Package impedance and termination effect on COM (update)

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Introduction

- **This is an update to dudek_3bs_02_0517. Key changes.**
  - Corrects a typo (and consequential changes) for the Mellitz 04 channel COM with the D3.1 package and die parameters.
  - As requested at the New Orleans meeting investigates the effect of leaving Av unchanged when the die Rd value is changed.
  - Investigates the package return loss and compares it with the revised specification.
- **The presentation explores the impact of varying package impedance (Zc) and R_d termination on COM and return loss for the 400GAUI-8 (Clause 120D) chip to chip specification.**
- **COM uses a particular package trace impedance and die impedance for its calculations.**
- **Yasuo Hidaka in 802.3cd (e.g.) hidaka_3cd_01a_0317 has shown that for a large number of backplane channels the COM varies significantly (on the order of +/-0.5dB) depending on the choice of package trace impedance and die impedance within a 10% manufacturing tolerance and that no one choice of impedances gives the worst case.**

Methodology

- Four variations from the IEEE P802.3bs/D3.1 COM parameters are evaluated to cover manufacturing tolerances and potential different target impedance values.
- All COM parameters, other than those shown in tables, are the same as in IEEE P802.3bs/D3.1 spec.
- Av was adjusted so that the steady state voltage Vf is kept equal to 0.4V for all the combinations. However comparisons are also included when Vf is not changed.
- The first eight channels evaluated are found at http://grouper.ieee.org/groups/802/3/bs/public/channel/index.shtml . The additional two channels have smaller capacitive discontinuities and higher impedance (but not higher than 110 ohms).

COM comparison to D3.1 ORIGINAL

Changed

	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	Delta mod1 to original	Delta mod2 to original	Delta mod3 to original
package_Zc (ohms)	90	100	110	95			
Av/Afe (V)	0.45	0.418	0.394	0.416			
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04		Largest negative difference	
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]		Largest positive difference	
Channels							
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	-0.03	-0.27	0.06
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	0.15	-0.21	0.18
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	-0.31	-0.86	-0.15
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	0.22	-0.17	0.06
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	-0.05	-0.23	0.01
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	-0.04	-0.43	0.1
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	-0.1	-0.5	0.11
shanbhag_01_0914	4.93	4.98	4.61	5.08	0.05	-0.32	0.15
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	0.58	0.22	0.47
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	0.5	0.15	0.4

COM comparison to Mod3 (OIF adopted)

