Consensus Discussion: CM noise and return loss

Matt Brown

Huawei Technologies Canada

P802.3ck Chief Editor

Introduction

- Dealing with topics and comments as follows:
  - KR/C2C TX AC common-mode (CM) noise [28, 29, 54, 205]
  - KR channel differential to common-mode conversion loss [11039]
  - C2M host/module output common-mode return loss [207, 208]
  - C2M module output test fixture return loss [170, 11078]
- Excluded similar comments relating to CR:
  - These can be dealt with independently
  - Work is currently under way to provide measured and simulated data.

TX AC CM noise comments

Cl 163 *SC* 163.9.1 *P* 177 *L* 38 # 28

Wu, Mau-Lin Mediatek

Comment Type T *Comment Status* D *common mode noise*

The 'AC common-mode RMS voltage (max.)' is 30 mV, which is the same as that in 802.3cd. By combining this spec with P/N skew mismatch of backplane channel, it will induce crosstalk to differential signal at receiver. From 50G to 100G, it's difficult to improve the P/N skew mismatch to half. Based on that, we shall modify AC common-mode RMS voltage. We shall align this spec to that in C2M (120G).

SuggestedRemedy

Change 30 mV to 17.5 mV.

Proposed Response *Response Status* W

PROPOSED REJECT

Note that comment #205 and #54 request the same change.The suggested remedy does not provide sufficient evidence that the proposed threshold is feasible.

Cl 163 *SC* 163.9.1 *P* 177 *L* 38 # 205

Ghiasi, Ali Ghiasi Quantum/Inphi

Comment Type TR *Comment Status* D *common mode noise*

30 mV AC common mode has significant amount of penalty given that RLCD ~RLDC or 12 dB depending on the loss of the channel the penalty can be 1-3 mV RMS

SuggestedRemedy

Consider reducing 30 mV RMS to 17.5 mV RMS

Proposed Response *Response Status* W

PROPOSED REJECT

[Editor's note: changed page from 148.]

Resolve using the response to comment #28.

Cl 163 *SC* 163.9.1 *P* 177 *L* 38 # 54

Mellitz, Richard Samtec

Comment Type TR *Comment Status* D *common mode noise*

30 mv of AC common-mode RMS voltage is too severe. Little work has been to justify this.

SuggestedRemedy

Set AC common-mode RMS voltage to TBD. Add a line to the table called AC common-mode deterministic voltage which essentially represents skew.

Proposed Response *Response Status* W

PROPOSED REJECT

Resolve using the response to comment #28.

Cl 120F *SC* 120F.3.1 *P* 205 *L* 13 # 29

Wu, Mau-Lin Mediatek

Comment Type T *Comment Status* D

The 'AC common-mode RMS voltage (max.)' is 30 mV, which is the same as that in 802.3cd. By combining this spec with P/N skew mismatch of backplane channel, it will induce crosstalk to differential signal at receiver. From 50G to 100G, it's difficult to improve the P/N skew mismatch to half. Based on that, we shall modify AC common-mode RMS voltage. We shall align this spec to that in C2M (120G).

SuggestedRemedy

Change 30 mV to 17.5 mV.

Proposed Response *Response Status* W

PROPOSED REJECT

It is not relevant to compare this with either CR or C2M since the noise color is modified by the host board. Also, the more stringent requirement for CR and C2M is due to the exposed connector.

Table 120F–1—Transmitter electrical characteristics at TP0a

Parameter	Reference	Value	Units
Signaling rate per lane (range)		53.125 ± 100 ppm	GBd
Differential peak-to-peak output voltage[a] (max) Transmitter disabled Transmitter enabled	93.8.1.3	 35 1200	 mV mV
Common-mode voltage[a] (max)	93.8.1.3	1.9	V
Common-mode voltage[a] (min)	93.8.1.3	0	V
AC common-mode output voltage[a] (max, RMS)	93.8.1.3	30	mV

Table 163–5—Summary of transmitter specifications at TP0a

Parameter	Reference	Value	Units
Signaling rate		53.125 ± 100 ppm	GBd
Differential pk-pk voltage (max.)[a] Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
DC common-mode voltage (max.)[a]	93.8.1.3	1.0	V
DC common-mode voltage (min.)[a]	93.8.1.3	0.2	V
AC common-mode RMS voltage (max.)[a]	93.8.1.3	30	mV
Effective return loss (ERL) (min.)	163.9.1.1	TBD	dB

History: 100GBASE-KR4

For 100GAUI-4 (25 Gb/s per lane) …

- The TX AC CM RMS noise was specified as 12 mV.

