Defining Reference equalizer for TDECQ with DFE
for comment #226

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Background

- Reference equalizer of TECQ/TDECQ was changed to 15tap FFE +1 tap DFE to get closer to what modern receiver are capable of, reducing the deviation of TECQ as a metric to distinguish good and bad transmitter.
- Tap limit was agreed to be <0.3
- However, many details of implementing DFE-based reference equalizer was not captured in the current draft
- This contribution aims to fill in the some of the required details, knowing that some other details may be captured by other contribution or in the electrical clauses.

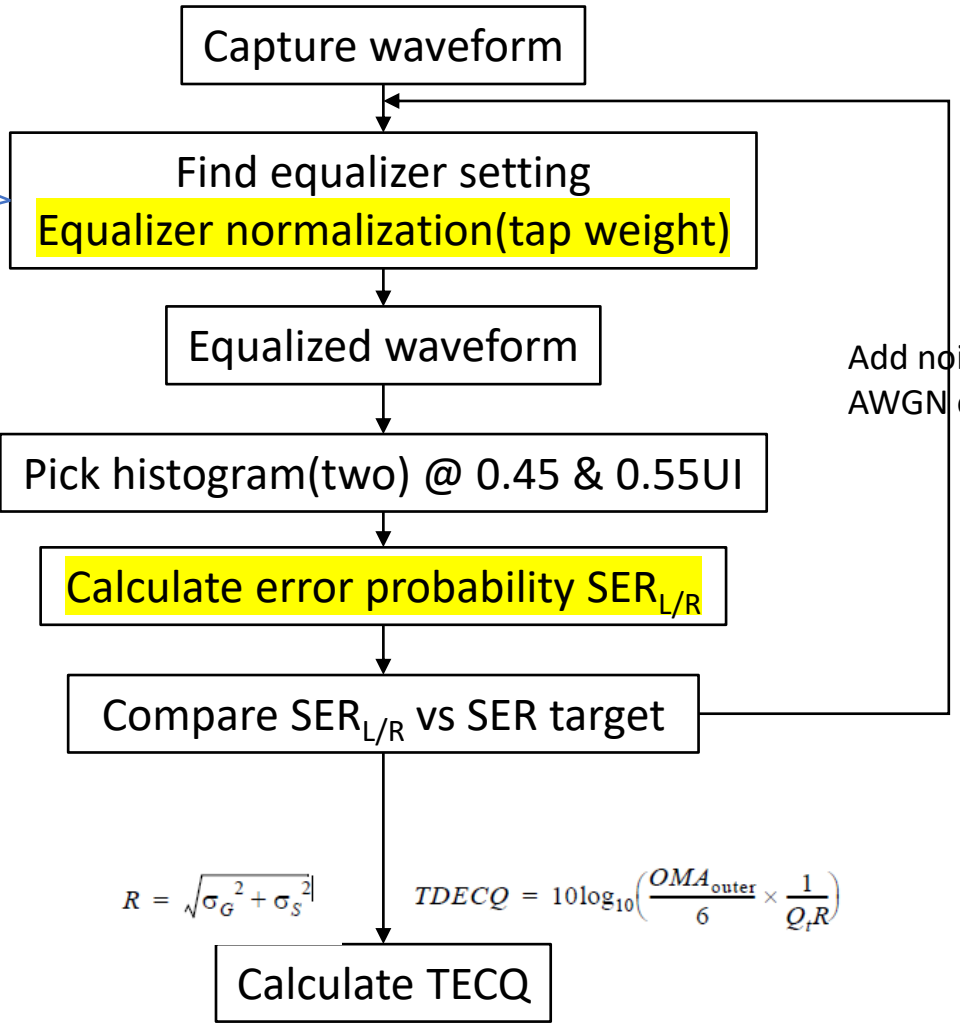
A flow view of getting TECQ/TDECQ

Decision @ sampling point of 0.5UI

FFE optimization based on 0.5UI histogram

Find FFE and DFE tap

Not in the scope of this contribution



Normalizing Equalizer tap weights

Input pulse $P_i(k) = P_{ave} + OMA/2 * D[k]$ $D[k] \in [-1, -1/3, 1/3, 1]$

For simplicity, pretend we already have four levels /suppose we have long-run 3 and -3

