802.3dj D1.3 Comment Resolution Electrical Track

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Incoming signals in SNDR

Comment 423

Incoming signals in SNDR
Comment 423

Cl **176D**	*SC* **176D.7.7**	*P* **733**	*L* **45**	# 423

Dudek, Mike Marvell

Comment Type **TR** *Comment Status* **X**

The referenced measurement for the measurement of SNDR does not include crosstalk from the Rx into the Tx. This is OK for 100GBASE-CR1 as the Rx signal at the measurement point is relatively small due to having to get through the channel to get to the measurement point and for the most critical systems the channel loss will be large. This is not the case for the host output where with a high loss channel the module will be requested to provide a large amplitude output.

SuggestedRemedy

Add an additional exception "- For the measurement of SNDR for the host output, the inputs to the host compliance board at TP4a shall be 1000mV peak to peak PAM4 signals with 5ps risetime and PRBS31Q, or PCS data. " Consider whether a similar requirement should be added for the module output with 500mV peak to peak amplitude and 10ps risetime.

C2M host output SNDR measurement refers to the definition in 179.9.4.5.

176D.7.7 Difference signal-to-noise-and-distortion ratio

Difference signal-to-noise-and-distortion ratio (dSNDR) for host output is defined in 179.9.4.5 with the following exceptions:

— Parameter values are taken from Table 176D–6.

— In the calculation of the reference channel transfer function in 179.9.4.5.2, the transmitter S-parameter model $S^{(t)}$ is calculated with the host model parameters in Table 176D–5, and S is the measured S-parameter matrix of the HCB used in the measurement mated with an MCB such that the mated test fixtures comply with the requirements in 179B.4.

Incoming signals in SNDR
Comment 423

The CR SNDR requires two measurements, distortion (σ_e, using linear fit) and noise (σ_n).
Neither one requires connecting any signals to the Rx lanes.

179.9.4.5.1 Measured SNDR

$SNDR^{(meas)}$ of a specific lane, at a specific equalization setting, is calculated by the following procedure.

Set the transmitter on the lane under test to transmit PRBS13Q and the transmitters on all other lanes to transmitting either PRBS31Q or PCS data.

Capture the output of the lane under test and compute the linear fit to the captured waveform and the linear fit pulse response, $p(k)$, and the linear fit error, $e(k)$, according to 179.9.4.1.1. The standard deviation of $e(k)$ is denoted by σ_e.

Measure the RMS deviation from the mean voltage at a fixed low-slope point in runs of at least 6 consecutive identical PAM4 symbols. PRBS13Q includes such a run for each of the PAM4 levels. The average of the four measurements is denoted by σ_n.

If the host has high NEXT, the input signal can create significant noise at the output which the module will suffer from. This crosstalk should affect SNDR.
Module SNDR has a similar concern although the crosstalk from the module is attenuated by the host's IL.

Incoming signals in SNDR
Comment 423

Previous generations of C2M specs had a “Crosstalk generator” fed into the input as part of the host/module output tests (which resulted in EH and VEC).

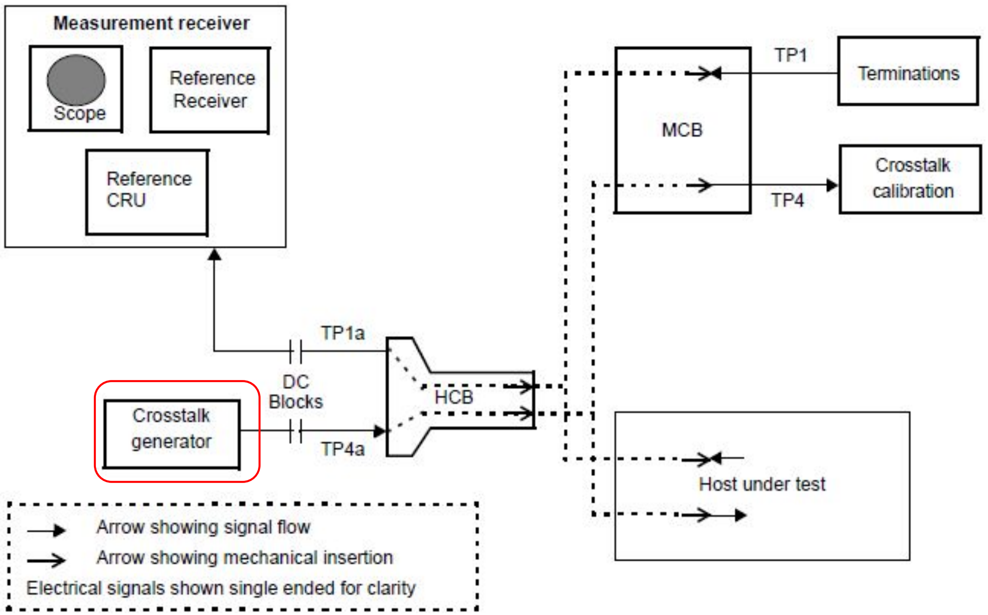


Figure 120G–6—Example host output test configuration

The crosstalk generator output is specified to be an asynchronous pattern with maximum differential peak-to-peak and minimum transition time at TP4. Equalization is not specified.

Incoming signals in SNDR
Comment 423

The suggested remedy is:

Add an additional exception "- For the measurement of SNDR for the host output, the inputs to the host compliance board at TP4a shall be 1000mV peak to peak PAM4 signals with 5ps risetime and PRBS31Q, or PCS data. " Consider whether a similar requirement should be added for the module output with 500mV peak to peak amplitude and 10ps risetime.

However, 1000 mV peak to peak at TP4a would likely violate the vf specification, and the initial setting of the module may be different. Also, rise time is currently unspecified.
The editor's proposal is to add a similar requirement with slightly different wording, as shown below, and include a NOTE informing the reader of the importance of the input signals.

176D.7.7 Difference signal-to-noise-and-distortion ratio

Difference signal-to-noise-and-distortion ratio (dSNDR) for host output is defined in 179.9.4.5 with the following exceptions:

— Parameter values are taken from Table 176D–6.

— In the calculation of the reference channel transfer function in 179.9.4.5.2, the transmitter S-parameter model $S^{(t)}$ is calculated with the host model parameters in Table 176D–5, and S is the measured S-parameter matrix of the HCB used in the measurement mated with an MCB such that the mated test fixtures comply with the requirements in 179B.4.

— The host inputs at TP4a on each lane are driven by asynchronous signals created by PRBS31Q or PCS data, with the maximum steady-state voltage specified in Table 176D–1, and transmit equalization (see 176D.7.6) set to "preset 1".

NOTE—The input signals are included to excite the NEXT that will be present when a module is plugged into the host under test.

If the initial setting in ILT is changed from "preset 1" to something else, the requirement here should change accordingly.

