

Improving TDECQ Reference Equalizer Tap Limits

Addressing comments 268-295

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Plenary Meeting

Vancouver, Canada

November 12, 2024

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Addressing comments: 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295

Overview

- ❑ **Currently adopted FECo tap limits**
- ❑ **TECQ tap values for FECo and FECi transmitter**
 - Absolute taps
 - Pre/post taps normalized to main
- ❑ **Current and proposed tap limits**
- ❑ **Summary**
- ❑ **Backup**
 - Background on TDECQ equalizer
 - Is there a benefit to control the tap weight so tightly
 - Typical C2M equalizer tap weights
 - TECQ FECo vs FECi data.

802.3bs/cd and 802.3db Equalizers

□ TDECQ 50G/100G SMF and 50G MMF equalizers in the 802.3bs/cd is

- 5 tap T-spaced (FFE), where the sum of the equalizer tap coefficients is equal to 1. Tap 1, tap 2, or tap 3, has the largest magnitude tap coefficient, which is constrained to be at least 0.8.
 - Implies TDECQ equalizer having 0, 1, or 2 pre-cursor
 - With sum of tap coefficient=1 implies the FFE has no gain/loss
 - Any combination of pre or post tap weight that satisfy unity gain is acceptable.

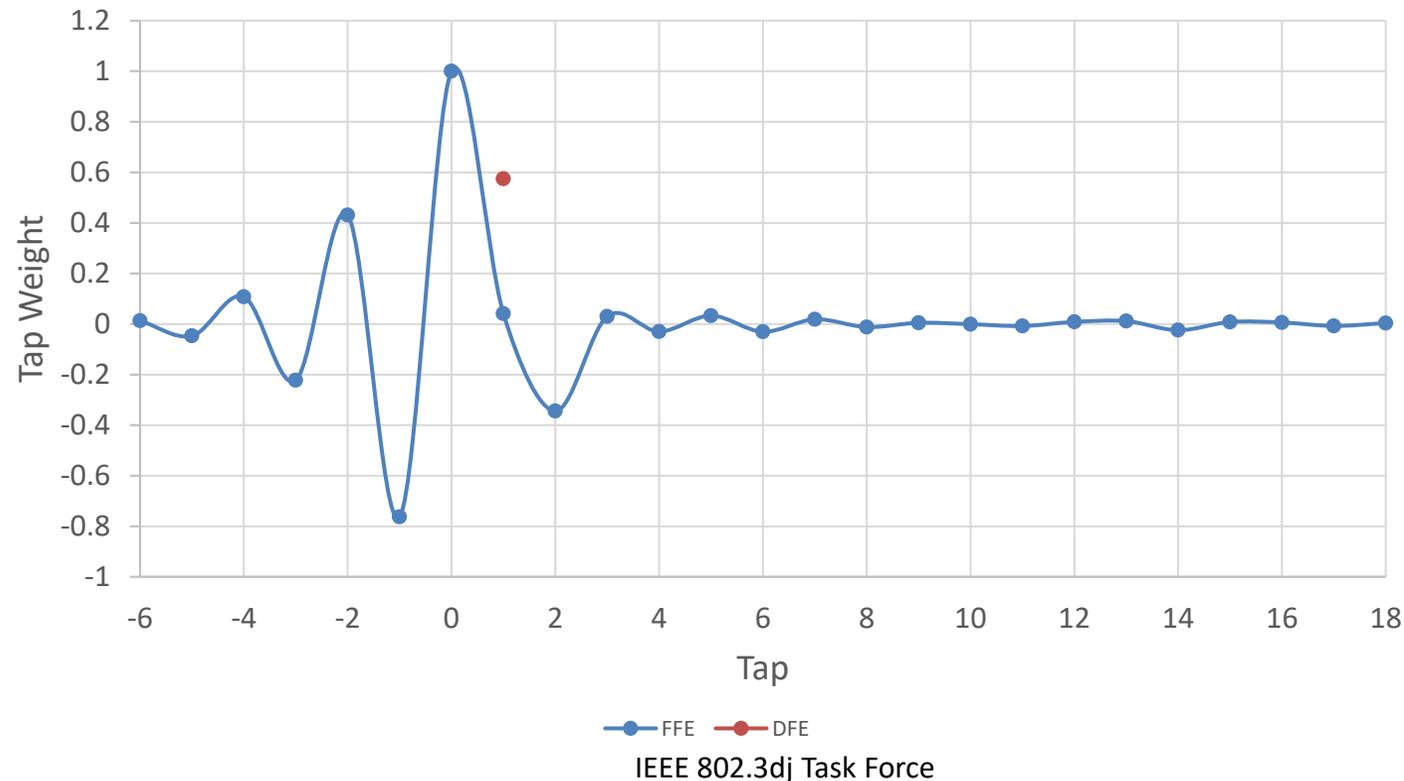
□ TDECQ 100G MMF equalizers in the 802.3db

