

QSFP-DD SMT MCB/HCB Performance vs. 802.3ck D1.2



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Overview:

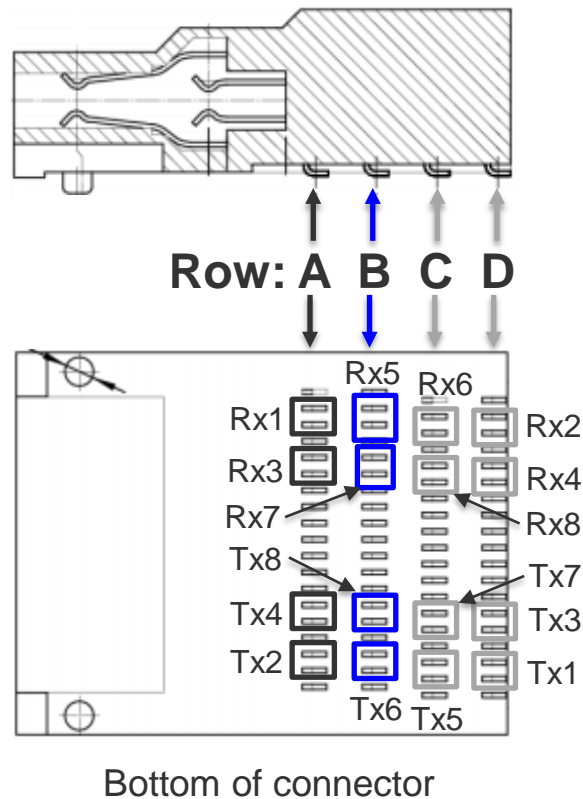
- OBJECTIVE: To evaluate DDQ SMT (1x1) performance against the 802.3ck D1.2 MCB/HCB limits
 - Several parameters have not yet been defined
 - The data presented will be used to determine a proposal for these undefined parameters
- Both simulated and measured data sets are presented
 - Simulated data captures the performance of the entire connector
 - Measured data is more realistic, but only “proof of concept” (POC, partially populated) results are available, so the data set is incomplete

Notes About Data:

Legacy Pairs
DD Pairs
Unpopulated

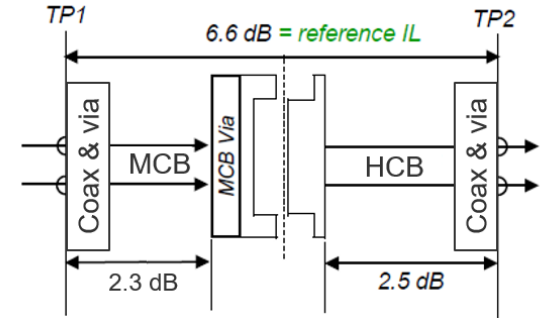
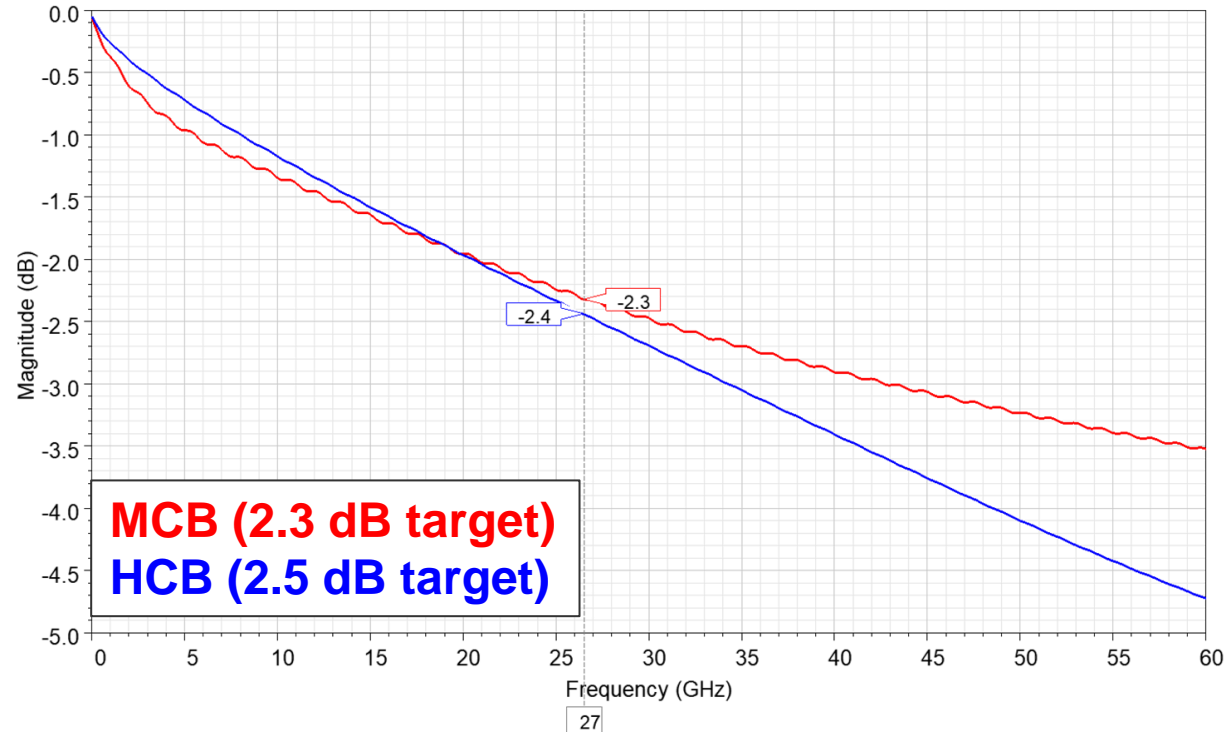
- Simulated Data:
 - The connector model was concatenated with trace models & RF connector model
- Measured Data: (see figures at right)
 - Molex test boards are lossier than what is specified in the spec
 - Measured data were fully de-embedded using AFR, then concatenated with simulated MCB/HCB traces & RF connectors
 - Physical connectors are proof of concept (POC) parts and are only partially populated
 - For crosstalk analysis, some pairs were doubled to better approximate full crosstalk response
 - See slide 19 for more information

