200 Gbps/lane AUI C2M Channel Selection Criteria

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- Adam Healey, Broadcom
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Introduction

- There are complex relationships between the AUI C2M channel characteristics, the AUI C2M BER target, AUI C2M TX/RX complexity, the optical PMD BER target, etc.
- Many AUI C2M channels are available for study via the 3dj TF website as well as through other industry groups
  - Over 100 channels with various assumptions and differing levels of maturity and complexity

Goals

- The goals of this contribution are to:
  - Form several “classes” of reference equalizers for comparison purposes
  - Selectively reduce the number of AUI C2M channels for analysis in order to focus baseline proposal development efforts
  - Provide a relative comparison using COM with these reduced channels
  - Start discussions in the Task Force on which contributed AUI C2M channels should pass versus which should fail
    - Discuss the ones that fall in the middle
- Not debating the C2M specification parameters at this time, including the reference receiver model, package parameters and COM, etc.
  - Please look for the high-level trends, not at the minutiae

Classes of Reference Equalizers

- Various contributions look at different reference equalizers
- Propose different classes for the relative comparison of performance for *direction finding* purposes
  - Taken from https://www.ieee802.org/3/dj/public/23_03/li_3dj_01a_2303.pdf

(Mild) ↓ (Spicy!)

  - Class I: 802.3ck C2M-like
  - Class II: 802.3ck C2M-like + Floating Taps
  - Class III: 802.3ck CR-like
  - Class IV: 802.3ck CR-like + MLSE
- Note: these classes are starting points, not specific recommendations. We had to start with *something* ☺

Reference EQ Highlights – By Class

- Class I/II/III/VI

				Exploratory of 802.3dj Medium Loss AUI C2M		Exploratory of 802.3dj High Loss AUI C2M	
Parameter	802.3ck C2M	802.3ck CR	802.3ck KR	802.3ck C2M-like	802.3ck C2M-like + FLT	802.3ck CR-like	802.3ck CR-like + MLSE
DER_0	1E-5	1E-4	1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4
SNR_TX	32.5	32.5	33	32.5	32.5	33	33
R_LM	0.95	0.95	0.95	0.95	0.95	0.95	0.95
TxFIR Length	4 (2 pre)	5 (3 pre)	5 (3 pre)	5 (3 pre)	5 (3 pre)	6 (4 pre)	6 (4 pre)
eta_0	4.10E-08	9E-09	8.2E-09	2.05E-08	2.05E-08	4.1E-09	4.1E-09
N_b	4	12	12	8	8	24	24
N_bg	0	3	3	0	**3**	6	6
N_bf	-	3	3	3	3	3	3
N_f	-	40	40	80	80	80	80
MLSE	0	0	0	0	0	0	**1**
Ref TX/RX Class				**I**	**II**	**III**	**VI**

(Mild) (Spicy!)

Note: these classes are starting points, not specific recommendations.

https://www.ieee802.org/3/dj/public/23_03/li_3dj_01a_2303.pdf

Reducing the # of Channels

- Across the inventory of AUI C2M channels available, we attempted to reduce the total number of channels down to ~10-15 unique, representative channels
  - Decrease analysis time
  - Assess the outliers
  - Eliminate obviously bad channels
- Channel parameters that we used include: Fit IL, ERL, ICN, ICR

802.3dj C2M Channel Contributions

Contribution	Channel List	Host Type
akinwale_3df_01_2209 (21x)	C2M_PCB_85ohms_10~30dB_202208016_v2_thru1	CONV PCB
akinwale_3df_02_2209 (21x)	C2M_PCB_93ohms_10~30dB_202208016_v2_thru1	CONV PCB
akinwale_3df_03_2209 (21x)	C2M_PCB_100ohms_10~30dB_202208016_v2_thru1	CONV PCB
rabinovich_3df_01_2209 (3x) rabinovich_3dj_02_230116 (1x)	Rabinovich_C2M_200G_Ortho_[19, 67, 93]mil_092122_Thru.s4p Rabinovich_C2M_200G_Ortho_135mil_011723_Thru.s4p	CONV PCB
rabinovich_3df_02_2209 (3x) rabinovich_3dj_03_230116 (1x)	Rabinovich_C2M_200G_Paral_[19, 67, 93]mil_092122_Thru.s4p Rabinovich_C2M_200G_Paral_135mil_011723_Thru.s4p	CONV PCB
tracy_3df_02_2211	TE_224G_C2M_Conventional_[5,7,13]inHst_100622_THRU.s4p	CONV PCB
	TE_224G_C2M_NCC_100622_THRU.s4p	NCC
	TE_224G_C2M_CPC_CPB_091622_THRU_mod.s4p	CPC

