Causal pulse shape and tap limits

(comments I-468 , R1-282 and R2-204)

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The comments (approx. latest first)

- R2-204 SC 180.9.6.3 P 484 L 25 TR
- D3.0 comment 468: causal vs. anticausal pulse shapes are not equivalent. This pre-post equalizer coefficient difference limit |w(1)/w(0) - b(1) - w(-1)/w(0)| seeks to keep the attack and decay of the signal pulse similar. Yet the evidence from https://ieee802.org/3/dj/public/25_05/chayeb_3dj_01_2505.pdf#page=8 and 9, plotted in https://ieee802.org/3/ds/public/Interim_May_27-28-2026/dawe_3ds_01_260527.pdf , shows that for a real receiver, the situation is very far from symmetrical; relatively fast attack (c(-1) close to zero) and slow decay (c(+1) strongly -ve) is tolerated well (naturally), but the opposite is not. A constrained optimiser can find a solution by choosing a bad sampling phase - but the reported ECQ would be bad.
- Remove the absolute bars | |. Add a minimum limit, -0.4, remembering that there are acceptable signals off the bottom of the plot in dawe_3ds_01_260527.

R1-282

- R1-282 180 SC 180.9.6.3 P 483 L 25 TR TDECQ tap limit (O)
- D3.0 comment 468: causal vs. anticausal pulse shapes are not equivalent.
  This pre-post equalizer coefficient difference limit |w(1)/w(0) - b(1) - w(-1)/w(0)| seeks to keep the attack and decay of the signal pulse similar. Yet the evidence from https://ieee802.org/3/dj/public/25_05/chayeb_3dj_01_2505.pdf#page=8 and 9, plotted in https://ieee802.org/3/ds/public/Interim_May_27-28-2026/dawe_3ds_01_260527.pdf , shows that for a real receiver, the situation is very far from symmetrical; relatively fast attack (c(-1) close to zero) and slow decay (c(+1) strongly -ve) is tolerated well (naturally), but the opposite is not.
- Remove the absolute bars | |. If necessary, add a minimum limit, e.g. -0.55, remembering that there are acceptable signals off the bottom of the plot in dawe_3ds_01_260527.
- REJECT. This is a resubmission of Draft 3.0 Comment I-468 in the following comment report:
  https://www.ieee802.org/3/dj/comments/D3p0/8023dj_D3p0_comments_final_clause.pdf
  No new substantive information on the desired outcome is provided in the suggested remedy.
  Note that the contribution cited in the comment (dawe_3ds_01_260527) was not presented to the IEEE 802.3dj task force or CRG, but rather was presented to another task force (802.3ds).
  After CRG discussion there was no consensus to make the proposed change.

