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The need for an additional Tx specification for 100Gbase-KR.

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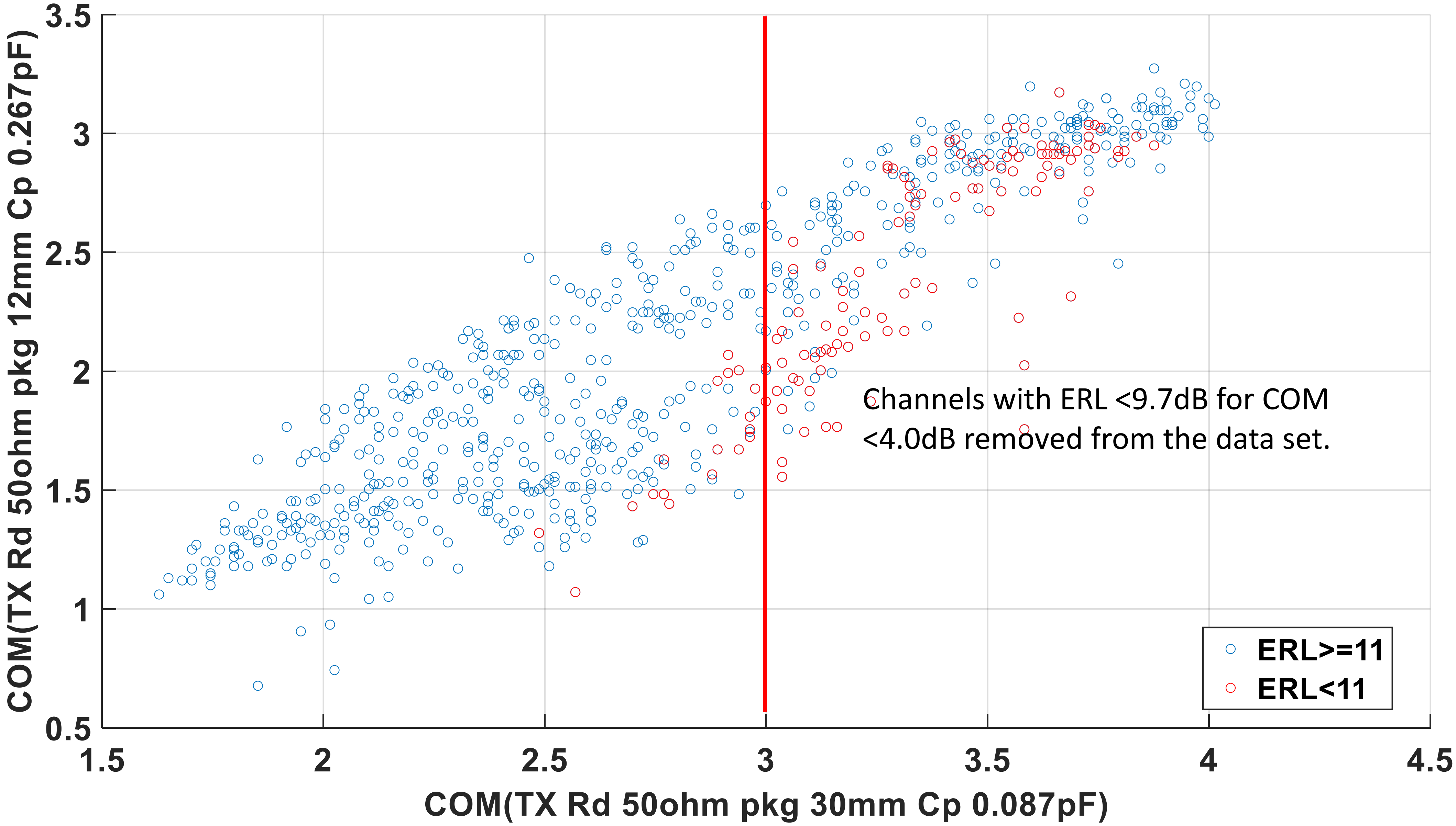
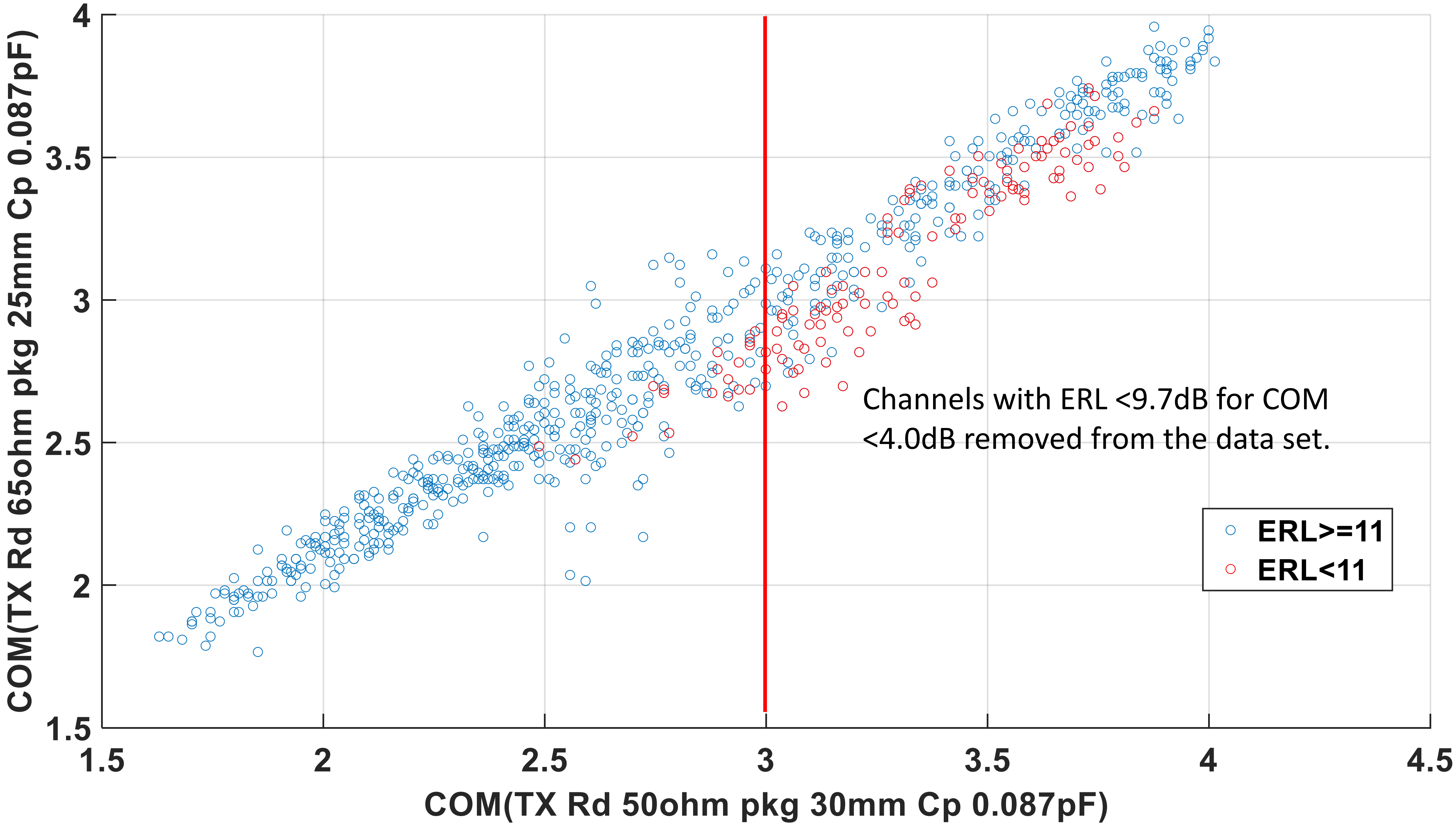
Introduction

- In Dudek_3ck_adhoc_01_0428 it was shown that the existing backplane specification with Tx dERL specification of -3dB allowed a 12mm package with Cp=0.267pF to pass the Tx specifications.
- In Dudek_3ck_01_0521 it was shown that with this passing transmitter there were multiple channels that passed the COM test that had poor system performance (COM less than 2dB). A proposal was made to tighten the dERL specification to fail the false passing transmitter.
- Li_3ck_adhoc_01_063021 confirmed this poor performance on more channels but also showed that if dERL were degraded by changing Rd or Zc instead of Cp the system performance was still adequate. i.e. tightening the dERL specification would lead to false fails for transmitters with low Cp and varying Rd and Zc.
- This presentation confirms the results in Li_3ck_adhoc_01_063021, evaluates a likely reason that the transmitters with similar dERL, dRpeak, and dVf have very different system performance, and proposes an additional specification that differentiates between these transmitters. It is in support of Draft 2.1 comment #75

Results from Degraded Kareti KR channel OAch1_t.s4p (Dudek_3ck_01_0521)



Results from Degraded Kareti KR channel OAch1_t.s4p with Rd adjusted instead of Cp



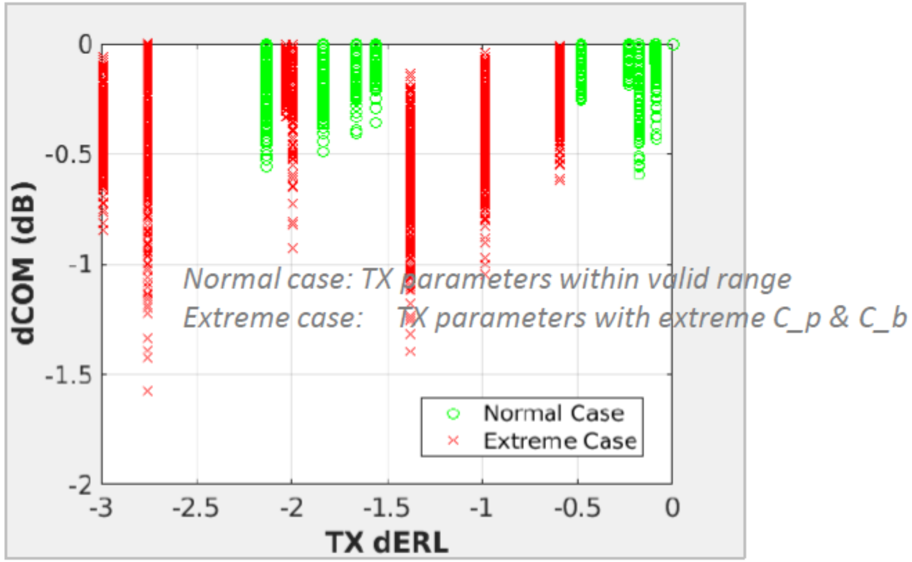
dCOM Sensitivity with TX dERL

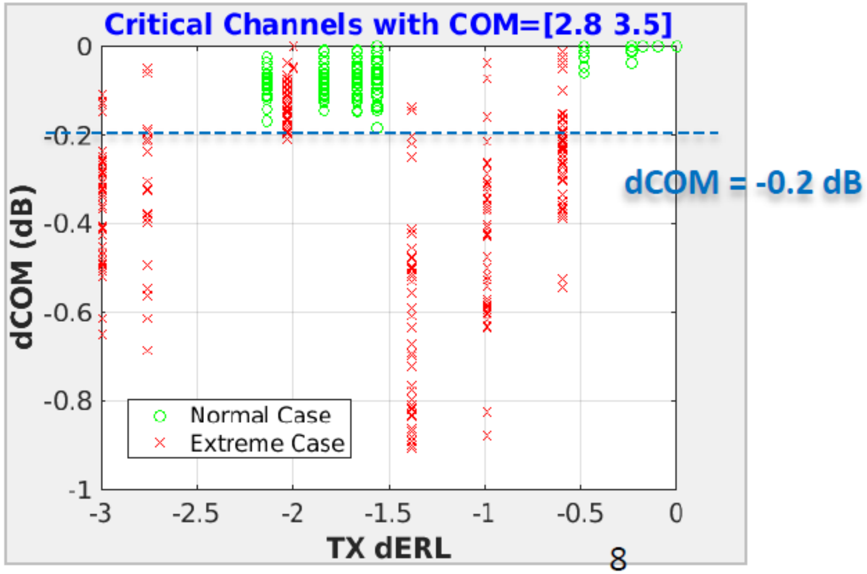
- dCOM = COM - Reference COM (calculated based on the following TX parameters specified in D2p0)

R_d (Ohm)	C_p (nF)	C_b (nF)	Z_c (Ohm)	Z_p (mm)	ERL
50.00	0.87	0.30	87.50	31.00	18.60

- **Normal case**:
  - COM is not sensitive to R_d & Z_c variations
  - For critical channels with COM = [2.8 3.5], COM degradation **<= 0.2 dB**
- **Extreme case**:
  - It's apparently larger C_p & C_b cause worse dERL and hence degrade COM more
  - dCOM > 0.5 dB even we tighten TX dERL specification up to -1 dB

→ Is it necessary to allocate dERL margin for C_p & C_b?