Extreme impedance corners
(not included at this time)

Technology still stabilizing
(not included at this time)

https://www.ieee802.org/3/df/public/tools/index.html

Expanded List of Channels

Fit IL (dB)	<= 16	16 < X <= 28	> 28

	Max	Q3	Med	Q1	MIN
ERL	19.19	13.46	12.79	12.02	10.29

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52

- **This presentation does not intend to propose any channel specifications**
- **The relative ERL, ICN, and ICR are compared under largely channel commonality:**
  - **OSFP connector (possibly from the same contributor)**
  - **Host type: CONV PCB (except one is NCC)**

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

Relative COM Comparison with Proposed Channels

- The assumed AUI C2M BER targets were 1E-5, 2E-5, 5E-5, 8E-5
  - Much less interest in 1E-4
- Of course, the reported COM results will change depending on the channel, Cd, Cp, host and module package trace lengths, reference receiver model architecture & settings, etc.
- One package scenario: 30mm + 8mm (~9 dB IL)

Straw Poll #1 and 2 -- directional

At this time, I prefer the 200 Gbps/lane AUI BER target option per brown_3dj_elec_01_230420 slide 18:

a. Option A: C2M and C2C AUI BER 1E-5
b. Option B: C2M and C2C AUI BER 2E-5
c. Option C: C2M and C2C AUI BER 5E-5
d. Option D: C2M and C2C AUI BER 1E-4
e. Option E: C2M AUI BER 8E-5 and C2C AUI BER 2E-5

SP#1 Results (Chicago rules): A: 29 B: 19 C: 25 D: 8 E: 24

SP#2 Results (Choose one): A: 12 B: 4 C: 17 D: 0 E: 12 NMI: 11

https://www.ieee802.org/3/dj/public/adhoc/electrical/23_0420/straw_polls_3df_elec_adhoc_230420.pdf

A Relative Comparison

Fit IL (dB)	<= 16	16 < X <= 28	> 28
COM (dB)	>= 3.5	2.5 <= X < 3.5	< 2.5

	Max	Q3	Med	Q1	MIN
ERL	19.19	13.46	12.79	12.02	10.29

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)	COM (DER_0 = 1E-5, 30mm/8mm)				COM (DER_0 = 5E-5, 30mm/8mm)				COM (DER_0 = 1E-4, 30mm/8mm)			
								I	II	III	IV	I	II	III	IV	I	II	III	IV
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96												
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63												
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28												
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20												
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65												
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85												
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66												
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87												
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57												
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29												
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46												
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89												
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83												
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68												
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00												
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90												
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24												
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93												
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79												
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32												
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23												
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15												
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47												
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12												
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52												

Medium Loss AUI C2M Candidates

These channels need more equalization (class III or better) than the others

High Loss AUI C2M Candidates

These channels could work with a Medium complexity Equalizer (class I-II)

Medium Loss AUI C2M Candidates

- This presentation does not intend to propose any channel specifications
- The relative ERL, ICN, and ICR are compared under largely channel commonality:
  - OSFP connector (possibly from the same contributor)
  - Host type: CONV PCB (except one is NCC)

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

A Relative Comparison – Focus on Class I

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)	COM (DER_0 = 1E-5, 30mm/8mm)				COM (DER_0 = 5E-5, 30mm/8mm)				COM (DER_0 = 1E-4, 30mm/8mm)			
								I	II	III	IV	I	II	III	IV	I	II	III	IV
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96												
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63												
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28												
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20												
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65												
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85												
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66												
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87												
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57												
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29												
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46												
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89												
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83												
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68												
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00												
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90												
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24												
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93												
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79												
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32												
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23												
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15												
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47												
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12												
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52												

Class I EQ is not strong enough to pass most of the available channels, regardless of the BER target

- **This presentation does not intend to propose any channel specifications**
- **The relative ERL, ICN, and ICR are compared under largely channel commonality:**
  - **OSFP connector (possibly from the same contributor)**
  - **Host type: CONV PCB (except one is NCC)**

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

A Relative Comparison – Focus on Class II

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)	COM (DER_0 = 1E-5, 30mm/8mm)				COM (DER_0 = 5E-5, 30mm/8mm)				COM (DER_0 = 1E-4, 30mm/8mm)			
								I	II	III	IV	I	II	III	IV	I	II	III	IV
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96												
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63												
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28												
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20												
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65												
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85												
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66												
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87												
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57												
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29												
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46												
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89												
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83												
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68												
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00												
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90												
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24												
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93												
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79												
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32												
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23												
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15												
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47												
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12												
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52												