Steady-state voltage in ILT

Comments 136, 137, 138, 139, 140

Steady-state voltage in ILT
Comments 136, 137, 138, 139, 140

Cl **178B** *SC* **178B.11.4** *P* **781** *L* **37** # 136

Slavick, Jeff Broadcom

Comment Type **TR** *Comment Status* **X**

The steady state measurement technique differs from 136 for 179.

SuggestedRemedy

Remove the "(see `136.9.3.1.2)"

Obsolete reference

Proposed Response *Response Status* **O**

Cl **178** *SC* **178.8.9** *P* **340** *L* **34** # 137

Slavick, Jeff Broadcom

Comment Type **TR** *Comment Status* **X**

steady state measurement is also needed by ILT

SuggestedRemedy

Add "The steady state voltage specifiction needed in 178B.11.4 is specified in 178.9.2.4" to the subclause.

Proposed Response *Response Status* **O**

Cl **179** *SC* **179.8.9** *P* **372** *L* **34** # 138

Slavick, Jeff Broadcom

Comment Type **TR** *Comment Status* **X**

steady state measurement is also needed by ILT

SuggestedRemedy

Add "The steady state voltage specifiction needed in 178B.11.4 is specified in 179.9.4.1.2" to the subclause.

Proposed Response *Response Status* **O**

Cl **176C** *SC* **176C.4.3.1** *P* **704** *L* **19** # 139

Slavick, Jeff Broadcom

Comment Type **TR** *Comment Status* **X**

steady state measurement is also needed by ILT

SuggestedRemedy

Add "The steady state voltage specifiction needed in 178B.11.4 is specified in 178.9.2.4" to the subclause.

Proposed Response *Response Status* **O**

Cl **176D** *SC* **176D.7.6** *P* **732** *L* **50** # 140

Slavick, Jeff Broadcom

Comment Type **TR** *Comment Status* **X**

steady state measurement is also needed by ILT

SuggestedRemedy

Add "The steady state voltage specifiction needed in 178B.11.4 is specified in 176D.7.4" to the subclause.

Proposed Response *Response Status* **O**

Steady-state voltage in ILT
Comments 136, 137, 138, 139, 140

Proposed response to #138

PROPOSED ACCEPT IN PRINCIPLE.

[Editor's note: changed line from 34 to 43.]

It seems that the comment pertains to the steady-state voltage referred to in 178B.11.4 (in the definition of the function CHECK_EQ), addressed by comment #136.
"steady-state voltage" currently points to 136.9.3.1.2 - which is superseded by 179.9.4.1.

One way to handle this is to change 178B.11.4 to point to 179.9.4.1 (definition of steady-state voltage in this project) instead.
However, we should not expect the ILT implementation (which is probably 100% logic design nowadays) to verify that steady-state voltage (essentially an electrical/analog spec) is not exceeded .
It seems preferable to change the definition of CHECK_EQ such that it does not refer to the steady-state voltage but only the the equalization capability (which is more natural in the context of ILT).
To ensure that the steady-state voltage is not exceeded by equalization, an explicit requirement should be added in the electrical specifications, that the sum of the absolute values of all coefficients does not exceed 1.

For CRG discussion.

Text in question

CHECK_EQ(ck_ask,k)

Compares the transmitter's steady-state voltage that would result from setting transmit equalization coefficient $c(k)$ value to ck_ask, while keeping all other coefficients unchanged, against the transmitter's steady-state voltage (see 136.9.3.1.2) and equalization capability. Returns true if the resulting combination of coefficients would exceed the maximum steady-state voltage or the transmitter's equalization capability. Otherwise returns false.

Note that the steady-state voltage is specifically defined in 179.9.4.1.2 with transmitter set to preset 1; so the current wording does not make sense.

179.9.4.1.2 Steady-state voltage and linear fit pulse peak ratio

The linear fit pulse peak v_{peak} and steady-state voltage v_f are defined using the linear fit pulse response $p(1)$ through $p(M \times N_v)$ with $N_v = 400$, measured with transmit equalizer set to preset 1 (no equalization). The linear fit procedure for obtaining $p(k)$ and the values of M and N_p are defined in 179.9.4.1.1.

Steady-state voltage in ILT
Comments 136, 137, 138, 139, 140

The transmitter's equalization capability is currently specified (as a minimum) in Table 178–6, Table 179–7, Table 176C–1, and Table 176D–1, all referencing 179.9.4.1.5 ("Coefficient range").

It is assumed that the sum of the coefficients does not exceed 1, such that the "preset 1" setting creates the maximum swing (otherwise, the v_f specification becomes pointless); the words "the combination of coefficients" are supposed to address that. However, **this is not stated explicitly in 179.9.4.1.5** (nor anywhere else).

179.9.4.1.5 Coefficient range

When sufficient "increment" or "decrement" requests have been received for a given coefficient, the coefficient reaches a lower or upper bound based on the range of that coefficient or the combination of coefficients.

With $c(-3)$, $c(-2)$, and $c(-1)$ set to zero and both $c(0)$ and $c(1)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(1)$ shall be less than or equal to -0.2.

With $c(-3)$, $c(-2)$, $c(-1)$, and $c(1)$ set to zero and having received sufficient "decrement" requests so that it is at its minimum value, $c(0)$ shall be less than or equal to 0.5.

With $c(-3)$, $c(-2)$, and $c(1)$ set to zero and both $c(-1)$ and $c(0)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(-1)$ shall be less than or equal to -0.34.

With $c(-3)$, $c(-1)$, and $c(1)$ set to zero, $c(0)$ having received sufficient "decrement" requests so that it is at its minimum value, and $c(-2)$ having received sufficient "increment" requests so that it is at its maximum value, $c(-2)$ shall be greater than or equal to 0.12.

With $c(-2)$, $c(-1)$, and $c(1)$ set to zero and both $c(-3)$ and $c(0)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(-3)$ shall be less than or equal to -0.06.

NOTE—Any of the coefficients $c(-3)$, $c(-2)$, $c(-1)$, or $c(1)$ may be set to zero by asserting a coefficient request of "no equalization" for that coefficient, using the control function specified in 179.8.9, or by implementation specific means.

Steady-state voltage in ILT
Comments 136, 137, 138, 139, 140

Proposed changes in 178B.11.4

CHECK_EQ(ck_ask,k)

Compares the transmitter's steady-state voltage that would result from setting transmit equalization coefficient c(k) value to ck_ask, while keeping all other coefficients unchanged, against the transmitter's ~~steady-state voltage (see 136.9.3.1.2) and~~ equalization capability. Returns true if the resulting combination of coefficients would exceed the ~~maximum steady-state voltage or~~ the transmitter's equalization capability. Otherwise returns false.

Proposed addition to 179.9.4.1.5

179.9.4.1.5 Coefficient range

When sufficient "increment" or "decrement" requests have been received for a given coefficient, the coefficient reaches a lower or upper bound based on the range of that coefficient or the combination of coefficients.

