Coefficient Adjustments for a DFE-Based Reference Receiver (In support of comments #313 and #314)

Roberto Rodes, Coherent

Outline

- Proposed Changes to Coefficient Limits (in support of Comments #313 and #314)
- Rx Performance Evaluation with New Reference Equalizer

Background

- Draft 2.1 introduced a 1-tap Decision Feedback Equalizer (DFE) in the reference receiver.
- FFE coefficient limits in Table 180-15 were originally set based on an FFE-only receiver.
- Adding DFE changes the FFE tap behavior, especially the first postcursor.
- Therefore, coefficient limits for main tap and pre/post difference need revision.

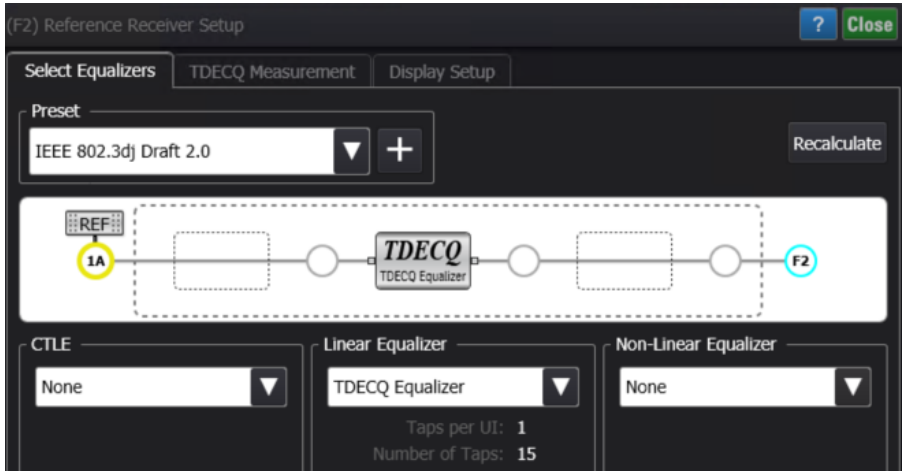
Table 180–15—Reference equalizer tap coefficients

Parameter	Symbol	Value	
		Minimum	Maximum
Feed-forward equalizer (FFE) length	N_w	15	
Number of equalizer pre-cursor taps	—	0	3
Main tap coefficient limit	$w(0)$	0.9	2.5
Normalized equalizer coefficient limits:	$w(i)/w(0)$		
$i = -3$		–0.15	0.1
$i = -2$		–0.1	0.25
$i = -1$		–0.5	0.1
$i = 1$		–0.6	0.2
$i = 2$		–0.2	0.3
$i = 3$		–0.15	0.15
$i = 4$		–0.15	0.15
$i = 5$		–0.15	0.15
$i = 6$		–0.15	0.15
$i \geq 7$		–0.1	0.1
Pre-post equalizer coefficient difference limit: $\lvert w(1) - w(-1) \rvert$, for $w(1) > 0$	—	—	0.25
Equalizer DC gain[a]	—	1	
Decision feedback equalizer (DFE) length	N_b	1	
DFE coefficient limit	$b(1)$	0	0.3

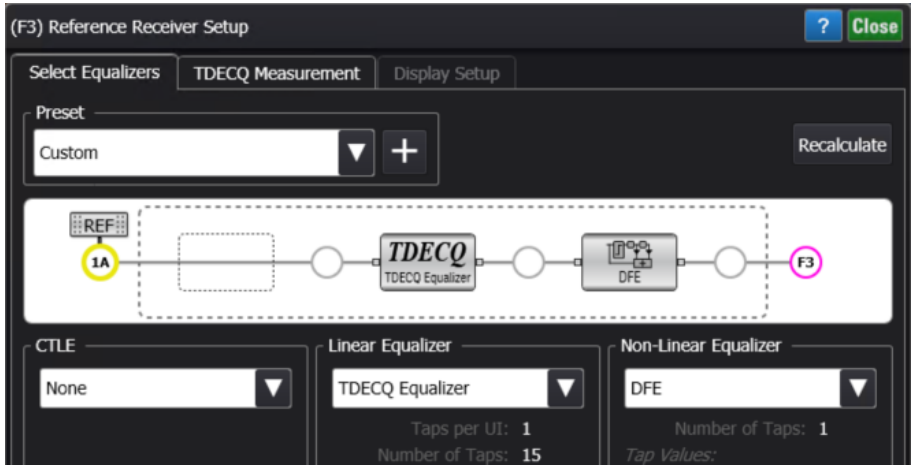
[a] The sum of all 15 equalizer coefficients, $w(i)$.