System Performance conclusions.

- The system performance is very different between the transmitter where Cp was made large versus where Rd and other parameters were adjusted.
- To create an inter-operable specification the transmitters with the large Cp need to fail Tx specifications.

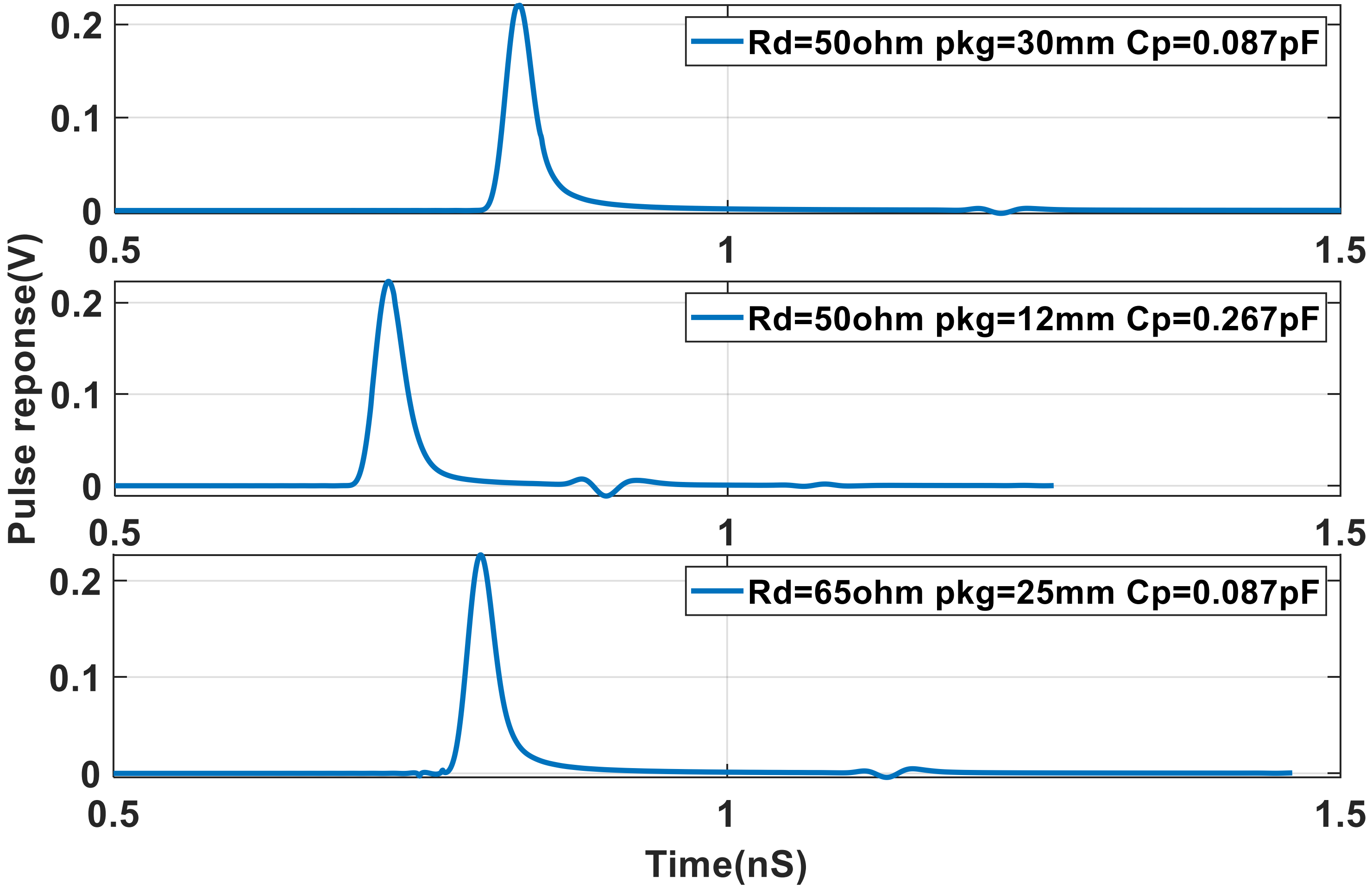
- What is the difference between these transmitters and how they meet the existing Transmitter specification?

4dB test fixture and TxSNR=33dB

	Np	Rd(ohm)	Cp(pF)	Package(mm)	dRpeak	dERL(dB)	SNDR(dB)
Reference	29	50	0.087	30	0	0	32.89
High Cp	29	50	0.267	12	0.006	-2.69	32.98
High Rd	29	65	0.087	25	0.017	-2.97	32.93

- There is obviously a difference between the transmitters that is not being captured by the existing specifications.

Pulse responses from these transmitters.



- It is obvious that for the high Cp case there is much more energy outside the main pulse that can interact with reflections in the channel resulting in the need for many more DFE taps and or banks of DFE floating taps than the KR reference receiver has.

Proposed specification.

- Investigating a new parameter “Residual ISI” Defined as sigma_e/Pmax) with Np=11 using the same definitions as used for SNDR i.e. as defined in 162.9.3.3 with the exception that Np=11 instead of 29.

4dB test fixture and TxSNR=33dB

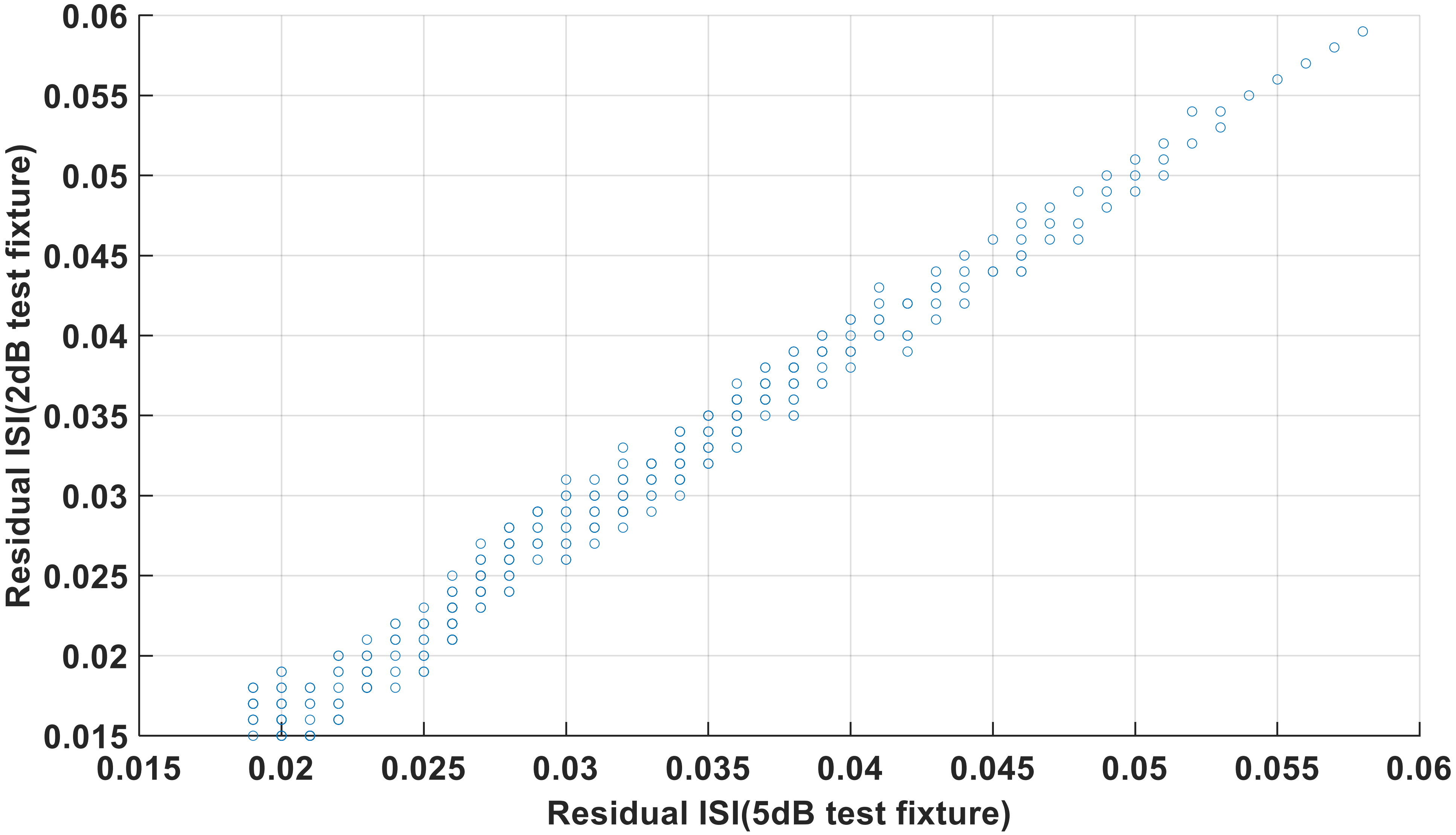
	Np	Rd(ohm)	Cp(pF)	Package(mm)	dRpeak	dERL(dB)	SNDR(dB)	Residual ISI
Reference	11	50	0.087	30	0	0	30.46	0.02
High Cp	11	50	0.267	12	0.006	-2.69	26.53	0.041
High Rd	11	65	0.087	25	0.017	-2.97	29.66	0.024

The pass fail criterion proposed is “Residual ISI (max) = 0.027

Values of Residual ISI for some other transmitters (4dB test fixture).