<u>The sum of the absolute values of $c(-3)$, $c(-2)$, and $c(-1)$, $c(0)$, and $c(1)$ shall be less than or equal to 1.</u>

With $c(-3)$, $c(-2)$, and $c(-1)$ set to zero and both $c(0)$ and $c(1)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(1)$ shall be less than or equal to -0.2.

ILT presets and initialization

Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

Cl **178B** *SC* **178B.11.2** *P* **779** *L* **38** # 125

Slavick, Jeff — Broadcom

Comment Type **TR** *Comment Status* **X**

Pseudo code should have check for unsupported requests.

SuggestedRemedy

change the else to be "else if CHECK_REQ(ic_req)"

add "else ic_sts = updated coeff_sts = not supported" before the end if

add the following after the end if
CHECK_REQ(ic_req)
Compares the ic_req against the list of specified presets for the AUI component or PMD.
Returns true if the requested preset is specified and false otherwise.

Implement with editorial license

The comment generalizes the idea proposed by comment #336 against D1.1 (see below), which was accepted but was implemented outside of the UPDATE_IC pseudo-code.

Cl **176A** *SC* **176A.8.2** *P* **638** *L* **7** # 336

Rechtman, Zvi — Nvidia

Comment Type **TR** *Comment Status* **A** *Coefficients*

According to this sentence, if a preset is unsupported, the Initial Condition status should indicate 'not-updated.' On the receiving side, this status is ambiguous as it does not clarify whether the remote side has not yet responded to the preset request or if it does not support it at all.
Similarly, if the Initial Condition status indicates 'updated,' it remains unclear whether this means the preset request was successfully handled or if the coefficient configuration is not supported

SuggestedRemedy

Define the following behavior:

If a preset request is received and supported by the AUI/PMD, set the Initial Condition status (bit 8) to '1 - updated' and the Coefficient status (bits 2:0) to '000 - not updated.'

If a preset request is received but not supported by the AUI/PMD, set the Initial Condition status (bit 8) to '1 - updated' and the Coefficient status (bits 2:0) to '011 - Coefficient not supported.'

This remedy maintains backward compatibility when presets are supported and provides unambiguous indication when they are not

Response *Response Status* **C**

ACCEPT IN PRINCIPLE.
Implement suggested remedy with editorial license.

In addition, implementing this suggestion (with some additions) can enable changing the equalization setting at the beginning of training - as requested by other comments.
(without this change it would be harder)

The subsequent slides show the ***editorial changes*** suggested to address all comments in this group - independent of what the initial setting should be (a separate technical discussion).

Also, come changes are suggested to clarify that equalization changes are not supported for O1 interfaces.

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

178B.11.2 Initial condition setting response process

The handling of incoming requests is specified by the coefficient update state diagram (Figure 178B–10). The behavior of the UPDATE_IC function shall be consistent with the following algorithm.

```
if ic_req = ind_ctl
    ic_sts = not_upd
else
    if ic_req = preset 1
        Set coefficients to preset 1
    else if ic_req = preset 2
        Set coefficients to preset 2
    else if ic_req = preset 3
        Set coefficients to preset 3
    else if ic_req = preset 4
        Set coefficients to preset 4
    else if ic_req = preset 5
        Set coefficients to preset 5
    end if
    ic_sts = updated
    coef_sts = not_upd
end if
```

Addressed by #125

The variables ic_req and ic_sts are defined in 178B.14.3.1. The transmitter equalizer coefficients corresponding to each of the five presets shall be within the ranges specified in the AUI annexes or PMD clauses.

The transmitter equalizer is set to preset 1 upon entry to the QUIET state of the training control state diagram (Figure 178B–8).

Redundant,
see subsequent slide

If an AUI component or PMD is requested to configure a preset and it does not have specified coefficient values for that preset, then no changes are made to the existing coefficient values, ic_sts is set to updated and coef_sts to coefficient not supported.

Addressed by #125

Current content of 178B.11.2

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

Cl **179** *SC* **179.9.4.1.1** *P* **376** *L* **2** # 513

Dawe, Piers Nvidia

Comment Type **TR** *Comment Status* **X**

At present, the same preset 1, the loudest, is used for a special measurement condition and the default startup. While it makes sense to measure a large signal, it is bad practice to start a lane at maximum crosstalk, which exceeds the 900 mV limit for 50G/lane and 100G/lane AUIs which may be connected to a 200G AUI. C2C, C2M, CR and KR can stay aligned for convenience.

SuggestedRemedy

Assuming we like the association between 1 and default, change this to preset 6, defined in 179.9.4.1.3 as 0 0 0 1 0. Preset 1 becomes 0 0 0 0.75 0.
In 179.9.4.1.2, 179.9.5.3.3, 179.9.5.3.5 and 176D.7.12.4, change 1 to 6.
Similarly in and 176D.7.12.2, but in 176D.7.11, "preset 1" (the default startup) remains correct.

This comment, along with similar comments 512 and 514-516, suggests using a different setting at the beginning of ILT.

Related comment 457 suggests a similar change. Related comments 425 and 426 suggest a similar change with different values of c(0).

Preset 1 is specified in PMD clauses and AUI annexes to be used for linear fit (179.9.4.1.1) and for some electrical specifications. It is preferred to keep it. However, It seems reasonable to enable an initial setting that is different from preset 1. The initial conditions definitions (e.g. Table 179-8 below) contain provision for this in the OUT_OF_SYNC row. This can be used for another set of coefficients.

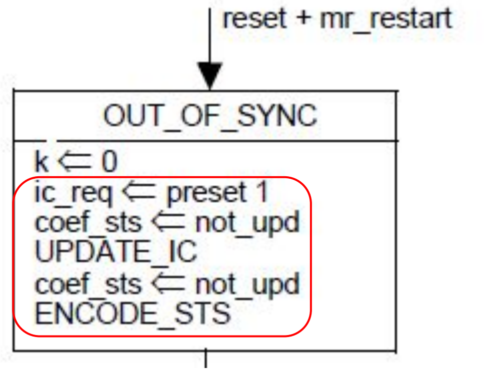
Table 179–8—Coefficient initial conditions

Coefficient update state	ic_req	$c(-3)$	$c(-2)$	$c(-1)$	$c(0)$	$c(1)$
OUT_OF_SYNC[a]	N/A	0	0	0	1	0
NEW_IC	preset 1[a]	0	0	0	1	0
	preset 2	0 ± 0.025	0 ± 0.025	0 ± 0.025	0.5 ± 0.025	0 ± 0.025
	preset 3	0 ± 0.025	0 ± 0.025	−0.075 ± 0.025	0.75 ± 0.025	0 ± 0.025
	preset 4	0 ± 0.025	0.05 ± 0.025	−0.2 ± 0.025	0.75 ± 0.025	0 ± 0.025
	preset 5	−0.025 ± 0.025	0.075 ± 0.025	−0.25 ± 0.025	0.65 ± 0.025	0 ± 0.025