Changed

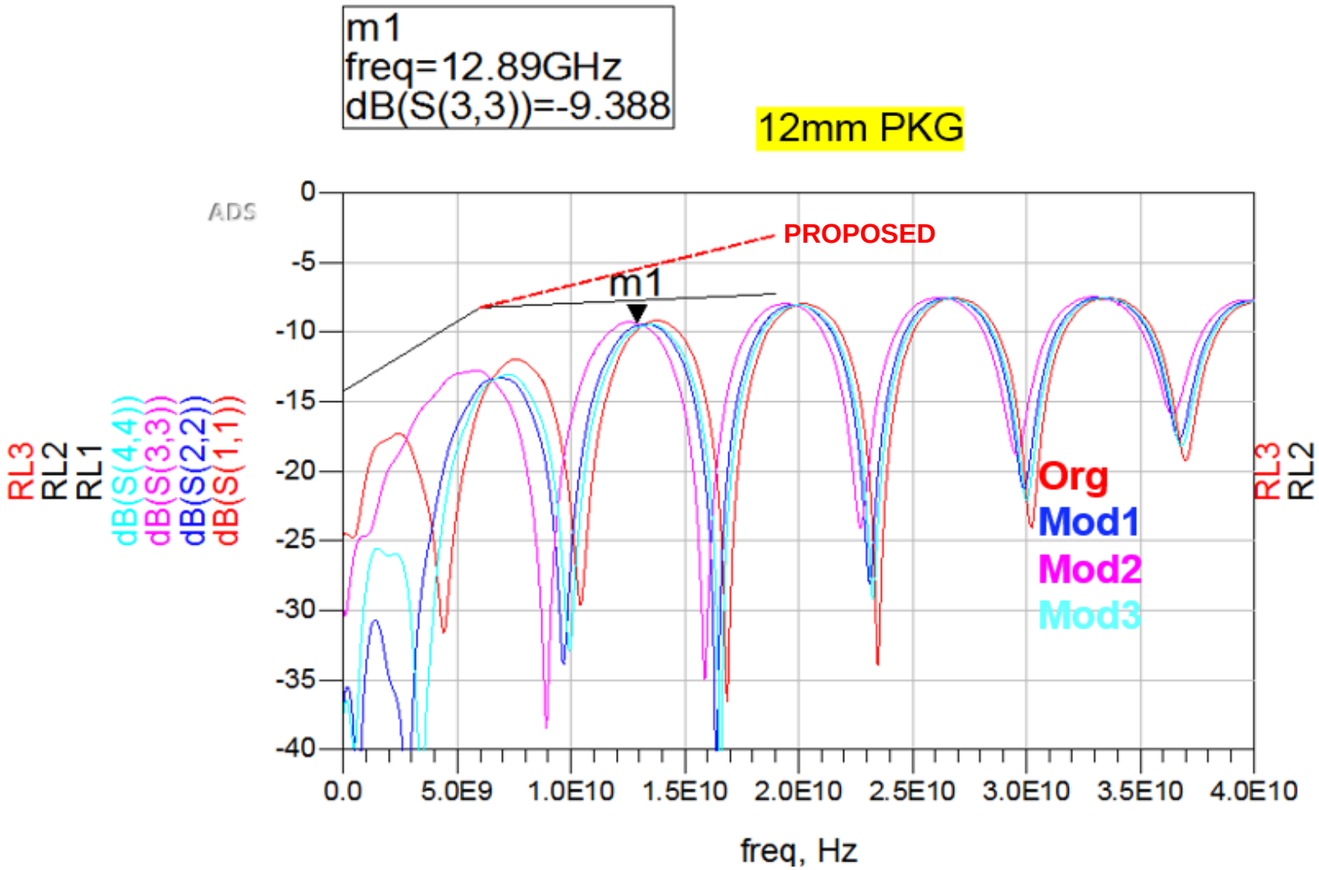
	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	Delta original to mod3	Delta mod1 to mod3	Delta mod2 to mod3
package_Zc (ohms)	90	100	110	95			
Av/Afe (V)	0.45	0.418	0.394	0.416			
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04		Largest negative difference	
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]		Largest positive difference	
Channels							
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	-0.06	-0.09	-0.33
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	-0.18	-0.03	-0.39
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	0.15	-0.16	-0.71
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	-0.06	0.16	-0.23
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	-0.01	-0.06	-0.24
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	-0.1	-0.14	-0.53
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	-0.11	-0.21	-0.61
shanbhag_01_0914	4.93	4.98	4.61	5.08	-0.15	-0.1	-0.47
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	-0.47	0.11	-0.25
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	-0.4	0.1	-0.25