- 9 tap T-spaced (FFE), where the arithmetic sum of the equalizer tap coefficients are equal to 1. Tap 1, tap 2, tap 3, or tap 4 has the largest magnitude tap coefficient, which is constrained to be at least 0.8. In addition 802.3db limits absolute value of $C(7)<0.3$, $C(8)<0.2$, and $C(9)<0.1$
 - Mandates TDECQ equalizer having 0, 1, or 2 pre-cursor
 - With sum of tap coefficient=1 implies the FFE has no DC gain/loss
 - Any combination of pre or post tap weight that satisfy unity gain is acceptable.

Typical 802.3dj C2M FFE Taps

- Channel for the example illustrated below is [Kareti](#) SL No 10 with 32 dB bump-bump loss
 - COM FFE uses normalized FFE taps and for this channel result in 12.57 dB of signal loss (unlike 802.3bs/cd/db TDECQ equalize that have unity gain)
 - Similar SerDes/DSP expect to handle at least ± 0.8 for taps near the main
 - To satisfy TDECQ equalizer unity gain as in 802.3bs/cd/db with strong 1st pre/post cursors the main tap typically ~ 1.6 .

C2M FFE/DFE Taps (FFE Gain=-12.57 dB)



Adopted 802.3dJ TDECQ Tap Weight

- TDECQ tap weights were based on [welch 3dj 01 2405](#) proposal with fixed 3 pre-cursors
 - DSP receiver have negligible cost even for tap weight of 0.8, but tail taps > ~0.25 has small power penalty
 - Compared to BS/CD/DB equalizer by limiting tap weight so much the adopted 15 tap equalizer effectively may end up to be equivalent of 5-tap equalizer!