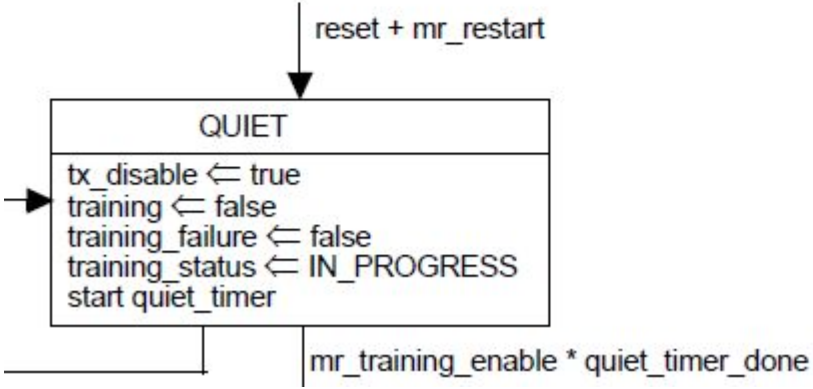
[a] Preset 1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 179.9.4.1.1). As a result, the normalized coefficients for preset 1 and OUT_OF_SYNC do not include any tolerances.

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

OUT_OF_SYNC state in Figure 178B-10



QUIET state in Figure 178B-8



The marked part should be modified to enable a separate initial setting.

Note that **both diagrams enter these states in response to the same conditions, reset + mr_restart** (QUIET is also entered from SEND_LOCAL, but only when training is disabled. In that case there is no change of coefficients).
Therefore, **there is no need to set the equalization state explicitly to "preset 1" in the QUIET state** (as in the current text of 178B.11.2).
Also, UPDATE_IC includes setting coef_sts to not_upd, so its assignment in OUT_OF_SYNC (twice) is redundant.

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

Proposed UPDATE_IC pseudo-code (based on comment #125) and subsequent text in 178B.11.2

```
if ic_req = ind_ctl
        ic_sts = not_upd
else if CHECK_REQ(ic_req)
        Set coefficients according to ic_req
        ic_sts = updated
        coef_sts = not_upd
else
        ic_sts = updated
        coef_sts = coefficient not supported
end if
```

The variables ic_req~~ and~~, ic_sts, and coef_sts are defined in 178B.14.3.1. The transmitter equalizer coefficients ~~corresponding to each of the five presents~~ shall be within the range~~s~~ specified in the AUI annex~~es~~ or PMD clause~~s~~ for the selected preset.

Redundant - see previous slide

~~The transmitter equalizer is set to preset 1 upon entry to the QUIET state of the training control state diagram (Figure 178B–8).~~

Addressed by the pseudo-code

~~If an AUI component or PMD is requested to configure a preset and it does not have specified coefficient values for that preset, then no changes are made to the existing coefficient values, ic_sts is set to updated and coef_sts to coefficient not supported.~~

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

Proposed actions in OUT_OF_SYNC state

OUT_OF_SYNC

k <= 0
ic_req <= initialize
UPDATE_IC
ENCODE_STS

Proposed change to initial conditions (all tables) (with "Coefficient update state" column removed)

Table 179–8—Coefficient initial conditions

ic_req	$c(-3)$	$c(-2)$	$c(-1)$	$c(0)$	$c(1)$
~~N/A~~initialize	~~0~~<To be discussed> ± 0.025	~~0~~<To be discussed> ± 0.025	~~0~~<To be discussed> ± 0.025	~~1~~<To be discussed> ± 0.025	~~0~~<To be discussed> ± 0.025
preset 1[a]	0	0	0	1	0
preset 2	0 ± 0.025	0 ± 0.025	0 ± 0.025	0.5 ± 0.025	0 ± 0.025
preset 3	0 ± 0.025	0 ± 0.025	–0.075 ± 0.025	0.75 ± 0.025	0 ± 0.025
preset 4	0 ± 0.025	0.05 ± 0.025	–0.2 ± 0.025	0.75 ± 0.025	0 ± 0.025
preset 5	–0.025 ± 0.025	0.075 ± 0.025	–0.25 ± 0.025	0.65 ± 0.025	0 ± 0.025

[a] Preset 1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 179.9.4.1.1). As a result, the normalized coefficients for preset 1 ~~and OUT_OF_SYNC~~ do not include any tolerances.

The values in the "initialize" row are to be discussed separately from these changes. They may be different per case, e.g., for PMDs and for AUIs.
To enable the receiver to "return to initial state" using the training protocol, there has to be a preset with the same values as "initialize" (if necessary, a new preset will be added for this purpose).

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

Proposed definition of CHECK_REQ (new function in 178B.14.3.2)

CHECK_REQ(ic_req)

This function compares the value of ic_req against the list of specified presets for the AUI component or PMD, and returns true if the value is supported and false otherwise.

ILT presets and initialization
Comments 125, 425, 426, 457, 512, 513, 514, 515, 516

The following text currently appears in 178B.14.3.5 (State diagram figures), after the variable and function definitions. It should imply that some of the variables and functions (e.g., UPDATE_C and UPDATE_IC) are not used for O1 interfaces.
However, this is not obvious for the unsuspecting reader.

For E1 interfaces, the interface control, frame lock and coefficient update state diagrams shall be implemented for each lane.

For O1 interfaces, the interface control and frame lock state diagrams shall be implemented for each lane.

It also contradicts the initial paragraph in 178B.14.3, which does not make a distinction between interfaces…

An AUI component or PMD implements one instance of each of the Training control, the Training frame lock and Coefficient update state diagrams, and the set of associated variables, functions, counters and timers defined in this subclause, independently for each of the *n* physical lanes on each of its interfaces (see 178B.5).

It is suggested to delete the text in 178B.14.3.5 above, and update 178B.14.3 as shown.

An AUI component or PMD implements one instance of each of the Training control~~,~~ and the Training frame lock ~~and Coefficient update state diagrams~~, and ~~the set of~~ their associated variables, functions, counters and timers defined in this subclause, independently for each of the *n* physical lanes on each of its interfaces (see 178B.5).

E1 interfaces also implement one instance of the Coefficient update state diagram and its associated variables and functions independently for each of the *n* physical lanes. For O1 interfaces, this diagram and its associated variables and functions are not used.

Annex 178A topics

Comments 371, 372, 536, 537

Computation of noise and interference distribution function
Comments 371, 372

Comments illustrate that the process for computing the probability distribution function of noise and interference may be difficult to follow. To improve clarity, propose to consolidate the content of 178A.1.9 and 93A.1.7.1 through 93A.1.7.3 into a new subclause.

Editor's suggestion: With editorial license…

1. Remove 178A.1.9 (content to be located to new subclause)
2. Change the first sentence of 178A.1.10.2 to: "The probability distribution function of the noise and interference amplitude p(y) is calculated using the procedure defined in 178A.1.10.3."
3. Add new subclause 178A.1.10.3 with the content on the following slide.