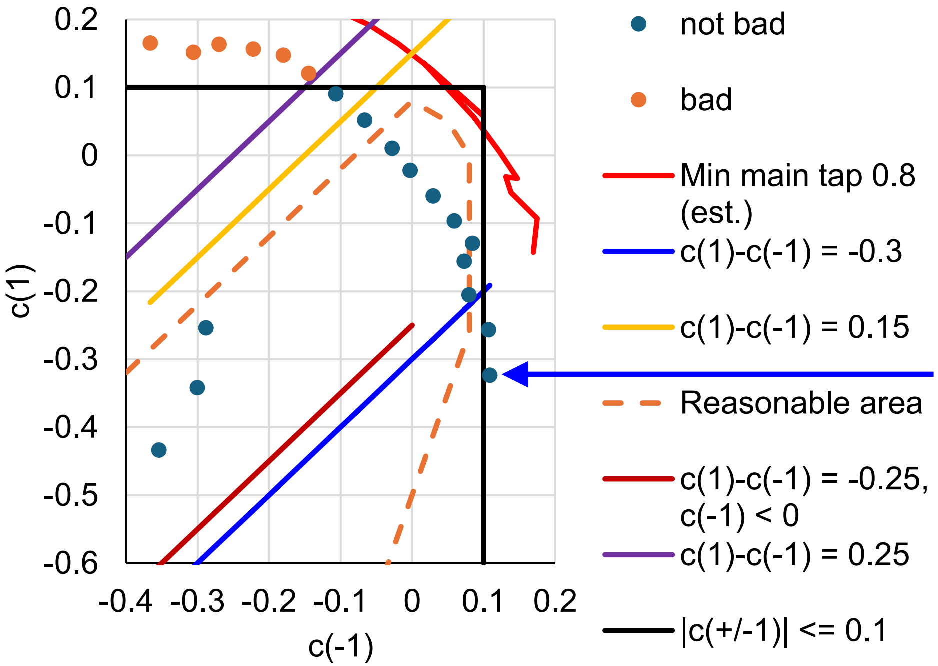
P802.3ds D1.1 comment 113

- P802.3ds D1.1 comment 113 193 SC 193.9.7.1 P 71 L 27 TR
- Causal vs. anticausal pulse shapes
  This pre-post equalizer coefficient difference limit |w(1)/w(0) - b(1) - w(-1)/w(0)| seeks to keep the attack and decay of the signal pulse similar. Yet the evidence from https://ieee802.org/3/dj/public/25_05/chayeb_3dj_01_2505.pdf#page=8 and 9, plotted in https://ieee802.org/3/ds/public/Interim_May_27-28-2026/dawe_3ds_01_260527.pdf , shows that for a real receiver, the situation is far from symmetrical; relatively fast attack (c(-1) close to zero) and slow decay (c(+1) strongly -ve) is tolerated well, but the opposite is not. Note that some acceptable signals on chayeb page 9 remembering are off the bottom of the plot in dawe_3ds_01_260527.
- Remove the absolute bars | |, and replace the dash in the minimum column with -0.4, so that the allowed range becomes -0.4 to +0.25.
  If necessary, state that this row is a constraint, just like the other tap limits (if there is a solution that fails this rule, and there is another solution that passes all the rules, that's a pass). But don't try to write out a constrained optimiser in the draft; it could be quite complicated and it's T&M implementation that should not appear in a standard anyway.
- ACCEPT IN PRINCIPLE. Set the pre-post equalizer coefficient difference limit
  $-0.4 < w(1)/w(0) - b(1) - w(-1)/w(0) < 0.25$.

I-468

- I-468 180 SC 180.9.6.3 P 480 L 17 TR tap weight-equation (OI)
- Causal vs. anticausal pulse shapes
  This pre-post equalizer coefficient difference limit |w(1)/w(0) - b(1) - w(-1)/w(0)| seeks to keep the attack and decay of the signal pulse similar. Yet the evidence from https://ieee802.org/3/dj/public/25_05/chayeb_3dj_01_2505.pdf#page=8 and 9, plotted in https://ieee802.org/3/dk/public/2511/3dk_dawe_2511_1.pdf , shows that for a real receiver, the situation is very far from symmetrical; relatively fast attack (c(-1) close to zero) and slow decay (c(+1) strongly -ve) is tolerated well, but the opposite is not.
- Remove the absolute bars | |
- REJECT. If the absolute bars are removed then the associated limit likely needs to be adjusted. Further work to justify the change and the associated limit is required.
  There is no consensus to make the proposed change.

Content of dawe_3ds_01_260527 or 3dk_dawe_2511_1



This point is debatable: sensitivity is affected, error floor is fine. See next

Data from https://ieee802.org/3/dj/public/25_05/chayeb_3dj_01_2505.pdf#page=8 and 9 *Reproduced on next slide*

PAM4 100 Gb/s 400-DR4

chayeb_3dj_01_2505 slides 8 and 9

TDECQ Correlation to Link Performance

Ahmad El-Chayeb - Keysight Technologies
Vasu Parthasarathy - Broadcom Inc.
Fred Tang – Broadcom Inc.