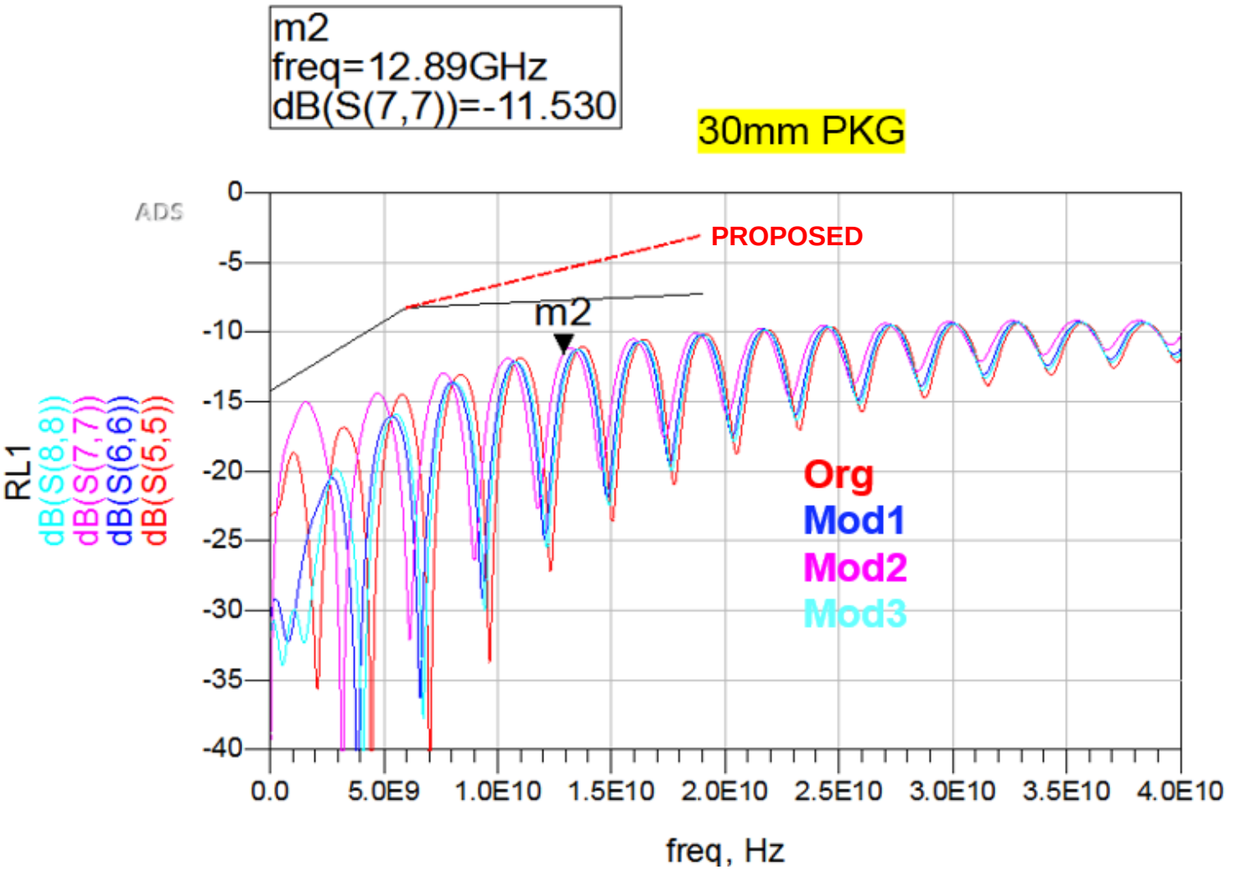
Effect of not changing Av.

	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	D3.1 CAVM mod1 /w Av = 0.45	D3.1 CAVM mod2 /w Av = 0.45	D3.1 CAVM mod3 /w Av = 0.45	Delta due to AV change Mod 1	Delta due to AV change Mod 2	Delta due to AV change Mod 3
package_Zc (ohms)	90	100	110	95	100	110	95			
Av/Afe (V)	0.45	0.418	0.394	0.416	0.45	0.45	0.45			
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04			
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]	[50 50]	[45 45]	[50 50]			
Channels										
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	3.63	3.42	3.65	-0.12	-0.15	-0.05
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	4.22	3.91	4.33	-0.05	-0.1	-0.13
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	4.31	3.55	4.2	-0.23	-0.02	0.04
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	3.27	3.08	3.38	0.08	-0.12	-0.19
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	2.7	2.53	2.7	-0.05	-0.06	0.01
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	4.1	3.73	4.27	-0.03	-0.05	-0.06
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	3.96	3.55	4.17	-0.04	-0.03	-0.04
shanbhag_01_0914	4.93	4.98	4.61	5.08	5.08	4.74	5.13	-0.1	-0.13	-0.05
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	3.41	3.16	3.33	-0.13	-0.24	-0.16
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	3.59	3.35	3.5	-0.13	-0.24	-0.14