Computation of noise and interference distribution function, continued

178A.1.10.3 Noise and interference probability distribution function (New)

Given the transmitter equalizer, receiver continuous-time equalizer, sampling time $t_s^{(k)}$ for each signal path k, and the coefficients of the receiver discrete-time equalizer that minimize the mean-squared error, the following procedure is used to compute the probability distribution function of noise and interference amplitude $p(y)$ for use in the calculation of COM.

The sampled values of the pulse response corresponding to signal path k at the output of the feed-forward filter are defined by Equation (178A–39).

$$h_w^{(k)}(n) = \sum_{n \in i} w_{lim}(n) h^{(k)}(n - d_w - 1) \tag{178A–39}$$

where

$h^{(k)}(n)$	is $h^{(k)}(t_s^{(k)} + nT_b)$
$w_{lim}(n)$	is the feed-forward filter coefficient vector computed in 178A.1.8.1
i	is the corresponding tap index vector defined in 178A.1.8.1

The notation $n \in i$ represents n assuming each value in the index vector i and hence the summation in Equation (178A–39) is over all of the values in i.

The residual intersymbol interference is computed from $h_w^{(0)}(n)$ and the feedback filter coefficients b_{lim} defined in 178A.1.8.1 using Equation (178A–40).

$$h_{ISI}(n) = \begin{cases} 0 & n = d + 1 \\ h_w^{(0)}(n) - b_{lim}(n - d - 1) & 1 \le n - d - 1 \le N_b \\ h_w^{(0)}(n) & \text{otherwise} \end{cases} \tag{178A–40}$$

where N_b and d are defined in 178A.1.8.1.

The probability distribution function $p_{ISI}(y)$ for the intersymbol interference is computed using the procedure defined in 93A.1.7.3 substituting $h_{ISI}(n)$ for $h(n)$. Initialize $p(y)$ to $p_{ISI}(y)$.

The sampled values of the pulse response corresponding to each crosstalk signal path k ($k > 0$) at the output of the feed-forward filter are computed using Equation (178A–39). The probability distribution function $p^{(k)}(y)$ of the interference from crosstalk signal path k is then computed using the procedure defined in 93A.1.7.3 substituting $h_w^{(k)}(n)$ for $h(n)$. The value of $p(y)$ is then assigned the result of conv[$p(y)$, $p^{(k)}(y)$] where conv[u, v] is the convolution of the u and v. This assignment is repeated for all k greater than zero to include probability distribution function of the interference from all crosstalk signals.

The slope of the victim signal path pulse response around each sampled pulse response value at the output of the feed-forward filter is computed using Equation (178A–20) substituting $h^{(J)}(n)$, as defined in 178A.1.7.4, for $h^{(k)}(n)$. Let $h_w^{(J)}(n)$ be the result of this calculation. The probability distribution function $p_{DD}(y)$ for the noise due to transmitter dual-Dirac jitter is then computed using the procedure defined in 93A.1.7.3 substituting $A_{DD} h_w^{(J)}(n)$ for $h(n)$. Assign the value of $p(y)$ to the result of conv[$p(y)$, $p_{DD}(y)$] in order to include the probability distribution function for the noise due to transmitter dual-Dirac jitter.

The combined variance of the remaining noise terms at the output of the feed-forward filter is defined by Equation (178A–41).

$$\sigma_G^2 = f_b \int_{-\pi}^{\pi} [S_{tn}(\theta) + S_{jn}^{(RJ)}(\theta) + S_{rn}(\theta) + S_{in}(\theta)] \left|H_{rxffe}(\theta)\right|^2 d\theta \tag{178A–41}$$

where

$S_{jn}^{(RJ)}(\theta)$	is the power spectral density of the noise due only to transmitter random jitter defined by Equation (178A–42)
$H_{rxffe}(\theta)$	is the transfer function of feed-forward filter defined by Equation (178A–43)

$$S_{jn}^{(RJ)}(\theta) = \sigma_X^2 \sigma_{RJ}^2 \left|\mathrm{DFT}[h^{(J)}(n)]\right|^2 / f_b \tag{178A–42}$$

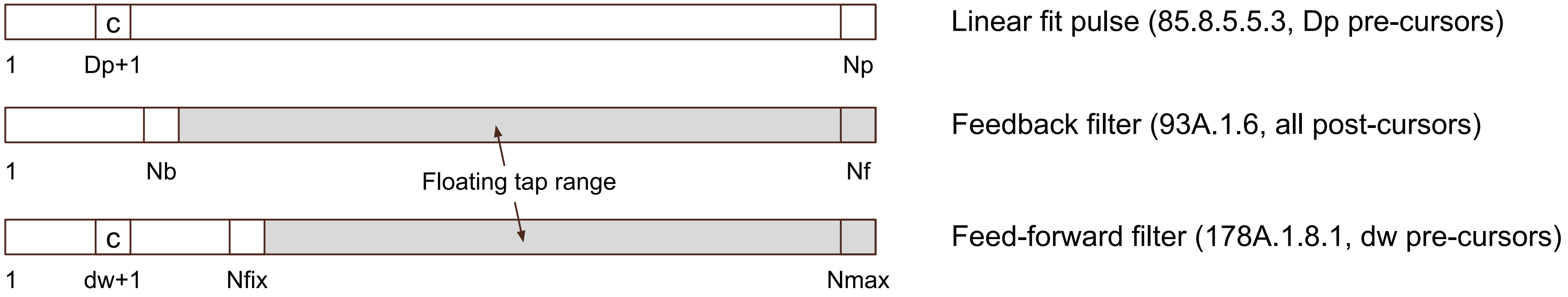
$$H_{rxffe}(\theta) = \sum_{n \in i} w(n) \exp[-j\theta(n - d_w - 1)] \tag{178A–43}$$

The probability distribution function $p_G(y)$ of the corresponding Gaussian noise amplitudes is defined by Equation (93A–50). Assign the value of $p(y)$ to the result of conv[$p(y)$, $p_G(y)$] in order to include the probability distribution function for Gaussian noise. The result is used for the calculation of COM.

Feed-forward filter tap indexing

Comment 536

Comment points out that tap indexing conventions for the feed-forward filter are unclear. A summary of various tap indexing conventions is below.



Add the following text to 178A.1.8.1 to explicitly state the tap indexing convention for the feed-forward filter:
"By convention, feed-forward filter tap index 1 corresponds to the earliest pre-cursor tap, tap index Nfix corresponds to the latest fixed-position post cursor tap, and Nmax corresponds to the highest index that can be chosen for a floating tap. This means that the feed-forward filter includes Nfix-dw-1 fixed-position post-cursor taps and a floating tap range of Nmax-dw-1 taps."