Experimental Data: "Good" TDECQ, "Bad" Link Performance

Ln0	FIR1	FIR2	FIR3	FIR4	FIR5	FIR6	FIR7	FIR8	Default	FIR9	FIR10	FIR11	FIR12	FIR13	FIR14	FIR15	FIR16
FIR1	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-39	-39	-39	-39	-39
FIR2	95	100	105	110	115	115	115	115	115	115	115	115	115	110	105	100	95
FIR3	-39	-39	-39	-39	-39	-34	-29	-24	-19	-14	-9	-4	0	5	10	15	20
FIR4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FIR5	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4
FIR6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
FIR7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7
Lvl0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0
TDECQ	2.52	2.11	1.81	1.61	1.52	1.38	1.26	1.12	1.03	0.9	0.85	0.84	0.85	0.98	1.15	1.34	1.66
ER	2.988	2.988	2.989	2.992	2.992	2.977	2.966	2.96	2.956	2.954	2.954	2.958	2.958	2.95	2.948	2.94	2.936
Ceq	0.44	0.33	0.19	0.05	-0.09	-0.08	-0.08	-0.06	-0.06	-0.05	-0.05	-0.05	-0.06	0.07	0.21	0.35	0.5
RLM	0.97	0.972	0.976	0.979	0.984	0.987	0.988	0.988	0.99	0.992	0.991	0.992	0.992	0.988	0.986	0.982	0.98
De-emp	-0.297619	-0.297619	-0.297619	-0.297619	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976	-0.2976
Overshoot (1e-2)	11.23	11.54	11.62%	12.35%	12.80%	10.89%	9.86%	8.78%	9.05%	9.87%	11.59%	13.45%	14.91%	14.82%	14.68%	14.31%	14.09%
Trans	17.40	16.40	15.40	10.60	11.00	10.60	10.60	10.00	10.00	10.00	10.00	10.00	10.00	10.00	14.40	15.20	16.20
FFE1	0.0914	0.0660	0.0545	0.0428	0.0337	0.0287	0.0293	0.0321	0.0375	0.0492	0.0603	0.0730	0.0827	0.0928	0.0989	0.1067	0.1113
FFE2	-0.3664	-0.3059	-0.2701	-0.2223	-0.1799	-0.1446	-0.1066	-0.0665	-0.0277	-0.0026	0.0293	0.0590	0.0845	0.0730	0.0797	0.0847	0.1087
FFE3	1.0312	1.0142	0.9860	0.9617	0.9432	0.9556	0.9610	0.9684	0.9749	0.9766	0.9733	0.9653	0.9581	0.9825	1.0090	1.0321	1.0420
FFE4	0.1652	0.1516	0.1632	0.1564	0.1473	0.1207	0.0904	0.0516	0.0104	-0.0220	-0.0599	-0.0968	-0.1294	-0.1560	-0.2053	-0.2569	-0.3238
FFE5	0.0786	0.0741	0.0663	0.0614	0.0557	0.0396	0.0259	0.0144	0.0049	-0.0013	-0.0031	-0.0004	0.0042	0.0076	0.0178	0.0335	0.0618
NormFFE1	5	4	4	3	2	2	2	3	4	5	5	6	7	7	7	7	7
NormFFE2	-21	-19	-18	-15	-13	-11	-9	-6	-3	0	3	5	7	6	6	6	7
NormFFE3	60	63	64	67	69	74	79	85	92	93	86	81	76	75	72	68	63
NormFFE4	10	9	11	11	11	9	7	5	1	-2	-5	-8	-10	-12	-15	-17	-20
NormFFE5	5	5	4	4	4	3	2	1	0	0	0	0	0	1	1	2	4
Pre-FEC (max AOP)	2.20E-04	1.14E-04	3.51E-05	7.10E-06	1.80E-06	2.18E-07	9.21E-09	3.37E-10	2.19E-11	3.18E-12	5.22E-13	EF	EF	EF	5.22E-14	5.22E-14	3.13E-12
Post-FEC (3min)	6.35E-06	1.02E-06	2.73E-08	1.50E-10	T=15 (soft)	T=9 (bursty)	T=3	T=2	T=1	T=1	T=1	T=0	T=0	T=0	T=1	T=1	T=1

Note: reset (Attenuator on/off toggle) applied for every Tx FIR change for Rx measurements

