Transition time study

Transmitter transition time in Clauses 193 and 194 — the further work invited by comment #102

IEEE P802.3ds D1.2, 200 Gb/s per Wavelength MMF PHYs Task Force

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Supporters

Supporters to be confirmed

What D1.2 specifies today

Tables 193-5 and 194-5, transmit characteristics, transcribed

Parameter	Ref	Cl 193 (SR)	Cl 194 (MR)	Unit
Signaling rate, each lane	—	106.25 ± 50 ppm	106.25 ± 50 ppm	GBd
TDECQ, each lane (max)	x.9.7	TBD	TBD	dB
TECQ, each lane (max)	x.9.8	TBD	TBD	dB
Overshoot and undershoot (max)	x.9.9	27	27	%
Transmitter power excursion (max)	x.9.10	2.3	2.3	dBm
Extinction ratio, each lane (min)	x.9.11	2	2	dB
Transmitter transition time (max)	**x.9.12**	**9**	**9**	**ps**

Both clauses run at 106.25 GBd, so 1 UI is 9.4118 ps and the 9 ps limit is 0.956 UI. TDECQ and TECQ are TBD, which is entirely normal at D1.2 and is not the point of this contribution. The point is that the transition time row is already numeric, and the value was chosen without a stated requirement behind it. Both clauses measure TDECQ using the methods of 180.9.6 [3], so ds inherits the P802.3dj reference equalizer and its coefficient constraints, restated as Table 193-13 [1].

Comment #102 against D1.1, and its disposition

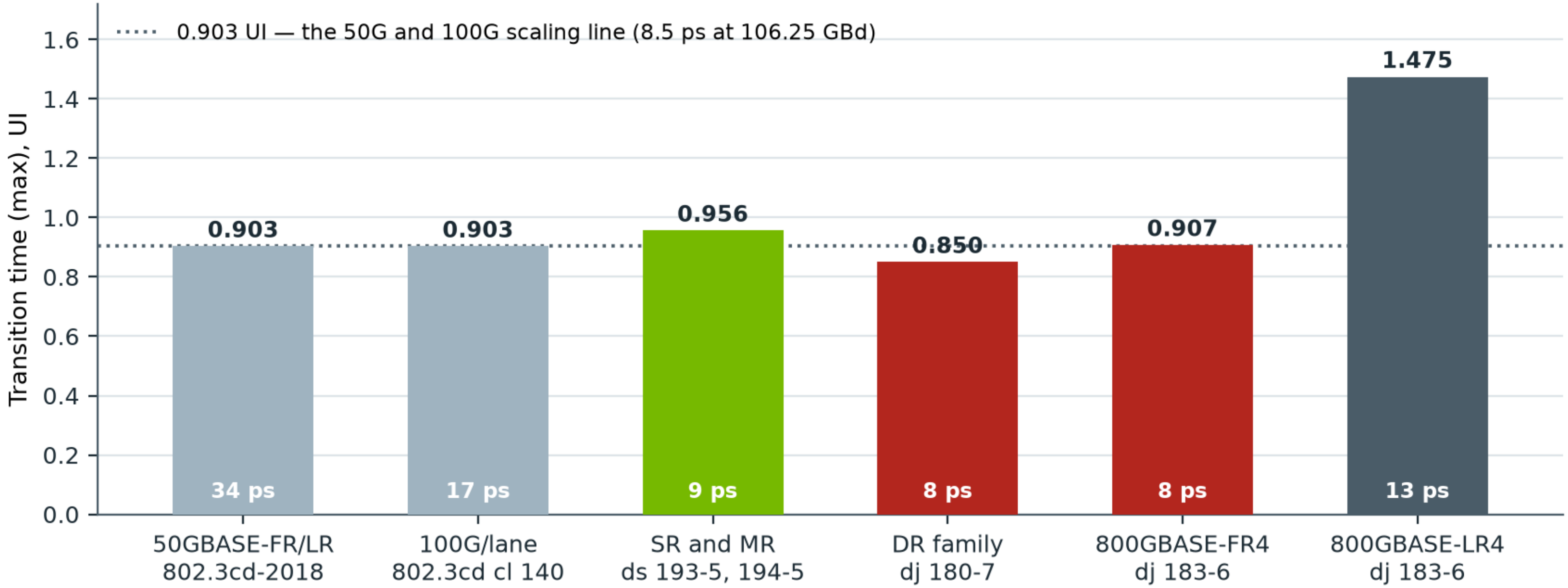
Dawe, NVIDIA — Cl 193, SC 193.7.1, P59 L39, type TR [2]