Measured Data:



Simulated Data: Traces

NOTE: These simulated traces were used with both simulated and measured data sets



Note: 2.3 d.3 dB MCB PCB includes test point IL
and Md MCB Via allowance is 0.2 dB

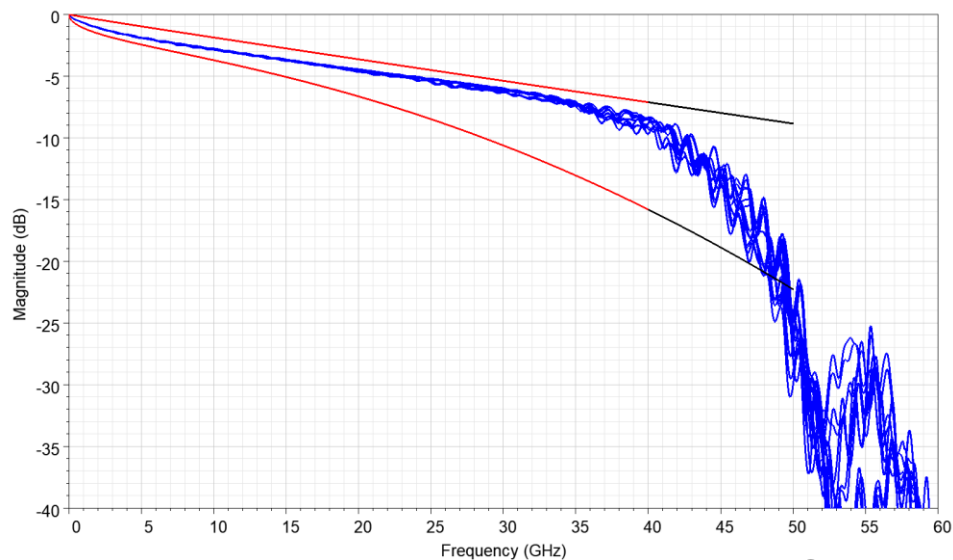
Notes on the Following Slides:

- Different stop frequencies due to data availability
 - Simulated data goes up to 60 GHz
 - Measured data goes up to 50 GHz
- High frequency passivity issues in measured data are due to de-embedding
- Limit lines:
 - **Black** lines show the current 802.3ck D1.2 limits
 - **Red** lines show the proposed limits

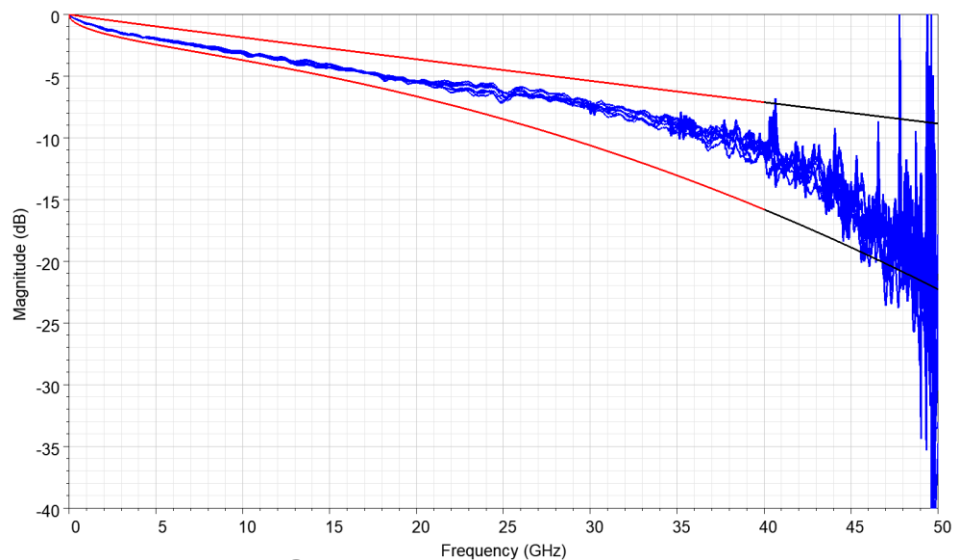
SDD21:

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:



Proposal: Stop limit lines at 40 GHz

FOM_{ILD}:

Parameter	Value
f_b	53.125 GHz
T_r	6.16 ps
f_r	0.75 x f_b
f_{start}	0.05 GHz*
f_{stop}	40 GHz
FOM _{ILD} Limit	0.18 dBrms

* The current D1.2 specification identifies $f_{start} = 0.01$ GHz (see next slide for more information)

