

DFE Differences Between Annex 178A and Clause 180

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Clause 178A DFE – the classic DFE

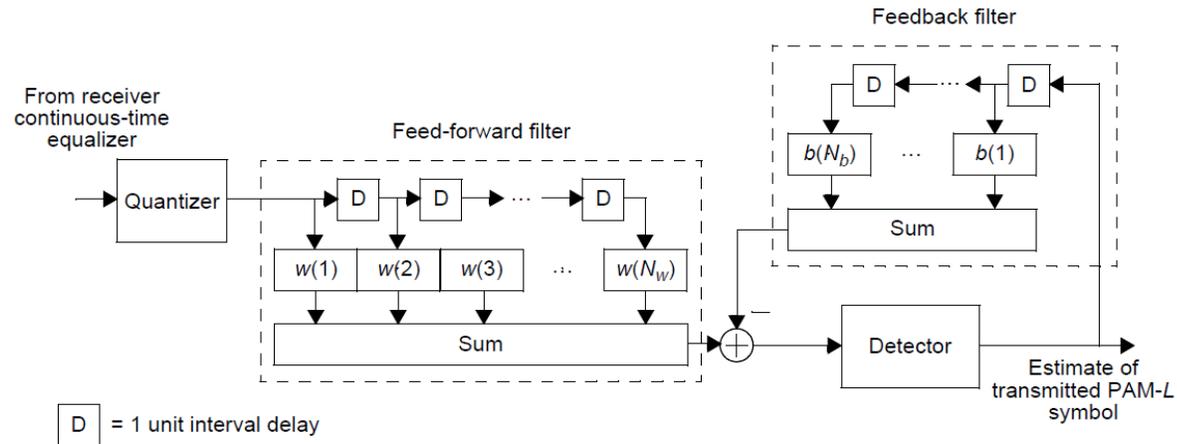


Figure 178A-9—Receiver discrete-time equalizer

- As the caption says, this is a discrete-time equalizer; all of the circuits are clocked at the symbol rate, $1/T$
 - I would prefer “Sampler” over “Quantizer”; it samples the analog waveform at discrete T-spaced time intervals
- This is the DFE described in most literature and textbooks.
 - T-spaced DFEs are often preceded by a matched filter
 - Fractionally spaced DFEs (with sampling faster than $1/T$) are also common.
- ***There is no eye diagram.*** There is simply one sample per UI.
 - An eye diagram requires a continuous time waveform at the input to the Detector

Clause 180 DFE

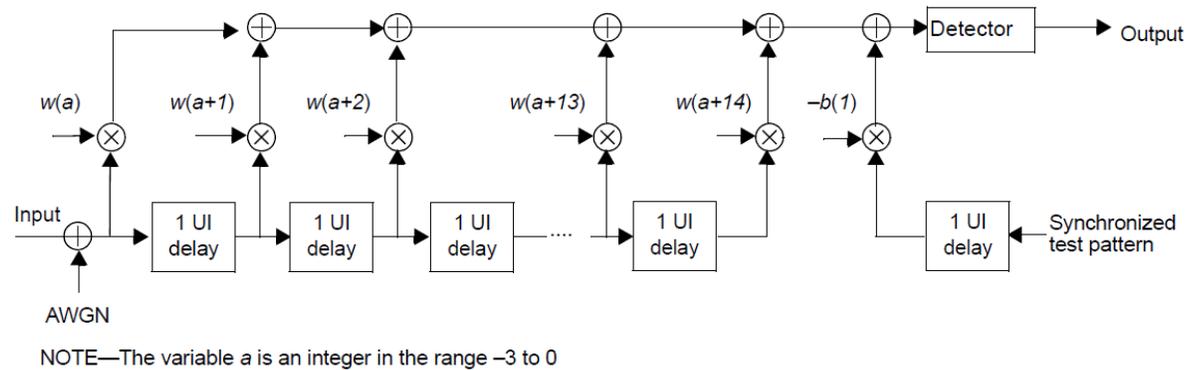


Figure 180–10—TDECQ reference equalizer functional model

- From 180.9.6.3 Reference equalizer:
 - “The reference equalizer is a 15-tap, T-spaced, feed-forward equalizer (FFE), followed by a 1-tap decision feedback equalizer (DFE)”
- This is not a DFE (there is no decision feedback path)
 - This is a “functional model” of a DFE, assuming correct decisions are made by the Detector.
- There is no figure of a true DFE in Clause 180
- Though not explicit, the use of the DFE implies a *continuous time* equalizer, which differs from that given in Annex 178A

