# RES_ISI related comments
(R1-{18, 19, 20, 21, 22, 23, 28, 32})
# Summary presentation

Adee Ran, Cisco

# Overview

- Issues with ISI_RES has been addressed in several ad hoc presentations:
  - Revisit ISI_RES Specification for 100Gbase CR, March 9th, Li & Wu
  - Equalization effects on Transmitter specifications, March 23rd, Ran (slides 7-8)
  - Proposed CR ISI_RES Spec Change, March 30th, Li & Wu
  - Residual ISI Specification, April 6th, Rysin & Dawe
  - Residual intersymbol interference, April 6th, Healey
- 8 technical comments related to ISI_RES have been submitted. (+1 editorial)
- These comments all address the "dispersive tail" issue, with 5 "groups" of suggested remedies… should preferably be resolved together.
  - ISI_RES is used in three clauses, increasing the number of comments.
  - Comment 28 addresses additional issues with ISI_RES, other than the "tail".
- Straw poll in April 6th ad hoc meeting (see minutes_040622_3ck_adhoc).

# Use Tx equalization (#19, #32)

Cl 163 SC 163.9.2.6 P 206 L 22 # R1-19

Wu, Mau-Lin MediaTek Inc.

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

The ISI_RES spec of CR are quite different from that for KR. Based on that, the calculation method as well as the spec limit of ISI_RES of CR shall be modified. The detailed analysis had be covered in li_3ck_adhoc_01_030922 & wu_3ck_adhoc_033022.

*SuggestedRemedy*

Add the following paragraph after the 1st sentence of 163.9.2.6,
"ISI_RES is calculated from measurements with a single transmit equalizer setting to compensate for the loss of the transmitter package and host channel. The equalizer setting is chosen to minimize ISI_RES."

*Proposed Response* *Response Status* W

PROPOSED REJECT.
The following presentation was reviewed by the task force at a previous ad hoc meeting:
https://www.ieee802.org/3/ck/public/adhoc/mar30_22/wu_3ck_adhoc_01a_033022.pdf
No concensus is observed to measure ISI_RES with a single transmit equalizer setting.
For task force discussion.
[Editor's note: CC: 162, 163]

Same suggested remedy

Cl 163 SC 163.9.2.6 P 206 L 27 # R1-32

Ran, Adee Cisco Systems, Inc.

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

*** Comment submitted with the file image.png attached ***

(Cross-clause - 162, 163, 120F)
(The attached file is a mistake, I can't remove it, should be ignored)

Following ad hoc presentation ran_3ck_01_032322, it is suggested to provide more specific definitions or guidance for Tx parameters that depend on equalization, to enable reasonable test times, both for design (simulations) and qualification (with instruments).

ISI_RES as currently defined is strongly dependent on equalization setting. Meeting the existing limit with equalization off may be impossible for CR devices due to ISI resulting from the dispersive loss between TP0 and TP2. Tx equalization can mitigate that, while emphasizing reflections in the path, which is the intent of this specification.

Excessive equalization will reduce the pulse peak and may degrade ISI_RES, so we should not specify it at any equalization setting, but rather allow equalization optimized to minimize ISI_RES.

*SuggestedRemedy*

Add the following paragraph after equation 163-1 and its variable list:

ISI_RES is calculated from measurements with a single transmit equalizer setting to compensate for the loss of the transmitter package and test fixture. The equalizer setting is chosen to minimize ISI_RES.

*Proposed Response* *Response Status* W

PROPOSED REJECT.
The following presentation was reviewed by the task force at a previous ad hoc meeting:
https://www.ieee802.org/3/ck/public/adhoc/mar23_22/ran_3ck_adhoc_01_032322.pdf
No concensus to adopt the suggested remedy is observed.
For task force discussion.
[Editor's note: CC: 162, 163, 120F]

# Use a reference CTLE (#22, #23, #28)

Cl 162 SC 162.9.4 P 167 L 16 # R1-23

Rysin, Alexander NVIDIA

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

ISI_RES is affected by the pulse dispersion when measured at TP2. COM reference receiver uses CTLE to mitigate the effect. Measuring ISI effects with CTLE was adopted in 120D.3.1.7. Presentation is planned

*SuggestedRemedy*

Add a comment stating the following:

For the ISI_RES measurement the linear fit pulse response p(k) and error e(k) are determined using the linear fit procedure in 162.9.4.1.1, after these have been recalculated with the continuous time filter described in 93A.1.4.3 using the parameters in Table 163-11 applied and optimized for maximum ISI_RES, with the exception that Np=12+Dp+1".

