ECQ method

(comment R2-205 and others)

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Comment R2-205

- R2-205 SC 180.9.6.3 P 483 L 13 TR
- 802.3 is not a test specification (the 802.3 companion test specification was withdrawn). We are not supposed to be writing a model of a DSP. We are supposed to be defining TECQ and TDECQ, which are measured with a scope. Different. The scope does not do T-spaced sampling, for example. Previously, and for ECQ in other clauses, we had " One way of doing this, using estimated PAM4 symbol error ratio as the figure of merit for the equalized signal, is described below." and "Alternative optimization methods such as minimum mean squared error (MMSE) may be used to determine equalizer tap weights to reduce test time, and are expected to report equal or higher values of TDECQ. These alternative methods should not be used for receiver sensitivity and stressed receiver sensitivity calibration." So it was clear that the normative value is the best value (which does not take long to find, in spite of assertions that it must). We said that a short cut that reads high may be used, where reading high does not weaken the spec. Which would have been the case even if not stated.
  But this says: "For a given sampling phase phi0 and assumed RMS value sigmaG for Gaussian noise eta(t), determine the equalizer coefficients w and b(1), subject to the limits in Table 180–16, that result in the minimum mean squared error (MMSE) between yn and x(n). Alternative optimization methods may be used to determine equalizer tap weights if they report comparable values of TDECQ." This tries to make the inaccurate high-reading over-prescriptive method normative.
  There are other flaws in this but the whole concept is misguided; they should be removed when the damage in this draft is undone.
- What a mess. Replace the whole of 180.9.6 with the normal stable ECQ definition, following 168.7.5 (the latest sound version, I believe) with the few known relevant modifications for signalling rate and number FFE taps and the addition of the DFE.

ECQ = TECQ, TDECQ or SECQ

Other comments

- R2-188, R2-206, R2-141, R2-205, R2-144, R2-15, R2-204, R2-194, R2-189, R2-16, R2-126, R2-17, R2-18 and R2-19 point out bugs in the draft 180.9.6, which can be avoided by referring back to Clause 121 as usual
- R1-284 and R1-287

For comparison: relevant section in Draft 2.1

180.9.5 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The TDECQ of each lane shall be within the limits given in Table 180–8 if measured using the methods specified in 121.8.5.1, 121.8.5.3, and 180.9.5.1, with the following exceptions:

— The signaling rate of the test pattern generator is as given in Table 180–8 and uses the test pattern specified for TDECQ in Table 180–16.

— TDECQ is defined with all receive lanes in operation using test pattern 3 or 5 (see Table 180–14).
The received test patterns shall be asynchronous to the pattern used to test the transmitter, and shall have power levels as specified in Table 180–9 for the aggressor lanes in the stressed receiver sensitivity test.

— For those cases where there is an xAUI-n chip-to-chip (C2C) or chip-to-module (C2M) interface (see Table 180–1 through Table 180–4), the clock source for the SSPRQ test pattern is derived from the clock recovered from the xAUI-n input signal. The pattern of the xAUI-n input signal may be PRBS31Q, scrambled idle, or a valid xBASE-R signal.

— The reference receiver, composed of the combination of the O/E converter and the oscilloscope, has a 3 dB bandwidth of approximately 53.125 GHz with a fourth-order Bessel-Thomson response to at least 1.3×106.25 GHz, and at frequencies above 1.3×106.25 GHz, the response should not exceed –20 dB. Compensation may be made for any deviation from an ideal fourth-order Bessel-Thomson response.

— The reference equalizer is a 15-tap, T-spaced, feed-forward equalizer (FFE), followed by a 1-tap decision feedback equalizer (DFE), where T is the symbol period, with equalizer coefficient constraints as shown in Table 180–18. The reference equalizer may be implemented in the oscilloscope, but it is not considered part of the reference receiver.

— The target PAM4 symbol error ratio is 4.56×10^{-4} and the related Qt value (see 121.8.5.3) is 3.428.

— The normalized noise power density spectrum N(f) is equivalent to white noise filtered by a fourth-order Bessel-Thomson response filter with a 3 dB bandwidth of 53.125 GHz.

— The optical return loss is as given in Table 180–8.

— The lowest measured TDECQ values are achieved with the equalizer optimization method described in 121.8.5. Alternative optimization methods such as minimum mean squared error (MMSE) may be used to determine equalizer tap weights to reduce test time, and are expected to report equal or higher values of TDECQ. These alternative methods should not be used for receiver sensitivity and stressed receiver sensitivity calibration.