Reference Equalizer Analysis Setup

- TECQ taps evaluated with and without 1-tap DFE
- Implemented using the latest Keysight FlexDCA release
- Measurements covered multiple:
  - Laser technologies
  - DSPs
  - Data rates
- Note: Only a subset of these variants is included in this presentation.



Scope Configuration for FFE only reference receiver



Scope Configuration for FFE+DFE reference receiver

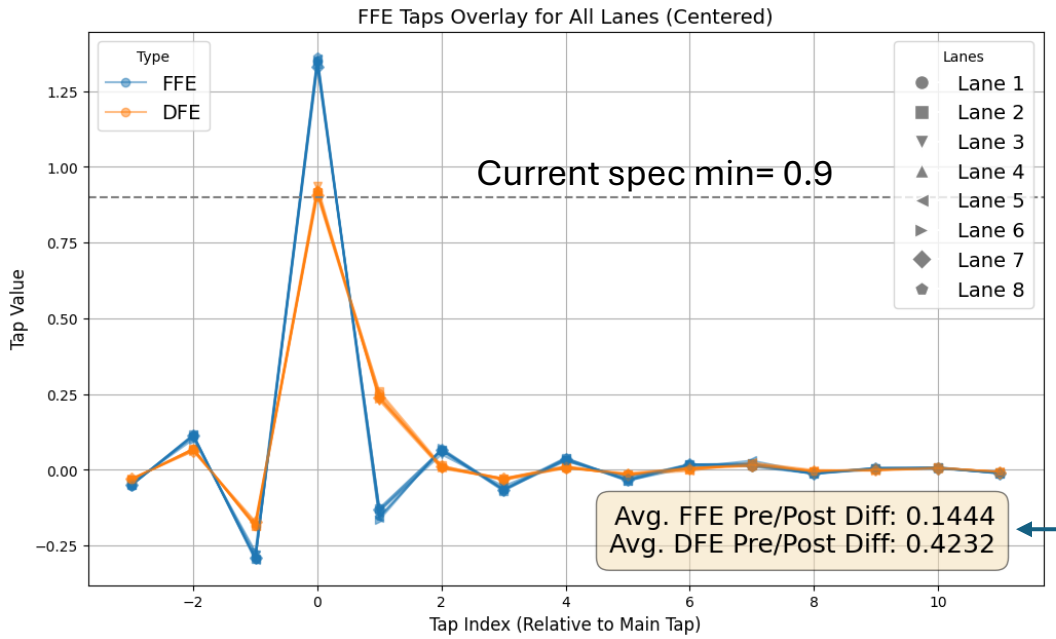
Impact of 1-Tap DFE

With a 1-tap DFE present, the first postcursor coefficient tends to shift toward a more positive value.

- The DFE cancels the intersymbol interference from the previous symbol.
- As a result, the FFE no longer needs to apply strong peaking at the first postcursor.

This impacts two Table 180-15 constraints:

- Minimum main tap value
- Pre–post coefficient difference



Current spec max= 0.25

Proposed Changes to Coefficient Limits

(Supporting Comments #313 and #314)

Current Spec:

Main tap min = 0.9

Pre–post difference max = 0.25

Proposed Update:

Main tap min → 0.8

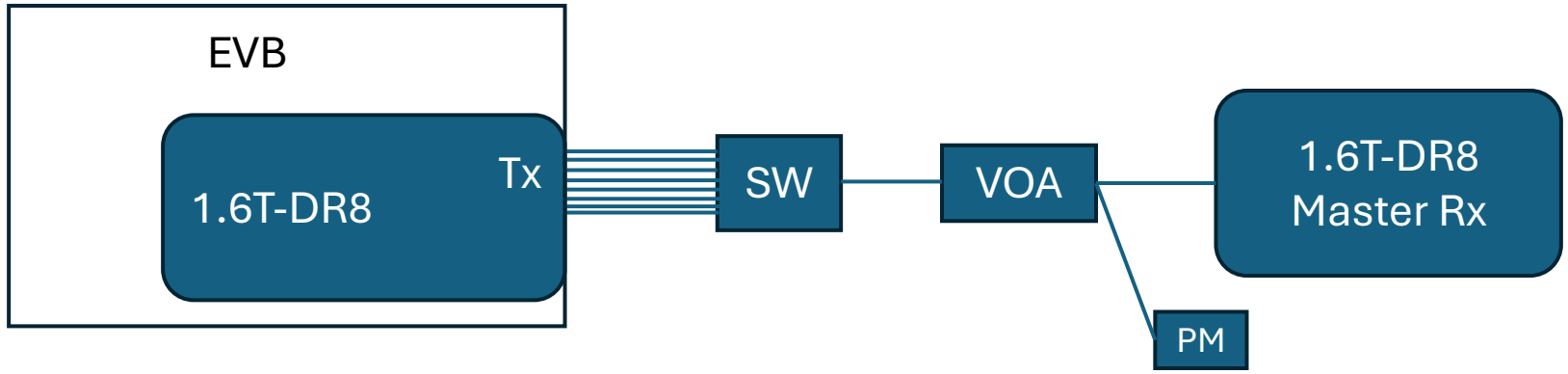
Pre–post difference max → 0.55

Table 180–15—Reference equalizer tap coefficients

Parameter	Symbol	Value	
		Minimum	Maximum
Feed-forward equalizer (FFE) length	N_w	15	
Number of equalizer pre-cursor taps	—	0	3
Main tap coefficient limit	$w(0)$	**0.8** ~~0.9~~	2.5
Normalized equalizer coefficient limits: $i = -3$ $i = -2$ $i = -1$ $i = 1$ $i = 2$ $i = 3$ $i = 4$ $i = 5$ $i = 6$ $i \geq 7$	$w(i)/w(0)$	 –0.15 –0.1 –0.5 –0.6 –0.2 –0.15 –0.15 –0.15 –0.15 –0.1	 0.1 0.25 0.1 0.2 0.3 0.15 0.15 0.15 0.15 0.1
Pre-post equalizer coefficient difference limit: $\lvert w(1) - w(-1) \rvert$, for $w(1) > 0$	—	—	**0.55** ~~0.25~~
Equalizer DC gain[a]	—	1	
Decision feedback equalizer (DFE) length	N_b	1	
DFE coefficient limit	$b(1)$	0	0.3

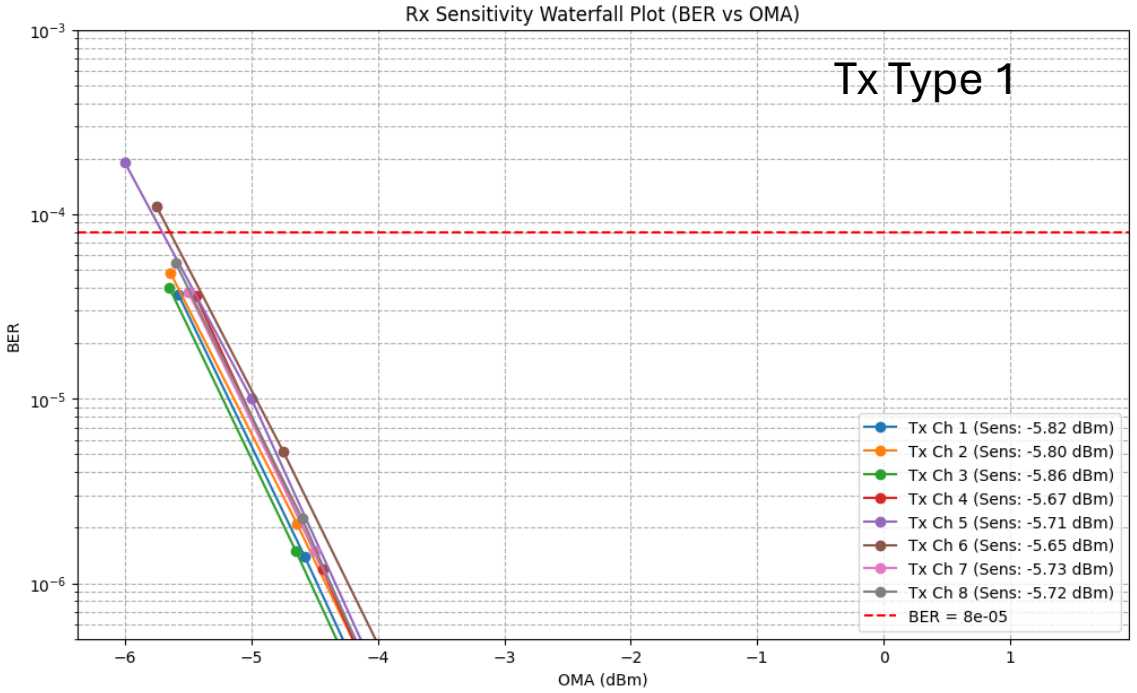
[a] The sum of all 15 equalizer coefficients, $w(i)$.