Eye Diagram

- The description of the TDECQ computation relies on a continuous-time receive eye diagram
 - Clause 180.9.6.4 speaks of zero crossings and “two vertical histograms [that] are measured through the eye diagram”
- The only way to have such an eye diagram is to remain in continuous time until the slicer
- The feedback filter must also be continuous time (unlike a classic DFE), but is **clocked**
 - It only changes value once every symbol period and holds that value until the next clocking

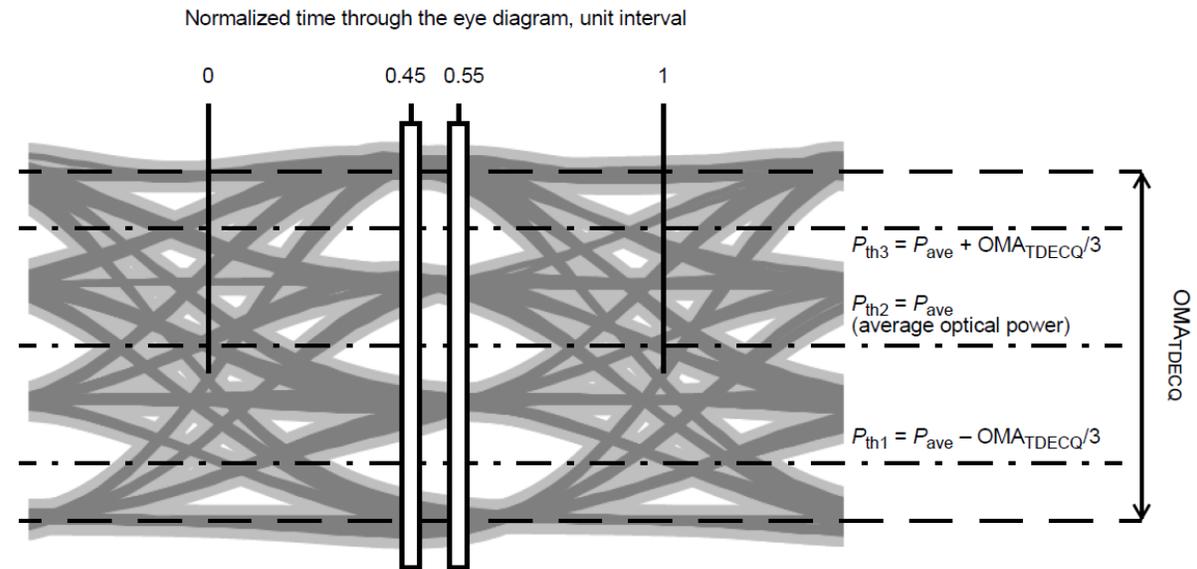
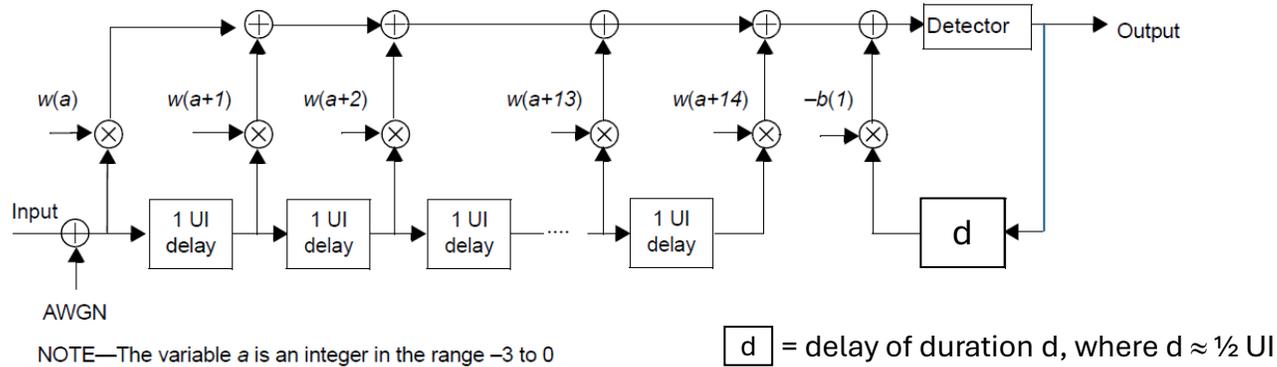