- **The ask.** Delete the transmitter transition time row from Table 193-5, delete 193.9.12, and delete the corresponding row in the mapping of parameters to test patterns.
- **The stated basis.** The limit “was scaled from 50G (34) then 100G (17) where a product receiver with FFE-based or other linear equalization was considered”. Today's receivers have DSP and tolerate slow signals well.
- **The principle.** “This is a specification; we specify outcomes, not possible causes. A signal that the ECQ equaliser finds difficult to equalise, gets a bad rating anyway.” Transition time is a cause; TDECQ and TECQ are the outcome.
- **The disposition.** REJECT — “Tx transition time has been retained as a parameter in 200G per lane DR links. Further work on this topic is encouraged.”

Two observations about the response. First, it does not defend the value; it observes that P802.3dj retains the parameter — a value itself under challenge in comments R2-195 and R2-200 [8]. Second, it explicitly invites further work [2]. This contribution supplies the quantitative backing that comment #102 asserted but did not carry. One drafting note if the comment is re-filed against D1.2: the remedy cites “Table 193-13, Mapping of parameters to test patterns”, which D1.2 renumbered to Table 193-11; 193-13 is now the reference equalizer coefficient constraints [1].

Where 9 ps comes from

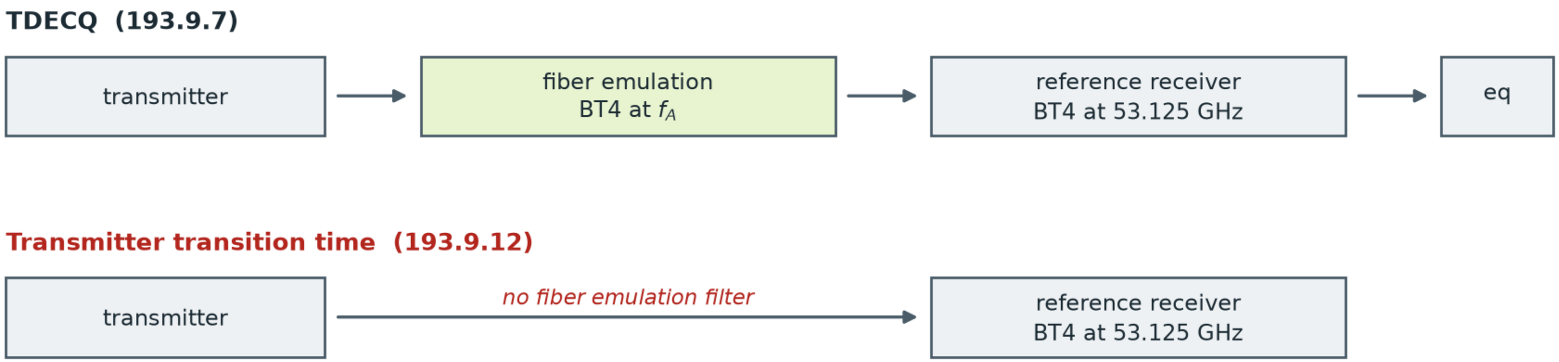
The limit follows the baud rate, not a requirement