Output pulse $P_k = \sum_{i=-3}^{11} w(i) \times P_{k+i} - b(1) \times P(k-1)$。

$$P_k = \left(\sum_{i=-3}^{11} w(i) - b(1)\right) \times P_{ave} + OMA/2 \times \left(\sum_{i=-3}^{11} w(i) \times D[k+i] - b(1) \times D[k-1]\right)$$

To maintain DC gain =1

Proposed change $\sum_{i=-3}^{11} w(i) - b(1) = 1$

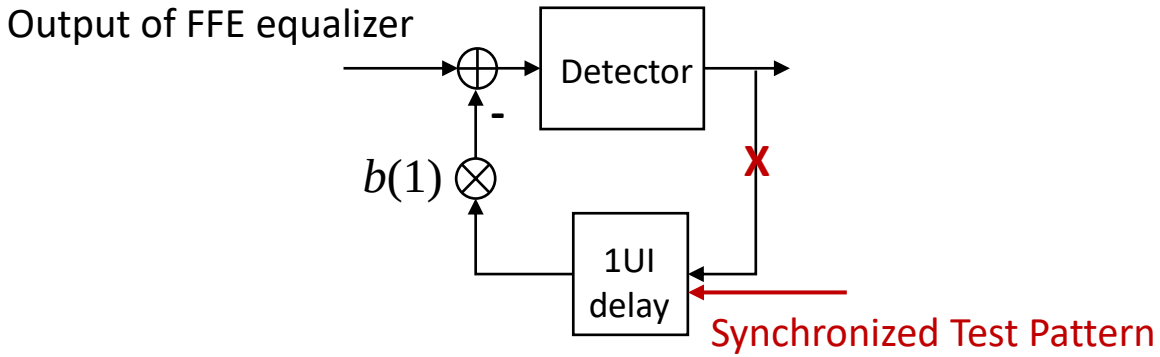
- Both w(i) and b(1) apply to OMA/2
- FFE limit are applied to the normalized weight, i.e., w(i)/w(0),
- However, DFE limit is not a normalized value.
- No need to call out normalization to OMA/2, in fact it is not a normalization, it is the definition of coefficient.

Calculating SER with DFE

- We could still follow the same procedure to estimate the SER of the equalized waveform.
- However, the addition of DFE brings error propagation, and uncertainty of the DFE error distribution, that need to be considered. Unlike the electrical PMDs and x-AUIn interfaces, SER target for optical clauses has not been adjusted for the effect of error propagation of DFE equalizer.
- One way adapting to the DFE equalizer, is to use a correction factor to get $SER_{EP} = SER_0 \times f$, then require SER_{EP} approximating SER target.

$$f = \frac{1}{1 - (P_E - SER_0)}, \qquad P_E = 3/4P$$

SER_0 is the calculated SER without error propagation, to achieve SER_0, one way is to apply correct symbol sequence instead of the estimated sequence in the feed-back equalizer



Summary of the proposed changes

Some major updates to Secion 180.9.5 **Transmitter and dispersion eye closure for PAM4 (TDECQ) is required to reflect the changes.**

1. Add Figure 180-8 TDECQ conformance test block diagram, In which it is beneficial to clearly point out
    1. the scope of reference receiver and reference equalizer,
    2. Point of measurement of OMA
    3. Point of noise addition
2. Add Figure 180-9 Illustration of the TDECQ measurement, based on Figure 121-5, but with the sampling point pointed out.
3. Add Figure 180-10 TDECQ reference equalizer functional model.
4. Change the normalization requirement in Table 180-18.
5. Add text to Calculation of error probability （pick the histogram after equalization?）