*Proposed Response* *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/rysin_3ck_01_0422.pdf
Resolve using the response to comment #28.

162

Cl 163 SC 163.9.2.6 P 206 L 27 # R1-22

Rysin, Alexander NVIDIA

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

ISI_RES is affected by the pulse dispersion when measured at TP2. COM reference receiver uses CTLE to mitigate the effect. Measuring ISI effects with CTLE was adopted in 120D.3.1.7. Presentation is planned.

*SuggestedRemedy*

In 163.9.2.6 change to: The linear fit pulse response p(k) and error e(k) are determined using the linear fit procedure in 162.9.4.1.1, after these have been recalculated with the continuous time filter described in 93A.1.4.3 using the parameters in Table 163-11 applied and optimized for maximum ISI_RES, with the exception that…".

Alternatively, add the exception only to CL162.

*Proposed Response* *Response Status* W

PROPOSED REJECT.
The following related presentation was provided for review by the task force:

163

Cl 162 SC 162.9.4 P 167 L 16 # R1-28

Healey, Adam Broadcom Inc.

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

ISI_RES includes the linear fit error computed as part of the SNDR metric and this linear fit error is primarily attributed to distortion. The simulations that served as the basis for the Clause 163 and Annex 120F ISI_RES limits (https://www.ieee802.org/3/ck/public/21_07/dudek_3ck_01_0721.pdf) used linear models with noise-dominated SNDR. Transmitters whose SNDR includes some linear fit error may have difficulty meeting the ISI_RES limit even with otherwise acceptable residual ISI. The limit for Clause 162 was set 1 dB higher but without demonstration that this is sufficient margin for the additional ISI introduced by a host channel. In addition, measurement of the transmitted waveform at the output of a dispersive channel will include an ISI "tail" that will be compensated by the reference receiver. Reflections are the primary focus of the ISI_RES specification and the inclusion of a reference equalizer to compensate the ISI tail would improve that focus. Finally, ISI_RES combines all errors independent of phase while ERL accounts for how the reflections align at the sampling phase. The performance penalty resulting from reflections could be more accurately predicted if such alignment was considered. These concerns can be addressed by the SNR_ISI metric defined in 120D.3.1.7.

*SuggestedRemedy*

Replace ISI_RES with SNR_ISI as defined in 120D.3.1.7 using the continuous time filter parameters in Table 163-11 and a time offset added to t_p whose value is swept from -0.5 UI to 0.5 UI when calculating ISI_cursors. Define SNR_ISI to be the minimum value found across the time offset sweep. For Clause 162, set N_b to 12 and SNR_ISI (min.) to 26 dB. For Clause 163 and Annex 120F, set N_b to 6 and SNR_ISI (min.) to 28 dB.

*Proposed Response* *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/healey_3ck_01_0422.pdf
Implement the suggested remedy with editorial license.
[Editor's note: CC: 120F, 162, 163]

162, 163, 120F

# Replace ISI_RES with $SNR_{ISI}$ (#28)

*Cl* **162** *SC* **162.9.4** *P* **167** *L* **16** # R1-28

Healey, Adam — Broadcom Inc.

*Comment Type* **TR** *Comment Status* **D** *TX ISI_RES (CC)*

ISI_RES includes the linear fit error computed as part of the SNDR metric and this linear fit error is primarily attributed to distortion. The simulations that served as the basis for the Clause 163 and Annex 120F ISI_RES limits (https://www.ieee802.org/3/ck/public/21_07/dudek_3ck_01_0721.pdf) used linear models with noise-dominated SNDR. Transmitters whose SNDR includes some linear fit error may have difficulty meeting the ISI_RES limit even with otherwise acceptable residual ISI. The limit for Clause 162 was set 1 dB higher but without demonstration that this is sufficient margin for the additional ISI introduced by a host channel. In addition, measurement of the transmitted waveform at the output of a dispersive channel will include an ISI "tail" that will be compensated by the reference receiver. Reflections are the primary focus of the ISI_RES specification and the inclusion of a reference equalizer to compensate the ISI tail would improve that focus. Finally, ISI_RES combines all errors independent of phase while ERL accounts for how the reflections align at the sampling phase. The performance penalty resulting from reflections could be more accurately predicted if such alignment was considered. These concerns can be addressed by the SNR_ISI metric defined in 120D.3.1.7.