Class II EQ is ok for some medium-loss AUI channels.
Class II EQ is <u>not</u> strong enough for higher-loss AUI channels

- **This presentation does not intend to propose any channel specifications**
- **The relative ERL, ICN, and ICR are compared under largely channel commonality:**
  - **OSFP connector (possibly from the same contributor)**
  - **Host type: CONV PCB (except one is NCC)**

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

A Relative Comparison – Focus on Class III

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)	COM (DER_0 = 1E-5, 30mm/8mm)				COM (DER_0 = 5E-5, 30mm/8mm)				COM (DER_0 = 1E-4, 30mm/8mm)			
								I	II	III	IV	I	II	III	IV	I	II	III	IV
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96												
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63												
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28												
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20												
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65												
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85												
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66												
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87												
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57												
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29												
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46												
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89												
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83												
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68												
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00												
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90												
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24												
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93												
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79												
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32												
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23												
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15												
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47												
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12												
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52												

Class III EQ covers most of the available channels, regardless of BER target

- **This presentation does not intend to propose any channel specifications**
- **The relative ERL, ICN, and ICR are compared under largely channel commonality:**
  - **OSFP connector (possibly from the same contributor)**
  - **Host type: CONV PCB (except one is NCC)**

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

A Relative Comparison – Focus on Class IV

Challenge	Channel	IL (dB)	Fit IL (dB)	FOM_ILD (dB)	ERL (DER_0 = 1E-5)	ICN (mV)	ICR (dB)	COM (DER_0 = 1E-5, 30mm/8mm)				COM (DER_0 = 5E-5, 30mm/8mm)				COM (DER_0 = 1E-4, 30mm/8mm)			
								I	II	III	IV	I	II	III	IV	I	II	III	IV
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_10dB	8.77	10.35	0.53	11.33	2.55	26.96												
Reflection	ak Saved to U: Drive 2209/C2M_PCB_93ohms_11dB	9.61	11.22	0.52	11.56	2.32	27.72												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_12dB	10.45	12.07	0.52	11.80	2.11	27.11												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_13dB	11.31	12.92	0.52	12.02	1.93	27.58												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_14dB	12.17	13.83	0.55	11.48	1.91	26.96												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_15dB	13.03	14.67	0.56	11.68	1.76	27.07												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_16dB	14.73	16.33	0.57	12.03	1.50	26.75												
Reflection	akinwale_3df_02_2209/C2M_PCB_93ohms_17dB	15.55	17.16	0.58	12.18	1.40	26.63												
	akinwale_3df_02_2209/C2M_PCB_93ohms_18dB	16.42	17.98	0.59	12.33	1.30	26.28												
	akinwale_3df_02_2209/C2M_PCB_93ohms_19dB	17.24	18.80	0.60	12.46	1.22	26.20												
	akinwale_3df_02_2209/C2M_PCB_93ohms_20dB	18.11	19.62	0.61	12.59	1.15	25.65												
	akinwale_3df_02_2209/C2M_PCB_93ohms_21dB	19.80	21.25	0.64	12.80	1.04	24.85												
	akinwale_3df_02_2209/C2M_PCB_93ohms_22dB	20.63	22.06	0.65	12.89	0.99	24.66												
	akinwale_3df_02_2209/C2M_PCB_93ohms_23dB	21.49	22.87	0.66	12.98	0.95	23.87												
	akinwale_3df_02_2209/C2M_PCB_93ohms_24dB	22.33	23.68	0.68	13.06	0.92	23.57												
	akinwale_3df_02_2209/C2M_PCB_93ohms_25dB	24.02	25.29	0.70	13.21	0.86	22.29												
	akinwale_3df_02_2209/C2M_PCB_93ohms_26dB	24.87	26.09	0.72	13.27	0.84	21.46												
	akinwale_3df_02_2209/C2M_PCB_93ohms_27dB	25.71	26.89	0.73	13.33	0.83	20.89												
	akinwale_3df_02_2209/C2M_PCB_93ohms_28dB	26.56	27.70	0.74	13.38	0.81	20.06												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_29dB	28.25	29.30	0.76	13.49	0.79	18.57												
IL, Xtalk	akinwale_3df_02_2209/C2M_PCB_93ohms_30dB	29.10	30.11	0.78	13.53	0.78	17.83												
	Rabinovich_C2M_200G_Ortho_19mil_092122	12.38	13.57	0.70	18.06	1.79	28.68												
	Rabinovich_C2M_200G_Ortho_67mil_092122	14.70	14.87	0.69	17.50	2.71	27.00												
	Rabinovich_C2M_200G_Ortho_93mil_092122	14.17	14.81	0.95	15.36	2.83	24.90												
Xtalk	Rabinovich_C2M_200G_Ortho_135mil_011723	13.35	14.99	0.96	15.20	3.39	22.24												
	Rabinovich_C2M_200G_Paral_19mil_092122	12.27	13.16	0.47	18.30	2.35	26.93												
	Rabinovich_C2M_200G_Paral_67mil_092122	13.32	13.91	0.50	17.90	2.87	26.79												
Xtalk	Rabinovich_C2M_200G_Paral_93mil_092122	13.44	14.12	0.67	14.98	3.17	24.32												
Xtalk	Rabinovich_C2M_200G_Paral_135mil_011723	12.93	14.44	0.49	15.51	3.78	22.23												
	tracy_3df_02_2211_C2M_CONV_5p4dB_HOST	10.26	10.64	0.55	18.76	1.58	45.15												
	tracy_3df_02_2211_C2M_CONV_7p6dB_HOST	12.36	12.79	0.56	18.94	1.24	46.47												
	tracy_3df_02_2211_C2M_CONV_14dB_HOST	18.78	19.18	0.62	19.19	0.64	49.12												
	tracy_3df_02_2211_C2M_NCC_HOST	10.43	11.09	0.41	15.27	2.28	28.52												