Proposed text for 180.9.6 *(start)*

180.9.6 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The TDECQ of each lane shall be within the limits given in Table 180–7 if measured using the test setup specified in 121.8.5.1, with the optical channel specified in 180.9.6.1, the measurement method in 121.8.5.3, and the reference equalizer in 180.9.6.2, with the following exceptions:

— The signaling rate of the test pattern generator is as given in Table 180–7.

— The test pattern is as specified for TDECQ in Table 180–14.

— TDECQ is defined with all receive lanes in operation using test pattern 3 or 5 (see Table 180–14).

— The received test patterns shall be asynchronous to the pattern used to test the transmitter, and shall have power levels as specified in Table 180–8 for the aggressor lanes in the stressed receiver sensitivity test.

— For those cases where there is an xAUI-n chip-to-chip (C2C) or chip-to-module (C2M) interface (see Table 180–1 through Table 180–4), the clock source for the SSPRQ test pattern is derived from the clock recovered from the xAUI-n input signal. The pattern of the xAUI-n input signal may be PRBS31Q, scrambled idle, or a valid xBASE-R signal.

— The combination of O/E converter and the oscilloscope and the clock recovery unit are as defined for the reference receiver in 180.9.2. Compensation may be made for any deviation from an ideal fourth-order Bessel-Thomson response.

— OMAouter is defined by 180.9.5.

— The target PAM4 symbol error ratio is 4.56×10^{-4} and the related Qt value (see 121.8.5.3) is 3.428.

— The normalized noise power density spectrum, $N(f)$ in Equation (121–9) and Equation (121–10), is equivalent to white noise filtered by a fourth-order Bessel-Thomson response filter with a 3 dB bandwidth of 53.125 GHz.

— The optical return loss is as given in Table 180–8.

…continued (option 1, using "A" 1/3)

— If necessary, the calculation of $F(yi)$ and $CFL1(yi)$, $CFL2(yi)$, $CFL3(yi)$, $CFR1(yi)$, $CFR2(yi)$, and $CFR3(yi)$ in 121.8.5.3 is modified to allocate samples according to their positions in time in the test pattern rather than where they are found in the y dimension.

— The nominal threshold levels depend on the equalizer coefficients; they are $Pave - A/3$, $Pave$, and $Pave + A/3$, where A is the difference between the average of the equalized samples in both histograms derived from threes in the pattern and the average of the equalized samples in both histograms derived from zeros.

— $Pth1$, $Pth2$, and $Pth3$ are varied from their nominal values by up to ±2% of OMAouter in order to optimize TDECQ.

A block diagram for the TDECQ conformance test is shown in Figure 180–9. Other equivalent measurement implementations may be used with suitable calibration.

[Figure 180–9, TDECQ conformance test block diagram, as in D3.2]