Key:
Legacy Pair
DD Pair
Proposed Value

Pair	Simulated	Measured
1 (Tx1)	0.040	
2 (Tx3)	0.042	
3 (Tx5)	0.046	
4 (Tx7)	0.053	
5 (Tx6)	0.040	0.132
6 (Tx8)	0.045	0.121
7 (Tx2)	0.072	0.099
8 (Tx4)	0.064	0.093
9 (Rx4)	0.043	
10 (Rx2)	0.040	
11 (Rx8)	0.051	
12 (Rx6)	0.047	
13 (Rx7)	0.047	0.110
14 (Rx5)	0.042	0.133
15 (Rx3)	0.062	0.118
16 (Rx1)	0.069	0.114
MAX	0.072	0.133

FOM_{ILD}: Start frequency

- Start frequency for FOM_{ILD} calculation is unrealistic
- Most VNAs with the necessary frequency range (50+ GHz) cannot measure below 0.05 GHz
- Additionally, changing the start frequency has a negligible effect on the results since low frequency IL is well behaved (see chart)
- NOTE: Calculation parameters (except for the start frequency) are the same as what's shown on the previous slide

Key:
Legacy Pair
DD Pair

Pair	Simulated	
	f _{start} = 0.01 GHz	f _{start} = 0.05 GHz
1 (Tx1)	0.041	0.040
2 (Tx3)	0.042	0.042
3 (Tx5)	0.047	0.046
4 (Tx7)	0.053	0.053
5 (Tx6)	0.041	0.040
6 (Tx8)	0.045	0.045
7 (Tx2)	0.072	0.072
8 (Tx4)	0.065	0.064
9 (Rx4)	0.044	0.043
10 (Rx2)	0.041	0.040
11 (Rx8)	0.052	0.051
12 (Rx6)	0.047	0.047
13 (Rx7)	0.047	0.047
14 (Rx5)	0.042	0.042
15 (Rx3)	0.063	0.062
16 (Rx1)	0.070	0.069
MAX	0.072	0.072

A Note on the FOM_{ILD} Value Proposed:

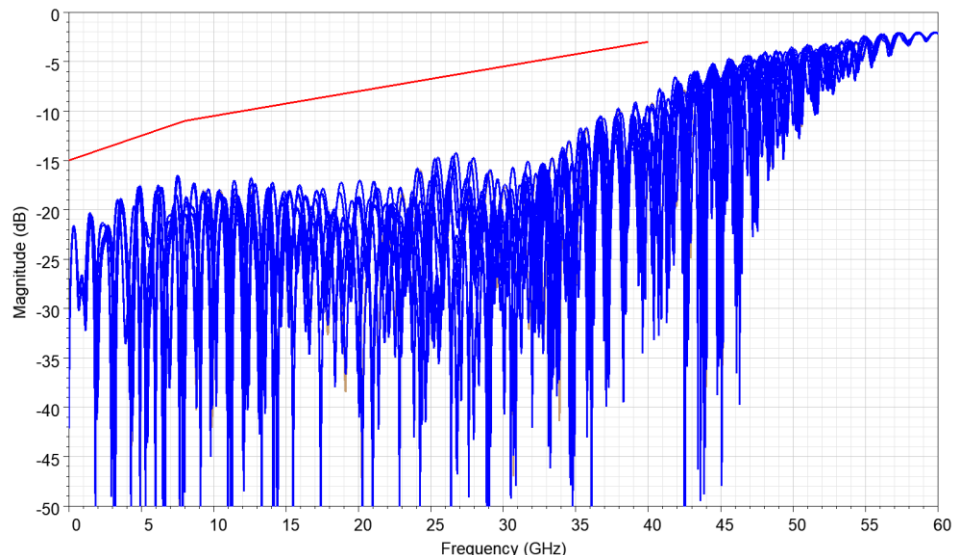
- FOM_{ILD} values for measured data are significantly worse than those predicted by simulation
- The worst measured FOM_{ILD} value for the available, limited data set is 0.133 dBrms
- Therefore, a limit of 0.18 dBrms is proposed
- **Proposal:**
 - $T_r = 6.16$ ps
 - $f_{start} = 0.05$ GHz
 - $f_{stop} = 40$ GHz
 - FOM_{ILD} Limit = 0.18 dBrms

SDD11:

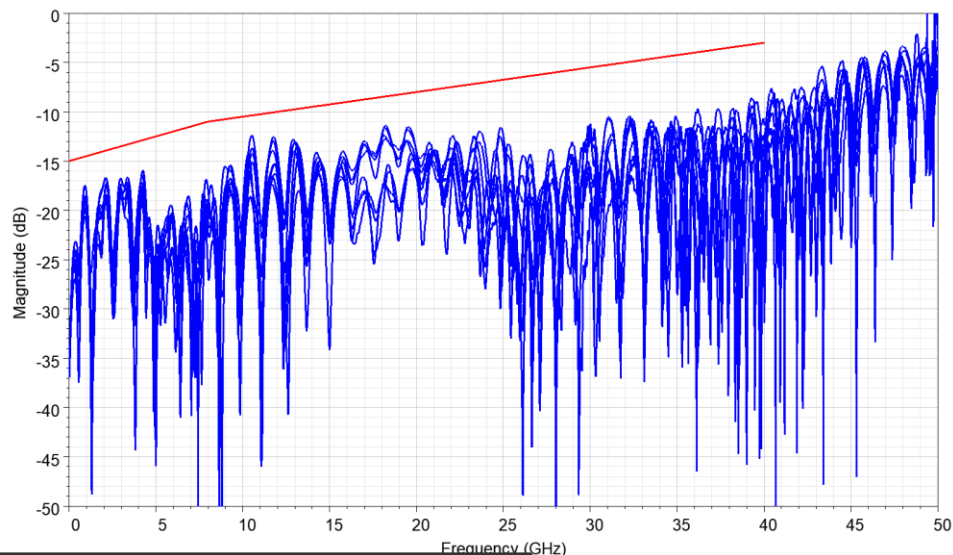
NOTE: 802.3ck D1.2
does not include a limit
line for this parameter