Note: Assuming the same spectral noise density for 50 Gb/s per lane transmitters, this would scale to:
12 mV * sqrt(2) = 17 mV

Table 93–4—Summary of transmitter characteristics at TP0a

Parameter	Subclause reference	Value	Units
Signaling rate	93.8.1.2	25.78125±100 ppm	GBd
Differential peak-to-peak output voltage (max.) Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
DC common-mode output voltage (max.)	93.8.1.3	1.9	V
DC common-mode output voltage (min.)	93.8.1.3	0	V
AC common-mode output voltage (RMS, max.)	93.8.1.3	12	mV
Differential output return loss (min.)	93.8.1.4	Equation (93–3)	dB

93.8.1.3 Signal levels

The differential output voltage v_{di} is defined to be SL*i*<p> minus SL*i*<n>. The common-mode output voltage v_{cmi} is defined to be one half of the sum of SL*i*<p> and SL*i*<n>. These definitions are illustrated by Figure 93–6.

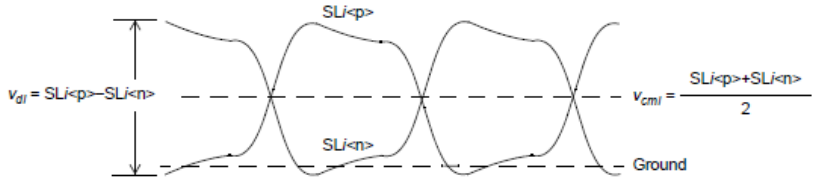


Figure 93–6—Transmitter output voltage definitions

Measurement of the DC common-mode voltage is made with a high-impedance connection to TP0a where each conductor of the differential pair is AC-coupled to a 50 Ω termination.

The peak-to-peak differential output voltage shall be less than or equal to 1200 mV regardless of the transmit equalizer setting. The peak-to-peak differential output voltage shall be less than or equal to 30 mV while the transmitter is disabled (refer to 93.7.6 and 93.7.7).

The DC common-mode output voltage shall be between 0 V and 1.9 V with respect to signal ground. The AC common-mode output voltage shall be less than or equal to 12 mV RMS with respect to signal ground. Common-mode output voltage requirements shall be met regardless of the transmit equalizer setting.

History: 400GAUI-8 et al

120D.3.1 200GAUI-4 and 400GAUI-8 C2C transmitter characteristics

A 200GAUI-4 or a 400GAUI-8 chip-to-chip transmitter shall meet the specifications given in Table 120D–1. The transmit output waveform may optionally be manipulated via the feedback mechanism described in 120D.3.2.3.

A test system with a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth is to be used for all transmitter signal measurements, unless otherwise specified.

Table 120D–1—200GAUI-4 and 400GAUI-8 C2C transmitter characteristics at TP0a

Parameter	Reference	Value	Units
Signaling rate per lane (range)		26.5625 ± 100 ppm	GBd
Differential peak-to-peak output voltage[a] (max) Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
Common-mode voltage[a] (max)	93.8.1.3	1.9	V
Common-mode voltage[a] (min)	93.8.1.3	0	V
AC common-mode output voltage[a] (max, RMS)	93.8.1.3	30	mV

For 400GAUI-4 (50 Gb/s per lane) …

- TX AC CM RMS noise specified in 120D.3.1 and Table 120D-1.
- The TX AC CM RMS noise was increased to 30 mV.

History: 50GBASE-KR, 50GAUI-1, et al

137.9.2 Transmitter characteristics

The transmitter shall meet the specifications given in Table 120D–1, with the following exceptions:

a) The value of linear fit pulse peak (min) is $0.75 \times v_f$.

b) The output waveform Pre-cursor equalization and Post-cursor equalization parameters are replaced by the "Transmitter output waveform" specifications summarized in Table 136–11 and detailed in 136.9.3.1.

c) The differential output return loss (min) and SNR_{ISI} (min) requirements are replaced by the transmitter effective return loss (ERL) specification in 137.9.2.1.

d) The value of SNDR (min) is 32.5 dB.

e) The J4u limit in Table 120D–1 does not apply. The maximum J3u (see 136.9.3.3) is 0.106 UI.

135F.3.1 50GAUI-1 C2C and 100GAUI-2 C2C transmitter characteristics

The 50GAUI-1 C2C or 100GAUI-2 C2C transmitter shall support 1/(1+D) mod 4 precoding, as specified in 135.5.7.2, that may be enabled or disabled as required.

A 50GAUI-1 C2C or a 100GAUI-2 C2C transmitter shall meet all specifications in 120D.3.1.