Np	Av(V)	Zpkg(ohm)	Lpkg(mm)	Rd(ohm)	Zvia(ohm)	Lvia(mm)	Cp(pF)	Vpeak(V)	Vf(V)	Rpeak	Sigmae(mV)	SNDR(dB)	Residual ISI
11	0.372	87.5	12	40	92.5	1.8	0.087	0.253	0.401	0.632	4.652	30.764	0.018
11	0.413	87.5	12	50	92.5	1.8	0.087	0.251	0.402	0.623	5.315	30.217	0.021
11	0.454	87.5	12	60	92.5	1.8	0.087	0.248	0.402	0.618	6.335	29.387	0.026
11	0.372	87.5	30	40	92.5	1.8	0.087	0.224	0.401	0.558	4.144	30.737	0.019
11	0.413	87.5	30	50	92.5	1.8	0.087	0.22	0.401	0.549	4.404	30.457	0.02
11	0.454	87.5	30	60	92.5	1.8	0.087	0.22	0.401	0.547	4.941	29.967	0.023
11	0.372	87.5	12	40	92.5	1.8	0.167	0.241	0.402	0.6	6.891	28.807	0.029
11	0.413	87.5	12	50	92.5	1.8	0.167	0.239	0.402	0.593	7.676	28.139	0.032
11	0.454	87.5	12	60	92.5	1.8	0.167	0.237	0.402	0.59	9.325	26.891	0.039
11	0.372	87.5	30	40	92.5	1.8	0.167	0.217	0.402	0.54	5.106	29.76	0.024
11	0.413	87.5	30	50	92.5	1.8	0.167	0.213	0.401	0.531	5.523	29.308	0.026
11	0.454	87.5	30	60	92.5	1.8	0.167	0.211	0.401	0.527	6.521	28.375	0.031
11	0.372	87.5	12	40	92.5	1.8	0.267	0.227	0.402	0.565	8.325	27.347	0.037
11	0.413	87.5	12	50	92.5	1.8	0.267	0.223	0.402	0.555	9.255	26.533	0.041
11	0.454	87.5	12	60	92.5	1.8	0.267	0.221	0.402	0.55	11.558	24.908	0.052
11	0.372	87.5	30	40	92.5	1.8	0.267	0.201	0.402	0.502	5.916	28.653	0.029
11	0.413	87.5	30	50	92.5	1.8	0.267	0.199	0.401	0.497	6.472	28.086	0.032
11	0.454	87.5	30	60	92.5	1.8	0.267	0.198	0.402	0.493	7.997	26.709	0.04

Check that residual ISI isn't affected by Test fixture loss.

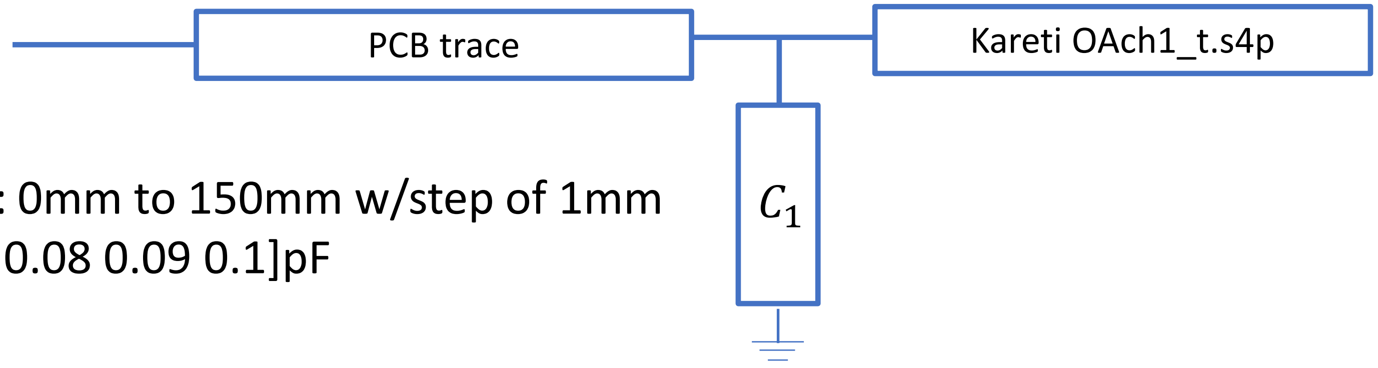


Conclusion

- Residual ISI is reasonably invariant with the test fixture loss.
- Residual ISI does separate the transmitters with high values of Cp from those with similar poor ERL created by higher Zp.
- In order to not have false passing transmitters an additional specification is required. If this is not done the specification is not inter-operable.
- The task force should add an additional specification of Residual ISI (max) value of 0.027.

Backup. Slides from previous presentations

Degraded Kareti KR channel



PCB length: 0mm to 150mm w/step of 1mm
C1: [0 0.05 0.08 0.09 0.1]pF

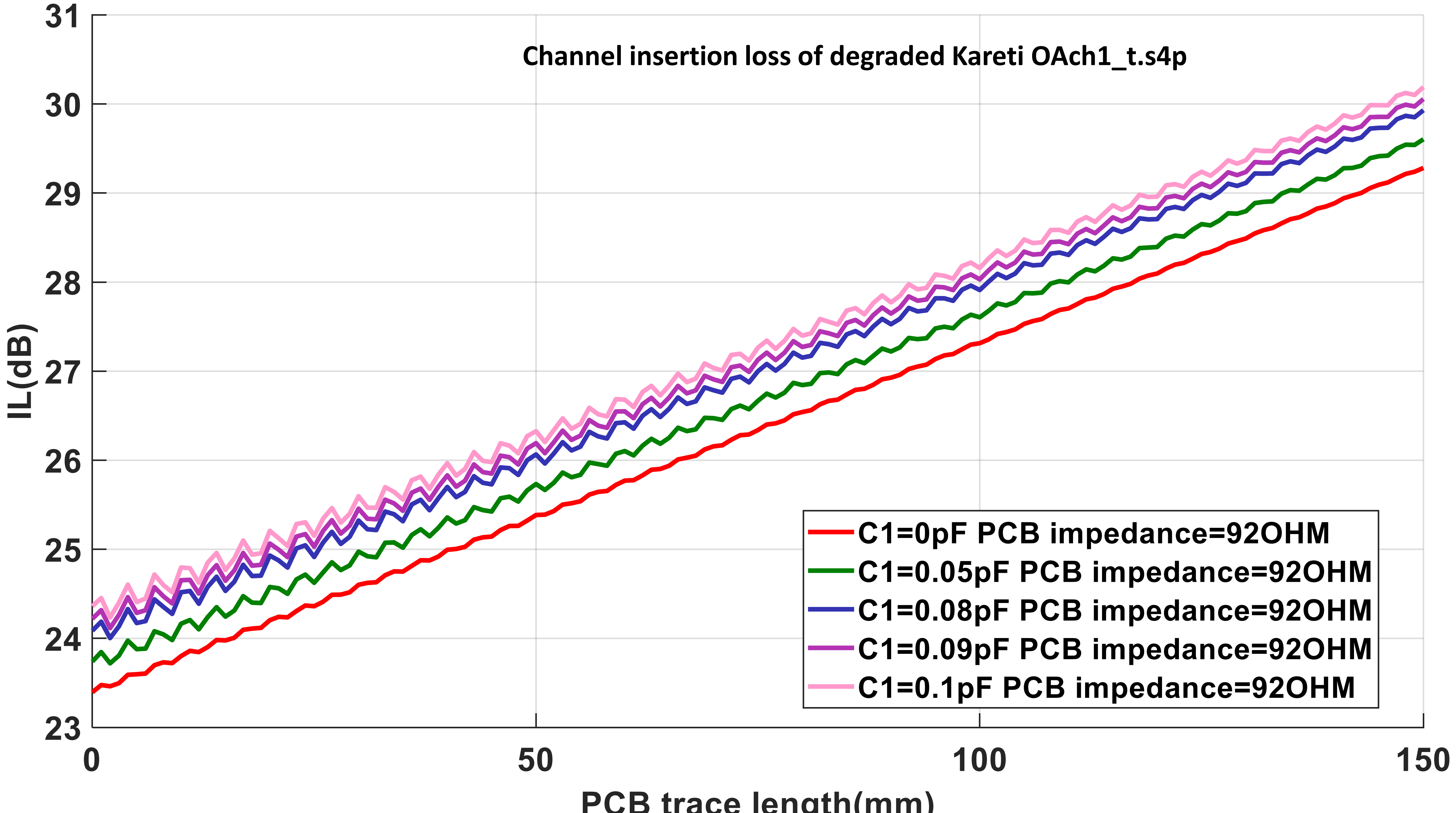
163.10.3 Channel ERL

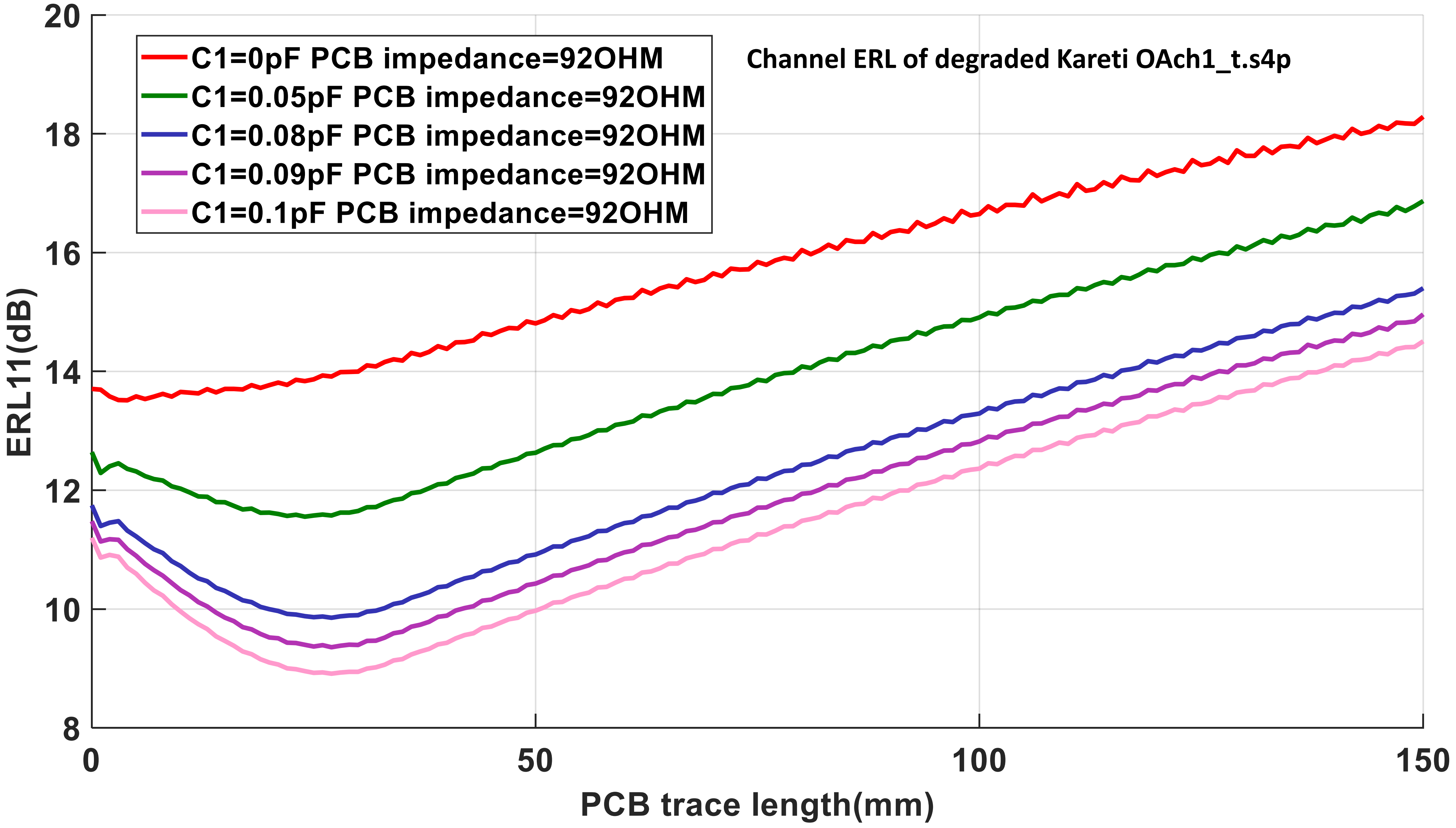
ERL of the channel at TP0 and at TP5 are computed using the procedure in 93A.5 with the values in Table 163–11. Parameters that do not appear in Table 163–11 take values from Table 163–10.