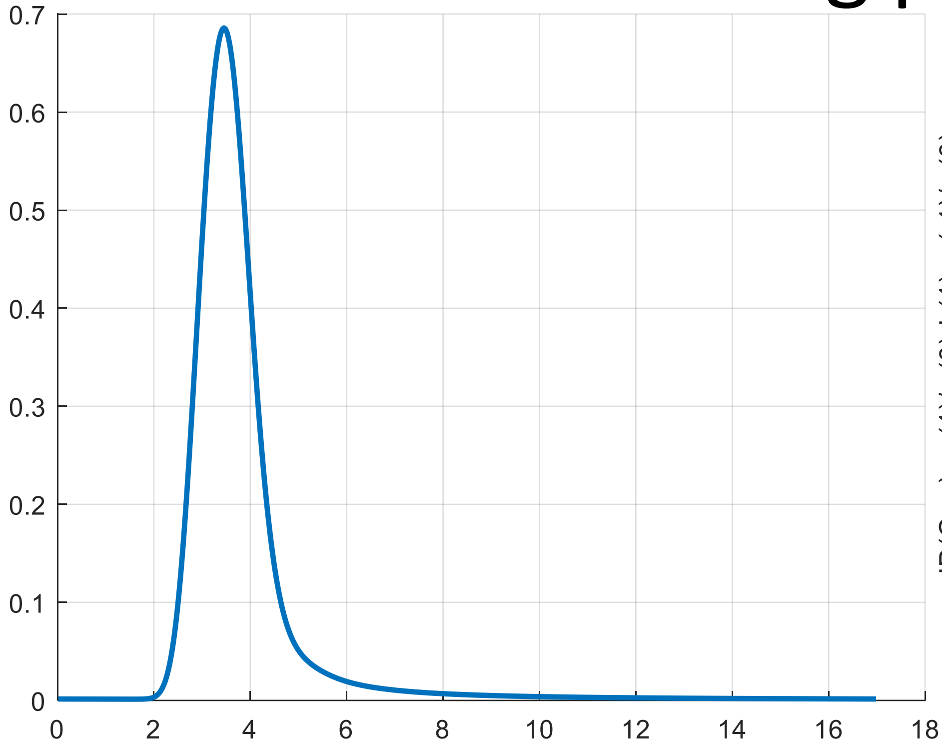
AOP (60s m	FIR1	FIR2	FIR3	FIR4	FIR5	FIR6	FIR7	FIR8	Default	FIR9	FIR10	FIR11	FIR12	FIR13	FIR14	FIR15	FIR16
-0.12	2.20E-04	1.14E-04	3.51E-05	7.10E-06	1.80E-06	2.18E-07	9.21E-09	2.97E-10	2.19E-11	3.18E-12	5.22E-13	EF	EF	EF	5.22E-14	5.22E-14	3.12E-12
-1.3	2.16E-04	3.41E-05	6.00E-06	1.37E-06	2.87E-07	4.44E-08	1.71E-09	6.66E-11	1.55E-11	2.66E-12	4.69E-13	1.56E-13	3.12E-13	EF	EF	1.57E-13	8.93E-12
-2.42		1.42E-04	1.09E-05	1.18E-06	2.35E-07	2.43E-08	1.97E-09	1.12E-10	1.71E-11	4.38E-12	1.88E-12	3.13E-13	1.57E-13	1.25E-12	6.25E-13	3.13E-12	1.77E-11
-3.52		7.52E-05	1.14E-05	1.71E-06	4.56E-07	4.88E-08	4.43E-09	4.91E-10	8.43E-11	2.78E-11	7.02E-12	1.72E-12	5.64E-12	1.06E-11	1.82E-11	6.65E-11	6.00E-10
-4.59		7.85E-05	1.04E-05	1.93E-06	5.55E-07	1.16E-07	2.07E-08	4.62E-09	1.59E-09	4.98E-10	1.82E-10	1.29E-10	1.47E-10	2.74E-10	8.20E-10	3.31E-09	2.40E-08
-5.65			1.91E-05	4.39E-06	1.69E-06	5.23E-07	1.79E-07	5.64E-08	3.24E-08	1.38E-08	7.63E-09	5.73E-09	6.94E-09	1.33E-08	3.40E-08	1.32E-07	1.60E-06
-6.71			8.10E-05	2.28E-05	1.09E-05	4.69E-06	2.46E-06	1.27E-06	7.77E-07	5.09E-07	3.80E-07	2.97E-07	2.91E-07	5.60E-07	1.49E-06	4.55E-06	9.75E-05
-7.75				1.84E-04	8.65E-05	5.25E-05	3.38E-05	2.07E-05	1.65E-05	1.26E-05	1.01E-05	9.44E-06	9.17E-06	1.54E-05	3.36E-05	1.29E-04	
-8.78						4.31E-04	3.23E-04	2.57E-04	2.08E-04	1.83E-04	1.57E-04	1.48E-04	1.54E-04	2.34E-04	2.47E-04		