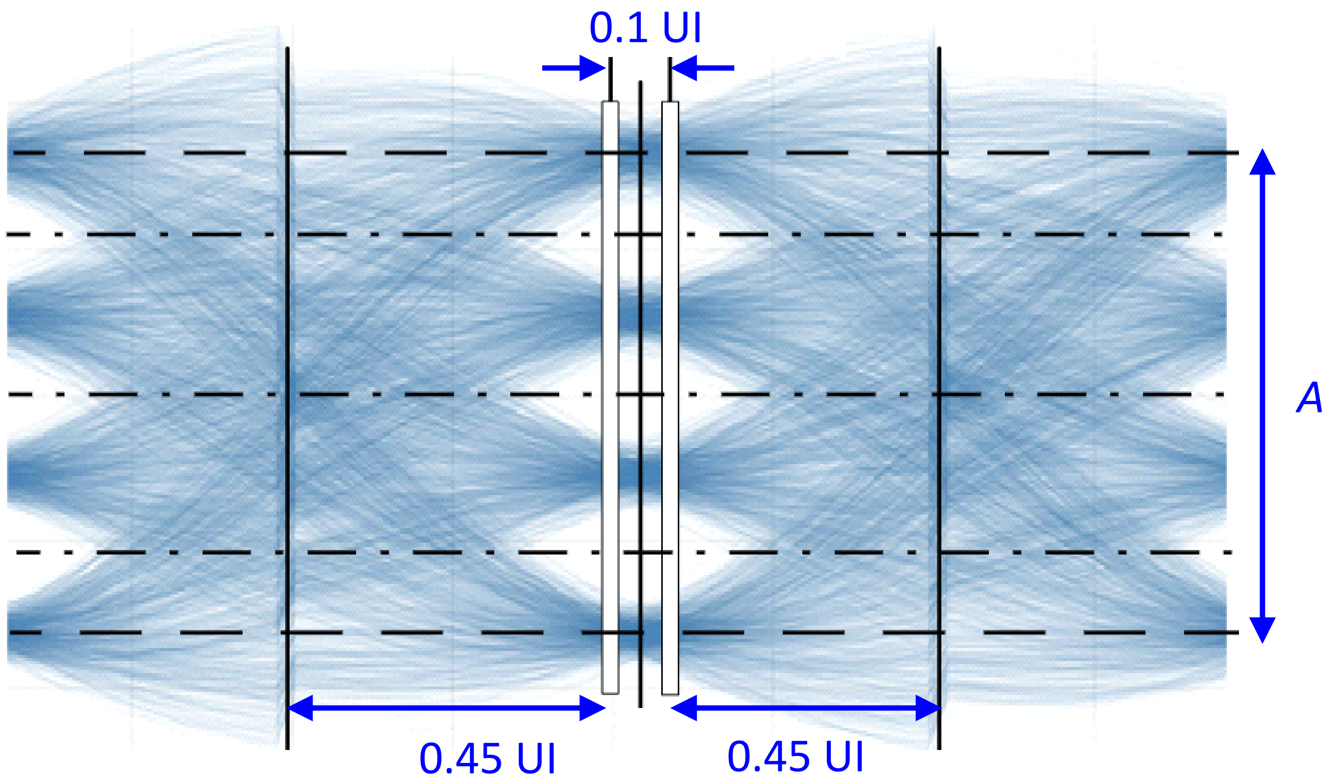
An example of an equalized eye diagram is shown in Figure 180–10.

— The lowest measured TDECQ values are achieved with the equalizer optimization method described in 121.8.5. Alternative optimization methods such as minimum mean squared error (MMSE) may be used to determine equalizer tap weights to reduce test time, and are expected to report equal or higher values of TDECQ. These alternative methods should not be used for receiver sensitivity and stressed receiver sensitivity calibration.

The note about allocating samples is probably unnecessary for 180 and 181, but it could improve accuracy in 182 and 183 where Qt is lower

Option 1, using "A" 2/3

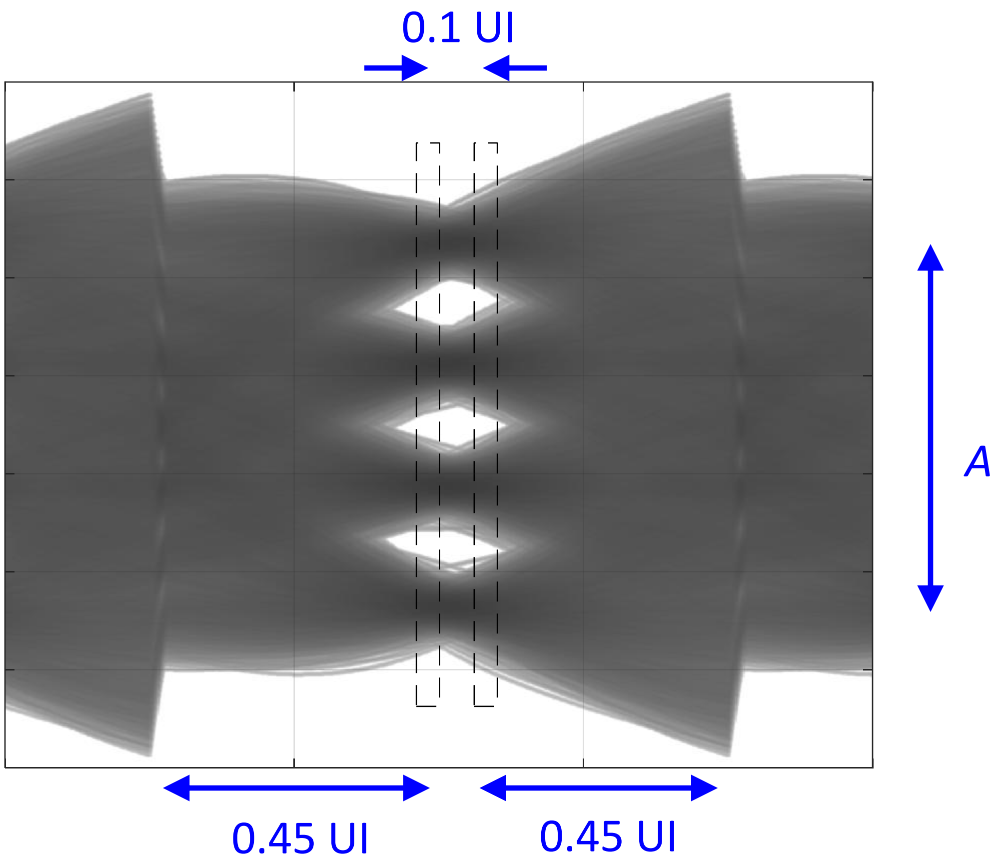
Figure 180–10—Illustration of the TDECQ measurement