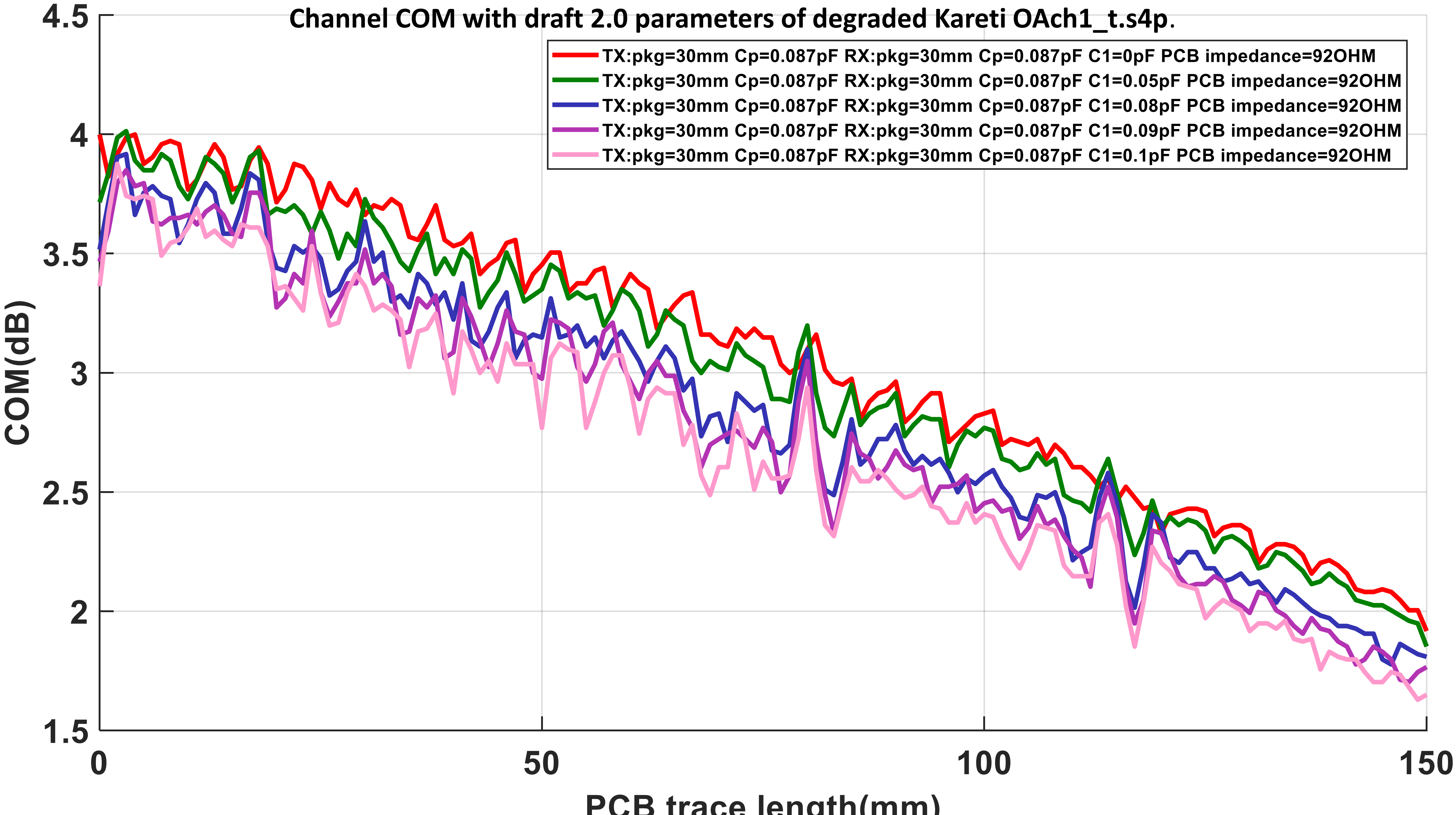
Channel ERL at TP0 and at TP5 shall be greater than or equal to 9.7 dB.

Table 163–11—Channel 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	3500	UI
Equalizer length associated with reflection signal	N_{bx}	21	UI
Time-gated propagation delay	T_{fx}	0	ns
Tukey window flag	*tw*	1	—

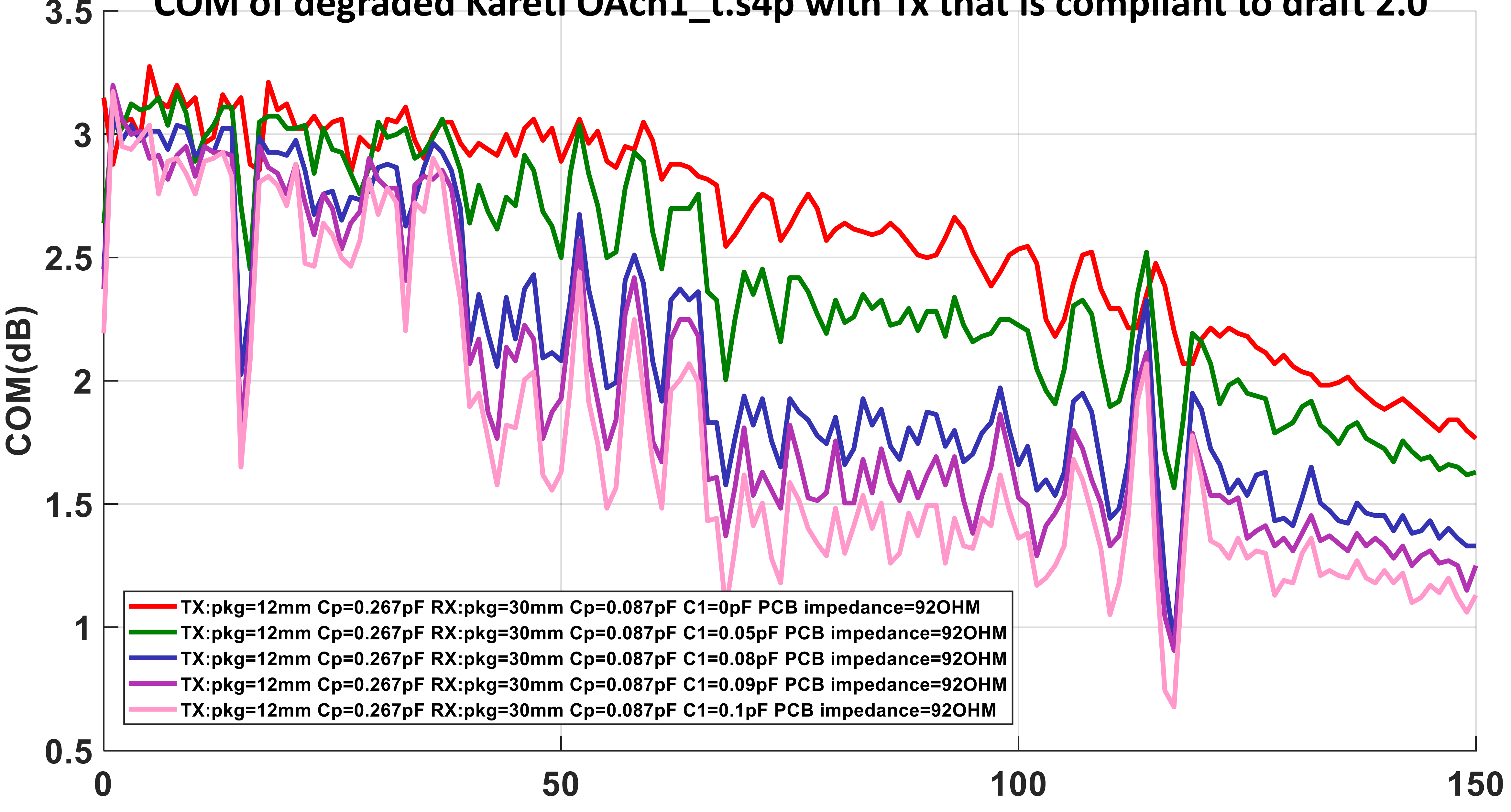

Channel insertion loss of degraded Kareti OAch1_t.s4p
IL(dB)
PCB trace length(mm)
23
24
25
26
27
28
29
30
31
0
50
100
150
C1=0pF PCB impedance=92OHM
C1=0.05pF PCB impedance=92OHM
C1=0.08pF PCB impedance=92OHM
C1=0.09pF PCB impedance=92OHM
C1=0.1pF PCB impedance=92OHM

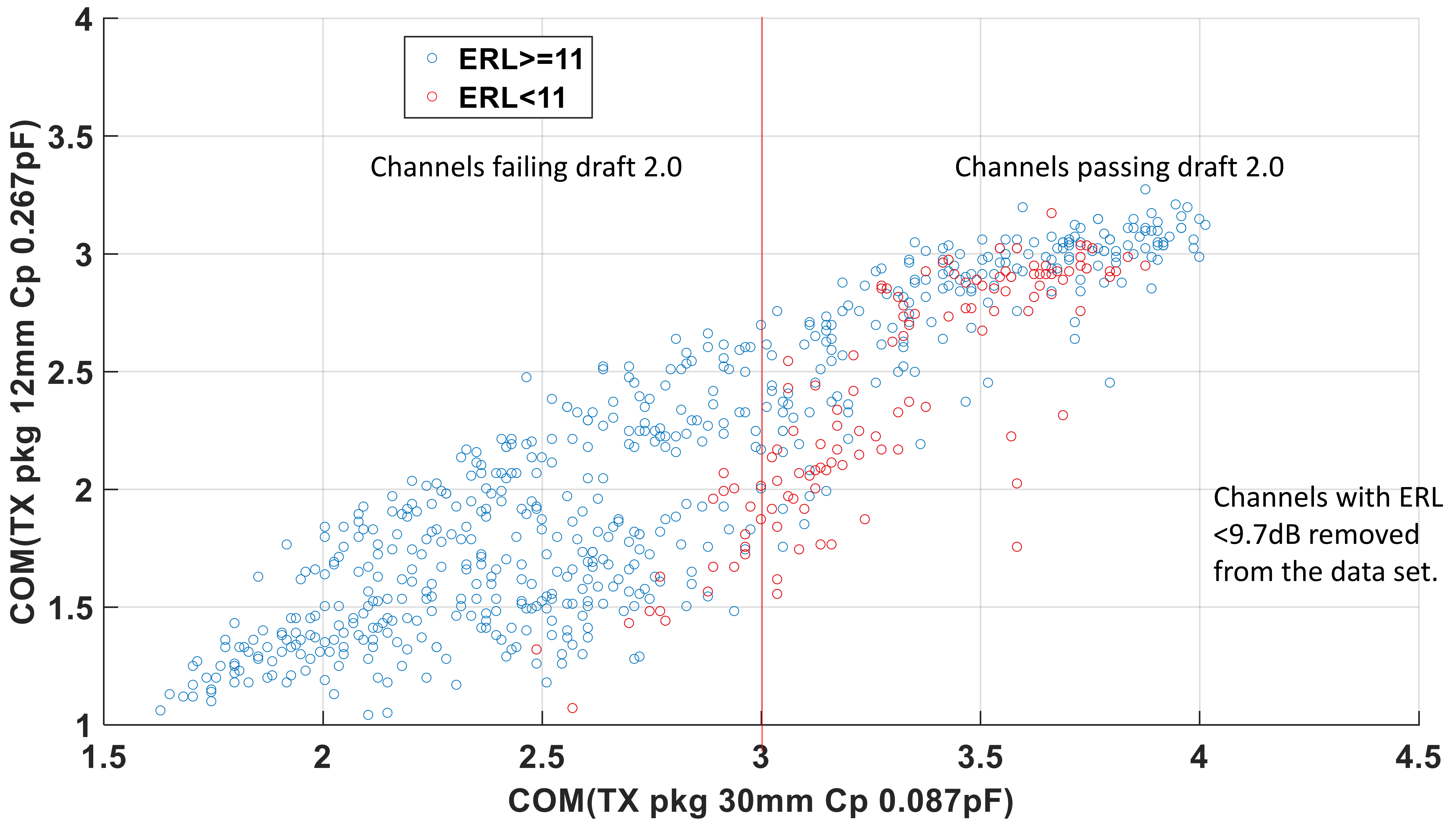

C1=0pF PCB impedance=92OHM
C1=0.05pF PCB impedance=92OHM
C1=0.08pF PCB impedance=92OHM
C1=0.09pF PCB impedance=92OHM
C1=0.1pF PCB impedance=92OHM
Channel ERL of degraded Kareti OAch1_t.s4p
ERL11(dB)
20
18
16
14
12
10
8
0
50
100
150
PCB trace length(mm)