However, it does not look like the Nmax values in Clauses 178 and 179, and Annexes 176C and 176D, are consistent with this convention. E.g., for a floating tap range of 80, Nmax should have been set to dw+1+80.
So, in addition, change Nmax in Clauses 178 and 179 to 6+1+80 = 87 and in Annexes 176C and 176D to 5+1+50 = 56.

COM receiver noise filter and continuous-time equalizer

Comment 537

Comment appears to propose two separate, but somewhat related, actions:

$$H_{ctf}(f) = \frac{\left(10^{g_1/20} + j\frac{f}{f_{z1}}\right)\left(10^{g_2/20} + j\frac{f}{f_{z2}}\right)}{\left(1 + j\frac{f}{f_{p1}}\right)\left(1 + j\frac{f}{f_{p2}}\right)\left(1 + j\frac{f}{f_{p3}}\right)}$$

Equation (178A-13), continuous-time equalizer transfer function

Proposal #1: fp2 is always fb. Remove it as a variable from the COM parameter tables.

Editor's suggestion: If it is clear that no value other than fb will ever be chosen, then remove fp3 from the parameter tables, assign values currently assigned to fp3 to fp2, and change fp3 to fb in Equation (178A-13). These changes would not alter COM results. Otherwise, reject on the basis that other values of fp2 could be chosen in the future.

$$H_{ctf}(f) = \frac{\left(10^{g_1/20} + j\frac{f}{f_{z1}}\right)\left(10^{g_2/20} + j\frac{f}{f_{z2}}\right)}{\left(1 + j\frac{f}{f_{p1}}\right)\boxed{\left(1 + j\frac{f}{f_{p2}}\right)}\left(1 + j\frac{f}{f_{p3}}\right)}$$

Proposal #2: Combine pole fp2 and noise filter.

move

Receiver noise filter

Editor's suggestion: Purpose of reorganization is not clear. Method of combination is also unclear (add pole to noise filter, increase Butterworth filter order, decrease fr, other?). Reject based on insufficient information to implement a change.

AUI-C2C

Comments 440, 443, 445

C2C TX ACCM
Comment 440

Cl 176C *SC* 176C.4.3.2 *P*705 *L*4 # 440

Dudek, Mike Marvell

Comment Type TR *Comment Status* D C2C ACCM

The C2C target BER is lower than the C2M target. The probability for measurement should be at least as low as that for C2M (p=-7) which should be adequate even for the C2C BER target.

SuggestedRemedy

Remove the exception.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
For CRG discussion.

The comment proposes to increases the amount of the ACCM distribution that is accounted for from all but 10^{-5} to all but 10^{-7} (as in C2M), to reflect the more stringent BER target for C2C.

Editor’s recommendation: Accept

176C.4.3.2 Peak-to-peak AC common-mode voltage

The low-frequency and full-band peak-to-peak AC common-mode voltage, VCM_{LF} and VCM_{FB}, respectively, are defined by the method specified in 176D.7.1 with the exception that the peak-to-peak AC common-mode voltage is defined as the AC common-mode voltage range measured at TP0v that includes all but 10^{-5} of the measured distribution, from 0.000005 to 0.999995 of the cumulative distribution.

The low-frequency peak-to-peak AC common-mode voltages shall meet the specification for VCM_{LF} (max) in Table 176C–1.

176D.7.1 Maximum voltages

Differential and common-mode signals are defined in 93.8.1.3.

Peak-to-peak output voltages are defined to a probability P, with respect to the distribution of the output voltage V_{out} sampled at an effective rate of at least two samples per UI. The sampling may be either synchronous or asynchronous.

A maximum output voltage is defined as the value V_{max} such that the probability that $V_{out} > V_{max}$ is $P/2$. A minimum output voltage is defined as the value V_{min} such that the probability that $V_{out} < V_{min}$ is $P/2$. A peak-to-peak output voltage is defined as $V_{max} - V_{min}$.

Differential peak-to-peak output voltage is defined with P=10^{-7} for the differential output signal. For compliance testing, it is sufficient to measure it from a square wave output with a period of at least 128 UI, while lanes not under test transmit PRBS31Q.

Full-band AC common-mode peak-to-peak voltage, VCM_{FB}, is defined with P=10^{-7} for the common-mode output signal. For compliance testing, it is sufficient to measure it from the PRBS13Q test pattern, while lanes not under test transmit PRBS31Q.

C2C RX RLcd
Comment 443

Cl 176C *SC* 176C.4.4.3 *P*706 *L*47 # 443

Dudek, Mike Marvell

Comment Type T *Comment Status* D *RX RLcd*

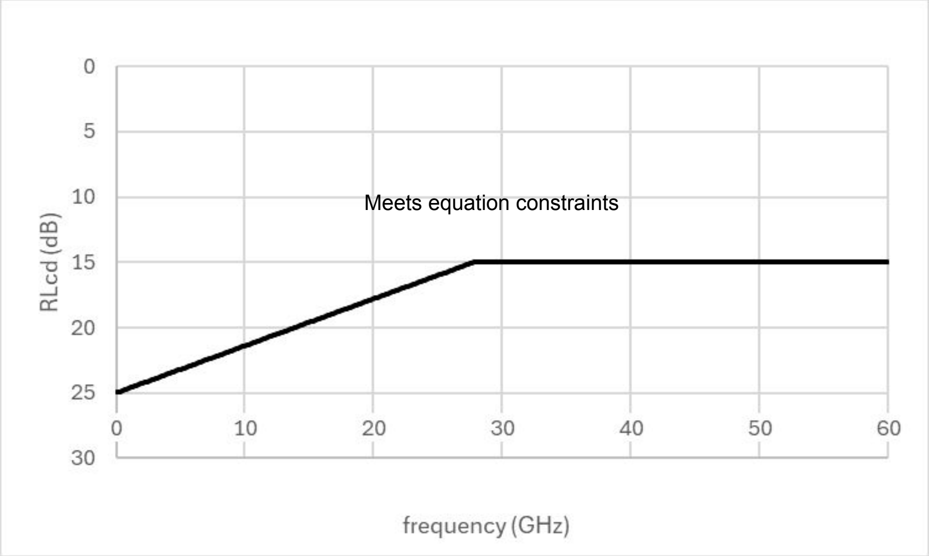
The differential-mode to common-mode return loss is TBD. It is an important parameter for system performance, but proceeding to working group ballot will be delayed if values are not available. Without further evidence that it could be relaxed it should be scaled from 100G.

SuggestedRemedy

Use 25-0.36f from 0.05 to 27.8GHz and 15 from 27.8GHz to 60GHz. Modify the editor's note on page 707 line 26 to still encourage further work.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
Implement the suggested response with editorial license.



The comment proposes an equation for (176C-1) and figure 176C-5 to replace TBDs.

Editor's note (to be removed by D2.0, or if values are adopted): Receiver differential-model to common-mode return loss requirements were left to be determined in the adopted baseline proposal. Contributions in this area are encouraged.

