Proposed CR ISI_RES Spec Change

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For IEEE 802.3ck Ad-Hoc

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Outlines

- Background
- Options
- Experiments
- Proposal

Background

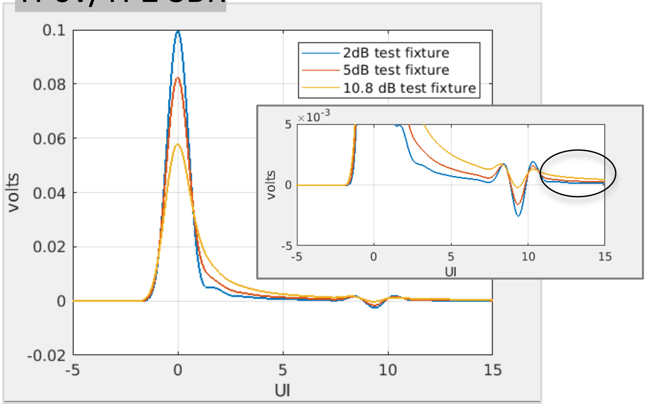
- In li_3ck_adhoc_01_030922, the issue of CR ISI_RES spec in D3.1 was raised & possible solutions were discussed
  - No consensus on solutions during the meeting, email off-line discussions followed
- Several options were proposed & discussed
  - ~~Option 1: change CR ISI_RES = -29 dB with Np = 18~~
  - Option 2: Including CTLE for CR ISI_RES calculation
  - Option 3: by different TX FIR setting to minimize ISI_RES
    - Option 3A: minimizing ISI_RES by one specific TX EQ & CR ISI_RES = -29 dB
    - Option 3B: p(k) with TX EQ off, minimizing e(k) by one specific TX EQ
- Compare these options

$$ISI\_RES = 20\log_{10}\left(\frac{\sigma_e}{p_{max}}\right)$$

where

ISI_RES	is the residual intersymbol interference in dB
σ_e	is the standard deviation of linear fit error $e(k)$
p_{max}	is the maximum value of linear fit pulse response $p(k)$

TP0v/TP2 SBR



Current spec in D3.1

	TX SNDR spec (Np = 200)	RES_ISI spec (Np = 11)
KR	32.5	-31
CR	31.5	-30

Option 2: Including CTLE for CR ISI_RES calculation

- The concept that 802.3 has already adopted in 120D.3.1.7, Transmitter output residual ISI

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.

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

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

$ISI_{cursors}$ 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

Option 3: by different TX FIR setting to maximize ISI_RES

- TX EQ can flatten the “long tail” due to dispersion in the TP0-TP2 channel
- Option 3: by different TX FIR setting to minimize ISI_RES
  - Option 3A: minimizing ISI_RES by one specific TX EQ & CR ISI_RES = -29 dB
  - Option 3B: p(k) with TX EQ off, minimizing e(k) by one specific TX EQ
- Option 3A vs. Option 3B
  - Option 3A makes more sense, while option 3B is too optimistic
- Proposed Option 3A → evaluate the ISI_RES limit next

Comparison of KR (TP0-TP0v) vs. CR (TP0-TP2) ERL

163.9.2.1.2 Test fixture effective return loss (ERL)

ERL of the test fixture at TP0v is computed using the procedure in 93A.5 with the values in Table 163–6. Parameters that do not appear in Table 163–6 take values from Table 163–11.

Table 163–6—Test fixture ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	T_r	0.01	ns
Incremental available signal loss factor	β_x	0	GHz
Permitted reflection from a transmission line external to the device under test	ρ_x	0.618	—
Length of the reflection signal	N	200	UI
Equalizer length associated with reflection signal	N_{bx}	0	UI
Time-gated propagation delay	T_{fx}	0	ns
Tukey window flag	tw	1	—

The ERL at TP0v shall be greater than or equal to 15 dB.

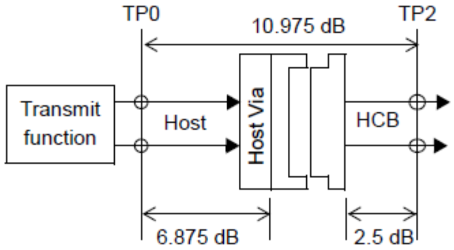
162.9.4.5 Transmitter effective return loss (ERL)

ERL of the transmitter at TP2 is defined by the procedure in 93A.5 with the values in Table 162–13. The value of T_{fx} is twice the delay between the test fixture test connector and the test fixture host-facing connection minus 0.2 ns. Parameters that do not appear in Table 162–13 take values from Table 162–19.