Tx and Rx return loss investigation

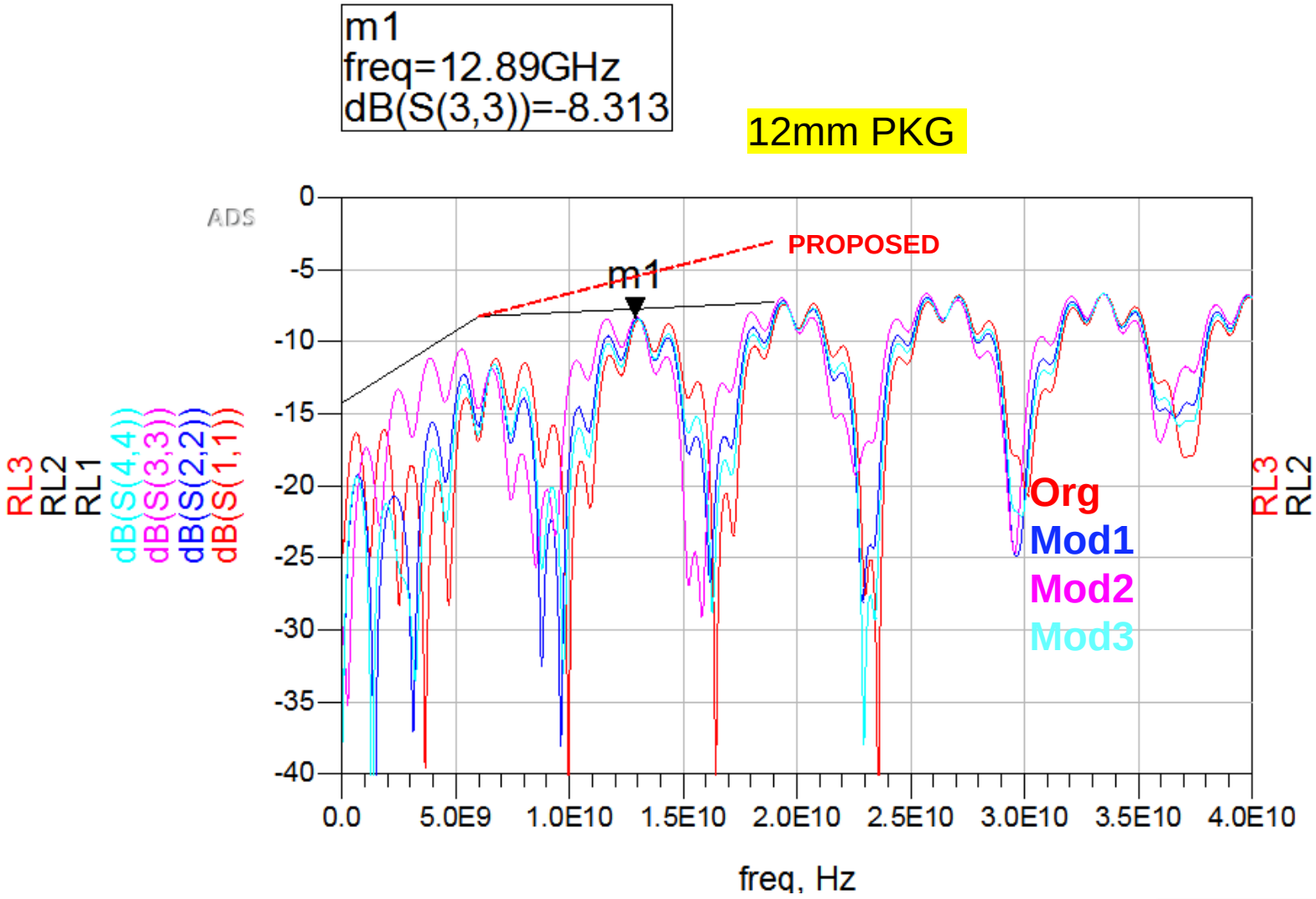
Return Loss at TP0a (Test trace = 100ohms)