Editor's recommendation: Accept

C2C ITT Cal
Comment 445

Cl 176C *SC* 176C.4.4.4.2 *P*708 *L*33 # 445

Dudek, Mike Marvell

Comment Type T *Comment Status* D *ITT Cal*

The target BER is approx 1e-5 so a lower probability than 1e-3 should be used. J4u03 is now used for KR.

SuggestedRemedy

Use J4u03 and equations 178-2 and 178-3.

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
Pending CRG discussion.

The comment proposes to replace J_{3u03}
With J_{4u03} in performing the ITOL calibration.

In addition, the following parameters are derived from measurements of the test transmitter collected using the test setup in Figure 93C-3.

a) The parameter SNR_{TX} is set to the measured value of SNDR with N_p = TBD.

b) The parameter R_{LM} is set to the measured value of R_{LM}.

c) The parameters A_{DD} and σ_{RJ} are calculated from the measured values of J_{3u03} and J_{RMS03} using Equation (176C–2) and Equation (176C–3) respectively.

J_{4_u03}

Editor's recommendation: Accept

Cross-Clause

Comments 253, 260, 426

JTOL (cc)
Comments 253, 260

Cl 176C *SC* 176C.4.4.5 *P* 710 *L* 4 # 253

Ghiasi, Ali Ghiasi Qunatum/Marvell

Comment Type TR *Comment Status* D *JTOL*

Real links must operate with noise, ISI, and SJ. Recomending that jitter tolerance test have no broadband noise will render JTOL test useless. C2M JTOL has always included broadband noise with SJ, the test method exist to perform such as test and given the concern about block error the JTOL test should be comprehensive. The KR/C2C JTOL leagcy goes back to 25G-KR which only tested the receiver with SJ, we all know any SerDes unstress will do good job tracking SJ and any SerDes can do good job with ISI in absent of SJ!

SuggestedRemedy

Given that the same JTOL test is used for C2M which historiclaly had comprehensive JTOL test change No broadband noise added to Broadband noise is redcued by 0.05 UI.

Proposed Response *Response Status* W

PROPOSED REJECT.
The comment proposes a change that breaks with prior methods without providing sufficient justification.
For CRG discussion.

The comments propose to include broadband noise to the JTOL calibration for C2C and C2M.

Cl 176D *SC* 176D.7.13.2 *P* 739 *L* 9 # 260

Ghiasi, Ali Ghiasi Qunatum/Marvell

Comment Type TR *Comment Status* D *JTOL*

Real links must operate with noise, ISI, and SJ. Recomending that jitter tolerance test have no broadband noise will render JTOL test useless. C2M JTOL has always included broadband noise with SJ, the test method exist to perform such as test and given the concern about block error the JTOL test should be comprehensive. The KR/C2C JTOL leagcy goes back to 25G-KR which only tested the receiver with SJ, we all know any SerDes unstress will do good job tracking SJ and any SerDes can do good job with ISI in absent of SJ!

SuggestedRemedy

Lets not weaken C2M JTOL test by not including broadband noise, change No broadband noise added to Broadband noise is redcued by 0.05 UI.

Proposed Response *Response Status* W

PROPOSED REJECT.
SJ is not an inherent impairment of links. It is a model of bounded uncorrelated jitter that transmitters can have, which is used in tests.

The interference tolerance (ITOL) test is calibrated with additive broadband noise using COM, in consideration of the jitter of the test transmitter (which is recommended to be adjusted to be adjusted "such that the jitter parameters are as close as practical to their specified limits"; this typically requires injection of both RJ and SJ). Thus, the ITOL itself requires tracking the maximum jitter that a transmitter is allowed to generate.
Note that the specified jitter limit is based on a dual-Dirac model with DJ amplitude A_DD=0.02 UI (peak-to-peak is 0.04 UI) and RJ with RMS of 0.01 UI.

Jitter tolerance (JTOL) is a separate test that covers the jitter tracking capability at multiple frequencies considering the expected CDR bandwidtrh. The jitter is sinusoidal and has a minimum peak-to-peak of 0.05 UI, larger than that of the dual-Dirac model, and at low frequencies that create colored noise, so it has a larger stress on the receiver than the COM model. As the NOTE under Table 176D-10 indicates, it is possible that this jitter will cause failure to meet the COM requirement even without additive noise. The statement "with the exception that no noise is injected" in 176D.7.13.2 pertains to the additive noise used in ITOL.

Contrary to the claim in the comment, C2M JTOL in previous generations does not include any broadband noise, only jitter (RJ and BUJ, whose values are not specified). See Figure 120G–10, Figure 120E–12, and Figure 83E–15. Thus the current C2M requirements are no weaker than in previous generations (in fact, ITOL is a new addition that make them stronger).

In practice, a receiver that is unable to track jitter as required will likely fail at one or more of the test frequencies regardless of the noise stress, which has a minor effect compared to untracked jitter. Adding more complexity to the test that is unrelated to the purpose (jitter tolerance) is not required.

JTOL (cc)
Comments 253, 260

176C.4.4.5 Receiver jitter tolerance

Receiver jitter tolerance is verified for each pair of jitter frequency and peak-to-peak amplitude values listed in Table 179–12. The test setup shown in Figure 93–12, or its equivalent, is used. The test channel meets the insertion loss requirement for Test 2 in Table 176C–4. The synthesizer frequency is set to the specified jitter frequency and the synthesizer output amplitude is adjusted until the specified peak-to-peak jitter amplitude

for that frequency is measured at TP0v. The test procedure is the same as the one described in 176C.4.4.4, with the following exceptions:

— No broadband noise is added.

— The test channel COM, calculated per items d) through g) in 176C.4.4.4, is at least 3 dB.

— For the COM parameter calibration described in item e), the test channel transmitter J_{RMS} and J4u values are measured with the jitter frequency and amplitude set according to Case F from Table 179–12.

The receiver under test shall meet the block error ratio in Table 176C–4 for each case in Table 179–12.

176D.7.13.2 Test procedure

The jitter tolerance test procedure is similar to that of 176D.7.12.4, with the exception that no noise is injected (i.e., step f in 176D.7.12.2 is not performed). Instead, jitter with the specified frequency and amplitude is applied to the pattern generator and the jitter amplitude is adjusted to obtain the peak-to-peak jitter specified for that frequency in Table 176D–10 at the Tx test reference (see Figure 176D–7a and Figure 176D–8a). The test channel COM, calculated per 176D.7.12.2 with the jitter-stressed transmitter output, shall not be lower than the value in Table 176D–9.

Editor’s recommendation: Reject

Amplitude Tolerance (cc)
Comment 426

Cl 178 *SC* 178.9.3.3. *P*347 *L*34 # 426

Dudek, Mike Marvell

Comment Type TR *Comment Status* D *Tx FFE presets*

The test transmitter used in the interference tolerance test is limited to a maximum peak to peak amplitude of 0.8V but it is possible that the allowed 1.0V peak to peak signal from a compliant transmitter will overload the Rx making it incapable of reducing the amplitude through the training protocol.