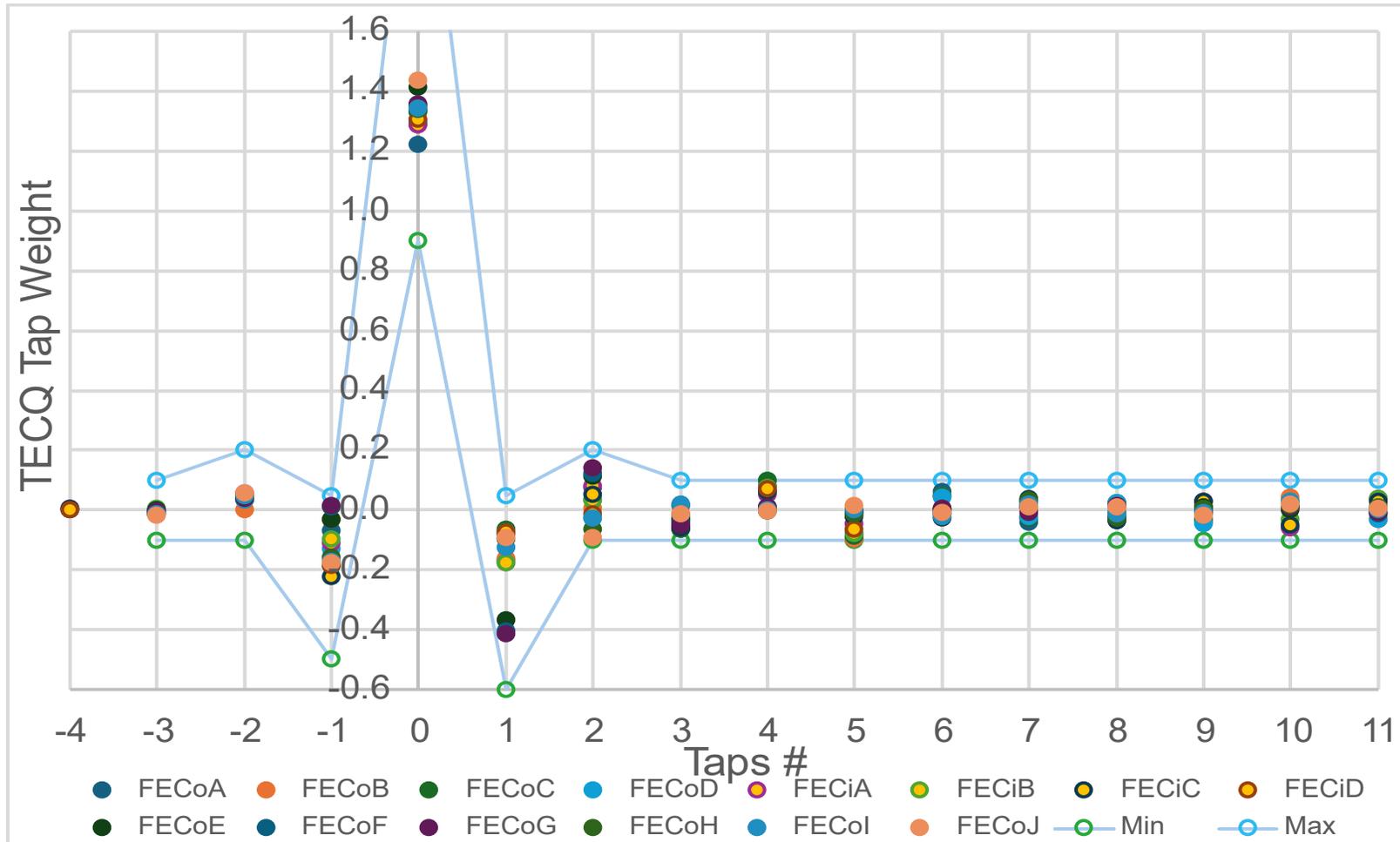
Parameter	Symbol	Minimum	Maximum
Feed-forward equalizer (FFE) length	N_b	—	15
Maximum equalizer pre-cursors	—	—	3
Main tap coefficient limit	—	0.9	2.5
Normalized equalizer coefficient limits: ^a	$c(i)$		
$c(-3)$		-0.1	0.1
$c(-2)$		-0.1	0.2 0.25
$c(-1)$		-0.5	0.05 0.1
$c(1)$		-0.6	0.05 0.2
$c(2)$		-0.1	0.2 0.3
$i \geq 3$		-0.1	0.1
Equalizer gain ^b	—	1	1

^aRelative to main tap.

^bThe sum of the equalizer coefficients is equal to 1.