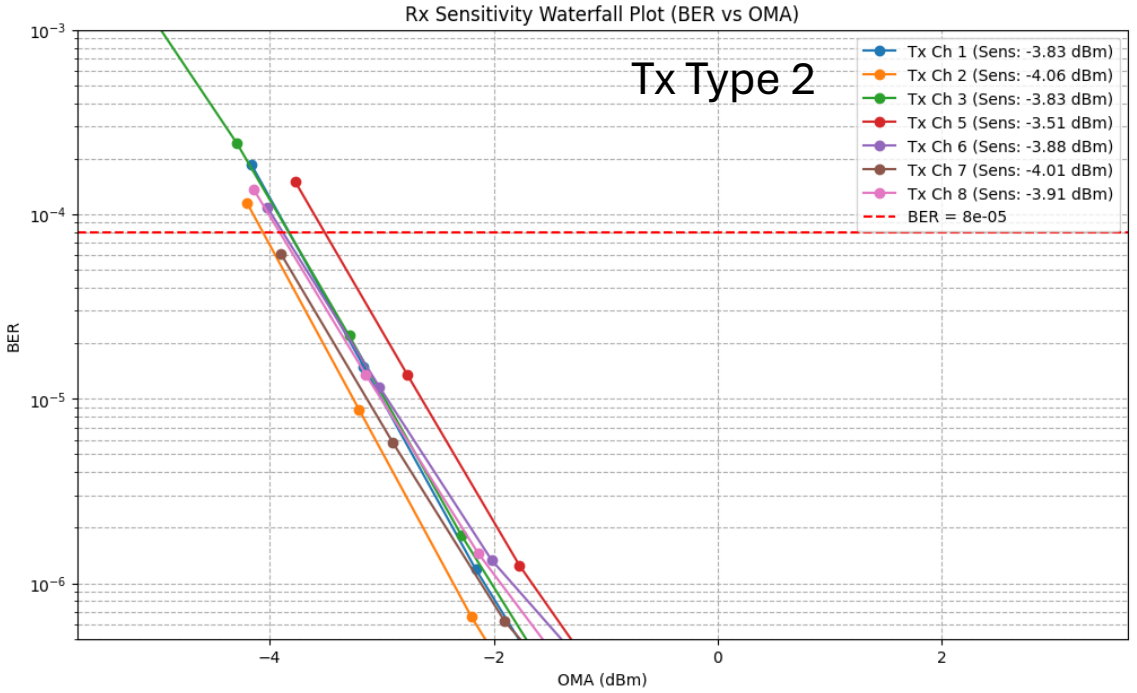
Rx Performance Evaluation with New Reference Equalizer



- Adding a 1-tap DFE in the reference receiver allows transmitters that previously failed the 3.4 dB TDECQmax spec to now pass.
- Evaluation performed with:
  - Transmitters that would previously fail spec, and lower-TECQ transmitters for comparison
  - 16 Tx lanes from two 1.6T-DR8 module types
  - All Tx measurements taken on the same Rx lane, chosen from the worst available Rx
- Rx sensitivity determined using preFEC waterfall data (non-standard method, applied here for study convenience).