Table 162–13—Transmitter and receiver ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	T_r	0.01	ns
Incremental available signal loss factor	β_x	0	GHz
Permitted reflection from a transmission line external to the device under test	ρ_x	0.618	—
Length of the reflection signal	N	800	UI
Equalizer length associated with reflection signal	N_{bx}	0	UI
Tukey window flag	tw	1	—

- TP0-TP2 ERL (based on Table 162-13 except T_fx = 0)
  - T_fx = 0: same as TP0-TP0v test fixture ERL calculation (163.9.2.1.2)



The Proposed CR ISI_RES Spec

- One TP0-TP2 channel that marginally passes TX ERL spec at TP2 was checked
  - TP0-TP2 ERL = 13.95 dB, ~1dB smaller than KR (15 dB)

Source	Company	S4p	TX ERL (min 7.3 dB)	TP0-TP2 ERL
C2M channels and xtalk (all lengths and variations)	Samtec	C2M__Z100_IL12_WC-BOR_H_L_H_THRU	7.44 dB	13.95 dB

- The ISI_RES spec limits between KR & CR should be adjusted based on
  - 1dB difference in TX SNDR → 1 dB smaller ISI_RES (-31 → -30 dB)
  - Different impedance discontinuity nature between TP0-TP0v & TP0-TP2 → 1 dB smaller ISI_RES (-30 → -29 dB)

	TX SNDR	Test fixture ERL (min.)	ISI_RES (D3.1)	Proposal
KR	32.5 dB	15 dB (163.9.2.1.2)	-31 dB	-31 dB
CR	31.5 dB	13.95 dB (TP0-TP2)	-30 dB	**-29 dB**

Example of Spec Methodology and Spec Limit

- TX FIR spec (Table 162–10)
  - Max. TX FIR peaking gain: ~11 dB

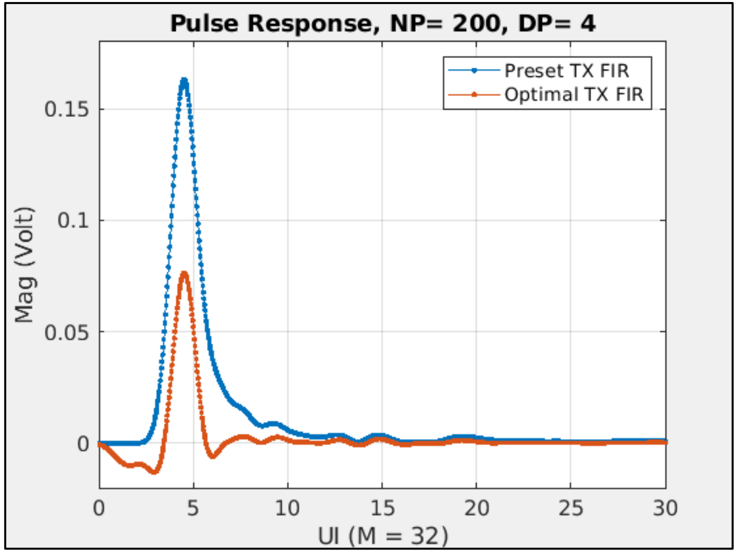
Transmitter output waveform			
absolute value of step size for all taps (min)	162.9.3.1.4	0.005	—
absolute value of step size for all taps (max)	162.9.3.1.4	0.025	—
value at minimum state for $c(-3)$ (max)	162.9.3.1.5	−0.06	—
value at maximum state for $c(-2)$ (min)	162.9.3.1.5	0.12	—
value at minimum state for $c(-1)$ (max)	162.9.3.1.5	−0.34	—
value at minimum state for $c(0)$ (max)	162.9.3.1.5	0.5	—
value at minimum state for $c(1)$ (max)	162.9.3.1.5	−0.2	—

- TX compliance results

	TX FIR Setting	ISI_RES (Np = 11)
Preset 1	[0 0 0 1 0]	-27.10 dB
Optional 3A	[-0.06 0 -0.14 0.6 -0.2]	**-29.15 dB**

  - TX FIR can flatten the "long tail" due to dispersion, although it may cause undershoot just before and after main cursor

** Take "C2M__Z100_IL12_WC-BOR_H_L_H_THRU" as example*



Proposed Modifications to D3.1

- Add the following paragraph after the 1st sentence of 163.9.2.6 [Thanks to Adee's contribution]
  - 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.
- In Table 162-10, change
  - ISI_RES (max) from -30 dB to -29 dB