Channel COM with draft 2.0 parameters of degraded Kareti OAch1_t.s4p.
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.05pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.08pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.09pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.1pF PCB impedance=92OHM
COM(dB)
4.5
4
3.5
3
2.5
2
1.5
0
50
100
150
PCB trace length(mm)

COM of degraded Kareti OAch1_t.s4p with Tx that is compliant to draft 2.0

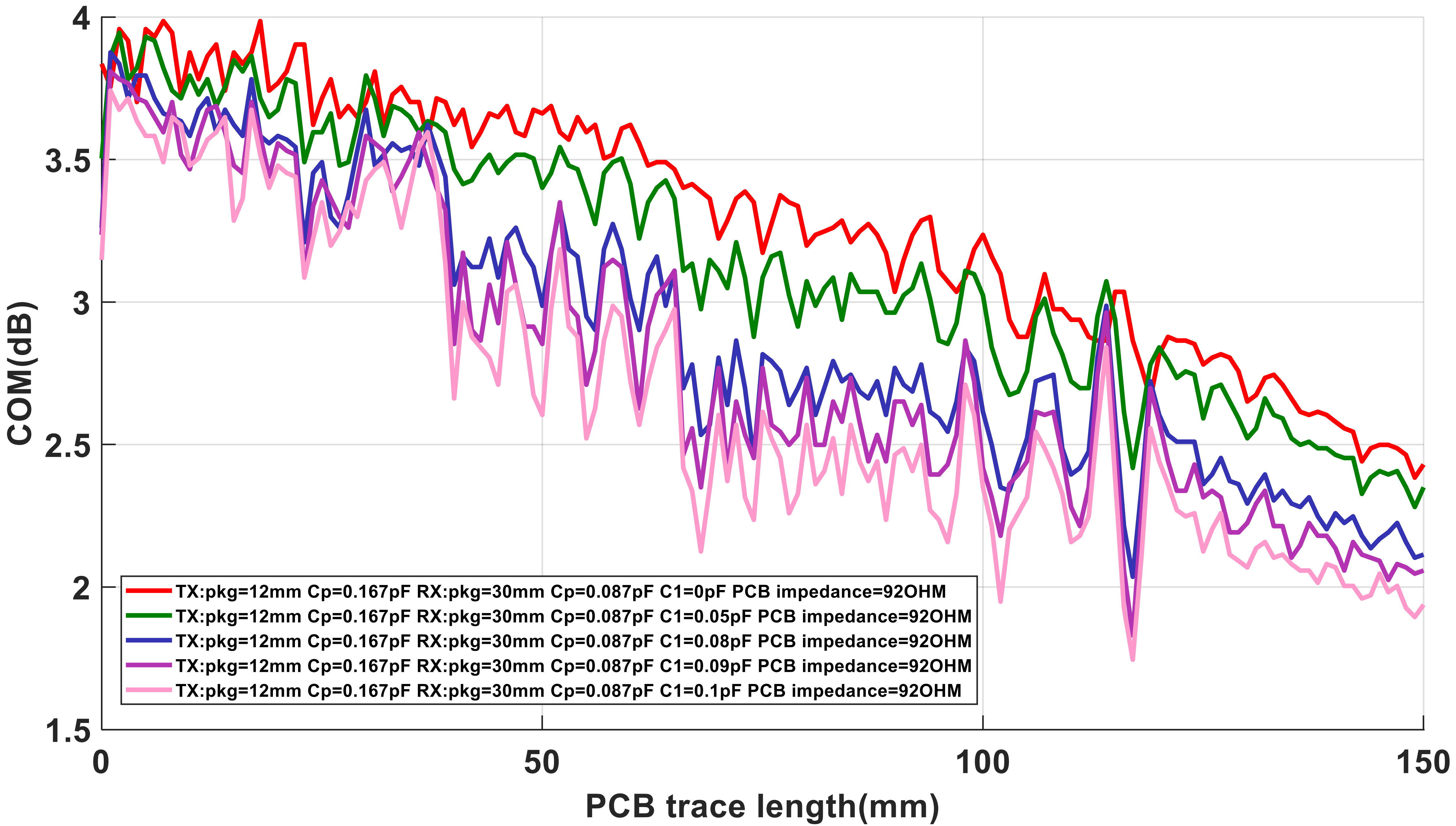




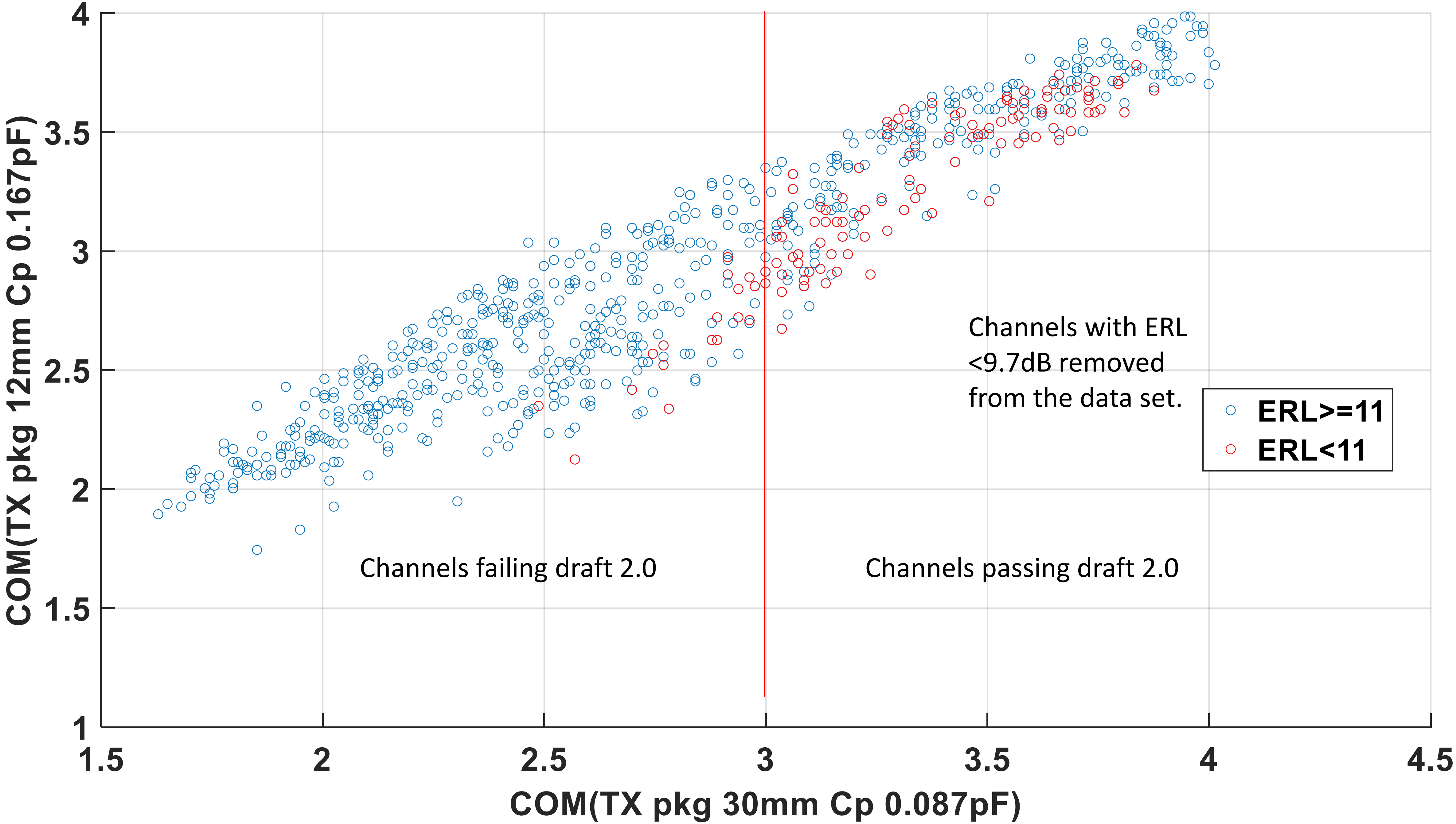
ERL>=11
ERL<11
Channels failing draft 2.0
Channels passing draft 2.0
Channels with ERL
<9.7dB removed
from the data set.
COM(TX pkg 12mm Cp 0.267pF)
COM(TX pkg 30mm Cp 0.087pF)
1
1.5
2
2.5
3
3.5
4
1.5
2
2.5
3
3.5
4
4.5

Conclusions

- There is a serious inter-operability issue with the existing backplane specification.
- For channels passing the COM specification, when the 12mm package with Cp of 0.267pF that passed the Tx specifications is used the COM of the signal going into the Rx is only approximately 1.5dB worst case.
- The following slides show what happens if the Tx dERL spec is tightened to -1dB.



COM(dB)
4
3.5
3
2.5
2
1.5
0
50
100
150
PCB trace length(mm)
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.05pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.08pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.09pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.1pF PCB impedance=92OHM

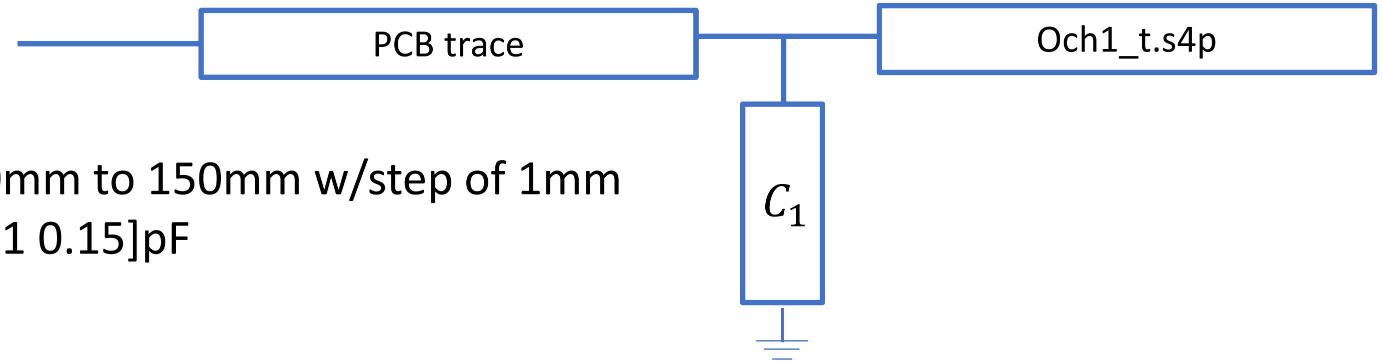

Channels with ERL
<9.7dB removed
from the data set.
ERL>=11
ERL<11
Channels failing draft 2.0
Channels passing draft 2.0
COM(TX pkg 12mm Cp 0.167pF)
COM(TX pkg 30mm Cp 0.087pF)
4
3.5
3
2.5
2
1.5
1
1.5
2
2.5
3
3.5
4
4.5

Conclusions with dERL specification of -1dB.

