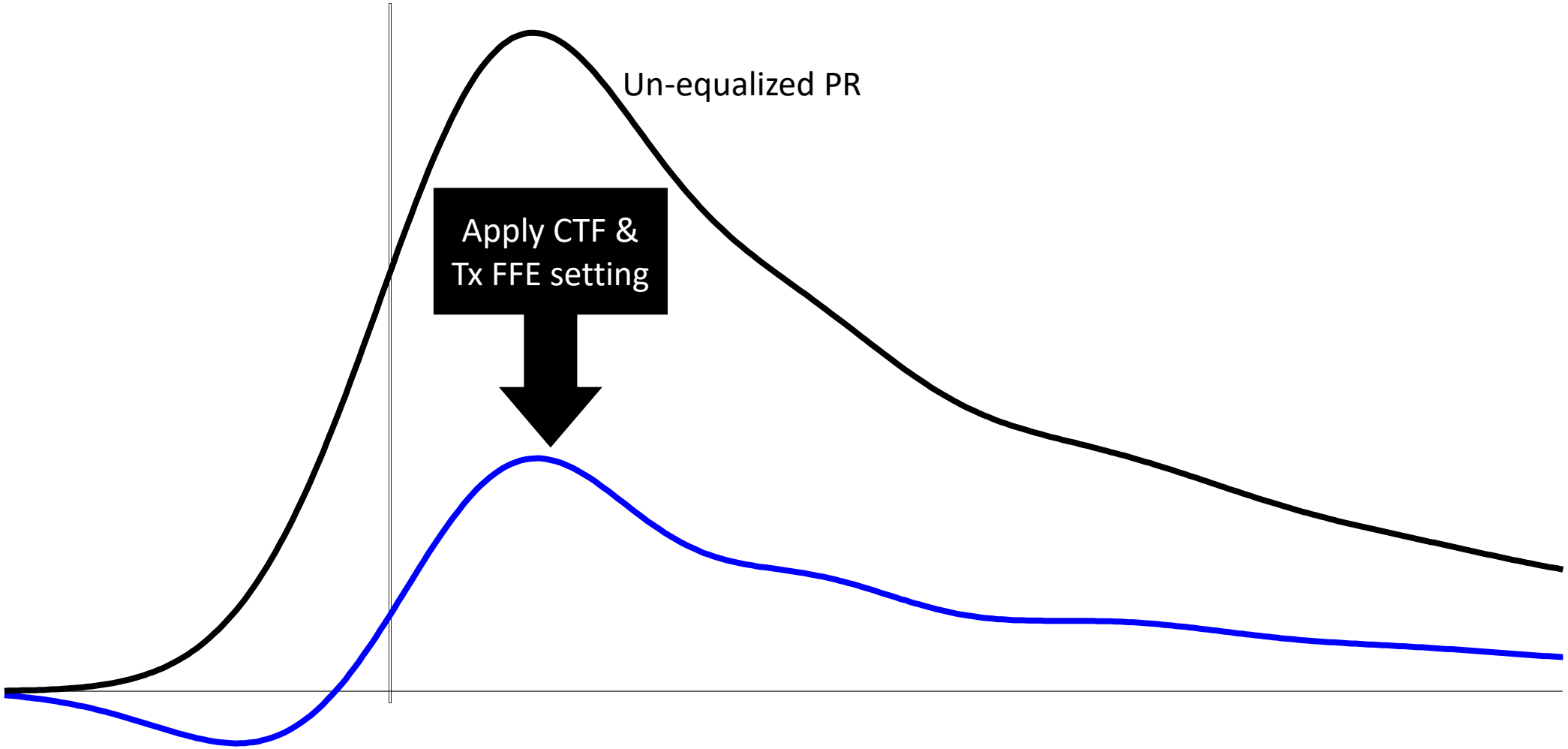
Added COM parameter	*Example value*	*Default*	*information*	*notes*
sample_adjustment	[-32 32]	0	Min max sample offset range from ts anchor	Integer related to M
ts_anchor	1	0	Ts anchor for sample adjustment (0,1)	See next slides

Revised COM parameter	*Example value*	*Default*	*information*	*notes*
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

Retired COM parameters	*Default*	*information*	*Notes. Defaulted in COM script*
ffe_backoff	**0**		