Propose to Add Figure 180-8 TDECQ conformance test block diagram

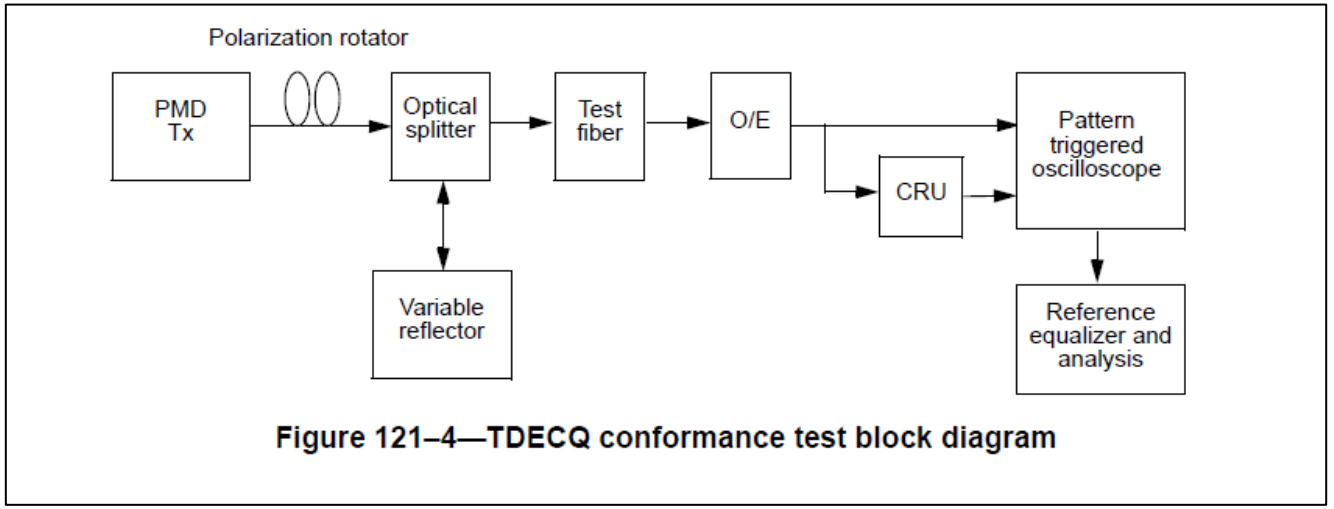


Figure 121–4—TDECQ conformance test block diagram

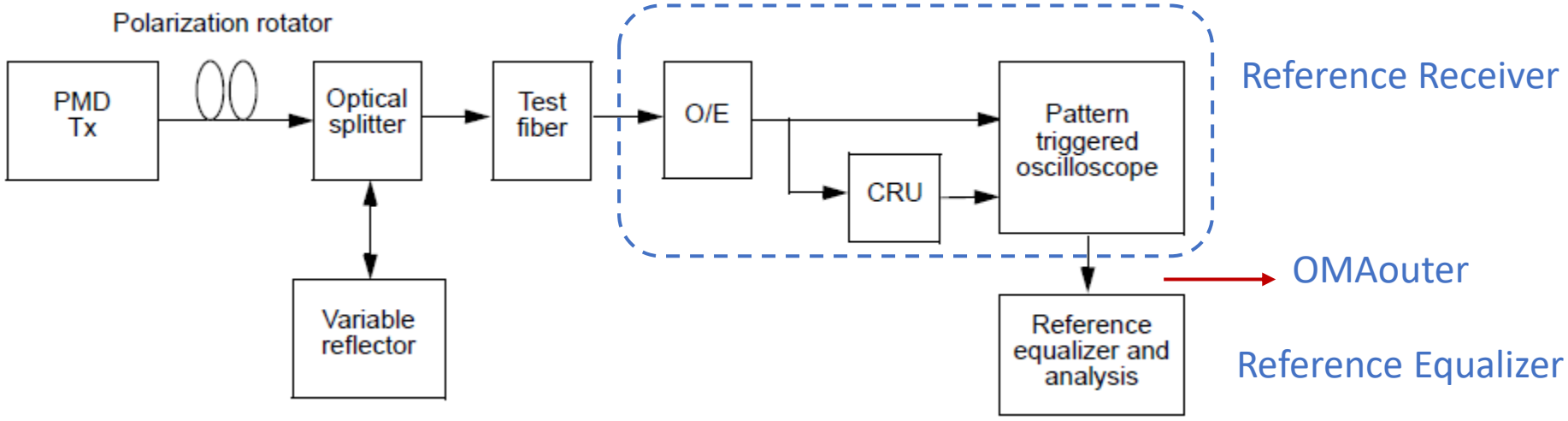