- Tightening the Tx dERL specification to -1dB significantly improves inter-operability. The worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) for these channels has 2.5dB COM.

Results when a lower loss channel is degraded.

Modified Kareti KR channel



PCB length: 0mm to 150mm w/step of 1mm
C1: [0 0.05 0.1 0.15]pF

PCB + C1 + Kareti KR channel

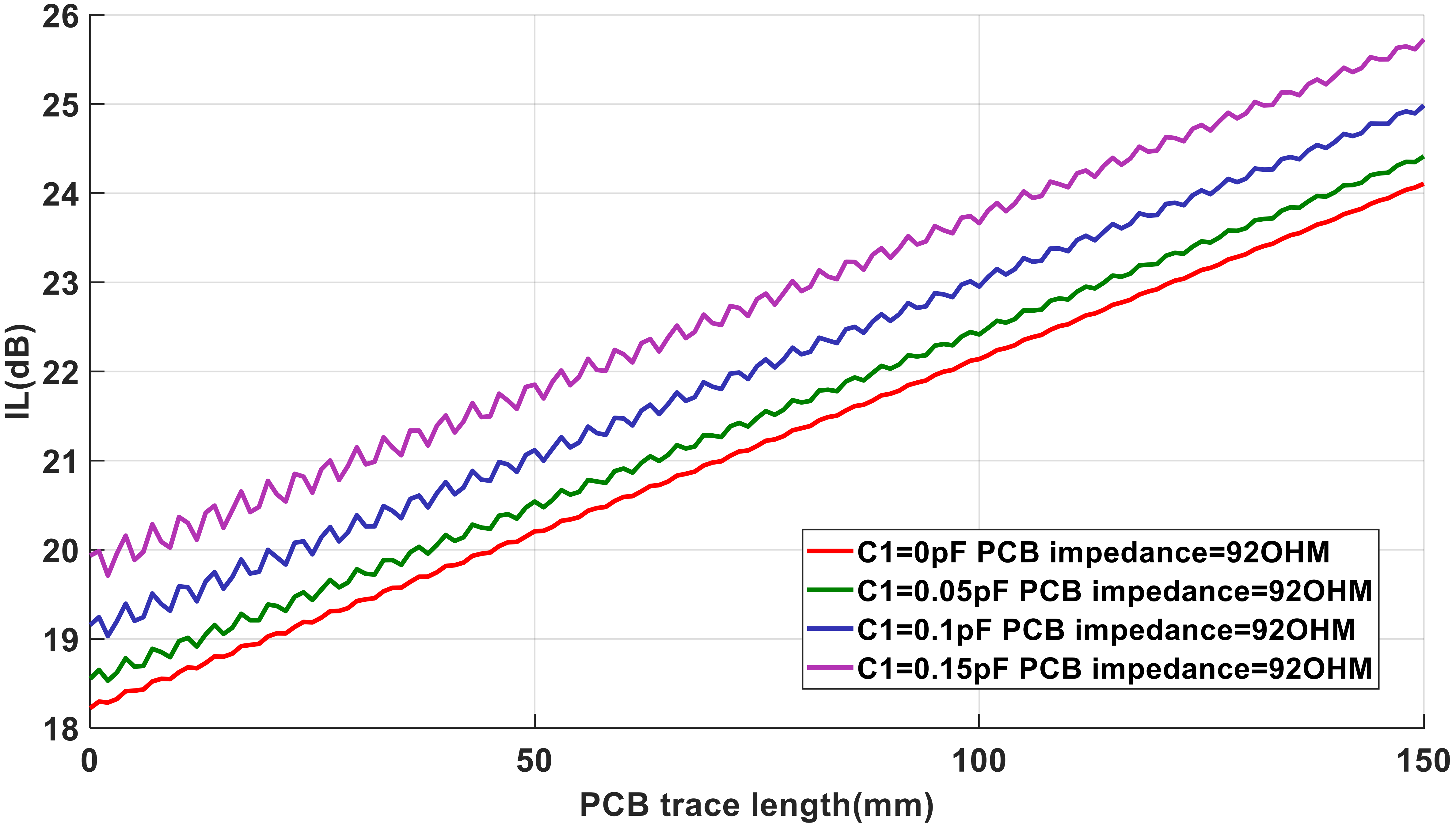
163.10.3 Channel ERL

ERL of the channel at TP0 and at TP5 are computed using the procedure in 93A.5 with the values in Table 163–11. Parameters that do not appear in Table 163–11 take values from Table 163–10.

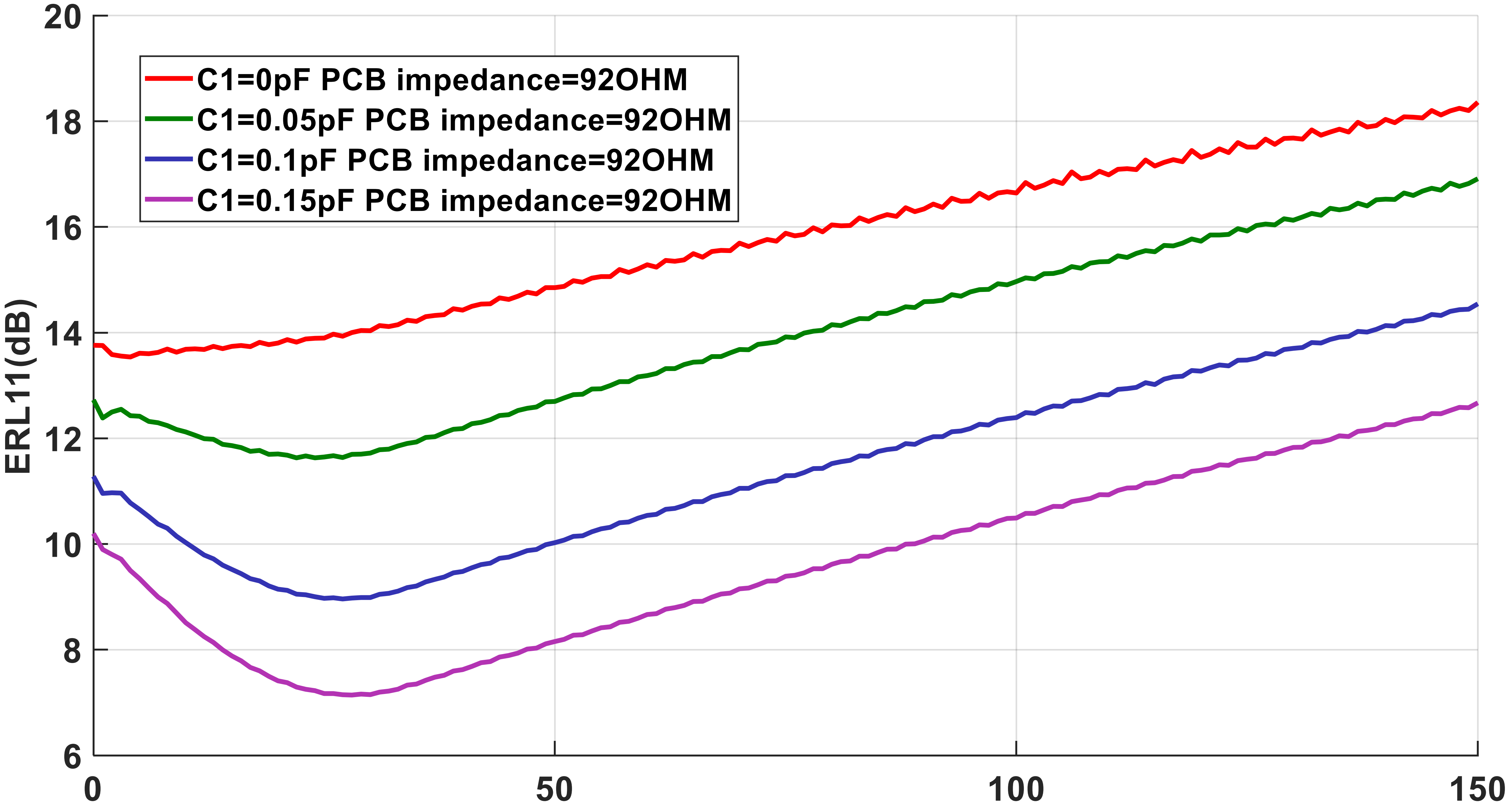
Channel ERL at TP0 and at TP5 shall be greater than or equal to 9.7 dB.

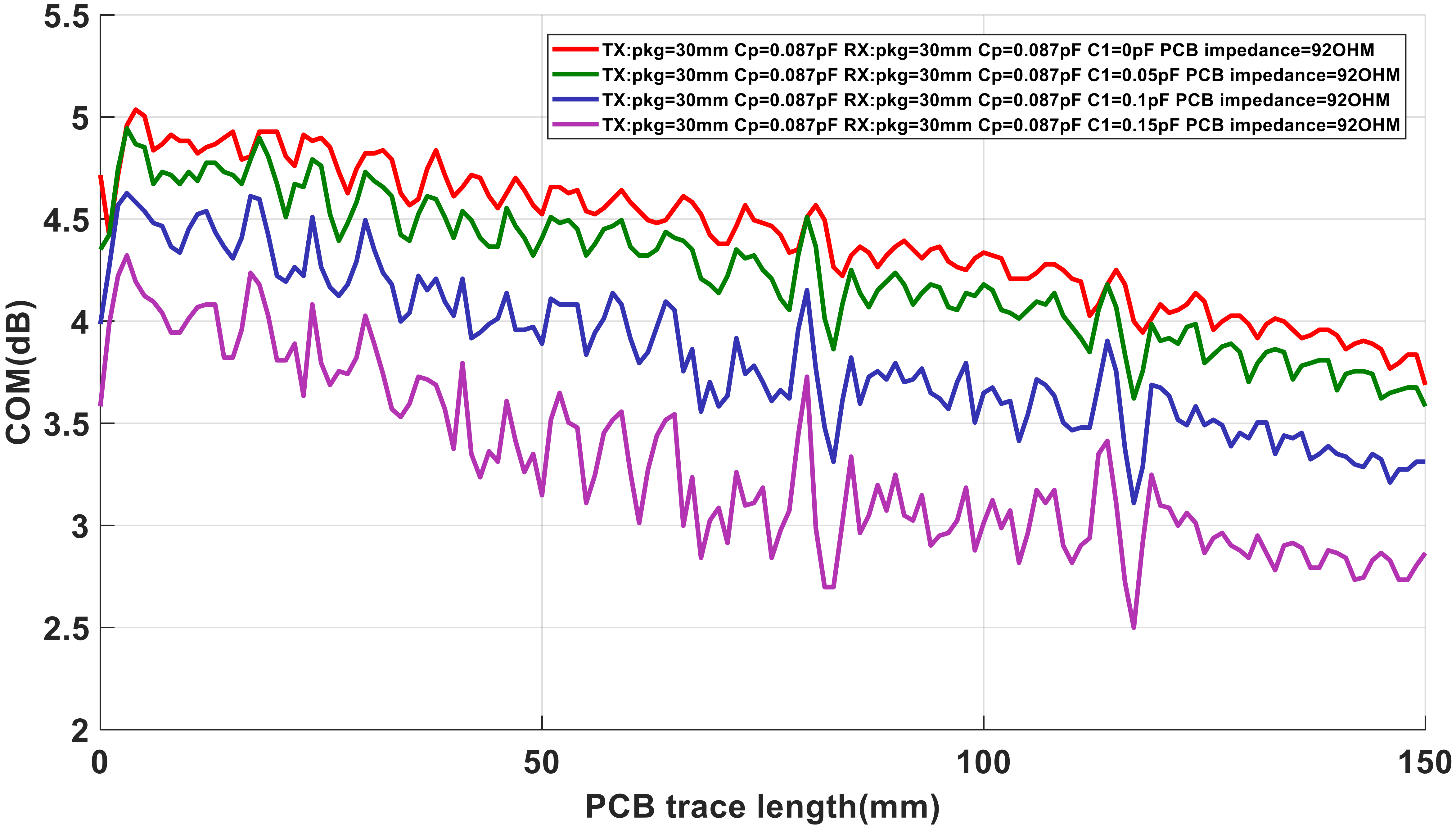
Table 163–11—Channel ERL parameter values

