Discussion on N_p for TX Output and RX Interference Tests

Mau-Lin Wu, Chung-Hsien Tsai, Chih-Long Dai, MediaTek

For IEEE 802.3ck

Supporters

- Adee Ran, Cisco

Outlines

- Background
- Recap Np usage in 802.3bs
- Recap Np changes in 802.3ck D2.1
- Possible solutions for Np settings in 802.3ck D2.2
- Proposal

Background – N_p Usage in 802.3ck D2.1

- This serves as 'alternative' remedy to comment <#29> proposed by Adee Ran
- N_p is the parameter used in 'linear-fit' to derive TX SNDR (min)
  - Defined in 85.8.3.3.5 and modified in 120D.3.1.3 & 162.9.3.1.1
- The method applied to both of TX SNDR measurement as well as RITT calibration for SNR_TX in COM calculation
- Different N_p parameters in different test specs
  - N_p for SNDR (min) in TX spec (Table 120F-1, Table 162-10, Table 163-5)
    - All of them adopted 162.9.3.3 → same N_p values (200 in D2.0 → 29 in D2.1)
  - N_p for RITT & RJTT calibration tests for SNR_TX in COM
    - Different N_p values for different clauses

Different N_p values in 802.3bs – Recap (1/2)

- N_p for TX SNDR spec
  - N_p shall be appropriate to enable 'linear fit' to catch "linearity" of TX response, measured at TX test point (including test fixture), due to the "fit-error" is counted as "distortion" (nonlinearity) in SNDR calculation in (120D-7)
  - Adopt appropriate value (200) to avoid "under-fitting" (test fixture reflection) or "over-fitting"
    - N_p = 200 proposed in healey_3bs_02_0916.pdf

$$SNDR = 10\log_{10}\left(\frac{p_{\max}^2}{\sigma_e^2 + \sigma_n^2}\right)$$

Clauses	802.3bs (C2C)	802.3cd (KR)	802.3cd (CA)
Np (TX SNDR)	200	200	200
Np (RITT)	13	13	13

Different N_p values in 802.3bs – Recap (2/2)

- RITT calibration for SNR_TX
  - Derivate the value of SNR_TX to achieve calculated COM value as close as possible to threshold (3 dB)
  - Broadband noise was added to make measured SNDR of TX (maybe PG or equipment-quality TX) aligned with calculated SNR_TX
  - Why Np = 13, instead of 200?
    - Avoid “over-stress” of RX by test system with “bad reflection” after 13 UI

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Clauses	802.3bs (C2C)	802.3cd (KR)	802.3cd (CA)
Np (TX SNDR)	200	200	200
Np (RITT)	13	13	13

Comments against 802.3ck D2.0 – Np parameters

- D2.0 comment #228
  - Np = 15 → 29 for RITT
  - Not for N_p in TX output SNDR spec

Cl **162** *SC* **162.9.4.3.3** *P* **162** *L* **36** # 228

Wu, Mau-Lin — MediaTek Inc.

Comment Type **TR** *Comment Status* **A** *RIT SNDR*

For the calculation of SNDR measured at the Tx test reference, the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 15 UI. The pulse length (N_p) shall be long enough to cover all 'linear response', such as reflection due to package length.In this case, the calculated SNDR includes nonlinearity only, instead of the far-away 'linear' reflection. The 15 UI spec here is the same as 50GBASE-CR, which is not reasonable for 100GBASE-CR1. We shall need a larger value of N_p here.
In 'li_3ck_01_1020', the authors proposed to consider TX + RX EQ capability to decide N_p value. In that contribution, N_p = 29 was proposed for Clause 163. I found no clues why we have different N_p value for Clause 162, since their TX + RX EQ capability are similar.

SuggestedRemedy

By considering the pulse length to at least cover reflection due to package trace length, whose maximum value is 31 mm. By considering the dielectrics constant, D_k, as in the range of 3.5 ~ 4.0, the location of reflection due to 31 mm trace length is around 22 ~ 24 taps after main cursor. Therefore, adopt N_p = 29 as Clause 163 seems reasonable.
Proposed to N_p value from 15 to 29.

Response *Response Status* **C**

ACCEPT IN PRINCIPLE.

Resolve using the response to comment #197.