Figure 180-8 – TDECQ conformance test block diagram

Propose to Add Figure 180-9 Illustration of the TDECQ measurement

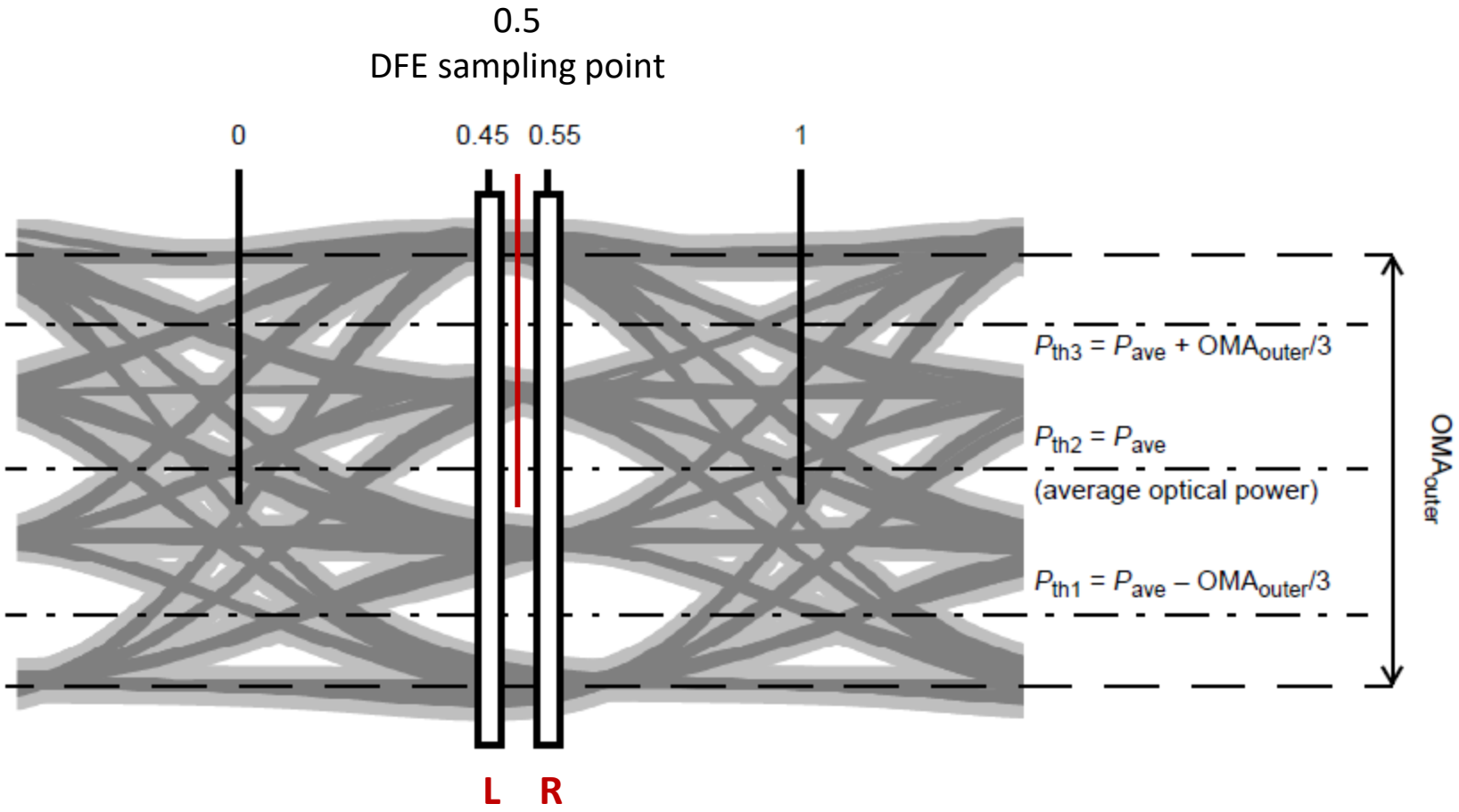


