AC common mode considerations for C2M

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Current specifications + History (C2M)

Table 120G–1—Host output characteristics at TP1a

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		53.125 ± 50 ppm[a]	GBd
DC common-mode output voltage (max)	120G.5.1	2.8	V
DC common-mode output voltage (min)	120G.5.1	–0.3	V
Single-ended output voltage (max)	120G.5.1	3.3	V
Single-ended output voltage (min)	120G.5.1	–0.4	V
AC common-mode RMS output voltage (max)	120G.5.1	17.5	mV

Table 120G–3—Module output characteristics (at TP4)

Parameter	Reference	Value	Units
Signaling rate, each lane (nominal)		53.125[a]	GBd
AC common-mode output voltage (max, RMS)	120G.5.1	17.5	mV

Previous generations:

Where	C2M Interface type	Signaling	Max AC CM RMS	Max diff PtP	Re-used by
120E	200GAUI-4, 400GAUI-8	26.5625 GBd PAM4	17.5 mV	880 mV	135G (100GAUI-2, 50GAUI-1)
83E	CAUI-4	25.78125 GBd NRZ	17.5 mV	900 mV	120C (200GAUI-8, 400GAUI-16), 135E (50GAUI-2, 100GAUI-4)
83B	XLAUI, CAUI-10	10.3125 GBd NRZ	20 mV	850 mV	

Specifications have not changed substantially in >10 years, over >5x signaling rate, and between NRZ/PAM4

Current specifications + History (others)

Table 162–10—Summary of transmitter specifications at TP2

Parameter	Subclause reference	Value	Units
Signaling rate, each (nominal)		53.125 ± 50 ppm[a]	GBd
Differential pk-pk voltage with Tx disabled (max)[b]	93.8.1.3	30	mV
DC common-mode voltage (max)[b]	93.8.1.3	1.9	V
AC common-mode RMS voltage, v_{cmi} (max)[b]	93.8.1.3	30	mV

Table 163–5—Summary of transmitter specifications at TP0v

Parameter	Reference	Value	Units
Signaling rate		53.125 ± 50 ppm[a]	GBd
Differential pk-pk voltage (max)[b] Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
DC common-mode voltage (max)[b]	93.8.1.3	1	V
DC common-mode voltage (min)[b]	93.8.1.3	0.2	V
AC common-mode RMS voltage (max)[b]	93.8.1.3	30	mV

Previous generations:

Where	Interface type	Signaling	Max AC CM RMS	Max diff PtP	Re-used by
120D	200GAUI-4, 400GAUI-8 C2C	26.5625 GBd PAM4	30 mV	1200 mV	50GBASE-KR, 50GBASE-CR +multi-lane versions
93	100GBASE-KR4	25.78125 GBd NRZ	12 mV	1200 mV	25GBASE-KR, CAUI-4 C2C
85	40GBASE-CR4	10.3125 GBd NRZ	30 mV	1200 mV	100GBASE-CR4, 25GBASE-CR
83A	XLAUI/CAUI-10 (C2C)	10.3125 GBd NRZ	15 mV	760 mV	

Specifications other than C2M are inconsistent

Problem statement

- With increases signaling rate, higher CM AC results are expected
  - Mode conversion e.g. due tp p/n skew creates CM signal correlated to the differential signal
  - High-rate Tx architectures can have other significant sources of CM noise
  - 17.5 mV RMS seems unfeasible
- Susceptibility of receivers to these types of CM outputs has not been addressed
  - The current specifications are not based on any analysis
  - There are no Rx common mode tolerance requirements or test definitions

Unfeasible Tx specs, hole in Rx specs, no relationship between Rx and Tx

Scope of this presentation:

- Only C2M specifications
  - Because output specifications at TP1a and TP4 much tighter than CR/KR Transmitter specifications
  - Because analysis is simpler – there is no channel; what you measure is what the receiver gets
  - No need to work on mode conversion specifications
- Looking for consensus on a direction and/or feedback

Previous work on CM specs

Presentation name	Title	Content
ran_3ck_adhoc_01_010621	Analysis of Common-Mode Signal at the Receiver Input	Assessment of CM levels at RX side for CR; need for CM stress test
mellitz_3ck_adhoc_01_121620	Common Mode (CM) Noise: Next Steps	CM noise from crosstalk
ran_3ck_04_1020	Considerations for TX AC Common-Mode Specifications	Correlated (mode conversion) vs uncorrelated (CM noise) effect
wu_3ck_01_1020	AC Common Mode Spec by TP0v	Proposal for CM AC specification at TP0v (KR)
wu_3ck_adhoc_01_090920	AC Common Mode Noise and Common Mode to Differential Conversion Exploration	Conversion loss metrics (IDCR/INCM) analysis for CR/KR
ghiasi_3ck_03a_0720, ghiasi_3ck_03_0720	Differential, Conversion, and Common Mode Return Losses (Return Loss and ERL Limits for C2M and CR)	Sources of CM; s-parameter results but no RMS results
wu_3ck_01a_0720	AC common mode and SDC21 limits	Analysis of uncorrelated CM noise effect on COM (CR/KR)
mellitz_3ck_adhoc_01_062420, mellitz_3ck_adhoc_01_061720	Common Mode: Fact or Fiction	Proposal to add Tx AC CM conversion term into COM à la SNR_{TX}