Rx Waterfall Results



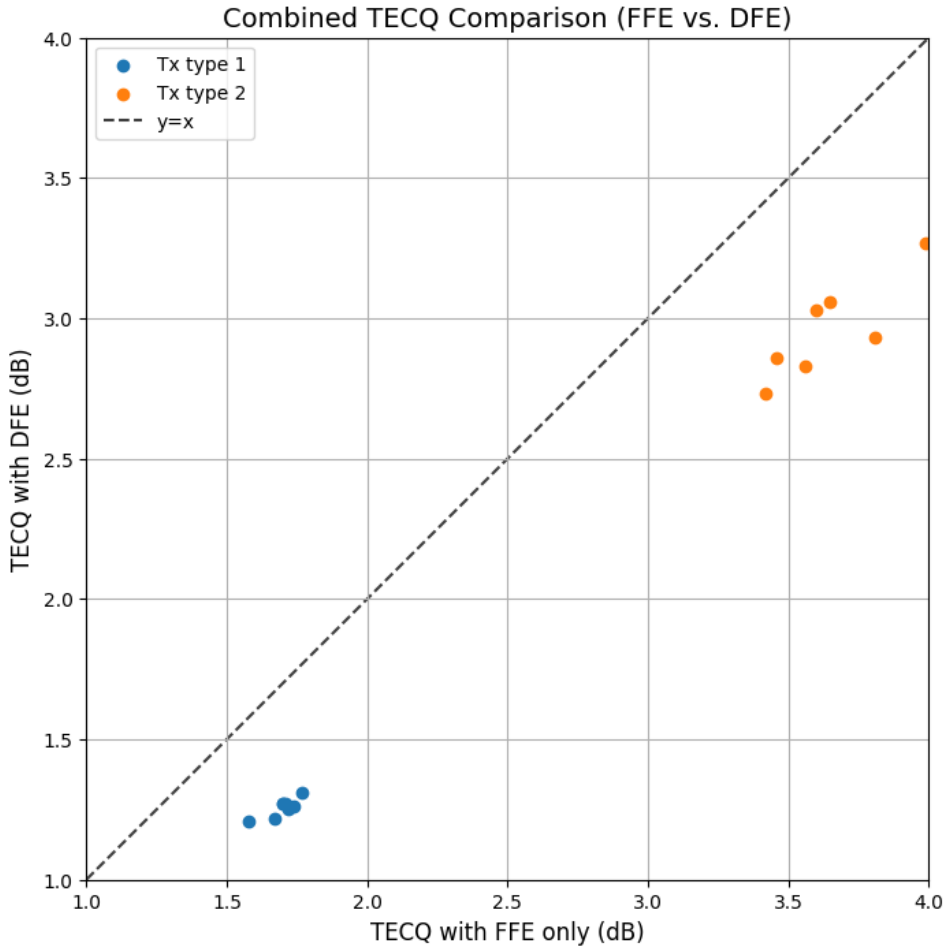


Rx sensitivity measured via:

- pre-FEC BER vs Rx OMA waterfall
- BER limit = 8e-5

TECQ results

- DFE in reference Rx reduced TECQ value by an average of 0.55dB



Results Rx Senstivity vs TECQ

DFE in the reference receiver enable to pass Txs that previously failed

However, these Txs show:

- Good link performance
- Rx sensitivity penalty consistent with TECQ expectations.

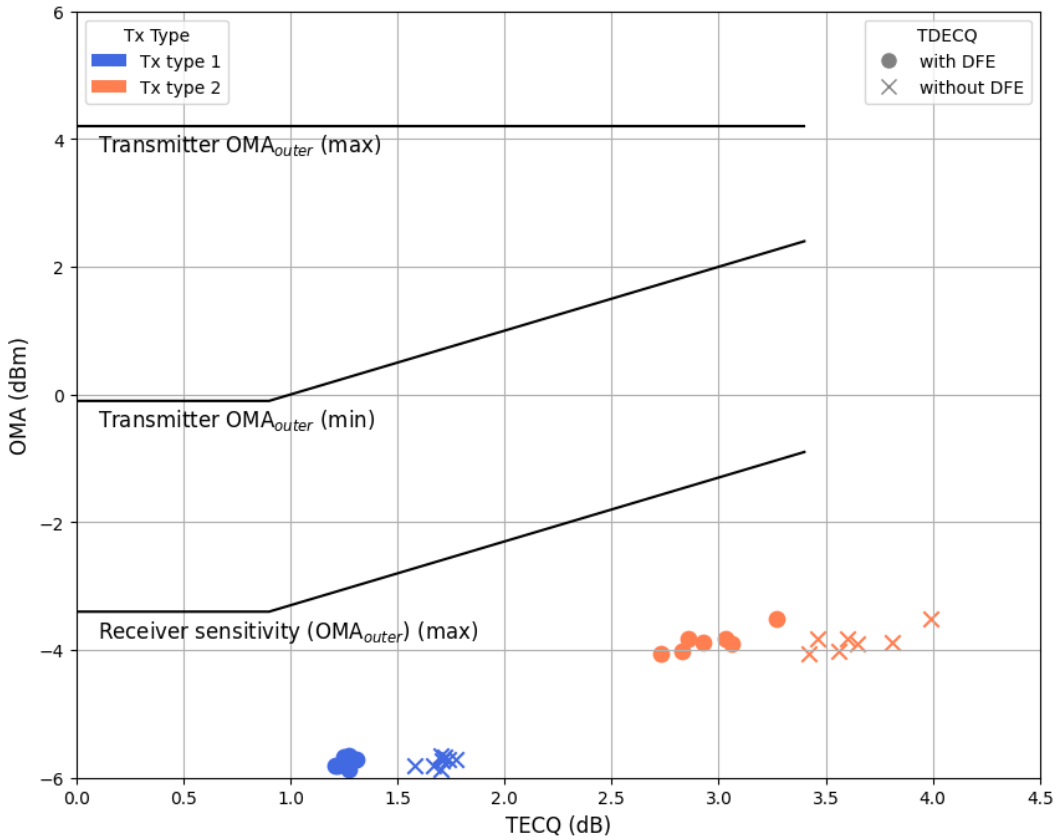


Figure 180–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