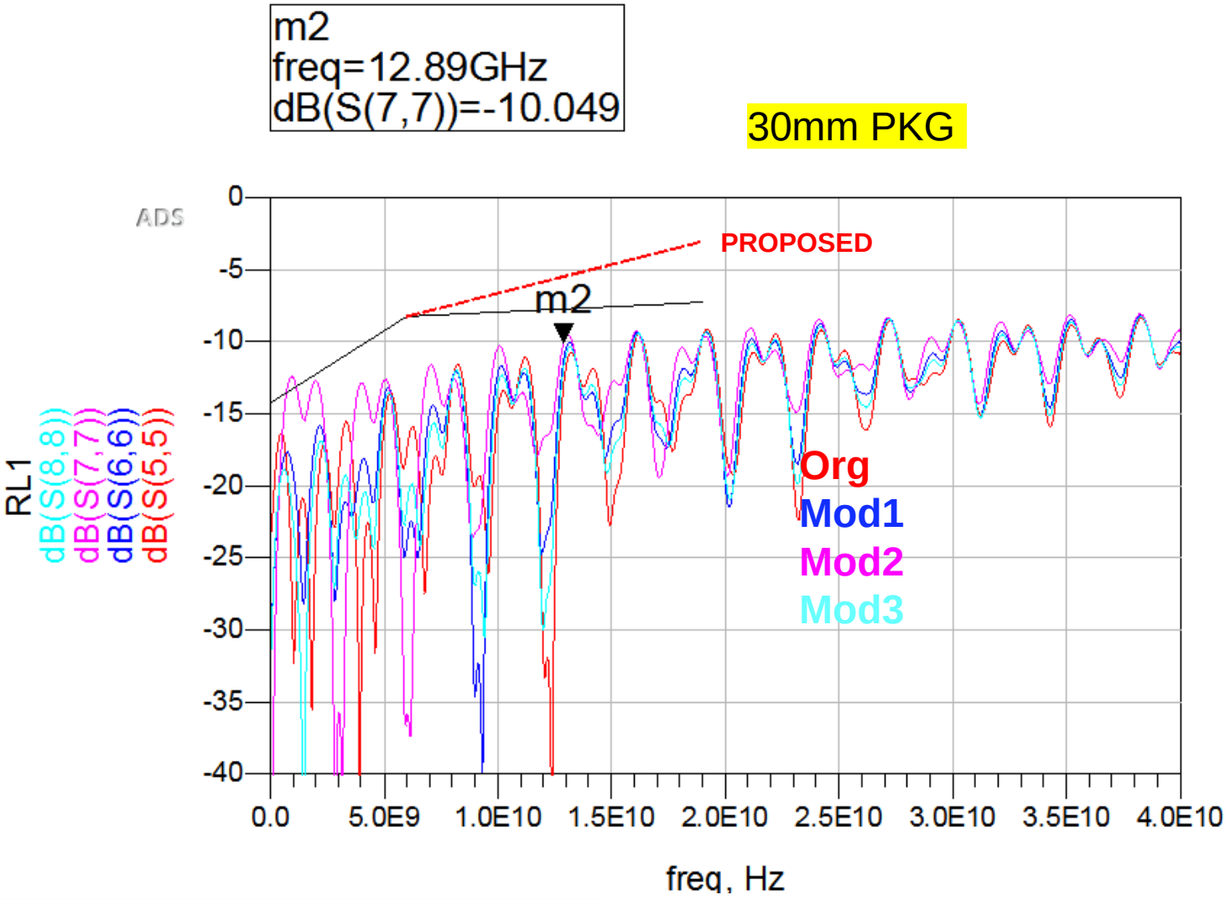




	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3
package_Zc (ohms)	90	100	110	95
Av/Afe (V)	0.45	0.418	0.394	0.416
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]