Class IV EQ make nearly every channel pass

- This presentation does not intend to propose any channel specifications
- The relative ERL, ICN, and ICR are compared under largely channel commonality:
  - OSFP connector (possibly from the same contributor)
  - Host type: CONV PCB (except one is NCC)

Package loss is ~7dB per 30mm, ~9dB total for 30mm+8mm.
Source: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf

Summary

- Established several “classes” of reference equalizers for relative comparison purposes
  - “Mild” (Class I) to “spicy” (Class IV)
- Selectively reduced the number of AUI C2M channels for analysis in order to focus baseline proposal development efforts
- Provided a relative comparison using COM with these reduced channels
  - Class I EQ is not strong enough to pass most of the available channels, regardless of the BER target
  - Class II EQ is ok for some medium-loss AUI channels. Class II EQ is not strong enough for higher-loss AUI channels
  - Class III EQ covers most of the available channels, regardless of BER target
  - Class IV EQ make nearly every channel pass

Thanks!

BACKUP

COM Reference Sheets for Class I/II/III/VI

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8; 0 0 ; 0 0 ; 0 0]	mm	[test cases]
z_p (FEXT)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8; 0 0 ; 0 0 ; 0 0]	mm	[test cases]
PKG_Tx_FFE_preset	0		
C_p	[0.5e-4 0.5e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=
A_fe	0.413	V	vp/vf=
A_ne	0.45	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:.02:0.12]		[min:step:max]
c(-3)	[-0.06:.02:0]		[min:step:max]
c(-4)	[0:.02:0.04]		[min:step:max]
c(1)	[-0.12:0.02:0.1]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		As/dffe1
b_max(2..N_b)	[0.5 0.3 0.3 0.2*ones(1,20)]		As/dfe2..N_b
b_min(1)	0.3		As/dffe1
b_min(2..N_b)	[0.2 0.05 0.05 -0.05*ones(1,20)]		As/dfe2..N_b
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr
Raised_Cosine	0	logical	include in fr

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\CAKR_[date]\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CAKR_RCos_eval_	
COM_CONTRIBUTION	0	logical
Operational		
ERL Pass threshold	10	dB
COM Pass threshold	3	db
DER_0	1.00E-04	
T_r	3.75E-03	ns
FORCE_TR	1	logical
PMD_type	C2C	
EW	1	
* TDR and ERL options		logical
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	800	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	8	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	4.10E-09	dB
SNR_TX	33	
R_LM	0.95	
Enforce Causality	1	
S-parameter magnitude extrap	trend_to_DC	
MLSE	1	logical