A closer look at C2M CM signal sources at TP1a/TP4

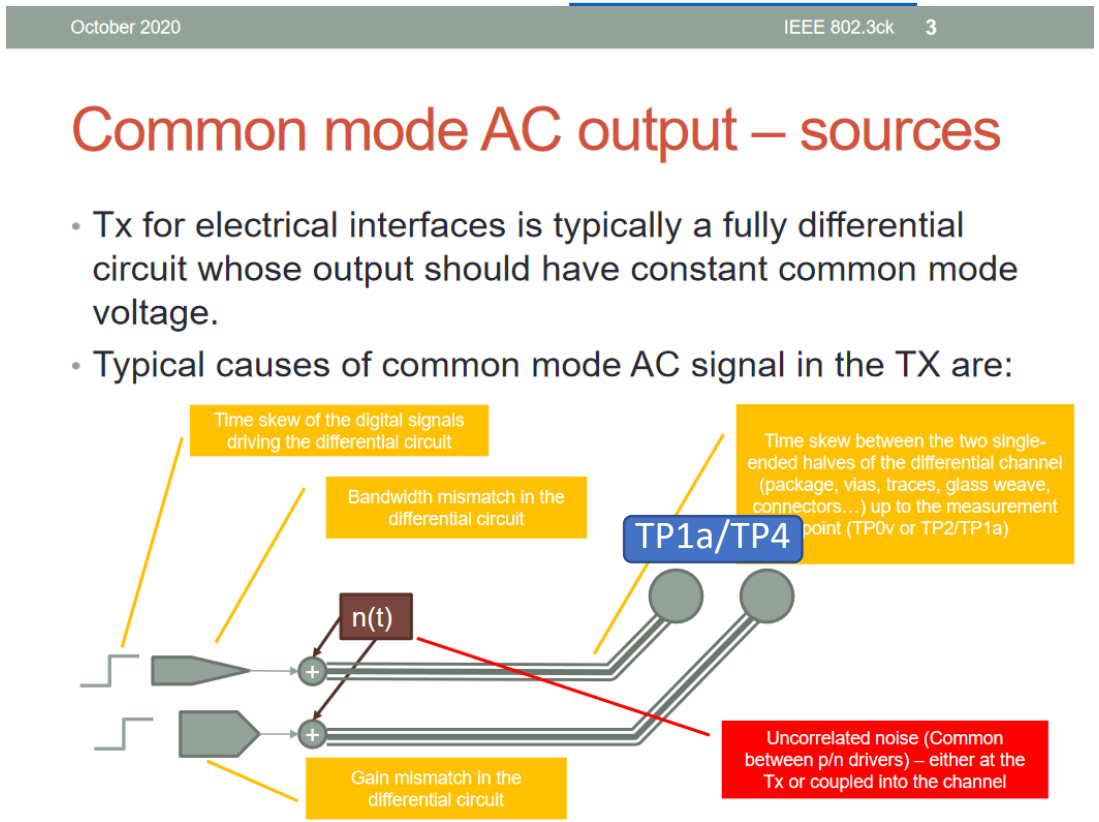
- Conversion of differential signal from the host/module Tx
  - Creates correlated broadband signal
  - Skew can be assessed through mixed-mode RL measurements
  - Effect on receiver is tolerable

  ⇒ it would be good if this component could be excluded
- Uncorrelated noise from the Tx + crosstalk
  - Can have adverse effects on the Rx

  ⇒ should be specified

  ⇒ Rx should be tested for tolerance

ran_3ck_04_1020



Typical sources of uncorrelated CM noise

- Supply noise
  - Typically below ~1 MHz
- Crosstalk
  - Wideband noise (see mellitz_3ck_adhoc_01_121620)
- Clock feed through
  - Typical time-interleaved Tx may have slightly different CM at the transitions between UIs and possibly between even/odd UIs
  - This can create CM tones at 2x and possibly 1x Nyquist frequency
  - However:
    - 2x Nyquist is strongly attenuated by the channel and likely outside of a receiver's bandwidth
    - Typical Rx designs are time-interleaved, so "even/odd noise" is inherently tolerable

  ⇒preferably this component should be excluded from measurement

Moving forward

Can we create consensus about the following?

- The current 17.5 mV specification may be feasible under the following conditions:
  - CM “noise” correlated to the differential signal is excluded – this can be done by performing a linear fit (as in CR/KR Tx methodology) and taking the fitting error
  - CM noise at and above Nyquist frequency is excluded (e.g. by low pass filtering below Nyquist freqency)

  If these components are not exluded, specification should be loosened 30 mV RMS
- A C2M receiver is expected to tolerate the same RMS level of uncorrelated broadband CM noise as the C2M Tx output
  - This can be done by adding a CM broadband noise component to the stressed input test

If there is consensus on the principle – we can get to the details (procedure, setup description, etc.)