- D2.0 comment #197
  - Align N_p in RITT with Np in TX SNDR – this means N_p in RITT = 15 → 200

Cl **162** *SC* **162.9.4.3.3** *P* **162** *L* **36** # 197

Dudek, Mike — Marvell

Comment Type **TR** *Comment Status* **A** *RIT SNDR*

SNDR should be measured as appropriate for this clause not as for C2C at 25G.

SuggestedRemedy

Change "SNDR is measured at the Tx test reference using the procedure in 120D.3.1.6, with the exception that the linear fit in120D.3.1.3 is performed with a pulse length (Np) of 15 UI." to "SNDR is measured at the Tx test reference using the procedure in 162.9.3.3"

Response *Response Status* **C**

ACCEPT IN PRINCIPLE.

The following presentation, supporting comment #228, was reviewed by the task force: https://www.ieee802.org/3/ck/public/21_05/wu_3ck_01a_0521.pdf

The reference to 162.9.3.3 as proposed in the suggested remedy would effectively change the Np value to 200.

Comment #228 proposes that the Np value should be 29.

With editorial license, implement the suggested remedy and set the value of Np to 29.

The N_p Changes in 802.3ck D2.1

- N_p = 15 → 29 in 162.9.4.3.2 for CA RITT test
  - This is the intent of D2.0 comment #228
  - No problems on this!

f) ~~The SNR_{TX} value that results in the required COM value for the test is calculated. The injected noise (sce) is set such that the SNDR matches the calculated SNR_{TX} value. SNDR is measured at the Tx test reference using the procedure in 120D.3.1.6, with the exception that the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 15 UI.~~

g) COM is used to calibrate the amplitude of the noise added to the signal before the Tx test reference using the definition of σ_{TX} given by Equation (162–9), Equation (162–10) and Equation (162–11). In Equation (162–9), SNR_{TX} is set to the SNDR value measured at the Tx test reference using the procedure in 120D.3.1 with the exception that the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 29 UI and with pattern generator noise disabled. Determine the value of σ_{bn} required to achieve COM value specified in Table 162–16. The amplitude of the noise added to the signal before the Tx test reference is σ_{itp} which is derived from σ_{bn} as defined in Equation (162–12).

- N_p = 200 → 29 in '162.9.3.1.1 Linear fit to the measured waveform' for TX SNDR test
  - This is NOT the original intent of D2.0 comment #228
  - Not sure whether it's the intent of D2.0 comment #197
  - This change applies to all of CA/KR/C2C, due to all of them refer to Clause 162

162.9.3.1.1 Linear fit to the measured waveform

Compute the linear fit pulse response $p(k)$, k=1 to $M \times N_p$, from the captured waveform, as specified in 85.8.3.3.5, with N_p = ~~200~~ 29 and D_p = 4, where the assigned symbols $x(n)$ are assigned normalized amplitudes −1, −*ES*, *ES*, and 1 to represent the PAM4 symbol values 0, 1, 2, and 3 respectively. *ES* is defined as (|*ES1*| + |*ES2*|)/2 where *ES1* and *ES2* are calculated according to 120D.3.1.2.

Summary of N_p in 50G & 100G Signaling Rates

Clauses	802.3bs (C2C)	802.3cd (KR)	802.3cd (CA)	802.3ck (C2C)		802.3ck (KR)		802.3ck (CA)	
Draft				D2.0	D2.1	D2.0	D2.1	D2.0	D2.1
Np (TX SNDR)	200 *1	200 *2	200	200	29 *5	200	29 *5	200	29 *4
Np (RITT)	13	13	13	11	11	29	29	15	29 *3

1. Proposed in healey_3bs_02_0916.pdf
2. Adopt appropriate value (200) to avoid "under-fitting" (test fixture reflection) or "over-fitting"

1. Neither D2.0 comment #228 nor #197 proposed to change Np for TX SNDR spec from 200 to 29
2. This changes applied to all of C2C, KR, &CA!

1. Proposed to align "Np for RITT" same as "Np for TX SNDR" in D2.0 comment #197, i.e. 15 → 200

1. Proposed in wu_3ck_01a_0521.pdf & D2.0 comment #228

Note: *1. SNR_ISI >= 34.8 dB required for C2C in 802.3bs. However, this value is significantly influenced by the measurement setup.
*2. The differential output return loss (min) and SNR_ISI (min) requirements are replaced by the transmitter effective return loss (ERL) spec.
*3. Np value for SNR_TX calibration in RITT had been proposed to change from 15 to 29 based on D2.0 comment #228 & wu_3ck_01a_0521.pdf.
*4. Based on D2.0 comment #197 & #228, Np = 200 had been changed to 29 for TX SNDR, Vf, & pulse peak ratio calculations, which was NOT the intent of D2.0 comments #197 & #228. D2.1 #29 was proposed to fix this!
*5. TX SNDR of Clause 120F & 163 follows 162.9.3.3.