For 50GBASE-KR (50 Gb/s per lane) …

- TX AC CM RMS noise was adopted from 400GAUI-8 (30 mV) by reference.

D2CM conversion loss comments

Cl 163	*SC* 163.10	*P* 184	*L* 1	# 11039

Ben Artsi, Liav — Marvell

Comment Type T — *Comment Status* D — *channel RLDC*

[Comment resubmitted from Draft 1.1. 163.10, P181, L26]

Differential to common mode conversion loss is not defined for a TP0 to TP5 interconnect channel characteristics

SuggestedRemedy

Specify that the differential to common mode conversion loss of TP0 to TP5 shall be [TBD] and correlated to the capability defined in 162.11.5 when measured with an MCB

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE

Add differential to common mode conversion loss of TP0 to TP5 with the threshold TBD.

For task force discussion.

162.11.5 Differential to common-mode conversion loss

The cable assembly differential to common-mode conversion loss shall meet the requirements of TBD.

Comment 11039 proposes to add a new parameter for the KR Channel:

- Add new subclause in 163.10 for channel differential to common-mode conversion loss
- Base specification on cable assembly parameter in 162.11.5.
- Specify equation(s) as TBD for now.

Should this also apply to 120F?

Possible revised response…

PROPOSED ACCEPT IN PRINCIPLE

Add channel differential to common-mode conversion loss specification based on 162.11.5 with constraints TBD in new subclause within 163.10. Implement with editorial license.

A similar specification is necessary for C2C…

Add channel differential to common-mode conversion loss specification based on 162.11.5 with constraints TBD in new subclause within 120F.4. Implement with editorial license.

RLCC comments

Cl 120G SC 120G.3.2 P 224 L 52 # 208

Ghiasi, Ali — Ghiasi Quantum/Inphi

Comment Type TR *Comment Status* D

Unless one end of the link has common mode termination the 17.5 mV allowed common mode does not get absorbed

SuggestedRemedy

Add common mode return loss with following equation = 12 - 9*f/1e9 dB up to 1 GHz
3 dB from 1GHz to 50 GHz
See ghiasi_03_0620

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE

[Editor's note: ch

Pending review o
http://www.ieee8

As the commente
module output or

Use 0.01 GHz for

For task force dis

Resolve with #20

Cl 120G SC 120G.3.1 P 221 L 23 # 207

Ghiasi, Ali — Ghiasi Quantum/Inphi

Comment Type TR *Comment Status* D

Unless one end of the link has common mode termination the 17.5 mV allowed common mode does not get absorbed

SuggestedRemedy

Add common mode return loss with following equation = 12 - 9*f/1e9 dB up to 1 GHz
3 dB from 1GHz to 50 GHz
See ghiasi_03_0620

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE

[Editor's note: changed subclause from 120G.3.]

Pending review of the following presentation:
http://www.ieee802.org/3/ck/public/20_07/ghiasi_3ck_03_0720.pdf

As the commenter points out, common-mode return loss is not specified for either the module output or the host input.

Use 0.01 GHz for the low frequency limit.

For task force discussion.

Resolve with #208.

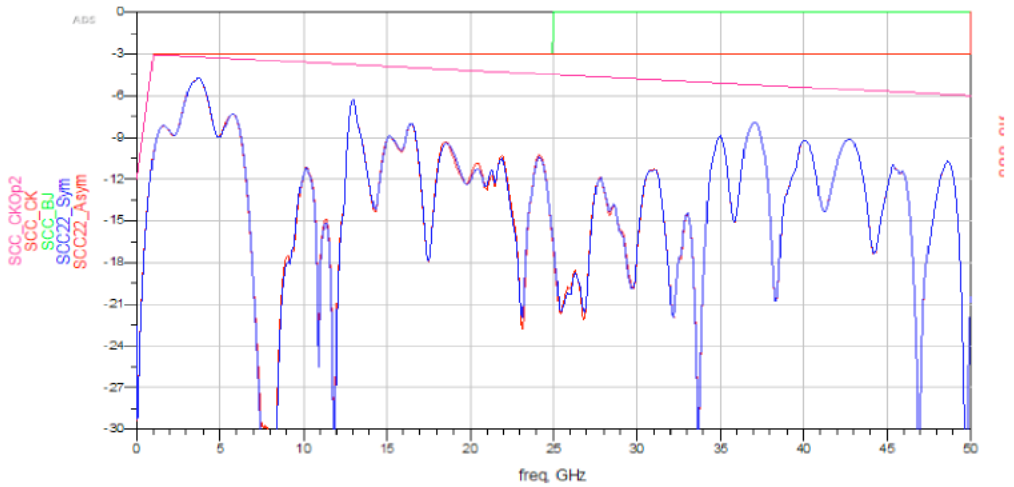
Comments 208 and 207 propose limits for C2M host/module output:
RLCC(f) >= …
12-9*f/1e9 dB, f = up to 1GHz
3 dB, f = 1GHz to 50 GHz
Lower should be limit be 0.01 GHz.
Upper limit should be 53.125 GHz to match other specs in 120G.