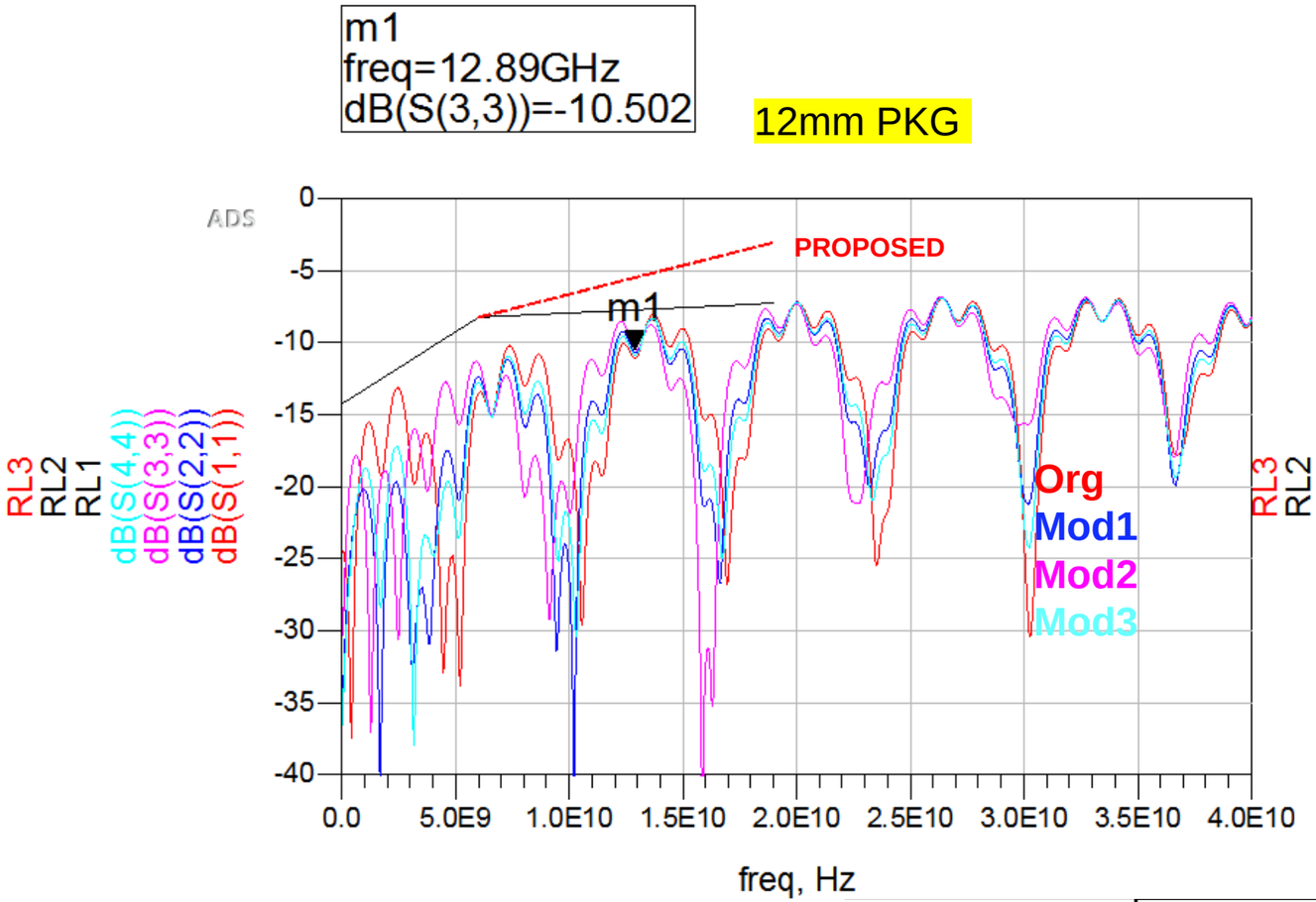
Return Loss at TP0a (Test trace = 90ohms)