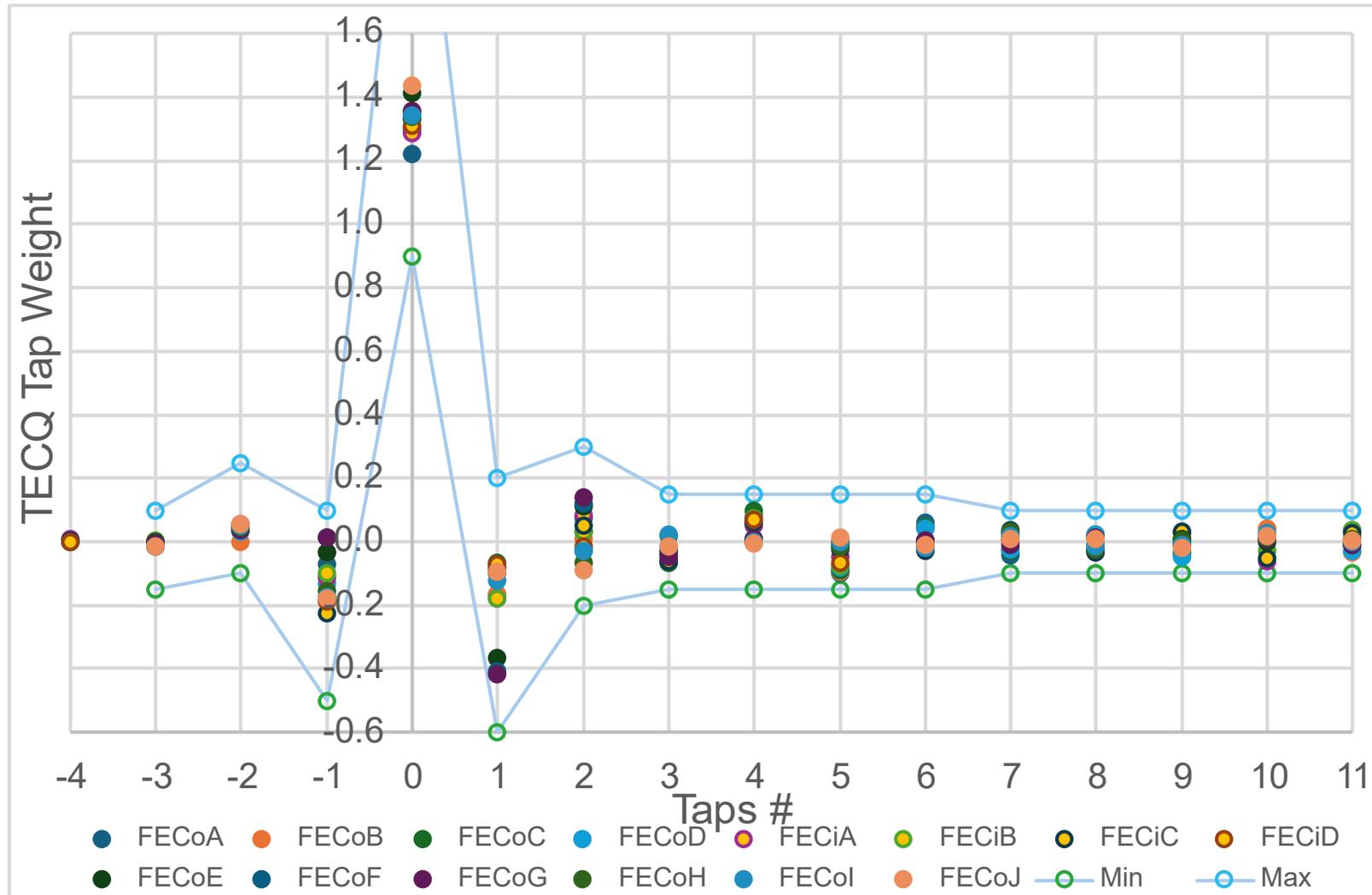
FECo and FECi TECQ Data (Pre/Post Taps Normalized to Main)

- **Current tap limits are overlaid on FECo and FECi TECQ data and these tap limits will increase due to CD**
 - Across temperature some of FECo transmitter TDECQ exceeded 3.4 dB (cautions these are early alpha units) so constraining tap weight may have real impact!



FECo and FECi TECQ Data (Pre/Post Taps Normalized to Main)

Proposed tap limits are overlaid on FECo and FECi TECQ data and these tap limits will increase due to CD!