34 ps at 26.5625 GBd and 17 ps at 53.125 GBd are both 0.903 UI: the limit was halved as the rate doubled. Carrying that same line to 106.25 GBd gives 8.5 ps, and Tables 193-5 and 194-5 carry 9 ps, or 0.956 UI. ***So P802.3ds is consistent with the lineage****, and this contribution does not claim otherwise. The question is whether the lineage was ever derived. 802.3cd adopted 34 ps against supporting simulations that proposed 27 ps to 30 ps [5], so the original anchor was already a rounded ceiling rather than a computed requirement, and every later value inherits it by division.*

The two measurements do not see the same signal

193.9.7 filters the signal before TDECQ; 193.9.12 does not



PMD type	Center wavelength (nm)	fiber emulation fA (GHz)
200/400/800GBASE-SR*-30, 1.6TBASE-SR8-30	844 – 868	60.7
200/400/800GBASE-SR*-50, 1.6TBASE-SR8-50	852 – 868	48.2
200GBASE-MR1 to 1.6TBASE-MR8	1052 – 1068	52.6

Tables 193-12 and 194-12 [1]. Two of the three fiber emulation bandwidths are ***narrower than the 53.125 GHz reference receiver itself****, so TDECQ is evaluated on a signal that has been rolled off twice, while transition time is evaluated after the reference receiver alone. TDECQ therefore penalises a slow transmitter considerably harder than the transition time measurement suggests.*

What Table 193-5 already bounds

Transition time is a narrow proxy; these limits are not, and this contribution changes none of them

- **TDECQ and TECQ** bound eye closure through the reference equalizer of 180.9.6 [3], whose Table 193-13 coefficient constraints cap how much equalization may be applied and so already bound slowness from above.
- **Overshoot and undershoot, 27% (max)**, and **transmitter power excursion, 2.3 dBm (max)**, bound the emphasis a transmitter may use.
- **Extinction ratio, 2 dB (min)**, bounds the drive amplitude.
- **The gap this leaves.** Comment #102 makes the sharp point: transition time is specified as a maximum only, so “a transmitter implementer with poor (bandwidth and shape) can get a pass on transition time by cranking up the emphasis, which makes the signal worse but compliant” [2]. The parameter can be satisfied by making the signal worse.
- **It adds no information either way.** Within the simple rolloff shapes, a measured 9 ps pins the 3 dB bandwidth to a narrow 27.2 to 29.1 GHz band [7], so the measurement tells us nothing a bandwidth figure would not. Outside that family, once emphasis is allowed, the same 9 ps admits signals of very different quality — comment #102's point that “the relation between bandwidth and transition time is not 1:1” [2]. Redundant in the easy case, uninformative in the hard one.
- **It also inherits another measurement's uncertainty.** 193.9.12 sets the 0% and 100% levels to P0 and P3 “as defined by the OMAouter measurement procedure (see 193.9.6)” [1], so the transition time reading moves with how OMAouter was extracted.

Turning the open TDECQ cell into a decision rule

TDECQ of a transmitter whose only impairment is low-pass rolloff, at T20-80 = 9 ps, 106.25 GBd [7]

Transmitter shape	TDECQ at 9 ps (dB)	C at 9 ps (dB)
Bessel-Thomson 4th order	3.83	3.17
Gaussian	3.80	3.14
Butterworth 2nd order	3.76	3.07
Single-pole RC	2.52	2.16

- **Read it as a rule, not a complaint.** If TDECQ (max) is set at or below about 3.8 dB, TDECQ binds before 9 ps and the transition time row removes nothing. If it is set above that, 9 ps becomes the binding constraint on slow transmitters — a decision the task force would then be making implicitly.
- **The ask is therefore about sequence.** Resolve TDECQ and TECQ, then decide whether the transition time row is needed at all.