*SuggestedRemedy*

Replace ISI_RES with SNR_ISI as defined in 120D.3.1.7 using the continuous time filter parameters in Table 163-11 and a time offset added to t_p whose value is swept from -0.5 UI to 0.5 UI when calculating ISI_cursors. Define SNR_ISI to be the minimum value found across the time offset sweep. For Clause 162, set N_b to 12 and SNR_ISI (min.) to 26 dB. For Clause 163 and Annex 120F, set N_b to 6 and SNR_ISI (min.) to 28 dB.

*Proposed Response* *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/healey_3ck_01_0422.pdf
Implement the suggested remedy with editorial license.
[Editor's note: CC: 120F, 162, 163]

# Change the limit at TP2 (#20, #18, #28)

Cl 162 SC 162.9.4 P 167 L 16 # R1-20

Rysin, Alexander NVIDIA

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

Currently proposed ISI_RES limit is too tight – commercial test equipment with a recommended TP0-TP2 channel loss fail the specification. Using TX FIR to optimize ISI_RES does not help enough. Presentation is planned.

*SuggestedRemedy*

In table 162-10, change the minimum ISI_RES value to -27. Alternatively, revise the measurement methodology. See separate comments proposing different method.

*Proposed Response* *Response Status* W

PROPOSED REJECT.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/rysin_3ck_01_0422.pdf
Resolve using the response to comment #18.

Cl 162 SC 162.9.4 P 167 L 16 # R1-18

Wu, Mau-Lin MediaTek Inc.

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

The ISI_RES spec of CR are quite different from that for KR. Based on that, the calculation method as well as the spec limit of ISI_RES of CR shall be modified. The detailed analysis had be covered in li_3ck_adhoc_01_030922 & wu_3ck_adhoc_033022.

*SuggestedRemedy*

Change "Residual intersymbol interference, ISI_RES (max)" from -30 dB to -29 dB in Table 162-10.

*Proposed Response* *Response Status* W

PROPOSED REJECT.
The following related presentations were reviewed by the task force in a previous ad hoc meeting:
https://www.ieee802.org/3/ck/public/adhoc/mar09_22/li_3ck_adhoc_01_030922.pdf
https://www.ieee802.org/3/ck/public/adhoc/mar30_22/wu_3ck_adhoc_01_033022.pdf
A method and values for ISI_RES were proposed in above presentations.
It is not clear that the suggested remedy has the appropriate value.
For task force discussion.

Cl 162 SC 162.9.4 P 167 L 16 # R1-28

Healey, Adam Broadcom Inc.

*Comment Type* TR *Comment Status* D *TX ISI_RES (CC)*

ISI_RES includes the linear fit error computed as part of the SNDR metric and this linear fit error is primarily attributed to distortion. The simulations that served as the basis for the Clause 163 and Annex 120F ISI_RES limits (https://www.ieee802.org/3/ck/public/21_07/dudek_3ck_01_0721.pdf) used linear models with noise-dominated SNDR. Transmitters whose SNDR includes some linear fit error may have difficulty meeting the ISI_RES limit even with otherwise acceptable residual ISI. The limit for Clause 162 was set 1 dB higher but without demonstration that this is sufficient margin for the additional ISI introduced by a host channel. In addition, measurement of the transmitted waveform at the output of a dispersive channel will include an ISI "tail" that will be compensated by the reference receiver. Reflections are the primary focus of the ISI_RES specification and the inclusion of a reference equalizer to compensate the ISI tail would improve that focus. Finally, ISI_RES combines all errors independent of phase while ERL accounts for how the reflections align at the sampling phase. The performance penalty resulting from reflections could be more accurately predicted if such alignment was considered. These concerns can be addressed by the SNR_ISI metric defined in 120D.3.1.7.

*SuggestedRemedy*

Replace ISI_RES with SNR_ISI as defined in 120D.3.1.7 using the continuous time filter parameters in Table 163-11 and a time offset added to t_p whose value is swept from -0.5 UI to 0.5 UI when calculating ISI_cursors. Define SNR_ISI to be the minimum value found across the time offset sweep. For Clause 162, set N_b to 12 and SNR_ISI (min.) to 26 dB. For Clause 163 and Annex 120F, set N_b to 6 and SNR_ISI (min.) to 28 dB.