- If available, replace the graphic with one with the correct histogram window widths, transparent histogram windows, without the three vertical lines, and with the feedback transitions at 180° from the histograms, as illustrated on the next slide
- No need to label the horizontal lines, which could be left out too

Option 1, using "A" 2/3

Figure 180–10—Illustration of the TDECQ measurement



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…continued (option 1, using "A" 3/3)

180.9.6.1 Channel requirements

[as in D3.2 but renumbered]

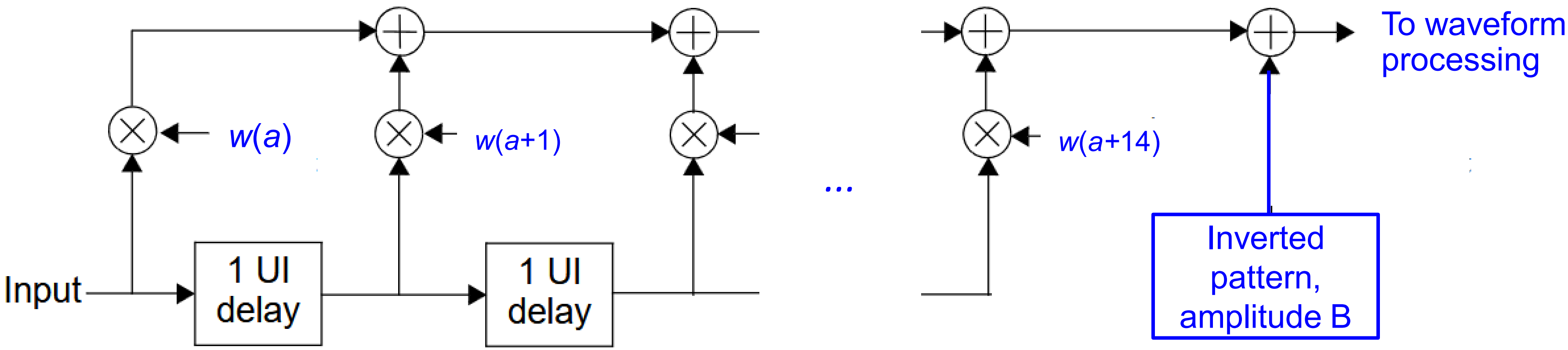
180.9.6.2 TDECQ reference equalizer

The reference equalizer has 15 T-spaced feed-forward taps, where T is the symbol period, and a pattern generator representing a single decision feedback tap. This feedback pattern is an inverted and level-shifted copy of the test pattern, with timing representing feedback from the previous unit interval. It is added as a high bandwidth signal with levels $–B/2$, $–B/6$, $B/6$, and $B/2$, changing value 0.5 UI after the mean timing of the histogram windows, as shown in Figure 180–10. The peak-to-peak amplitude B is to be optimised along with other tap coefficients, the three thresholds, and the timing of the pair of histogram windows, subject to the limit for $b(1)$, where $b(1) = B/A$.
A functional model of the reference equalizer is shown in Figure 180–11; the reference equalizer tap coefficients are specified in Table 180–16.

[Table 180–16 as in D3.2, without footnote b related to b(1)]

Both options

Figure 180–11—TDECQ reference equalizer functional model



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continued (option 2, using OMA_{TDECQ}) 1/3

— If necessary, the calculation of $F(yi)$ and $CFL1(yi)$, $CFL2(yi)$, $CFL3(yi)$, $CFR1(yi)$, $CFR2(yi)$, and $CFR3(yi)$ in 121.8.5.3 is modified to allocate samples according to their positions in time in the test pattern rather than where they are found in the *y* dimension.