Figure 180-8 – Illustration of the TDECQ measurement

Propose to Add Figure 180-10 TDECQ reference equalizer functional model （1）

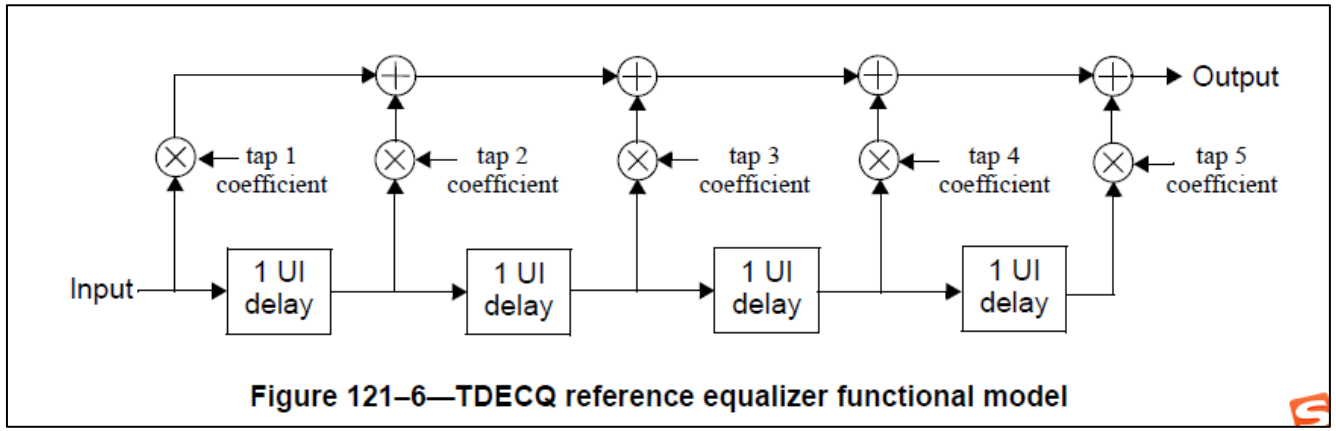
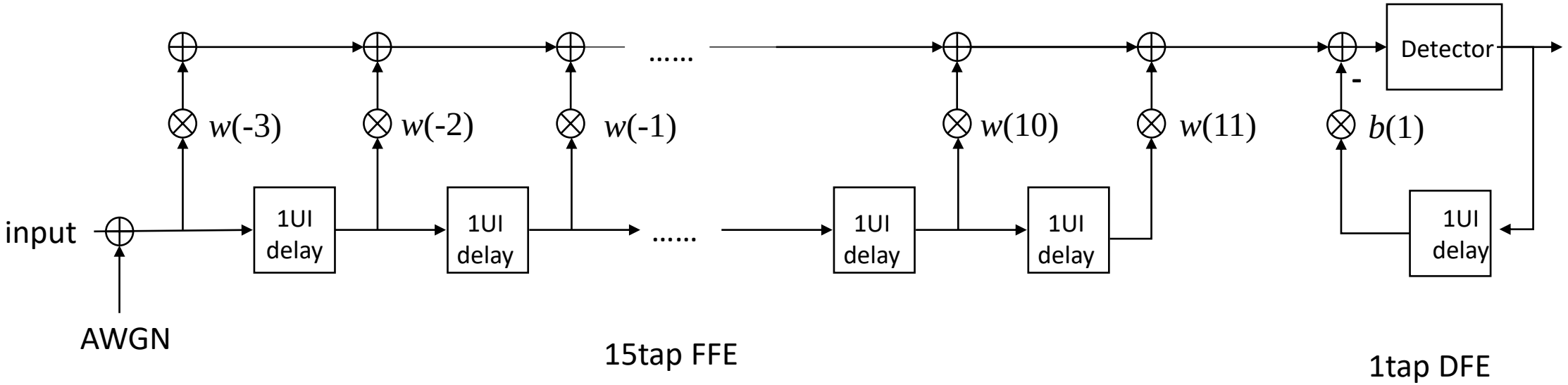