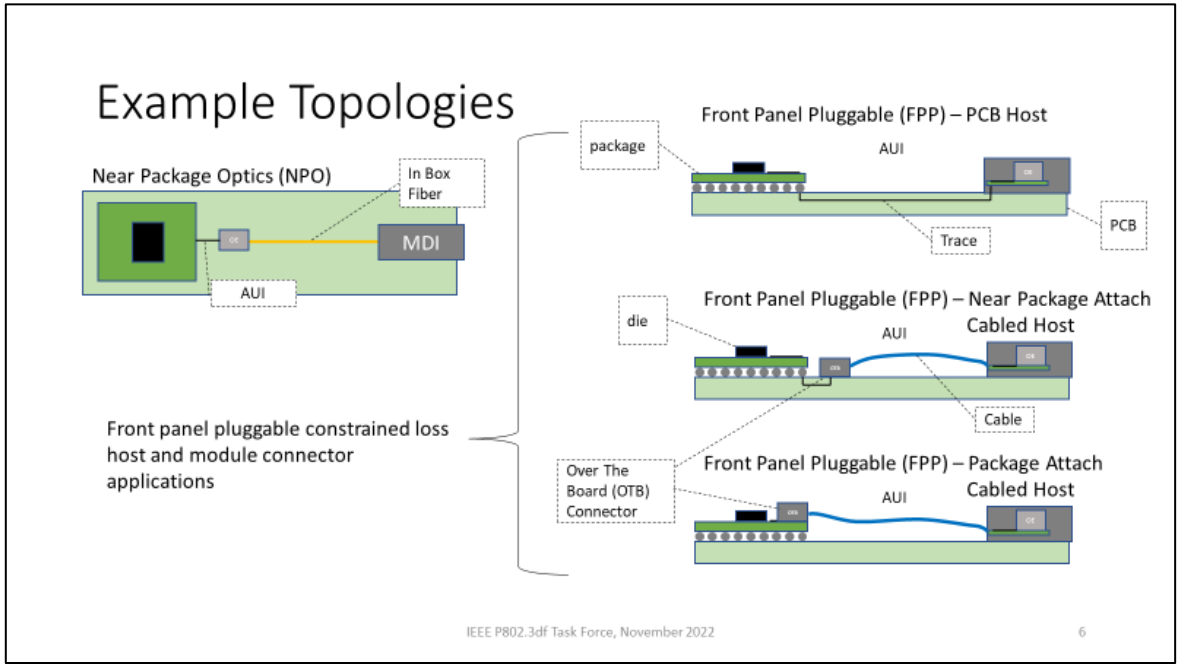
Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]	
package_tl_tau	0.00644805	ns/mm
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.5 db/in @ 56G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	*125*	mm
z_bp (NEXT)	*0*	mm
z_bp (FEXT)	*125*	mm
z_bp (RX)	*0*	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle,gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI
* ICN parameters		
f_v	0.594	Fb
f_f	0.594	Fb
f_n	0.594	Fb
f_2	79.688	GHz
A_ft	0.450	V
A_nt	0.450	V
Floating Tap Control		
N_bg	6	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	80	UI span for floating taps
bmaxg	0.2	max DFE value for floati
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

**ERL and ICN parameters*

*** Make changes of Class I/II/III/VI based on parameters listed in slide 6*

AUI C2M Loss Reminder

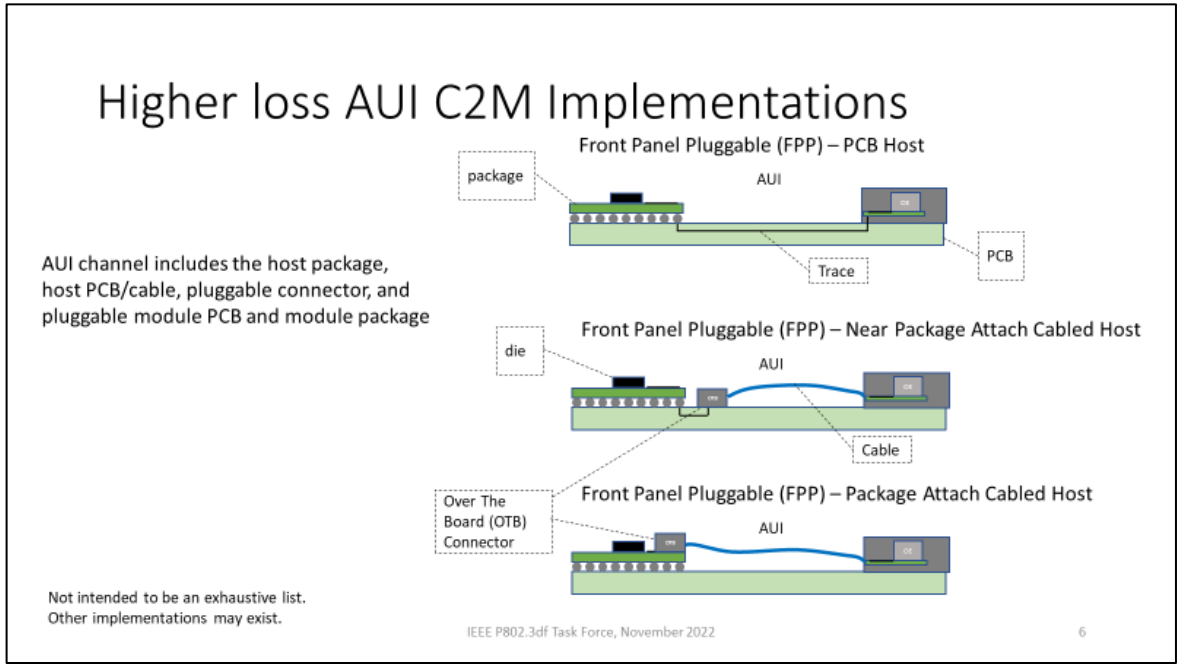
Medium Loss AUI C2M



- Targets ~22 dB IL die-die
- NPO and constrained loss FPP
- The COM reference transmitter and receiver models and parameters are an evolution from 3ck, scaled to the higher signaling rate