— The nominal threshold levels depend on the equalizer coefficients; they are $Pave - OMA_{TDECQ}/3$, $Pave$, and $Pave + OMA_{TDECQ}/3$, where OMA_{TDECQ} is OMA of the equalized waveform according to the method for OMA_{outer} defined in 180.9.5.

— $Pth1$, $Pth2$, and $Pth3$ are varied from their nominal values by up to ±2% of OMAouter in order to optimize TDECQ.

A block diagram for the TDECQ conformance test is shown in Figure 180–9. Other equivalent measurement implementations may be used with suitable calibration.

[Figure 180–9, TDECQ conformance test block diagram, as in D3.2]

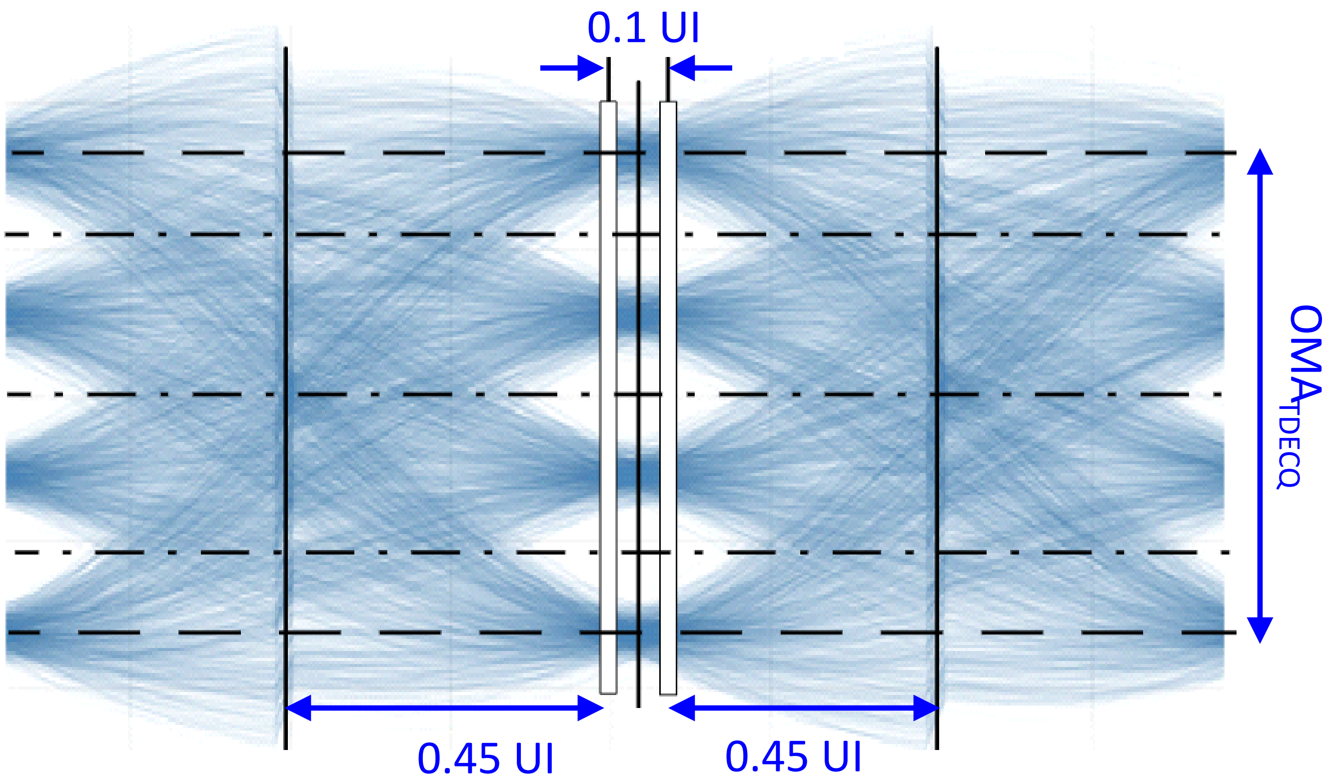
An example of an equalized eye diagram is shown in Figure 180–10.

— The lowest measured TDECQ values are achieved with the equalizer optimization method described in 121.8.5. Alternative optimization methods such as minimum mean squared error (MMSE) may be used to determine equalizer tap weights to reduce test time, and are expected to report equal or higher values of TDECQ. These alternative methods should not be used for receiver sensitivity and stressed receiver sensitivity calibration.