SuggestedRemedy

Either change the value of C(0) in the OUT-OF_SYNC condition in table 179-8 to 0.8 +/- 0.025 (see separate comment on Chip to Module) or add an additional subsection called "Receiver Overload". That states "The reciver shall also meet the interference tolerance requirements of 178.9.3.3 when the test transmitter has an initial peak to peak output amplitude of 1.0V and the limitation on the output amplitude of the test transmitter is removed. Make similar changes in Clause 179 and Annex 176C

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
For CRG discussion.
[Editor's note: CC 179, 176C]

The comment proposes to address the possibility of a 1.0V pk-pk output from a test transmitter overstressing a receiver by either:

1) Limiting the test transmitter output to 0.8V
2) Adding a requirement for the receiver meet ITT requirements when the test Tx initially transmits with 1.0V pk-pk

Note that Clause 179 and Annex 176D have Receiver amplitude tolerance requirements that address this issue.

Option 1

Change to 0.8 +/- 0.025

Table 179–8—Coefficient initial conditions

Coefficient update state	ic_req	c(−3)	c(−2)	c(−1)	c(0)	c(1)
OUT_OF_SYNC[a]	N/A	0	0	0	1	0
NEW_IC	preset 1[a]	0	0	0	1	0
	preset 2	0 ± 0.025	0 ± 0.025	0 ± 0.025	0.5 ± 0.025	0 ± 0.025
	preset 3	0 ± 0.025	0 ± 0.025	−0.075 ± 0.025	0.75 ± 0.025	0 ± 0.025
	preset 4	0 ± 0.025	0.05 ± 0.025	−0.2 ± 0.025	0.75 ± 0.025	0 ± 0.025
	preset 5	−0.025 ± 0.025	0.075 ± 0.025	−0.25 ± 0.025	0.65 ± 0.025	0 ± 0.025

[a] Preset 1 is the reference for the calculation of the normalized coefficients of the transmit equalizer (see 179.9.4.1.1). As a result, the normalized coefficients for preset 1 and OUT_OF_SYNC do not include any tolerances.

Note that preset changes are addressed by another set of comments.

Option 2

Add an “Amplitude tolerance” requirement to clause 178 and Annex 176, similar to that CR (179.9.5.2).

A new entry in Table 178–9 and a corresponding subclause under 178.9.3; similarly in 176C.

Implement with editorial license

KR

Comments 255, 256, 257

KR AC Coupling
Comments 255, 256, 257

Cl 178 *SC* 178.10.6 *P*354 *L*52 # 255

Ghiasi, Ali Ghiasi Qunatum/Marvell

Comment Type TR *Comment Status* D *AC Coupling*

Location of AC coupling may also be on chip and stating TP0 to TP5 would not allow that

SuggestedRemedy

change TP0 to TP5 to TP0d to TP5d

Proposed Response *Response Status* W

PROPOSED REJECT.
Resolve using the response to comment #256.

Cl 178 *SC* 178.8.1 *P*339 *L*39 # 256

Ghiasi, Ali Ghiasi Qunatum/Marvell

Comment Type TR *Comment Status* D *AC Coupling*

Location of AC coupling may also be on chip and stating TP0 to TP5 would not allow that

SuggestedRemedy

Add note to the figure that AC coupling shown between TP3 and TP5 but actual implementation may be on chip.

Proposed Response *Response Status* W

PROPOSED REJECT.
The use of on-chip AC coupling is addressed in 178.10.6 and is considered to be an engineered link. There can be additional requirements from devices that are beyond the scope of the standard.
The proposed change would make operation without on-board AC coupling a requirement from all devices, which is a new idea that has not discussed.

Cl 178 *SC* 178.14.4.5 *P*361 *L*29 # 257

Ghiasi, Ali Ghiasi Qunatum/Marvell

Comment Type TR *Comment Status* D *AC Coupling*

Location of AC coupling may also be on chip and stating TP0 to TP5 would not allow that

SuggestedRemedy

change TP0 to TP5 to TP0d to TP5d

Proposed Response *Response Status* W

PROPOSED REJECT.
Resolve using the response to comment #256.

The comments propose changes aimed at including on-chip AC coupling in the standard.

KR AC Coupling
Comments 255, 256, 257

TP0d and TP5d

178.10.6 AC-coupling

AC-coupling shall be implemented within the channel (between TP0 and TP5) using DC blocking capacitors. The low-frequency 3 dB cutoff of the channel shall be less than 100 kHz.

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Draft Amendment to IEEE Std 802.3-2022 — IEEE *Draft* P802.3dj/D1.3
IEEE P802.3dj 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet Task Force — 10 December 2024

Systems with no AC-coupling within the channel are considered engineered links. It is the system integrator's responsibility to verify that the transmitter and the receiver are compatible with the common-mode voltage differences that may exist in this configuration.

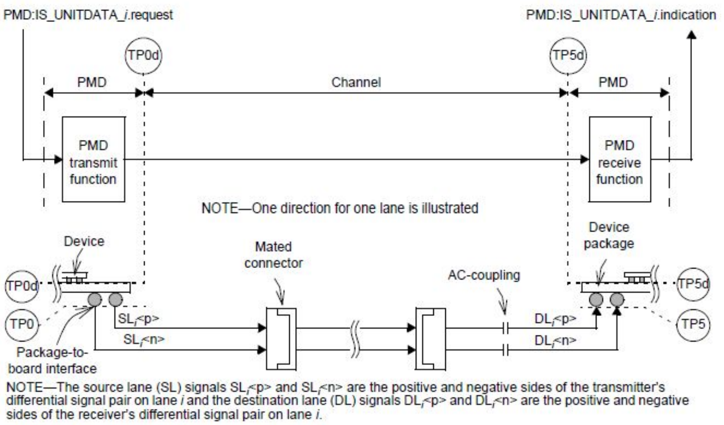

Figure 178–2—200GBASE-KR1, 400GBASE-KR2, 800GBASE-KR4, or 1.6TBASE-KR8 link

Note–AC coupling is shown between TP3 and TP4 but actual implementation may be on-chip.

178.14.4.5 Channel characteristics

TP0d and TP5d

Item	Feature	Subclause	Value/Comment	Status	Support
CC1	ERL	178.10.3	Greater than or equal to 9.7 dB	CHNL:M	Yes [ ] N/A [ ]
CC2	Channel Operating Margin (COM)	178.10	Greater than or equal to 3 dB	CHNL:M	Yes [ ] N/A [ ]
CC3	AC-coupling	93.9.4	Between TP0 and TP5, 3 dB cutoff frequency less than 100 kHz	CHNL:M	Yes [ ] N/A [ ]

Editor's recommendation: Reject.

The standard states that systems with no AC-coupling in the channel are considered engineered links and the system integrator has the responsibility to verify that Tx & Rx are compatible with the CM voltage differences that may exist.