https://www.ieee802.org/3/df/public/22_11/lusted_3df_03a_2211.pdf

High Loss AUI C2M

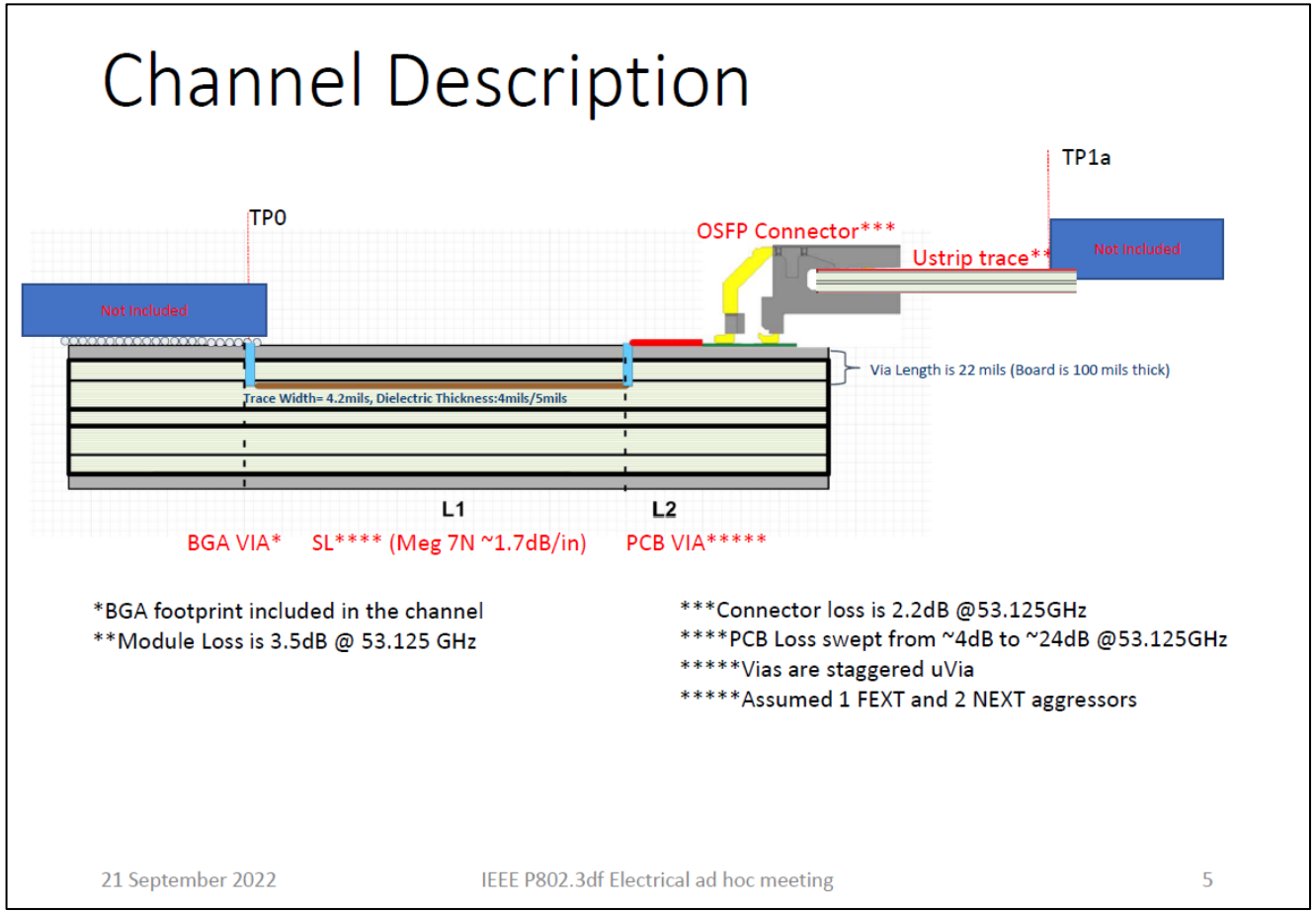


- Targets ~36 dB IL die-die
- Primarily FPP
- Reference receiver and transmitter models leveraged from 3ck backplane and copper cable, scaled appropriately

https://www.ieee802.org/3/df/public/22_11/lusted_3df_02_2211.pdf

C2M Channel Summaries (1/3)