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	3500	UI
Equalizer length associated with reflection signal	N_{bx}	21	UI
Time-gated propagation delay	T_{fx}	0	ns
Tukey window flag	tw	1	—

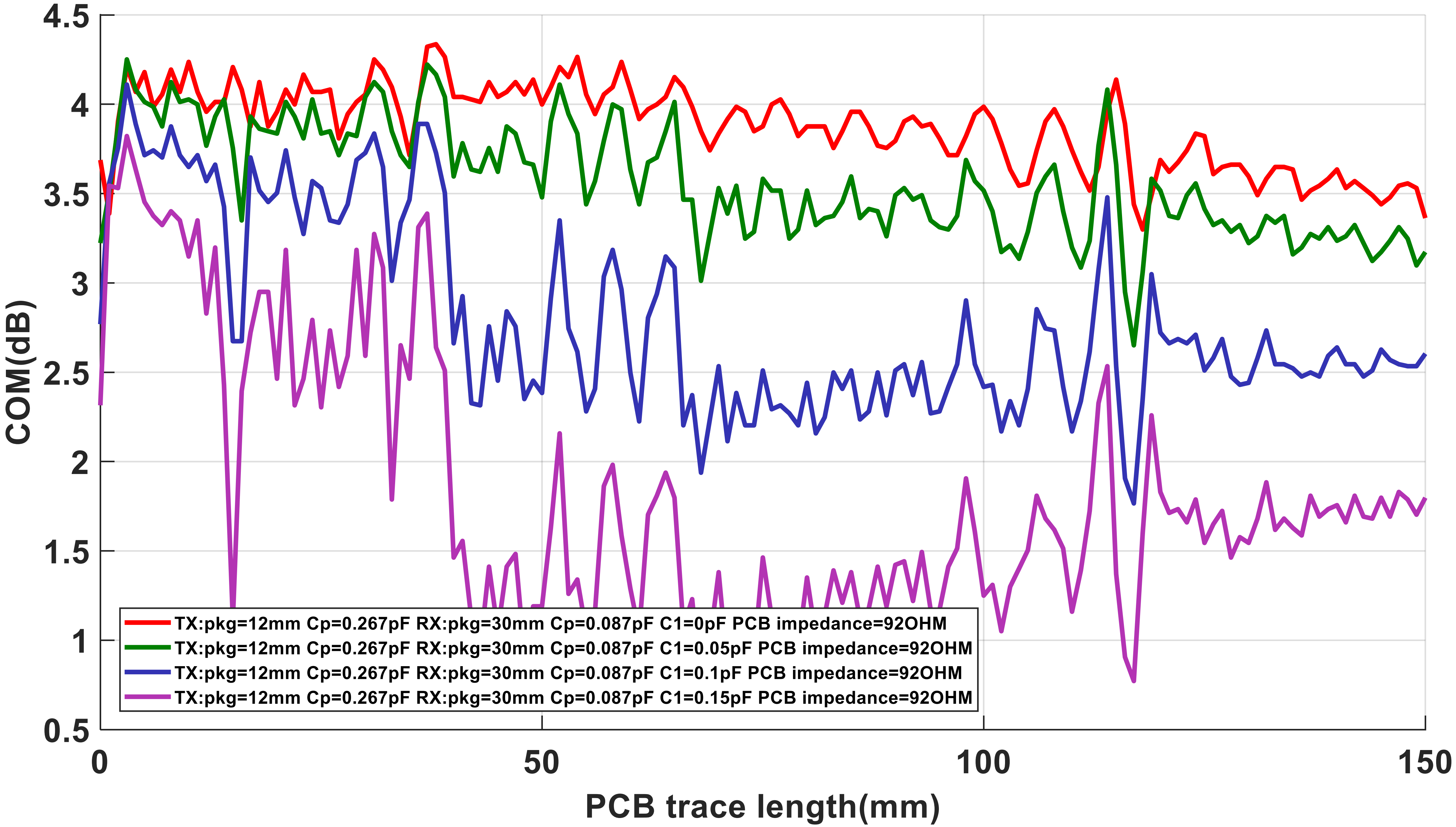


26
25
24
23
22
21
20
19
18
IL(dB)
0
50
100
150
PCB trace length(mm)
C1=0pF PCB impedance=92OHM
C1=0.05pF PCB impedance=92OHM
C1=0.1pF PCB impedance=92OHM
C1=0.15pF PCB impedance=92OHM

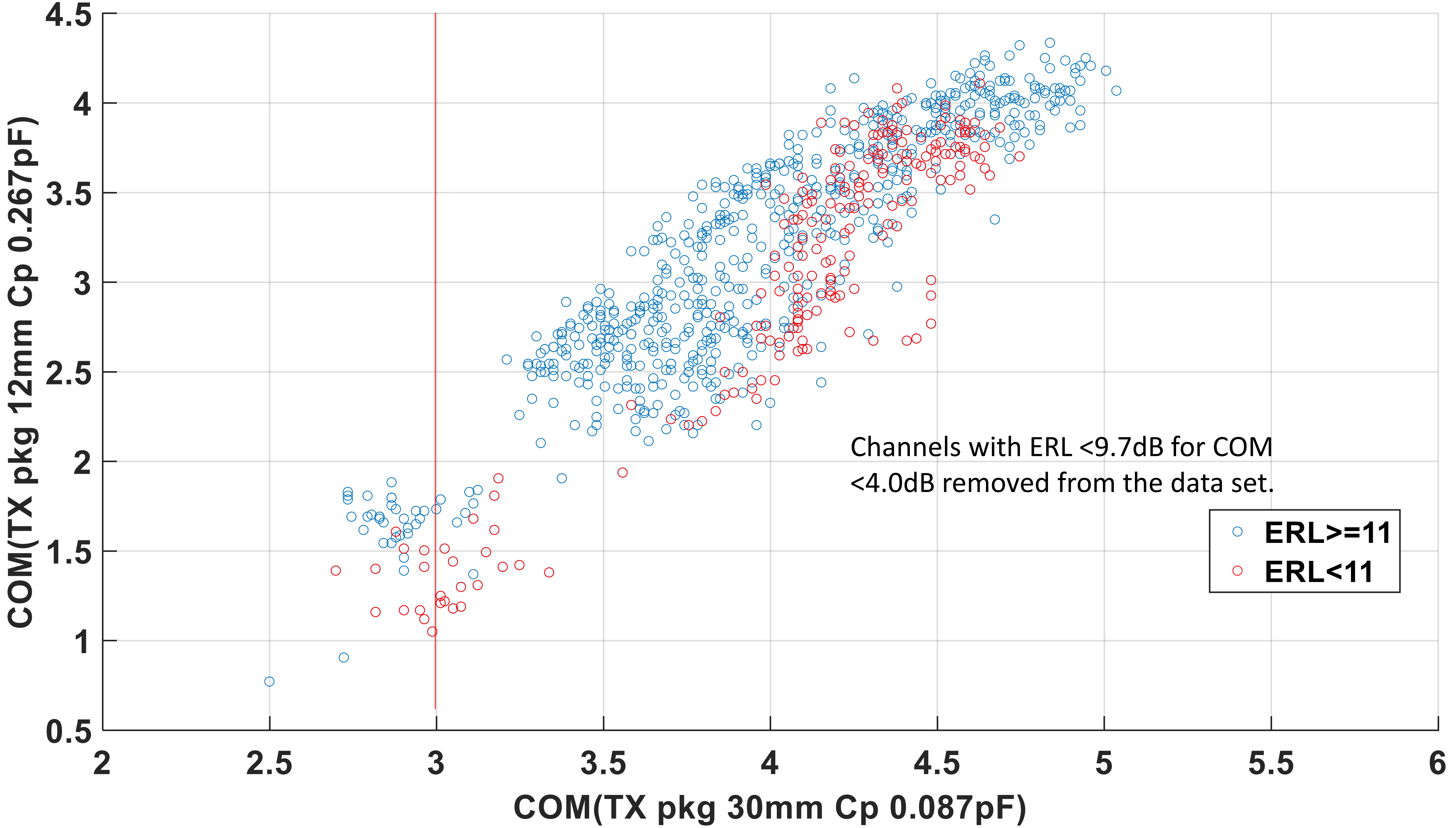

C1=0pF PCB impedance=92OHM
C1=0.05pF PCB impedance=92OHM
C1=0.1pF PCB impedance=92OHM
C1=0.15pF PCB impedance=92OHM
ERL11(dB)
PCB trace length(mm)
20
18
16
14
12
10
8
6
0
50
100
150