Note no RLCC for 400GAUI-8 C2M (120E).

Note that presentation has been reviewed at a previous adhoc meeting:
http://www.ieee802.org/3/ck/public/20_07/ghiasi_3ck_03a_0720.pdf

Potential response:
PROPOSED ACCEPT IN PRINCIPAL
In 120G.3.2 and 120G.3.1, specify RLCC as follows:
RLCC(f) >= …
12-9*f/1e9 dB, f = 0.01 GHz to 1 GHz
3 dB, f = 1 GHz to 53.125 GHz
Implement with editorial license.

Graph from ghiasi_3ck_03a_0720.



Test fixture RL comments

Cl 120F SC 120F.3.2.3 P 208 L 53 # 170

Ran, Adee Intel

Comment Type T *Comment Status* D

Addressing TBD in test setup requirements.

"The return loss of the test setup in Figure 93C–4 measured at TP5 replica towards TPt meets the
requirements of Equation (TBD)."

The test fixture can be considered as a channel that the transmitter is connected to. As such, it should meet the ERL requirements of the channel. There are no return loss requirements for a channel.

SuggestedRemedy

Change the quoted sentence to

"The effective return loss of the test setup in Figure 93C–4 measured at TP5 replica towards TPt meets the
requirements of 120F.4.3."

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE

Resolve using the response to comment #11078.

Cl 120F SC 120F.3.2.3 P 208 L 54 # 11078

Healey, Adam Broadcom Inc.

Comment Type T *Comment Status* D

[Comment resubmitted from Draft 1.1. 120F.3.2.3, P206, L48]

I believe the intent is for the return loss of the test setup to have "test fixture" grade performance.

SuggestedRemedy

In item b), change "Equation (TBD)" to "Equation (163-2)" (Test fixture reference return loss limit).

Proposed Response *Response Status* W

PROPOSED ACCEPT IN PRINCIPLE

Comment #170 proposes using ERL in 120F.4.3.
Comment #11078 proposes using DRL in 163.9.1.2 (KR test fixture specification).

It seems more relevant to use the same return loss specification as specified for the KR test fixture.

For task force discussion.

Comments 170 and 11078 are proposing return loss requirements for module output (TP4) test channel.
Comment #170 proposes using ERL in 120F.4.3.
Comment #11078 proposes using DRL in 163.9.1.2 (KR test fixture specification).

120F.3.2.3 Receiver interference tolerance

Receiver interference tolerance is defined by the procedure in Annex 93C with the exception that transmitter equalization is configured by management (see 120D.3.2.3) to the settings that provide the lowest FEC symbol error ratio. The receiver on each lane shall meet the FEC symbol error ratio requirement with channels matching the Channel Operating Margin (COM) and loss parameters for Test 1 and Test 2 in Table 120F–4. The following additional considerations apply to the interference tolerance test.

a) The test transmitter is constrained such that for any transmitter equalizer setting the differential peak-to-peak voltage (see 93.8.1.3) is less than or equal to 800 mV.

b) The return loss of the test setup in Figure 93C–4 measured at TP5 replica towards TPt meets the requirements of Equation (TBD).

120F.4.3 Channel effective return loss

ERL of the channel at TP0 and at TP5 is computed using the procedure in 93A.5 with the values in Table 120F–7. For parameters that do not appear in Table 120F–7, take values from Table 120F–6. The value of T_{fx} is 0. Channel ERL at TP0 and at TP5 shall be greater than or equal to TBD dB.

Table 120F–7—Transmitter and receiver ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	T_r	TBD	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	2000	UI
Equalizer length associated with reflection signal	N_{bx}	TBD	UI

163.9.1.2 Transmitter test fixture

The differential return loss of the test fixture shall meet Equation (163–2).

$$RL_d(f) \geq \begin{cases} 20 - f & 0.05 \leq f \leq 5 \\ 15 & 5 < f \leq 25 \\ 22.5 - 0.3f & 25 < f \leq 53.125 \end{cases} \quad (163\text{–}2)$$

Thanks