*Caveat, in the conservative direction: these values are computed through the reference receiver only and do **not** include the 193.9.7 fiber emulation filter. Adding it raises TDECQ at a given transition time, which moves the wall to faster transition times and makes the 9 ps row **more** redundant, not less. Single-pole RC is the outlier throughout this study and is not a realistic modulator response.*

What next

Two routes, in order of preference

- **Preferred: adopt comment #102 [2].** Delete the transmitter transition time row from Tables 193-5 and 194-5, delete 193.9.12 and 194.9.12, and delete the corresponding rows in Tables 193-11 and 194-11. TDECQ, TECQ, the Table 193-13 tap constraints and the overshoot limit already bound the signal, in a balanced way that emphasis cannot game.
- **Alternative: keep it, but make it an honest screen.** If the task force prefers to retain a cheap scope check, then state it as one: set the value outside the TDECQ wall once TDECQ is known, so it screens gross defects without silently bounding performance, and express it in UI so it does not need rescaling at the next rate.
- **Either way, sequence it after TDECQ.** The value cannot be known to be non-binding while TDECQ (max) is open.

One drafting consequence to settle either way. 193.9.15 and 194.9.15 require the stressed receiver conformance test signal to have "a transition time that is no greater than the value specified in Table 193-5" [1], so deleting the row would leave that requirement pointing at a value that no longer exists — and comment #102's remedy does not cover it. A complete remedy also strikes that exception, or states the calibration value in 193.9.15 directly. The stressed signal stays bounded either way: the same subclause already sets its SECQ equal to the TECQ measured per 193.9.8, and holds its overshoot, undershoot and power excursion to Table 193-5.

Summary

- P802.3ds carries 9 ps in Tables 193-5 and 194-5, which is 0.956 UI and sits on the 50G/100G scaling line of 0.903 UI. **The value is consistent; the lineage was never derived.**
- Comment #102 asked to delete the parameter and was rejected on the grounds that P802.3dj retains it, with further work invited [2]. The P802.3dj value is itself under challenge [8].
- TDECQ, TECQ, the inherited tap constraints and the 27% overshoot limit already bound slow and over-emphasised transmitters. Transition time adds a maximum-only proxy that can be passed by making the signal worse.
- TDECQ is measured through a fiber emulation filter that transition time does not see, and two of the three fA values are narrower than the reference receiver, so TDECQ is the harder constraint on slowness.
- At 9 ps the modelled TDECQ is about 3.8 dB for realistic transmitter shapes [7]. **Set TDECQ first, then decide whether this row is needed.**

References

[1] IEEE P802.3ds D1.2 (14 August 2026) — Tables 193-5, 193-11, 193-12, 193-13, 194-5, 194-12; subclauses 193.9.3, 193.9.7, 193.9.12, 193.9.15, 194.9.3, 194.9.12

[2] Comment #102 (Dawe, NVIDIA), P802.3ds D1.1 2nd Task Force review, Cl 193 SC 193.7.1 P59 L39, type TR, and its response — 8023ds_D1p1_Final_Responses_by_Clause.pdf

[3] IEEE P802.3dj D3.2 — Tables 180-7, 180-16, 183-6; subclauses 180.9.2, 180.9.6, 180.9.6.4, 180.9.12

[4] IEEE Std 802.3cd-2018 — Tables 139-6 and 140-6; subclause 139.7.5, the 5-tap feed-forward reference equalizer with no DFE

[5] king_3cd_02a_0518, Max rise fall time for PAM4 transmitters — the 0.8 UI and 0.9 UI anchors behind the 34 ps limit

[6] dawe_3cd_01b_0518, TDECQ and SRS — the bounded TDECQ map and its right-hand bound

[7] TDECQ map study, this contribution — 106.25 GBd, Table 180-16 reference equalizer, MMSE taps per 180.9.6.4; SSPRQ, 64 samples/UI

[8] Comments R2-195 (Christensen) and R2-200 (Dawe) and straw polls O-5 to O-7, P802.3dj D3.0 and D3.2