Comments against 802.3ck D2.1 – Np parameters

- Adee proposed to change Np in D2.1 comment <#29>
- Suggested Remedy in <#29>
  - “Np=200” for steady-state voltage & linear fit pulse peak
  - “Np=29” for TX SNDR
- My ‘alternative’ remedy
  - Change “Np=29” back to “Np=200”
  - This applies to all of steady-state voltage, linear fit pulse peak, & TX SNDR

Cl **162** *SC* **162.9.3.1.1** *P* **165** *L* **5** # 29

Ran, Adee — Cisco systems

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

Here it is stated that Np takes the value 29, but this value is only effective for calculation of SNDR. Other invocations of this procedure, for vf and vpeak, use Nv=200 instead. Nv appears several times and looks like a parameter, but it is not - it is a value that replaces Np; this is not stated anywhere.

In the remaining use of the linear fit, for calculation of the equalizer coefficients used in 162.9.3.1.3, 162.9.3.1.4, and 162.9.3.1.5, it does not matter whether 29 or 200 UI are used. So Np=29 is important only for SNDR, which is the exception.

Having two parameters instead of one parameter which takes two values is unnecessary and confusing.

SuggestedRemedy

In 162.9.3.1.1, change "Np=29" to "Np=200".

In 162.9.3.3 (Output SNDR) change "with the exception that the linear fit procedure in 162.9.3.1.1 is used" to "with the exception that the linear fit procedure in 162.9.3.1.1 is used with Np=29 instead of 200".

In 162.9.3.1.2 (Steady-state voltage and linear fit pulse peak) delete "using Nv=200".

In 163.9.2.3 (Difference steady state voltage) delete "with Nv = 200".

In 163A.3.1.1 (Steady-state voltage and pulse peak reference values) change "Nv" to "Np" (3 times).

In 163B.2 (Characteristics) delete "With Nv = 200".

With editorial license, change any remaining occurrence of Nv to Np.

Proposed Response *Response Status* **O**

Summary and Proposal

- N_p values for TX SNDR measurement & RITT calibration for SNR_TX in COM calculation shall be different
  - They are different due to some different purposes
- Reasons to adopt N_p = 200 & N_p = 29 for TX SNDR & RITT calibration had been disclosed
- Proposal
  - Change N_p form 29 back to 200 for TX SNDR measurement in '162.9.3.1.1 Linear fit to the measured waveform'
  - This will apply to all of CA/KR/C2C clauses
  - This serves as 'alternative' remedy to comment <#29> proposed by Adee Ran

Thank You

Comment to decide Np = 200 for TX SNDR in 802.3bs

- For TX spec
  - 802.3bs D2.0 comment <#24> : TX SNDR in TX output spec uses Np = 200 in 802.3bs D2.1
- Issues of small Np value raised by Adam Healey in [healey_3bs_02_0916.pdf]
  - If Np is too small, 'test fixture reflection" was counted in TX SNDR → not the intent of TX SNDR
  - If Np is too large, SNDR starts to fit the non-linear distortion when Np gets too large
  - Proposed Np = 200 in 802.3bs

Cl **120D** *SC* **120D.3.1** *P* **348** *L* **24** # 24

Healey, Adam — Broadcom Ltd.

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

The signal-to-noise-and-distortion ratio parameter refers to 94.3.12.7. However, the stringent 31 dB limit requires a more accurate and repeatable test procedure.

SuggestedRemedy

A presentation will provided with a description and analysis of the proposed test method.

Response *Response Status* **C**

ACCEPT IN PRINCIPLE.
Compute the linear fit pulse and linear fit error with Dp = 2 and Np = 200.

Make the changes detailed in szczepanek_3bs_02_0916.pdf
See also comments 564 & 23.

Presentations on how to account for uncontrolled ISI are solicited.