The note about allocating samples is probably unnecessary for 180 and 181, but it could improve accuracy in 182 and 183 where Qt is lower

Option 2, using "OMA_{TDECQ}" 2/3

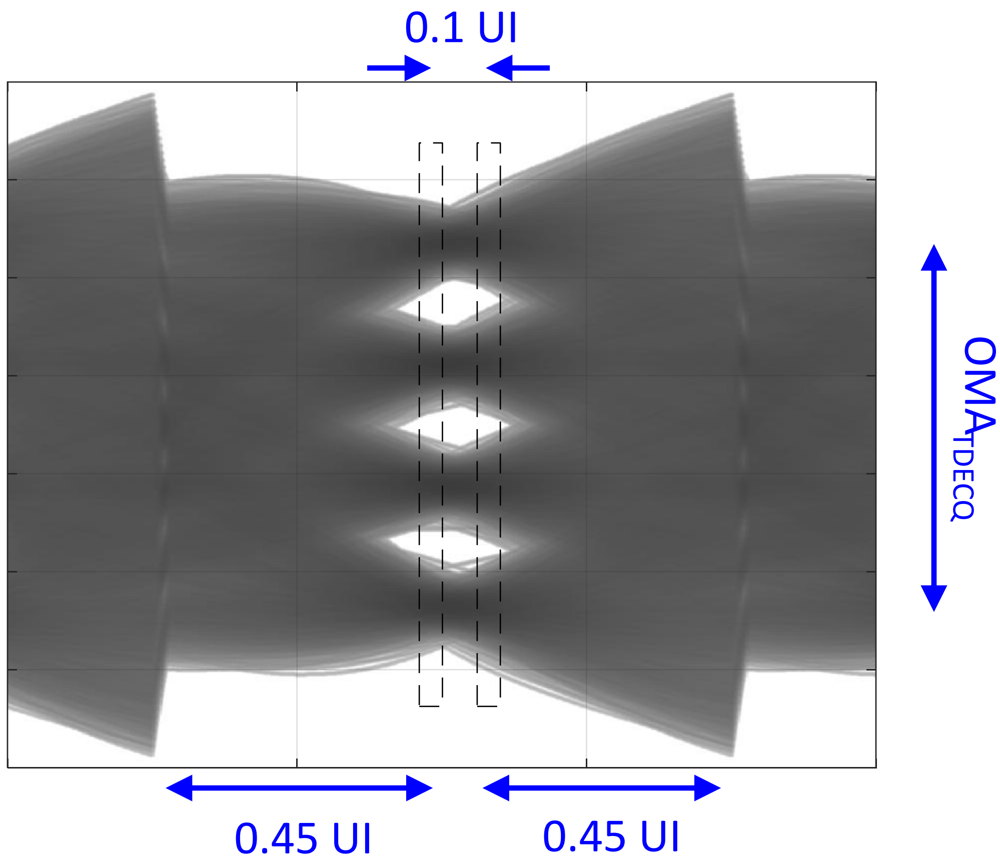
Figure 180–10—Illustration of the TDECQ measurement



- If available, replace the graphic with one with the correct histogram window widths, transparent histogram windows, without the three vertical lines, and with the feedback transitions at 180° from the histograms, as illustrated on the next slide
- No need to label the horizontal lines, which could be left out too

Option 2, using "OMA_{TDECQ}" 2/3

Figure 180–10—Illustration of the TDECQ measurement



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Option 2 using OMA_{TDECQ} 3/3

180.9.6.1 Channel requirements

[as in D3.2 but renumbered]

180.9.6.2 TDECQ reference equalizer

The reference equalizer has 15 T-spaced feed-forward taps, where T is the symbol period, and a pattern generator representing a single decision feedback tap. This feedback pattern is an inverted and level-shifted copy of the test pattern, with timing representing feedback from the previous unit interval. It is added as a high bandwidth signal with levels $–B/2$, $–B/6$, $B/6$, and $B/2$, changing value 0.5 UI after the mean timing of the histogram windows, as shown in Figure 180–10. The peak-to-peak amplitude B is to be optimised along with other tap coefficients, the three thresholds, and the timing of the pair of histogram windows, subject to the limit for $b(1)$, where $b(1) = B/OMA_{TDECQ}$. A functional model of the reference equalizer is shown in Figure 180–11; the reference equalizer tap coefficients are specified in Table 180–16.

[Table 180–16 as in D3.2, without footnote b related to b(1)]