Backup

Material to answer objections, not part of the main case

Backup: the P802.3dj value the response relies on

Table 183-6 carries two different limits at one signaling rate

PMD	Table	Signaling rate (GBd)	Transition time (max)	in UI	TDECQ (max)
200GBASE-DR1 and similar	180-7	106.25	8 ps	0.850	3.4 dB
800GBASE-FR4	183-6	113.4375	8 ps	0.907	3.4 dB
800GBASE-LR4	183-6	113.4375	13 ps	1.475	3.9 dB

800GBASE-FR4 and 800GBASE-LR4 sit in the same table at the same 113.4375 GBd and differ by 63% in this parameter, for PMDs that differ only in reach [3]. Comment #102 makes this point too: “for 800GBASE-LR4, the limit is 13 ps for a 7% faster line rate, and it's probably the same receiver DSP that tolerates this” [2]. So the parameter the rejection relies on for precedent is not internally consistent in P802.3dj either.

Backup: how much of the measurement is the instrument

De-embedding the 53.125 GHz reference receiver of 193.9.3 from a measured 9 ps

Transmitter shape	Tx 3 dB BW (GHz)	Tx-only T20-80 (ps)	in UI	Instrument share
Bessel-Thomson 4th order	29.08	8.12	0.863	10%
Gaussian	27.92	7.99	0.849	11%
Single-pole RC	27.22	8.11	0.862	10%
Butterworth 2nd order	28.63	8.26	0.878	8%

The reference receiver alone has a T20-80 of 4.446 ps, which is 0.472 UI at any rate because its bandwidth is defined as half the signaling rate. That looks like half of a 9 ps budget, but transition times cascade approximately in quadrature rather than linearly, so the instrument inflates the reading by only about 10%: a transmitter that measures 9 ps is about 8.1 ps on its own. ***We therefore do not argue that the specification mostly measures the instrument.*** *The relevant point is narrower: root-sum-square de-embedding is exact only for a Gaussian response and under-reads by up to 0.3 ps here, so a de-embedded number is shape-dependent and two labs can legitimately disagree [7].*

Backup: does the limit protect the receiver's clock recovery?

The one quantity TDECQ cannot see, and why it does not carry the argument

- **The mechanism is real.** TDECQ is an eye-closure penalty measured through a reference equalizer, so it does not directly bound the signal power near Nyquist that a receiver's timing loop extracts. A transition time limit does bound that, indirectly.
- **But no such requirement exists.** D1.2 specifies only the CRU corner frequency, 4 MHz with a 20 dB/decade slope, in 193.9.3 and 194.9.3 [1]. There is no timing-energy requirement anywhere to budget against.
- **And the existing limits are not consistent in it.** Modelled at the P802.3dj rates, normalised Nyquist-band power is 0.160 at that project's 8 ps limit but 0.0037 at its 13 ps limit for 800GBASE-LR4 — a factor of 43 between two PMDs in one draft [7]. A quantity that varies by 43x across a draft is not a deliberate budget.
- **Historically the concern was the other bound.** The 2018 material ties the right-hand bound of the TDECQ map to equalizer tap weights, not to clock recovery [6].

Backup: the TDECQ map, and what a transition time limit removes

C is the equalizable axis; K = TDECQ – C is the rest

- **The decomposition.** TDECQ splits into C, the part an equalizer can recover, and K, the part it cannot [6]. A transition time limit of T removes everything to the right of C(T), so C(T) is the position of the right-hand wall.
- **Why the wall is not the whole story.** The compliant region is already bounded by TDECQ = C + K ≤ the table limit. A transition time limit only removes something if it bites at a faster transition time than the TDECQ limit does.
- **What the model covers.** Transmitter and reference receiver at 106.25 GBd, the Table 180-16 reference equalizer with its coefficient constraints applied, MMSE taps per 180.9.6.4, SSPRQ at 64 samples per UI [7]. It was validated against the published 802.3cd result [4,6].
- **What it does not yet cover for ds.** The 193.9.7 fiber emulation filter. That work is in progress; its effect is to make the 9 ps row more redundant, because it raises TDECQ at any given transition time.