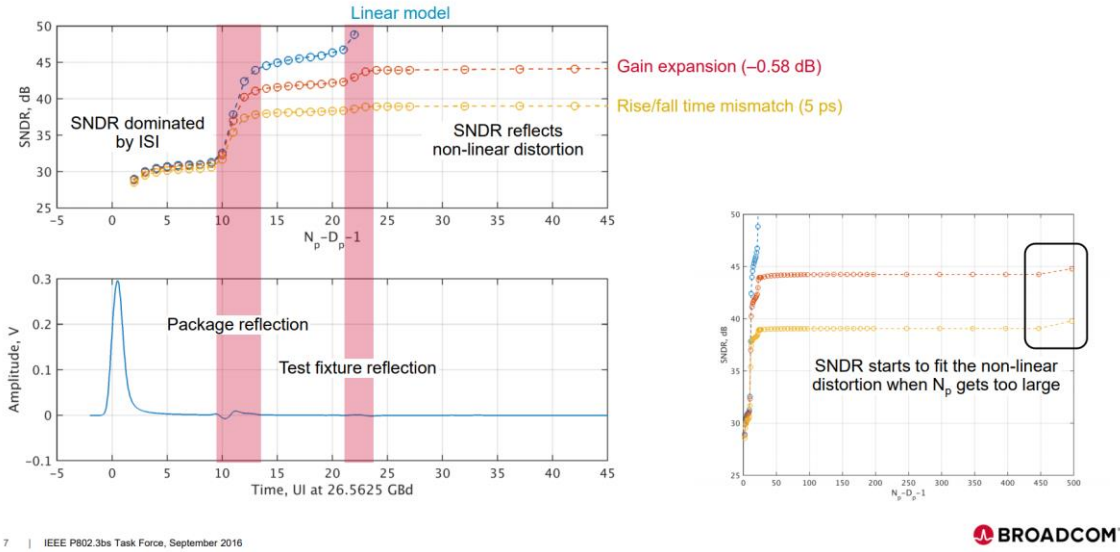
There was a straw poll on this change.
Straw Poll
1) In D2.1 compute the linear fit pulse and linear fit error with Dp = 2 and Np = 200.
2) In D2.1 make no change.

1): 10; 2): 1

Comment to decide Np = 200 for TX SNDR in 802.3bs

- For TX spec
  - 802.3bs D2.0 comment <#24> : TX SNDR in TX output spec uses Np = 200 in 802.3bs D2.1
- Issues of small Np value raised by Adam Healey in [healey_3bs_02_0916.pdf]
  - If Np is too small, 'test fixture reflection" was counted in TX SNDR (under-fitting) → not the intent of TX SNDR
  - If Np is too large, SNDR starts to fit the non-linear distortion when Np gets too large (over-fitting)
  - Proposed Np = 200 in 802.3bs

Courtesy of Adam Healey



Comment to decide N_p = 13 in 802.3bs

- Concerns raised in 802.3bs D3.0 #i-64
  - N_p = 200 allows the test system to have bad reflections after 13 UI that won't appear in the measurement of TxSNDR. This will overstress the RX.
  - N_p for RITT calibration
    - N_p = 200 → 13
- Alternative idea proposed in this comment
  - Add an extra very tight spec of SNR_ISI of 45 dB for the test transmitter (with N_p = 200)

Cl **120D** *SC* **120D.3.2.1** *P* **358** *L* **8** # i-64

Dudek, Michael — Cavium

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

This is a follow up to the un-satisfied comment #118 on draft 2.1 and comment # 49 on draft 2.2. The change to Np from 13 to 200 while calibrating the Interference Tolerance test allows the test system to have bad reflections after 13UI that won't appear in the measurement of TxSNDR (and hence input to TxSNR for the COM calibration). This will overstress the receiver.

SuggestedRemedy

Either use Np =13 for the measurement of the TxSNDR of the test transmitter Replace "The parameter SNRTX is set to the measured value of SNDR" with "The parameter SNRTX is set to the measured value of SNDR with Np=13,
or add an extra very tight specification of SNRisi of 45dB for the test transmitter. (Variations in SNRisi of the test transmitter will cause repeatability issues in the interference tolerance test if not calibrated out by the first solution). Add an extra bullet after a) at line 53 page 357. SNRisi of the test transmitter shall be greater than 45dB. It was agreed that this is a potential improvement in the comment resolution to D2.2

Response *Response Status* **C**

ACCEPT IN PRINCIPLE.

Change
"The parameter SNRTX is set to the measured value of SNDR,"
to
"The parameter SNRTX is set to the measured value of SNDR with Np=13"