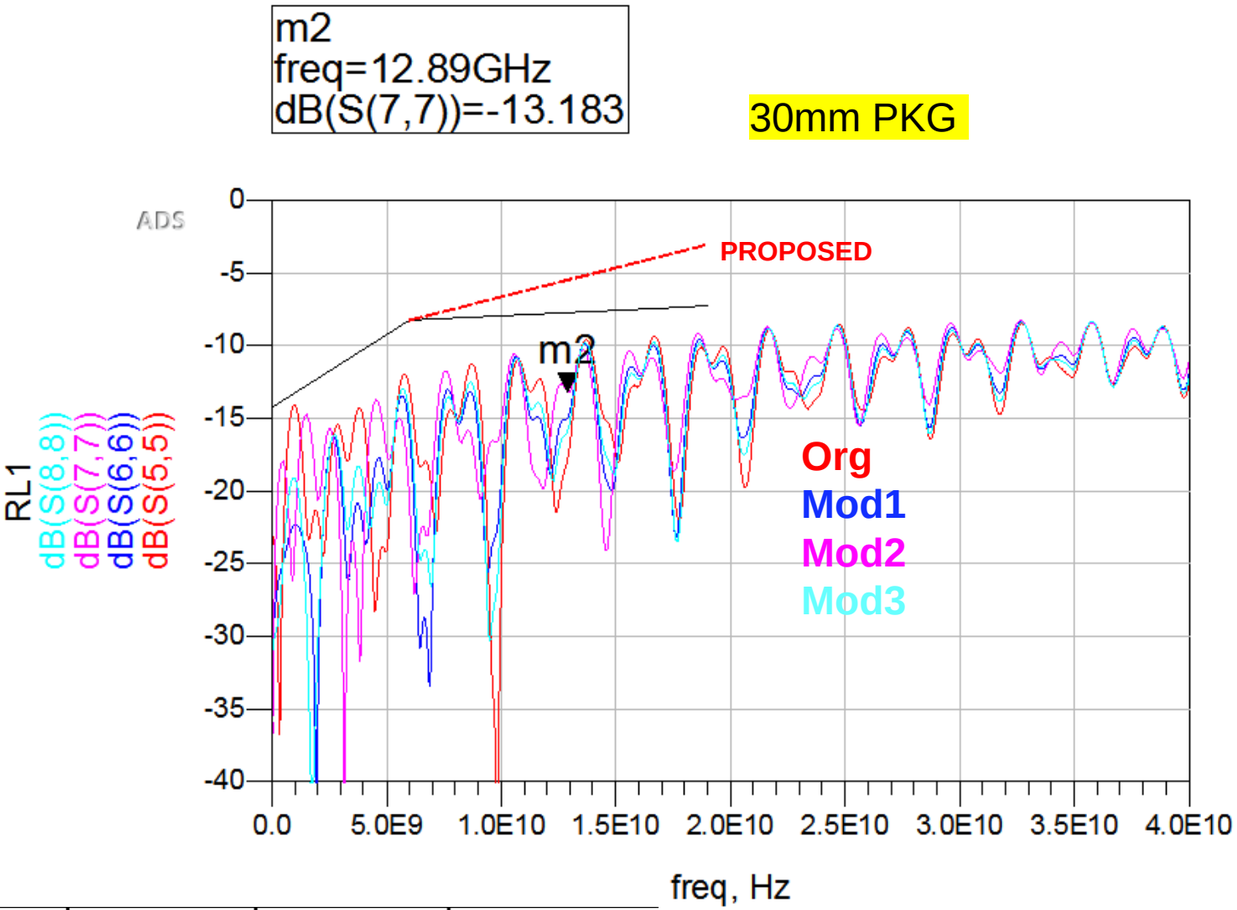




	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3
package_Zc (ohms)	90	100	110	95
Av/Afe (V)	0.45	0.418	0.394	0.416
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]

Return Loss at TP0a (Test trace = 110ohms)





	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3
package_Zc (ohms)	90	100	110	95
Av/Afe (V)	0.45	0.418	0.394	0.416
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]