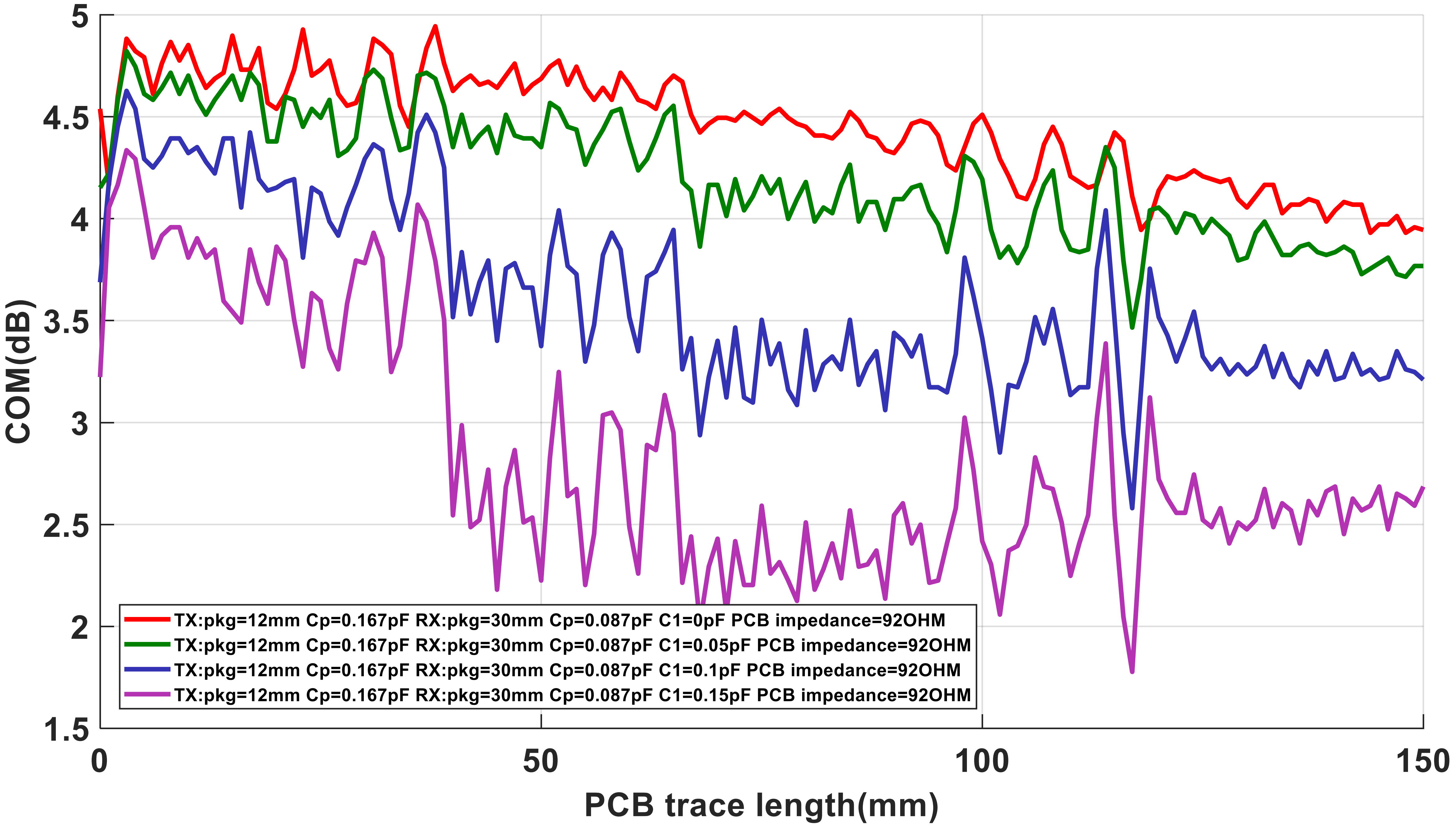


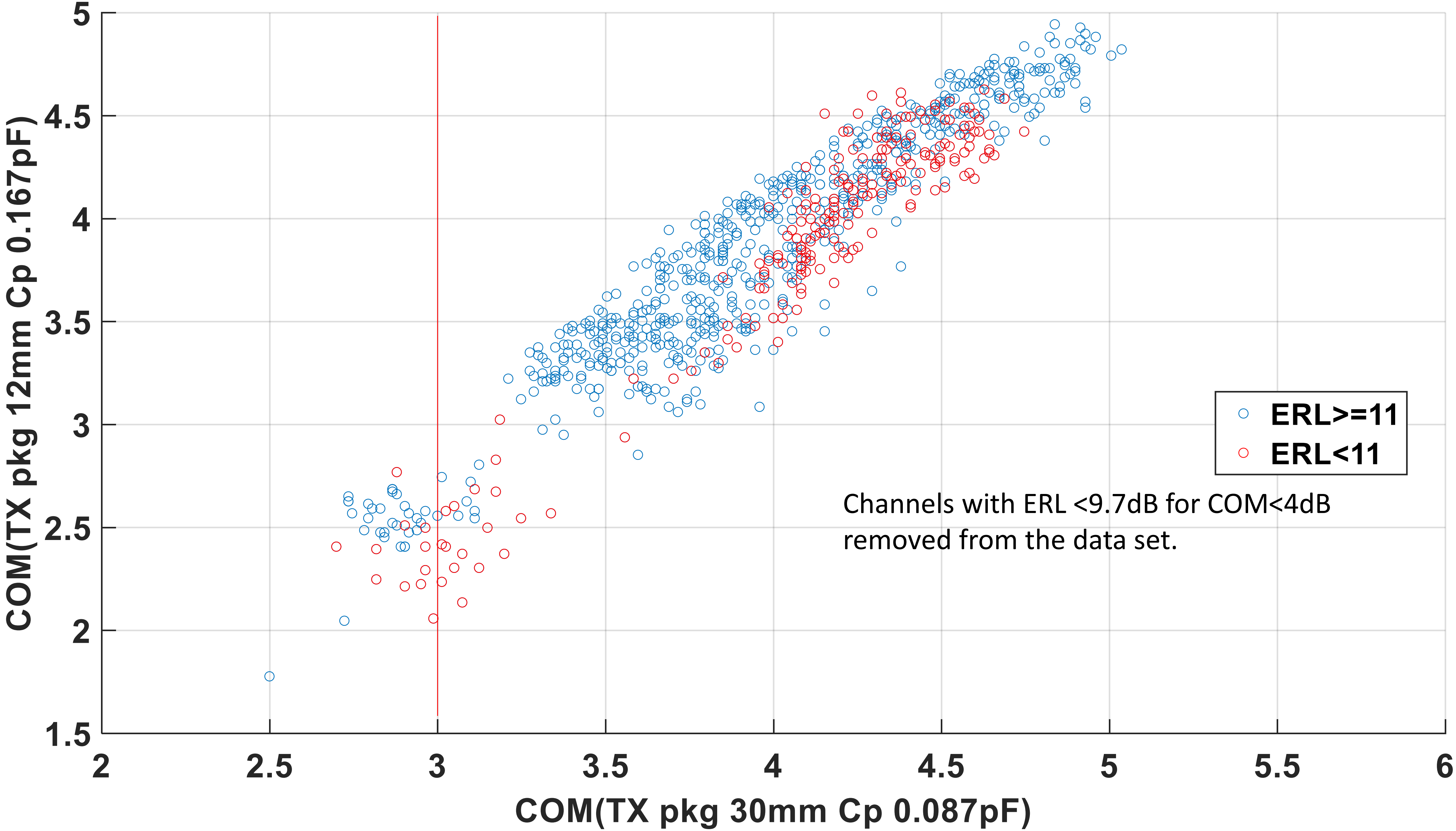
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.05pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.1pF PCB impedance=92OHM
TX:pkg=30mm Cp=0.087pF RX:pkg=30mm Cp=0.087pF C1=0.15pF PCB impedance=92OHM
COM(dB)
5.5
5
4.5
4
3.5
3
2.5
2
0
50
100
150
PCB trace length(mm)



4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
50
100
150
COM(dB)
PCB trace length(mm)
TX:pkg=12mm Cp=0.267pF RX:pkg=30mm Cp=0.087pF C1=0pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.267pF RX:pkg=30mm Cp=0.087pF C1=0.05pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.267pF RX:pkg=30mm Cp=0.087pF C1=0.1pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.267pF RX:pkg=30mm Cp=0.087pF C1=0.15pF PCB impedance=92OHM


COM(TX pkg 12mm Cp 0.267pF)
COM(TX pkg 30mm Cp 0.087pF)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Channels with ERL <9.7dB for COM
<4.0dB removed from the data set.
ERL>=11
ERL<11


5
4.5
4
3.5
3
2.5
2
1.5
COM(dB)
0
50
100
150
PCB trace length(mm)
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.05pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.1pF PCB impedance=92OHM
TX:pkg=12mm Cp=0.167pF RX:pkg=30mm Cp=0.087pF C1=0.15pF PCB impedance=92OHM



COM(TX pkg 12mm Cp 0.167pF)
COM(TX pkg 30mm Cp 0.087pF)
5
4.5
4
3.5
3
2.5
2
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
ERL>=11
ERL<11
Channels with ERL <9.7dB for COM<4dB removed from the data set.

Conclusions from the degraded lower loss chanels

- The inter-operability problem is even worse with the degraded lower loss channel.
- With the existing dERL specification of -3dB the worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) only has 1dB COM.
- Even with the dERL specification tightened to -1dB the worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) only has 2dB COM.
- Further specification tightening is required. Either further tightening of Tx dERL or the Channel ERL (or a combination of the two is indicated.

OAch1_t.s4p (IL=23.407dB, ERL11=13.706dB, ERL22=16.973dB)

9 FEXT and 9 NEXT included

TX Package(mm)	TX Cp(pF)	2dB TP0-TP0v		4dB TP0-TP0v		5dB TP0-TP0v		IL w/pkg(dB)	COM(dB)
		dERL(dB)	dRpeak(dB)	dERL(dB)	dRpeak(dB)	dERL(dB)	dRpeak(dB)		
30	0.087	**0**	**0**	**0**	**0**	**0**	**0**	31.714	3.986
	0.107	-0.034	-0.006	-0.026	-0.002	-0.036	-0.004	31.921	3.849
12	0.087	0.613	0.086	0.541	0.074	0.563	0.066	30.066	4.437
	0.107	-0.155	0.079	-0.065	0.068	0.037	0.06	30.381	4.265
	0.127	-0.649	0.068	-0.472	0.061	-0.325	0.054	30.734	4.194
	0.147	-1.009	0.059	-0.85	0.054	-0.686	0.047	31.114	4.082
	0.167	-1.341	0.05	-1.178	0.044	-1	0.038	31.513	3.836
	0.187	-1.638	0.034	-1.489	0.036	-1.309	0.033	31.923	3.795
	0.207	-1.983	0.028	-1.784	0.03	-1.626	0.026	32.338	3.622
	0.227	-2.239	0.019	-2.079	0.022	-1.938	0.019	32.754	3.388
	0.247	-2.489	0.01	-2.409	0.014	-2.279	0.011	33.167	3.173
	0.267	-2.781	0	-2.694	0.006	-2.563	0.004	33.575	3.135
	0.287	-3.029	-0.009	-2.965	-0.002	-2.843	-0.002	33.975	2.95
	0.299	-3.166	-0.015	-3.129	-0.006	-3.001	-0.007	34.212	2.793

Red results are transmitters that fail 802.3ck draft 2.0.

All others pass with at least one Tp0 to Tp0v test fixture..

COM spreadsheet

Table 93A-1 parameters				
Parameter	**Setting**	**Units**	**Information**	
f_b	53.125	GBd		
f_min	0.05	GHz		
Delta_f	0.01	GHz		
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]	
L_s	[0.12, 0.12]	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)	[12 31; 1.8 1.8]	mm	[test cases]	
z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]	
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]	
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]	
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]	
R_0	50	Ohm		
R_d	[50 50]	Ohm	[TX RX]	
A_v	0.413	V		
A_fe	0.413	V		
A_ne	0.608	V		
AC_CM_RMS	0	V	[test cases]	[0.0235 0.0256]
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)	[0:0.02:0.12]		[min:step:max]	
c(-3)	[-0.06:0.02: 0]		[min:step:max]	
c(1)	[-0.2:0.05:0]		[min:step:max]	
N_b	12	UI		
b_max(1)	0.85			
b_max(2..N_b)	[0.3 0.2*ones(1,10)]			
b_min(1)	0.3			
b_min(2..N_b)	[0.05 -0.03*ones(1,10)]			
g_DC	[-20:1:0]	dB	[min:step:max]	
f_z	21.25	GHz		
f_p1	21.25	GHz		
f_p2	53.125	GHz		
g_DC_HP	[-6:1:0]		[min:step:max]	
f_HP_PZ	0.6640625	GHz		

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
PLOT_CM	1	
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	*100*	Ohm
z_bp (TX)	*110.3*	mm
z_bp (NEXT)	*110.3*	mm
z_bp (FEXT)	*110.3*	mm
z_bp (RX)	*110.3*	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	**0**	**logical**
Floating Tap Control		
N_bg	3	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	**0.600**	V
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
new		

RX: 30mm package and 0.087pF Cp