- TP0 to TP1a IL range from 10.35dB to 29.56dB in two different model variants
  - Host PCB length
  - Host PCB impedance



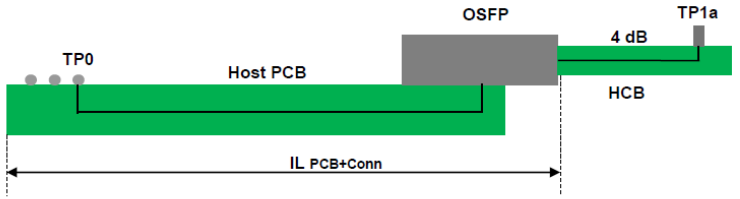
Contribution: akinwale_3df_elec_01_220921
Channel: akinwale_3df_01_2209, akinwale_3df_02_2209, akinwale_3df_03_2209

C2M Channel Summaries (2/3)

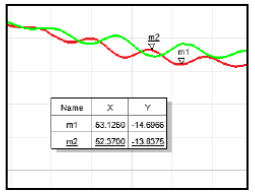
- TP0 to TP1a IL range from 10.64dB to 14.99dB in two different model variants
  - ASIC breakout topology
  - Via length

200G PAM4 C2M Via Length Effect Study

Structure View & Insertion Losses



- Full Structure:
  - Two adjacent channels
    - Matching segmentation meshing (i.e., common minimum element size)
  - Connector integrated with PCB
  - HCB is ideal transmission line with IL = 4 dB @ Nyquist
  - NEXT is evaluated at the ASIC model for more realistic results
- Vias = 19/67/93 mil long
- Blind Vias
- Frequency Sweep Range = 10 MHz to 120 GHz



Reflections Effect

IL @ Nyquist (53.125 GHz)

Parallel Breakout

- IL PCB+Conn = 8.24/9.32/10.31 dB
- IL HCB = 4 dB
- IL TP0-to-TP1a = 12.27/13.32/13.44 dB

Orthogonal Breakout

- IL PCB+Conn = 8.34/10.69/10.14 dB
- IL HCB = 4 dB
- IL TP0-to-TP1a = 12.38/14.69/14.17 dB

KEYSIGHT TECHNOLOGIES

Page 5

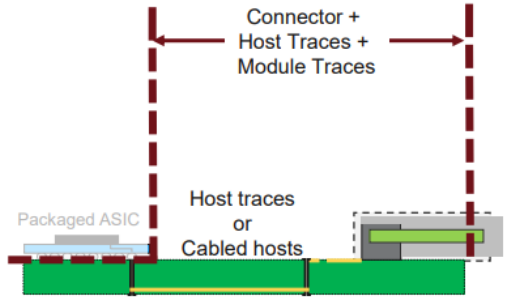
Contribution: rabinovich_3df_elec_01b_220921, rabinovich_3dj_01_230116
Channel: rabinovich_3df_01_2209, rabinovich_3df_02_2209, rabinovich_3dj_02_230116, rabinovich_3dj_03_230116

C2M Channel Summaries (3/3)

- TP0 to TP1a IL range from 7.54dB to 19.18dB in two different model variants
  - Host type
  - Host PCB length

Description

- Simulation for 200G chip to module channels using concept connector with various host architecture options
- Includes BGA escape model provided by Regee Petaja of Broadcom
- Does NOT include silicon package
- Current view of Chip to Module performance in various host implementations
- What this presentation is NOT:
  - Modulation proposal
  - Channel or host loss proposal
  - Compliance board proposal
  - A specific host architecture proposal;
    - comparative performance options are presented, i.e., traces vs. cabled host to “near ASIC” vs. co-package copper
  - Asymmetric architectures (managed deployment)