Effect of lower package impedance (Mod 4) that fails Tx SNR_{ISI}

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	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	D3.1 CAVM mod4	Delta mod1 to original	Delta mod2 to original	Delta mod3 to original	Delta mod4 to original
package_Zc (ohms)	90	100	110	95	80				
Av/Afe (V)	0.45	0.418	0.394	0.416	0.441				
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04		Largest negative difference		
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]	[55 55]		Largest positive difference		
Channels									
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	2.63	-0.03	-0.27	0.06	-0.91
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	3.1	0.15	-0.21	0.18	-0.92
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	3.53	-0.31	-0.86	-0.15	-0.86
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	2.43	0.22	-0.17	0.06	-0.7
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	2.25	-0.05	-0.23	0.01	-0.45
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	3.31	-0.04	-0.43	0.1	-0.8
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	3.29	-0.1	-0.5	0.11	-0.73
shanbhag_01_0914	4.93	4.98	4.61	5.08	4	0.05	-0.32	0.15	-0.93
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	1.57	0.58	0.22	0.47	-1.13
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	1.94	0.5	0.15	0.4	-1.02

Conclusions

- With realistic Tx package/die impedances the COM can be significantly worse (0.6dB) than with the values presently used in COM. This creates a “hole” in the specification that should be filled. Raising the COM requirement for the channel to 0.5dB above the COM used for the interference tolerance test will close the majority of the “hole” except for Zc=80 ohms Rd=55 ohms.
- Zc=80 ohms Rd=55 ohms has the worst COM of all cases and is not recommended. Additional analysis has shown that with Zc=80 ohms the package will not pass SNR_{isi} (it is 33.42dB). Therefore the bad COM is not an issue so long as the SNR_{isi} specification isn’t relaxed.
- Leaving Av unchanged changes the COM by less than 0.25dB. It is not the dominant effect.
- Changing to Zc=95 ohms Rd=50 ohms (nominal values) has improved COM over Zc=100 ohms and Zc=90 ohms for majority of channels and has reduced the variability somewhat.
- It is not possible to control the Rd and Zc impedances using return loss
- At higher frequencies the D3.2 return loss specification is too tight.

Proposal

- **In order to close the “hole” in the specification, increase the COM for measuring the channel to 3.5dB.**

- **Change to Zc=95 ohms Rd=50 ohms (nominal values) to make the results less dependent on the impedance of the channels.**

- **Change the second half of the Tx and Rx return loss specifications as highlighted below**

$$RL_d(f) \geq \begin{cases} 14.25 - f & 0.05 \leq f \leq 6 \\ \sout{8.7 - 0.075f} \; \mathbf{10.65 - 0.4f} & 6 < f \leq 19 \end{cases} \quad \text{dB} \qquad (120D\text{–}2)$$

Backup

COM comparison to Mod3 (OIF adopted) - Mod4 added

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	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	D3.1 CAVM mod4	Delta original to mod3	Delta mod1 to mod3	Delta mod2 to mod3	Delta mod4 to mod3
package_Zc (ohms)	90	100	110	95	80				
Av/Afe (V)	0.45	0.418	0.394	0.416	0.441				
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04		Largest negative difference		
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]	[55 55]		Largest positive difference		
Channels									
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	2.63	-0.06	-0.09	-0.33	-0.97
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	3.1	-0.18	-0.03	-0.39	-1.1
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	3.53	0.15	-0.16	-0.71	-0.71
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	2.43	-0.06	0.16	-0.23	-0.76
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	2.25	-0.01	-0.06	-0.24	-0.46
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	3.31	-0.1	-0.14	-0.53	-0.9
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	3.29	-0.11	-0.21	-0.61	-0.84
shanbhag_01_0914	4.93	4.98	4.61	5.08	4	-0.15	-0.1	-0.47	-1.08
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	1.57	-0.47	0.11	-0.25	-1.6
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	1.94	-0.4	0.1	-0.25	-1.42


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