*Proposed Response* *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/healey_3ck_01_0422.pdf
Implement the suggested remedy with editorial license.
[Editor's note: CC: 120F, 162, 163]

# Extend the “tolerated ISI” region (#21, #23)

163

*Cl* **163** *SC* **163.9.2.6** *P* **206** *L* **27** # R1-21

Rysin, Alexander NVIDIA

*Comment Type* **TR** *Comment Status* **D** *TX ISI_RES (CC)*

ISI_RES is calculated with Np=11. COM reference receiver uses a 12-tap DFE, which corresponds to Np=17. Presentation is planned.

*SuggestedRemedy*

In 163.9.2.6 change “with the exception that Np = 11.” to: “with the exception that Np=12+Dp+1”. Same change in Clause 162.

*Proposed Response* *Response Status* **W**

PROPOSED REJECT.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/rysin_3ck_01_0422.pdf
A receiver needs to equalize more than Np UI due to TX and channel interactions. This comment does not provide sufficient evidence for the suggested remedy.

162

*Cl* **162** *SC* **162.9.4** *P* **167** *L* **16** # R1-23

Rysin, Alexander NVIDIA

*Comment Type* **TR** *Comment Status* **D** *TX ISI_RES (CC)*

ISI_RES is affected by the pulse dispersion when measured at TP2. COM reference receiver uses CTLE to mitigate the effect. Measuring ISI effects with CTLE was adopted in 120D.3.1.7. Presentation is planned

*SuggestedRemedy*

Add a comment stating the following:

For the ISI_RES measurement the linear fit pulse response p(k) and error e(k) are determined using the linear fit procedure in 162.9.4.1.1, after these have been recalculated with the continuous time filter described in 93A.1.4.3 using the parameters in Table 163-11 applied and optimized for maximum ISI_RES, with the exception that Np=12+Dp+1".

*Proposed Response* *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
The following related presentation was provided for review by the task force:
https://www.ieee802.org/3/ck/public/22_04/rysin_3ck_01_0422.pdf
Resolve using the response to comment #28.

# Straw poll conducted in April 6th ad hoc meeting

- Direction checking
- Showed clear preference to using $SNR_{ISI}$ as a replacement for RES_ISI
  - This encompasses using a reference CTLE to handle the dispersive tail
- Based on the result, a decision straw poll is suggested, to adopt the method proposed in comment r1-28

**Straw Poll 1:**
I support the direction of:
a. updating the ISI_RES method and parameters similar to slide 8 of rysin_3ck_01_0422
b. replace with SNR_ISI with appropriate exceptions similar to slide 6 and 11 of healey_3ck_01_0422
c. leave it as it is
d. need more information
(chicago rules)
Results: A: 8 , B: 24 , C: 1 , D: 4

**Straw Poll 2:**
I support the direction of:
a. updating the ISI_RES method and parameters similar to slide 8 of rysin_3ck_01_0422
b. replace with SNR_ISI with appropriate exceptions similar to slide 6 and 11 of healey_3ck_01_0422
c. leave it as it is
d. need more information
(choose one)
Results: A: 4 , B: 16 , C: 0 , D: 4

# Remaining questions

- At what Tx equalization setting should $SNR_{ISI}$ be specified? – options are
  A. At all settings (as in 120D – but that had relatively few)
  B. Specific settings, e.g., the 5 presets
  C. One setting, chosen to maximize $SNR_{ISI}$ (in the spirit of #19, #32)
  D. Something else?
- Value of Nb ("tolerated ISI" region) – options are
  A. Set to 6 (matching Np=11 in ISI_RES) at TP0v, and 12 at TP2 (#28)
  B. Set to 12, corresponding to Nb in COM (#21, #23; note that Nb is 6 in 120F)
  C. Something else?
- Limit values
  A. 26 dB at TP2, 28 dB at Tp0v (#28)
  B. Something else?

These are independent questions that can be discussed separately.

Propose: discussion and direction checking straw polls after this presentation.

# Proposed framework for resolution
## (decision straw poll to approve this slide)

Use the following response to resolve comments R1-(18, 19, 20, 21, 22, 23, 28, 32)