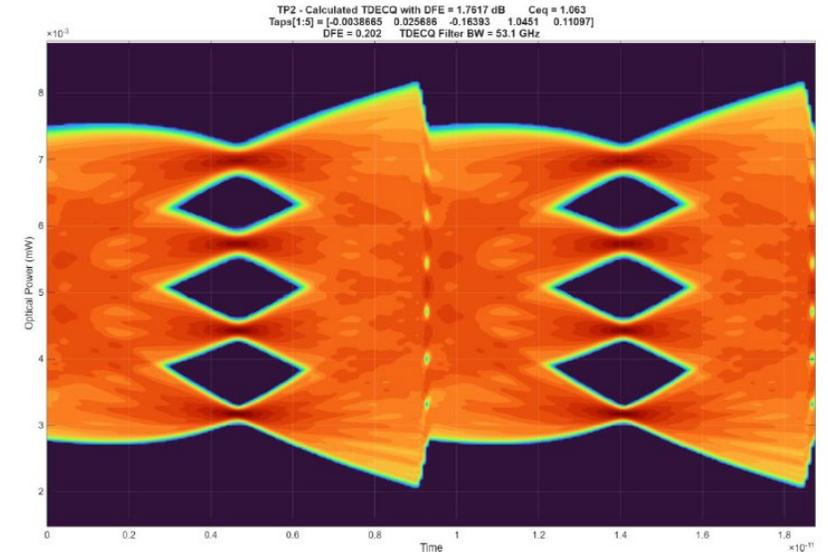
Figure 180-11—Illustration of the TDECQ measurement

Implied Clause 180 DFE



TDECQ continuous-time reference equalizer

- The signal in this block diagram is **continuous time**.
- The eye diagram is measured at the input to the Detector
- The Detector is clocked and the output changes once per symbol period and holds its value for 1 UI.
 - An infinite bandwidth feedback path is implied
- **The delay d in the feedback path is not 1 UI** for the continuous-time feedback
 - If the delay were 1 UI, the feedback would be changing value exactly when you are making the next decision
 - $d \approx \frac{1}{2}$ UI. The exact value is not critical, as long as $.14 \text{ UI} < d < .86 \text{ UI}$ to ensure that the feedback changes value before the left vertical histogram slice or after the right vertical histogram slice
 - This representation is consistent with the TDECQ description but does not imply an implementation



Eye diagram courtesy Mark Kimber, Semtech

Other points

- Describing the reference equalizer as a “feedforward equalizer followed by a feedback equalizer” is not standard terminology
 - A DFE is normally described as a transversal feedforward filter , a decision element, and a transversal feedback filter – that is, the DFE includes the feedforward section
- The eye diagram of Figure 180-11 should show a discontinuity where the feedback level changes value.

Recommendations (all editorial)

- Add a figure of the reference DFE shown on page 6
 - This can be a companion figure to Figure 180-10, the functional model shown on page 4
- Add text describing the DFE reference equalizer as a continuous-time equalizer
- Change the sample eye diagram in Figure 180-11 to show discontinuity resulting from feedback (see page 6)

- In 180.9.6.3, change:

The reference equalizer is a 15-tap, T-spaced, feed-forward equalizer (FFE), followed by a 1-tap decision feedback equalizer (DFE)

to

The reference equalizer is a continuous-time decision feedback equalizer consisting of 15 symbol-spaced feed-forward taps, a decision circuit (Detector), and 1 feedback tap.