Figure 121–6—TDECQ reference equalizer functional model



Propose to update calculated SER to reflect error propagation, with changes to the equalizer reference model(2)

$SER_{EP} = SER_0 \times f \rightarrow$ SER target

$$f = \frac{1}{1 - (P_E - SER_0)},$$

$$P_E = 3/4P$$

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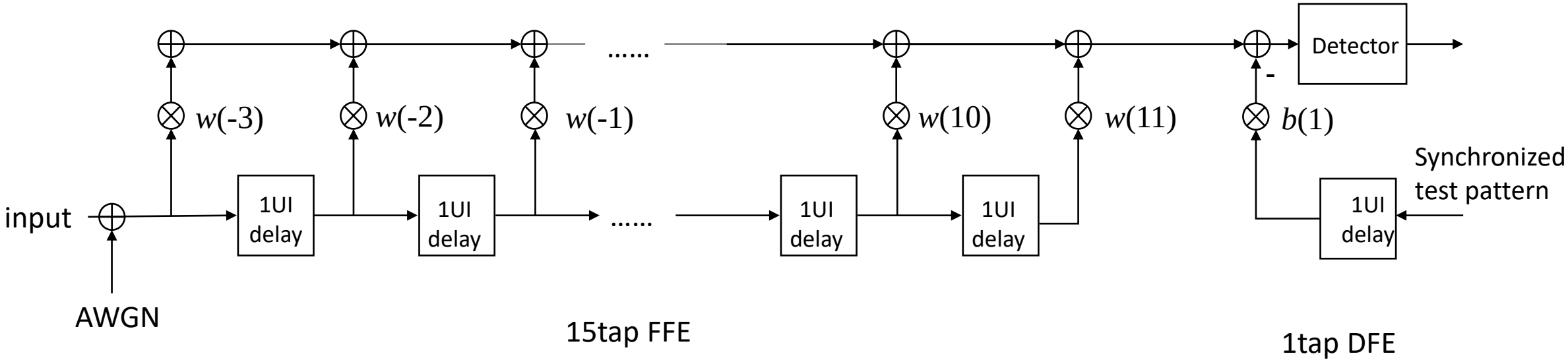

Propose to Add Figure 180-10 TDECQ reference equalizer functional model （1）

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: $i = -3$ $i = -2$ $i = -1$ $i = 1$ $i = 2$ $i = 3$ $i = 4$ $i = 5$ $i = 6$ $i \geq 7$	$w(i)/w(0)$	 –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 $w(1) > 0$	—	—	0.25
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, $w(i)$.

change footnote a to

“ The sum of 15 FFE equalizer coefficients, *w(i),* minus DFE equalizer coefficient, *b(1)*”

Or to

$$\sum_{i} \boldsymbol{w(i) - b(1)}$$

Thanks!