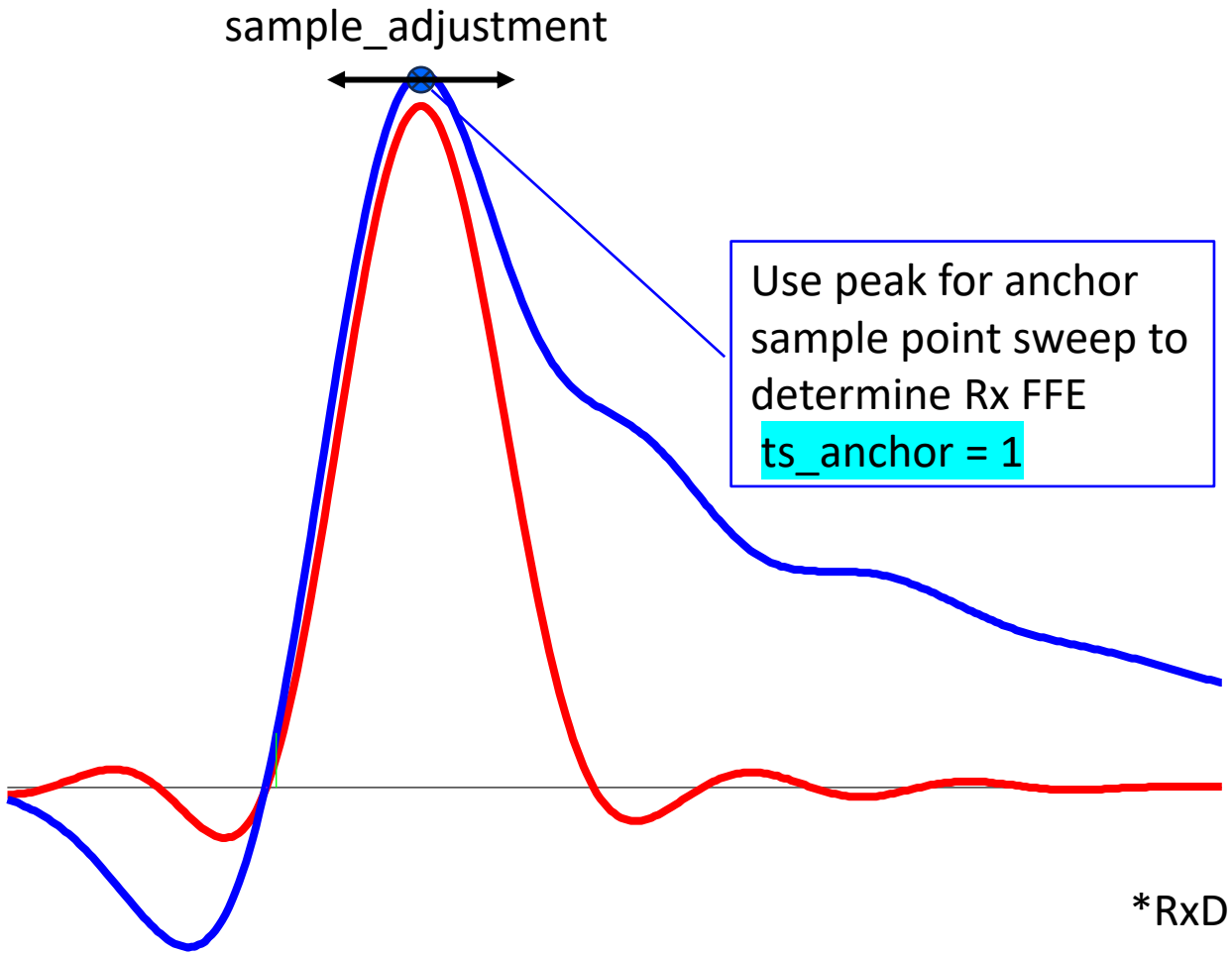
For each Tx_{ffe} and CTF setting

STEPS 1 AND 2



COM 4.1 T_s over sample sweep

***TS_ANCHOR = 1 FOR RX_{FFE}**



*RxDFE still uses MM (Ts_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}
    - $C_{RX} = \left(\left((HH^T\ HH)\right)^{-1} HH^T\right)^T\ FV^T$
  - 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 = [... 0, 0,FV0,FV1, 0, 0, 0, 0...]
- 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 (2.51 update)
  - FV1 = 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
- $h_{fferx}(f)$ is computed from the C found as in eq 93A-21