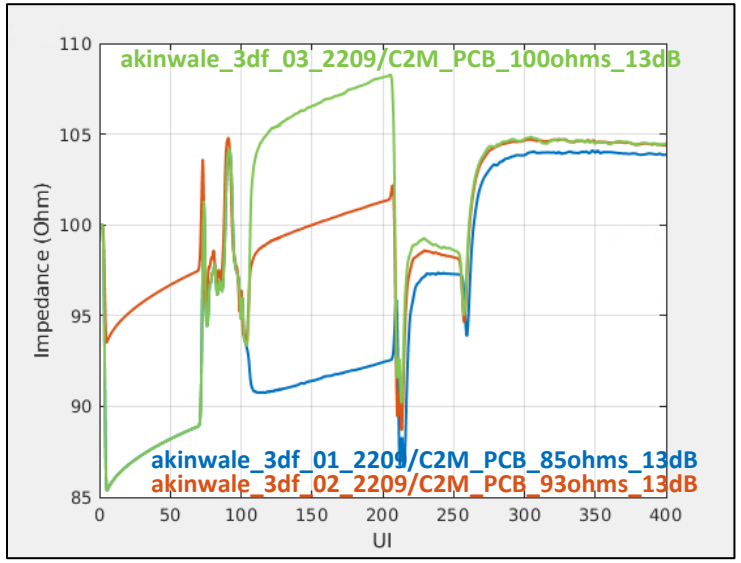


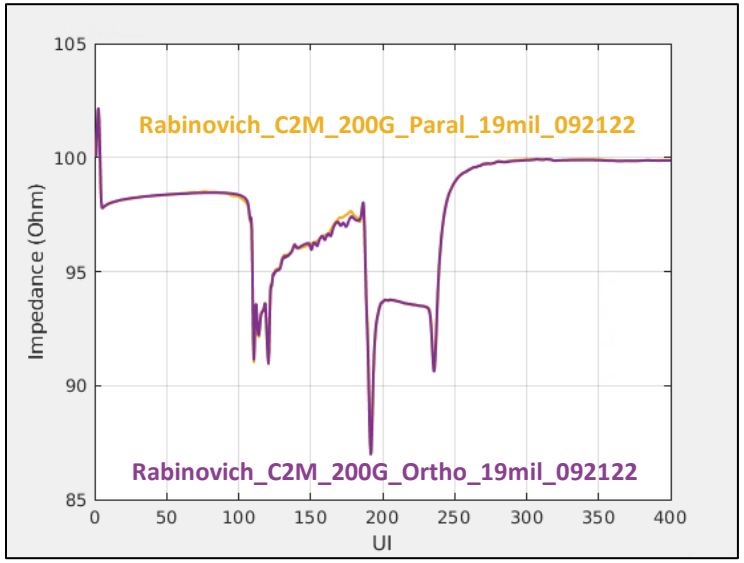
5

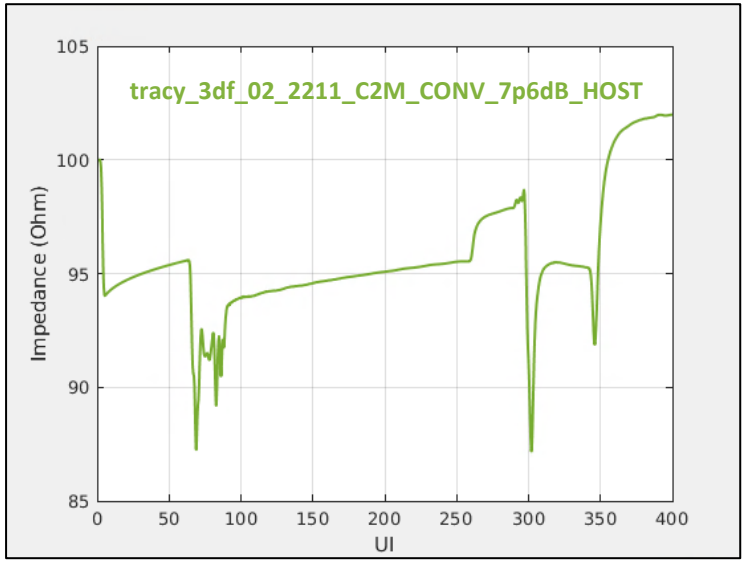
Contribution: tracy_3df_02_2211
Channel: tracy_3df_02_2211_sparameters

Coarse Selection via Impedance Corner

- TP1a-die (host) TDR
  - Impedance mismatch among MCB-Conn-HCB in **akinwale_3df_01_2209 (85Ohm)** and **akinwale_3df_03_2209 (100Ohm)** are greater than **10%**







Two AUI C2M Host Losses

Straw Poll #1

For the front panel pluggable use case, I am interested in 200 Gbps/lane AUI C2M specifications for:

A. medium loss only (e.g. up to ~22 dB IL die-die per lusted_3df_01_220927)
B. higher loss only (e.g. up to ~36 dB IL die-die per lusted_3df_01_220927)
C. both medium and higher loss
D. need more information

pick one

Results: A: 17, B: 11, C: 49, D: 12

https://www.ieee802.org/3/df/public/22_10/motions_3df_221004.pdf