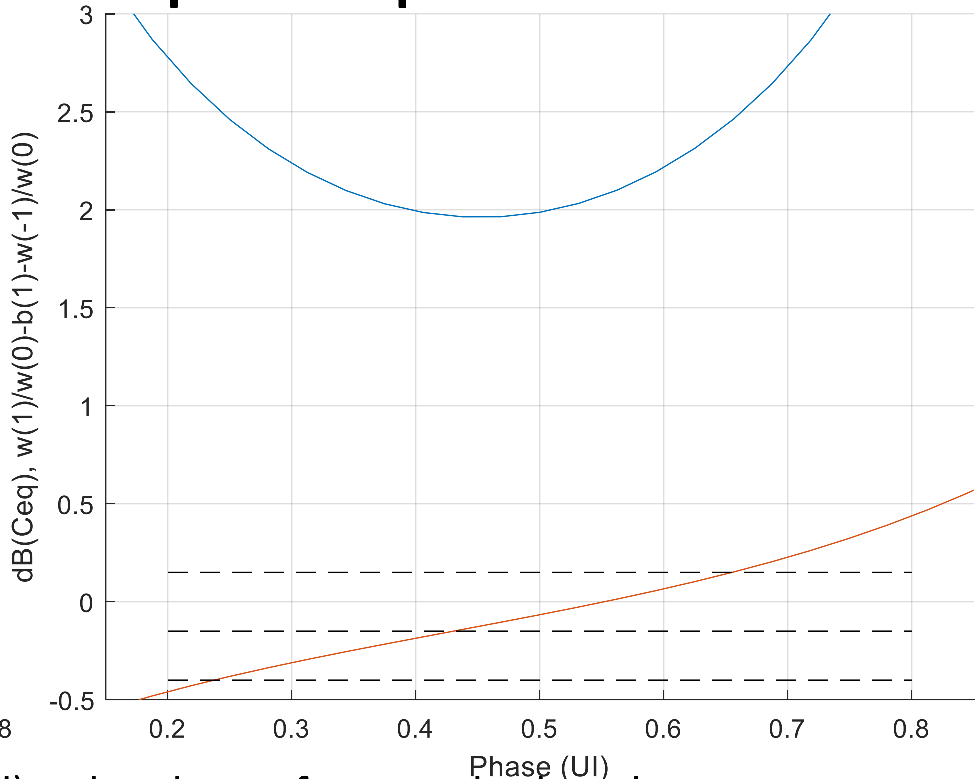
Red when there is post-FEC error

Experimental Data: "Bad" TDECQ, "Good" BER

Ln0	TECQ1	TECQ2	TECQ3	TECQ4	TECQ5
FIR1	0	0	0	0	0
FIR2	168	158	148	138	128
FIR3	0	10	20	30	40
FIR4	0	0	0	0	0
FIR5	0	0	0	0	0
FIR6	0	0	0	0	0
FIR7	0	0	0	0	0
Lvl0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0	0 2 -2 0
TDECQ	3.96	4.02	4.33	5.09	6.73
ER	6.952	6.925	6.908	6.992	7
Ceq	1.85	2.12	2.46	2.92	3.36
RLM	0.947	0.963	0.962	0.967	0.979
De-emp	0	0	0	0	0
Overshoot (1e-2)	1.82%	2.18%	2.51%	2.90%	2.85%
Trans time	15.80	17.60	18.20	22.8	23.8
FFE1	0.0437	0.0460	0.0597	0.05492	0.07337
FFE2	-0.2885	-0.3006	-0.3539	-0.36748	-0.44484
FFE3	1.5176	1.6055	1.7189	1.87493	2.03389
FFE4	-0.2537	-0.3420	-0.4340	-0.6253	-0.7858
FFE5	-0.0191	-0.0089	0.0093	0.06293	0.12341
NormFFE1	2	2	2	2	2
NormFFE2	-14	-13	-14	-12	-13
NormFFE3	71	70	67	63	59
NormFFE4	-12	-15	-17	-21	-23
NormFFE5	-1	0	0	2	4
Pre-FEC (max AOP)	EF	EF	6.15E-13	1.85E-13	1.34E-10
Post-FEC (3min)	T=0	T=0	T=1	T=1	T=1

Cost of force-fitting post-pre tap difference





- Left: example "causal" (natural, normal) pulse shape: fast attack, slow decay
  - More skew than this is commonplace
- Right: sweeping sampling phase. Best is ~0.45 UI where post-pre is almost -0.15 UI. This is a very ideal simulation; in practice the sweet spot would be narrower
- There is equal timing offset penalty at -0.25 UI and 0.67 UI where post-pre is -0.4 and +0.15
- The proposed limits are a significant improvement