- Remove the definition of ISI_RES in 163.9.2.6 (Residual intersymbol interference) and instead create a new subclause 162.9.4.X, "Transmitter output residual ISI", which will define $SNR_{ISI}$ based on 120D.3.1.7 with the following additions:
  - Use the continuous time filter parameters from Table 162–19 (COM parameters).
  - Use $N_b$ [TBD: 6 / 12 (from Table 162–19) / other]
  - Use a time offset added to tp whose value is swept from -0.5 UI to 0.5 UI when calculating $ISI_{cursors}$. Define $SNR_{ISI}$ as the minimum value found across the time offset sweep.
  - Defined with transmit equalizer setting [TBD: any / 5 presets/ one setting optimized to maximize $SNR_{ISI}$ / other]
- In Table 162–10, replace ISI_RES (max.) with $SNR_{ISI}$ (min.) with reference to 162.9.4.X and a value of [TBD: 26 dB / other]
- In Table 163–5, replace ISI_RES (max.) with $SNR_{ISI}$ (min.) with reference to [TBD: 162.9.4.X / different $N_b$?] and a value of [TBD: 28 dB / other]
- In Table 120F–1, replace ISI_RES (max.) with $SNR_{ISI}$ (min.) with reference to [TBD: 162.9.4.X / different $N_b$?] and a value of [TBD: 28 dB / other]
- [If $N_b$ is different in 163 and/or 120F.3.1, add a local subclause titled "Transmitter output residual ISI", and in that subclause refer to 162.9.4.X with an exception for $N_b$; The table would refer to that local subclause instead]
- Implement with editorial license.

# Direction/decision straw polls for details

Straw poll # 1 (decision)
In Clause 163, for the value of $N_b$ as used in Equation (120D-8), I support
A. 6 (consistent with D3.1)
B. 12 (consistent with Table 162–19)
A: 15 B: 11
~~C. Need more information~~

Straw poll # 2 (decision)
In Clause 162, for the value of $N_b$ as used in Equation (120D-8), I support
A. 6 (consistent with D3.1)
B. 12 (consistent with Table 162–19)
A: 15 B: 10
~~C. Need more information~~

Straw poll # 3 (decision)
In Annex 120F, for the value of $N_b$ as used in Equation (120D-8), I support
A. 6 (consistent with D3.1)
B. 12 (consistent with Table 162–19)
A: 20 B: 6
~~C. Need more information~~

**120D.3.1.7 Transmitter output residual ISI**

$SNR_{ISI}$ is defined by Equation (120D–9) computed from $p_{max}$ and $ISI_{cursors}$ after these have been re-calculated with the continuous time filter described in 93A.1.4.3 using the parameters in Table 120D–8 applied and optimized for maximum $SNR_{ISI}$. The $SNR_{ISI}$ specification shall be met for all transmit equalization settings.

$$ISI_{cursors} = [p(t_p + M \times (N_b + 1)), p(t_p + M \times (N_b + 2)), \ldots, p(t_p + M \times (N_p - D_p - 1))] \quad (120D\text{–}8)$$

$$SNR_{ISI} = 20\log_{10}\left(\frac{p_{max}}{\sqrt{\sum(ISI_{cursors}^{\ 2})}}\right) \quad (120D\text{–}9)$$

$ISI_{cursors}$ are computed from the linear fit pulse response, $p(k)$ in accordance with 120D.3.1.3, using Equation (120D–8), where

$t_p$ is the index of the linear fit pulse where $p(t_p)$ equals $p_{max}$
$M$ is the oversampling ratio of the measured waveform and linear fit pulse as defined in 85.8.3.3.4
$N_p$ is the linear fit pulse length given in 120D.3.1.3
$N_b$ is given in Table 120D–8

NOTE—The observed $SNR_{ISI}$ can be significantly influenced by the measurement setup, e.g., reflections in cables and connectors. High-precision measurement and careful calibration of the setup are recommended.

# Direction/decision straw polls for details (3)

Straw polls # 4 (chicago) and #5 (pick one)

I support $SNR_{ISI}$ specified with transmit equalizer setting:

A: One setting optimized to maximize $SNR_{ISI}$

B: All 5 defined presets

C: All valid settings

D: Need more information

#4 – A: 20 B: 9 C: 4 D: 3

#5 – A: 15 B: 5 C: 3 D: 1

# Direction/decision straw polls for details

Straw poll # 6 (chicago) #7 (choose one)
For the value of $SNR_{ISI}$ (min) in Clause 162, I support:
A: 25 db
B: 26 dB
C: 26.7 dB
#6 – A: 4 B: 14 C: 13
#7 – A: 2 B: 7 C: 12

~~Straw poll # 6~~
~~For the value of $SNR_{ISI}$ (min) in Clause 163, I support 28 dB~~
~~A. Yes~~
~~B. No~~

~~Straw poll # 7~~
~~For the value of $SNR_{ISI}$ (min) in Annex 120D, I support 28 dB~~
~~A. Yes~~
~~B. No~~