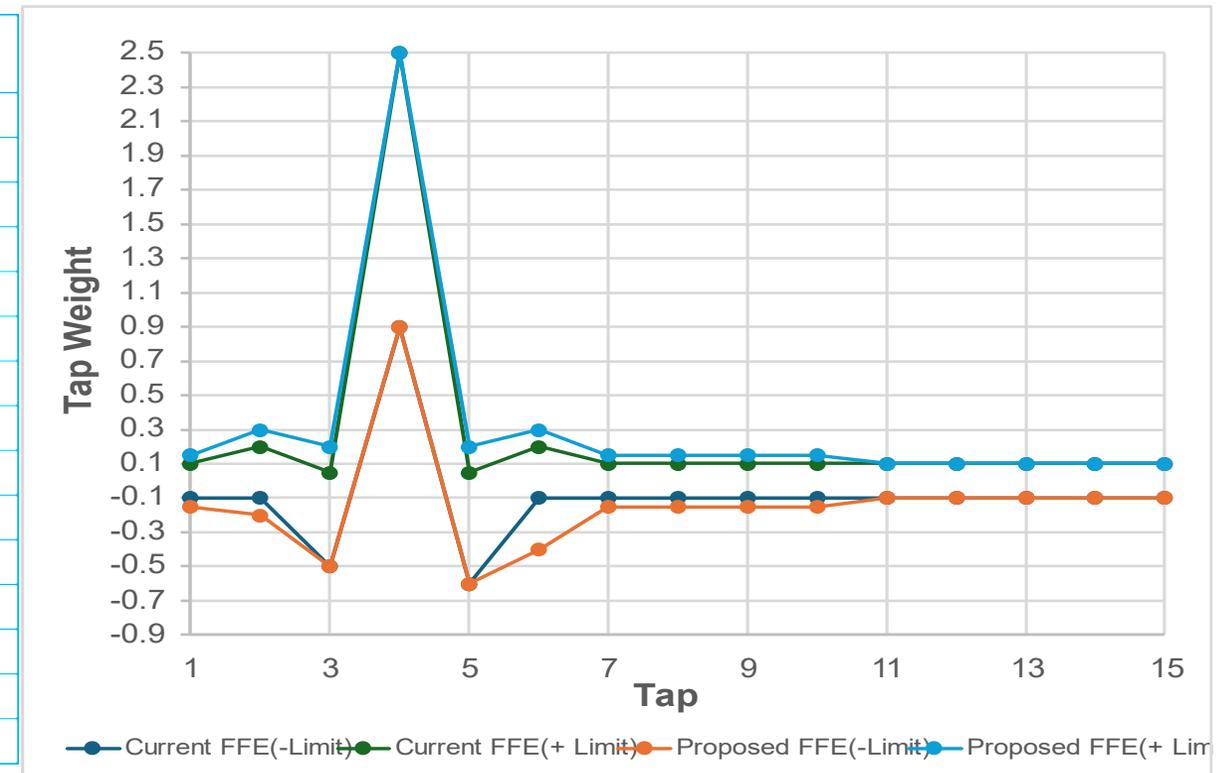
Current vs Proposed Tap Limit

☐ Same FECo limit applies to FECi tap weight

- Given the capability of DSP and negligible cost there is no reason to tightly control the taps where good transmitter may fail and complicate the TDECQ procedure!

Bold indicates a change.

Tap	Current FFE(-Limit)	Current FFE(+ Limit)	Proposed FFE(-Limit)	Proposed FFE(+ Limit)
C(-3)	-0.1	0.1	-0.15	0.1
C(-2)	-0.1	0.2	-0.1	0.25
C(-1)	-0.5	0.05	-0.5	0.1
C(0)	0.9	2.5	0.9	2.2
C(1)	-0.6	0.05	-0.6	0.2
C(2)	-0.1	0.2	-0.2	0.3
C(3)	-0.1	0.1	-0.15	0.15
C(4)	-0.1	0.1	-0.15	0.15
C(5)	-0.1	0.1	-0.15	0.15
C(6)	-0.1	0.1	-0.15	0.15
C(7)	-0.1	0.1	-0.1	0.1
C(8)	-0.1	0.1	-0.1	0.1
C(9)	-0.1	0.1	-0.1	0.1
C(10)	-0.1	0.1	-0.1	0.1
C(11)	-0.1	0.1	-0.1	0.1



Summary

- ❑ **Having some tap limits for DJ TDECQ equalizer would be an improvement over 802.3bs/cd where tap weight can be very large as long equalizer has unity gain**
 - Previously only 802.3db limited tail taps $C(7) \leq \pm 0.3$, $C(8) \leq \pm 0.2$, $C(9) \leq \pm 0.1$
 - 802.3bs/cd/db all allow main tap to have limited float instead of having fix # of pre-cursors
- ❑ **Current TDECQ oscilloscope tap optimization doesn't consider tap weights for convergence**
 - If tap weight are set very tight the current $\sim 3s$ TDECQ convergence time may significantly increase due to need for multiple re-optimization
- ❑ **Recommendations on tap weight for FECo and FECi per limit on page 9**
- ❑ **Given similar DSP/Eq that will be used for both C2M and optical DSP/Eq there is room even for further tap weight relaxation**
 - Given the DSP capability with somewhat relaxed tap limit then we wouldn't need to have different tap weight limit for DR, FR, FR4, and LR4 PMDs – for BS/CD PMDs there were no limits on tap weights!

Thank you!