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:



Proposal: $15 - 0.5f$
 $13 - 0.25f$

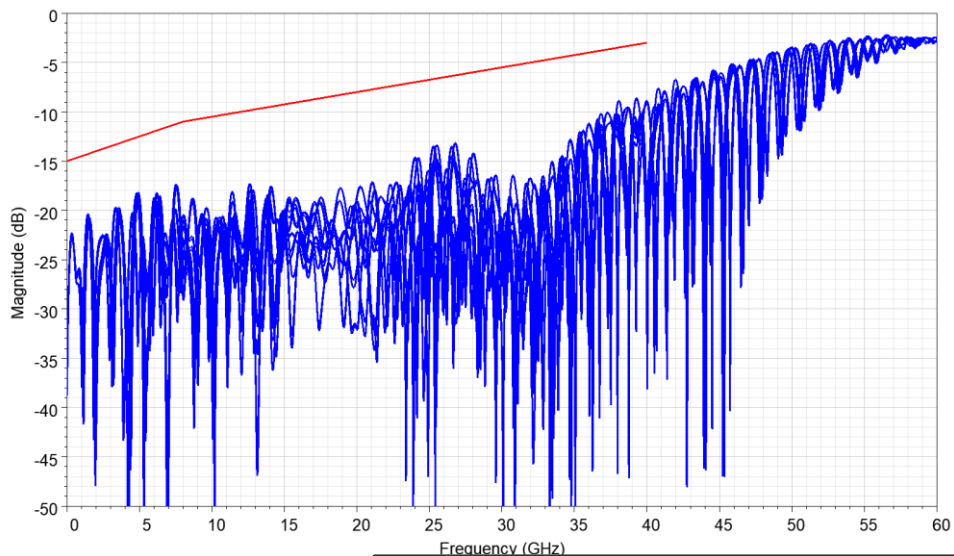
$f < 8 \text{ GHz}$
 $8 \text{ GHz} \leq f \leq 40 \text{ GHz}$

SDD22:

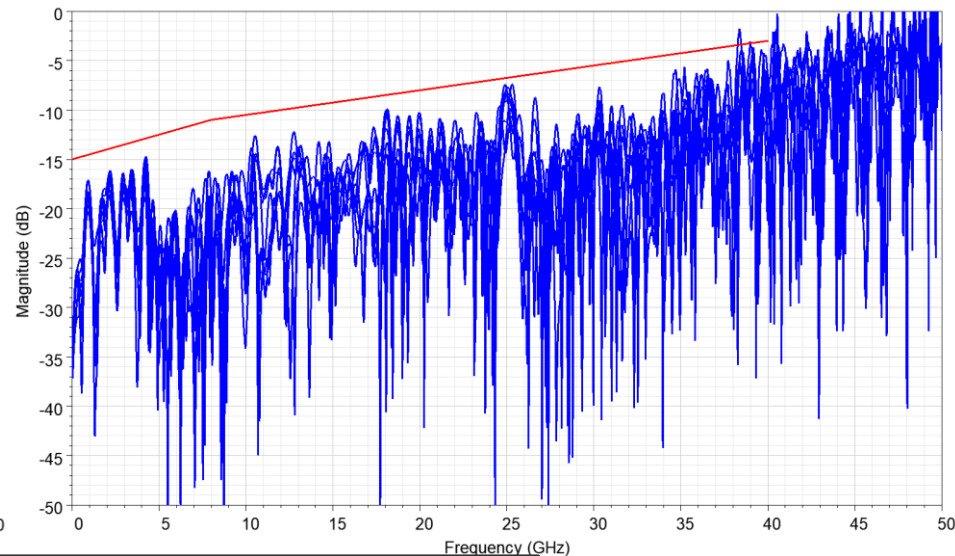
NOTE: 802.3ck D1.2
does not include a limit
line for this parameter

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:



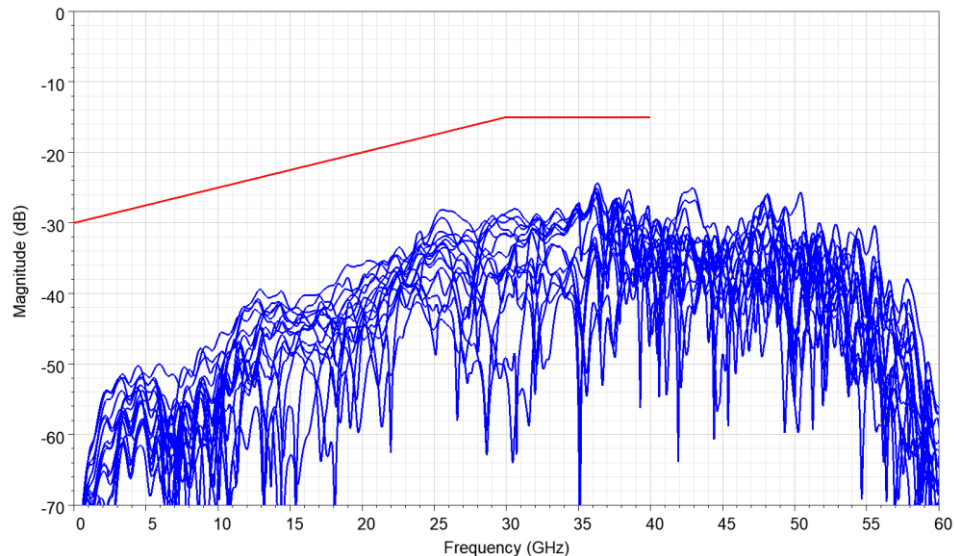
Proposal: $15 - 0.5f$ $f < 8 \text{ GHz}$
 $13 - 0.25f$ $8 \text{ GHz} \leq f \leq 40 \text{ GHz}$

SDC12:

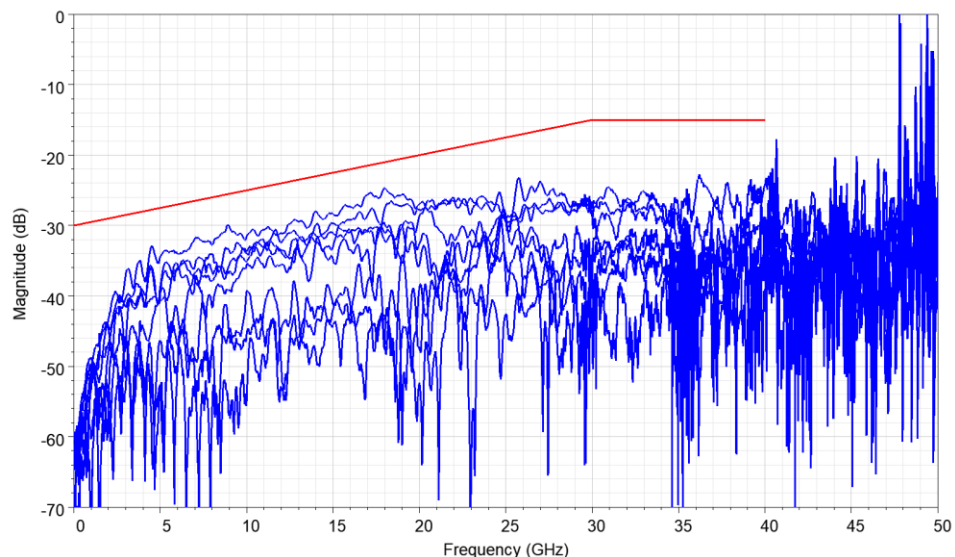
NOTE: 802.3ck D1.2
does not include a limit
line for this parameter

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:



Proposal: $30 - 0.5f$
15

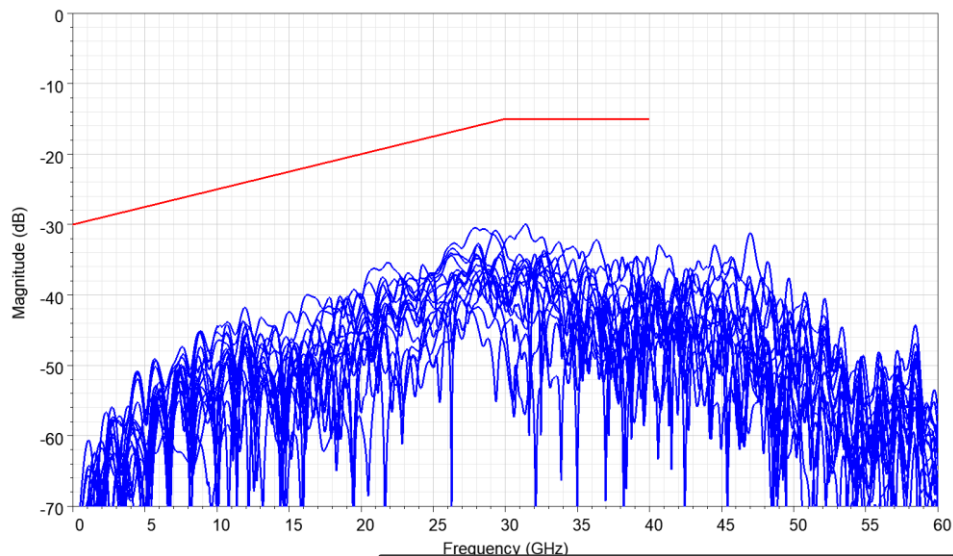
$f < 30 \text{ GHz}$
 $30 \text{ GHz} \leq f \leq 40 \text{ GHz}$

SDC21:

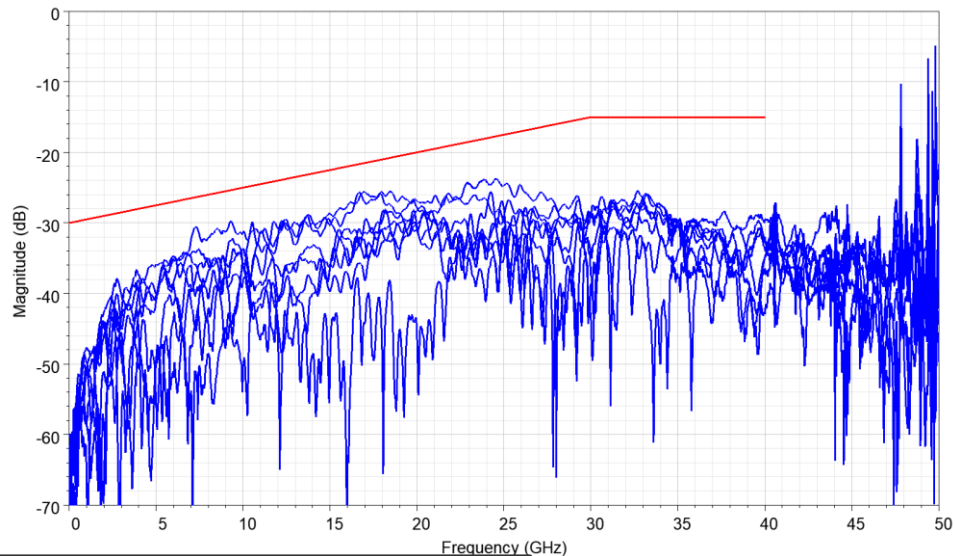
NOTE: 802.3ck D1.2
does not include a limit
line for this parameter

Key:
BLACK = Proposal
RED = 802.3ck D1.2

Simulated Data:



Measured Data:



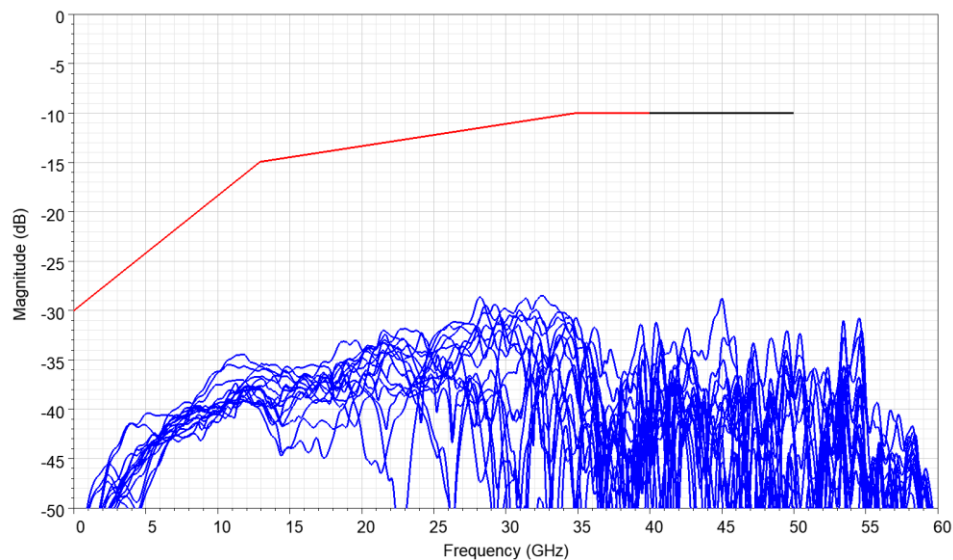
Proposal: $30 - 0.5f$
15

$f < 30 \text{ GHz}$
 $30 \text{ GHz} \leq f \leq 40 \text{ GHz}$

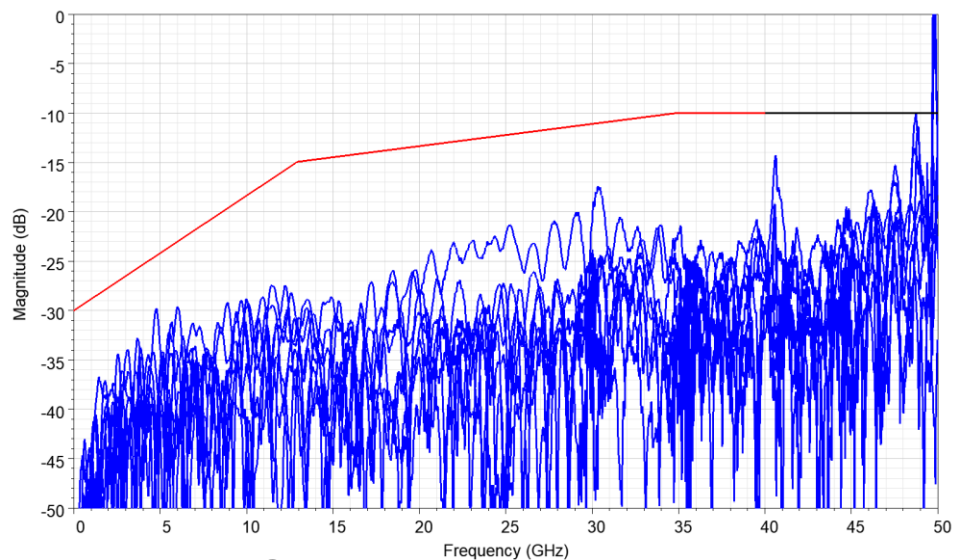
SDC11:

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:

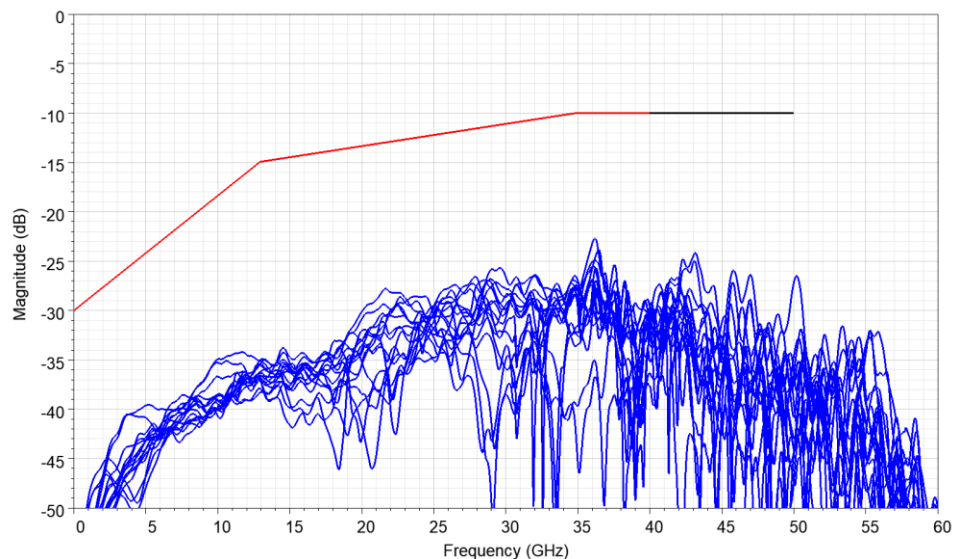


Proposal: Stop limit line at 40 GHz

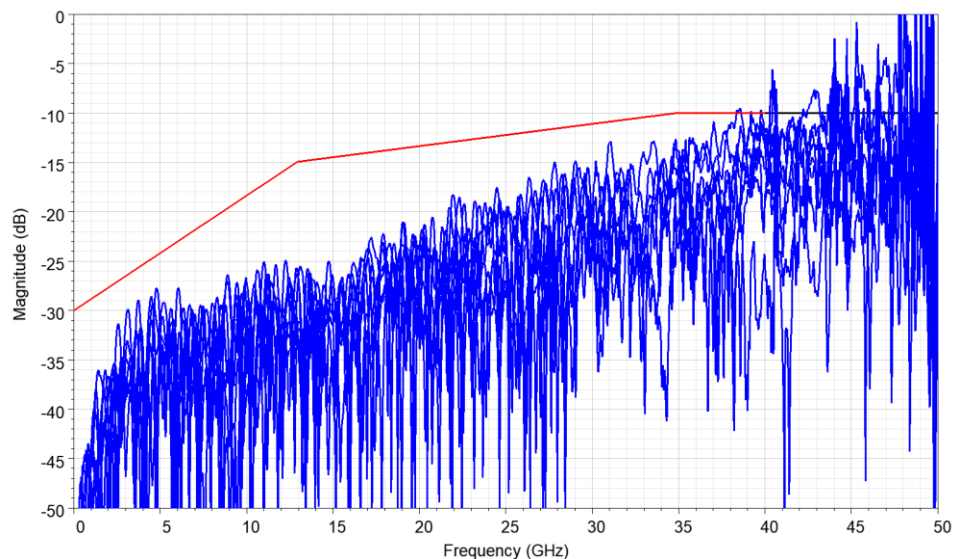
SDC22:

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:

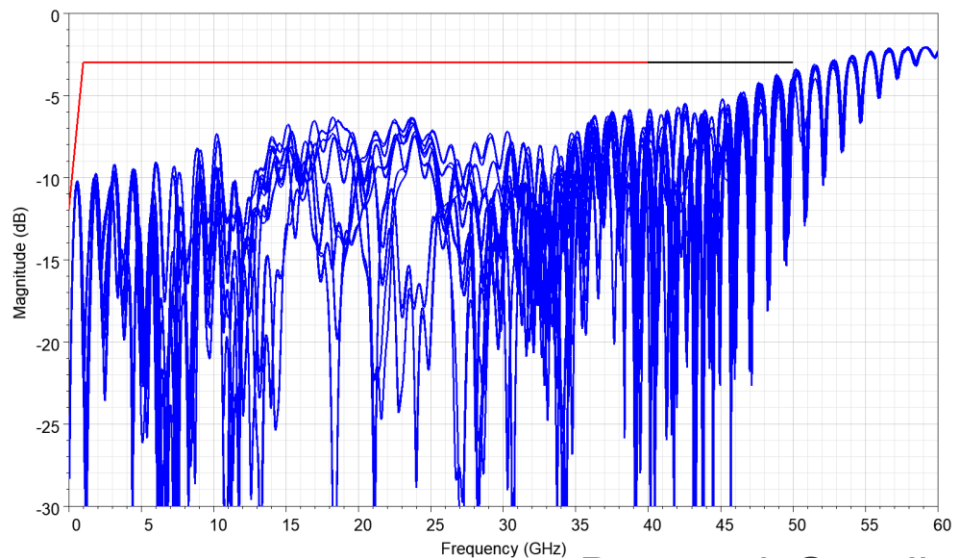


Proposal: Stop limit line at 40 GHz

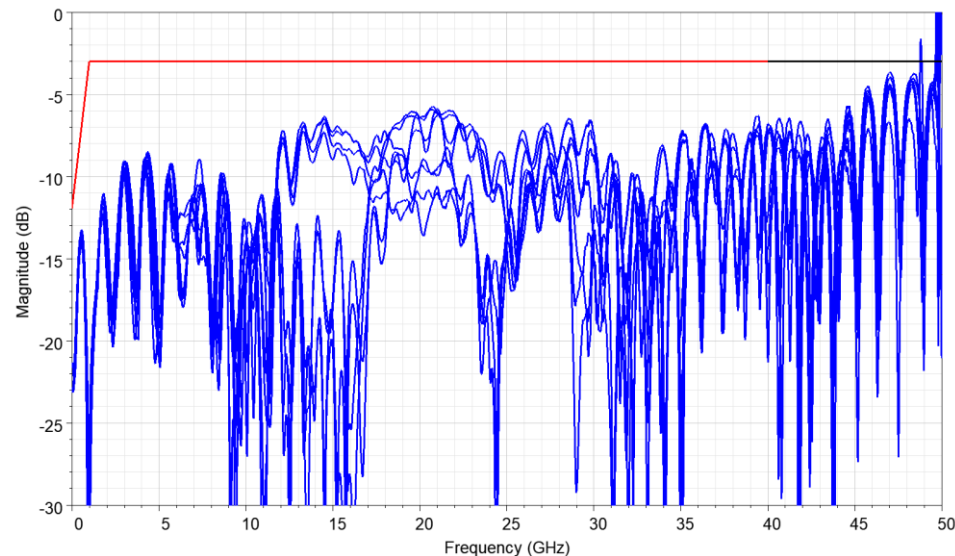
SCC11:

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:

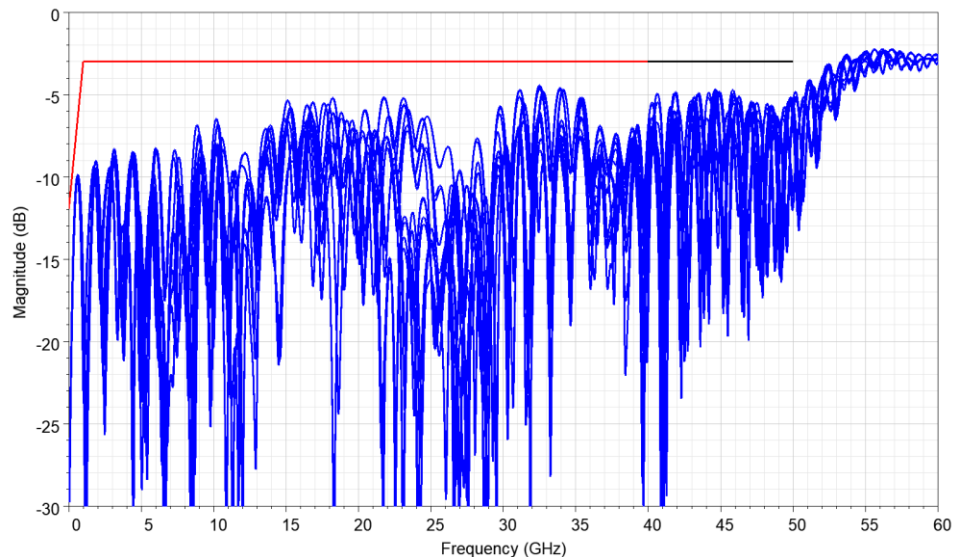


Proposal: Stop limit line at 40 GHz

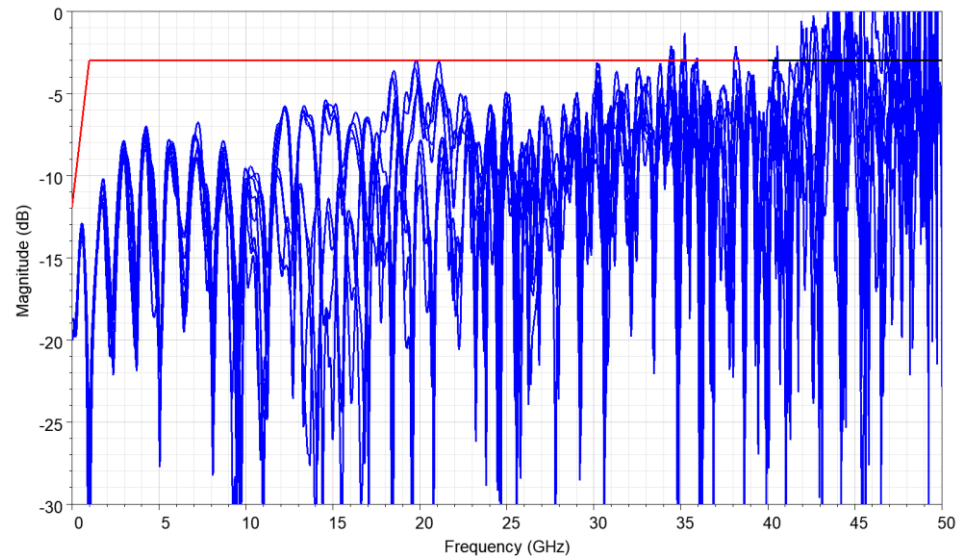
SCC22:

Key:
BLACK = 802.3ck D1.2
RED = Proposal

Simulated Data:



Measured Data:



Proposal: Stop limit line at 40 GHz

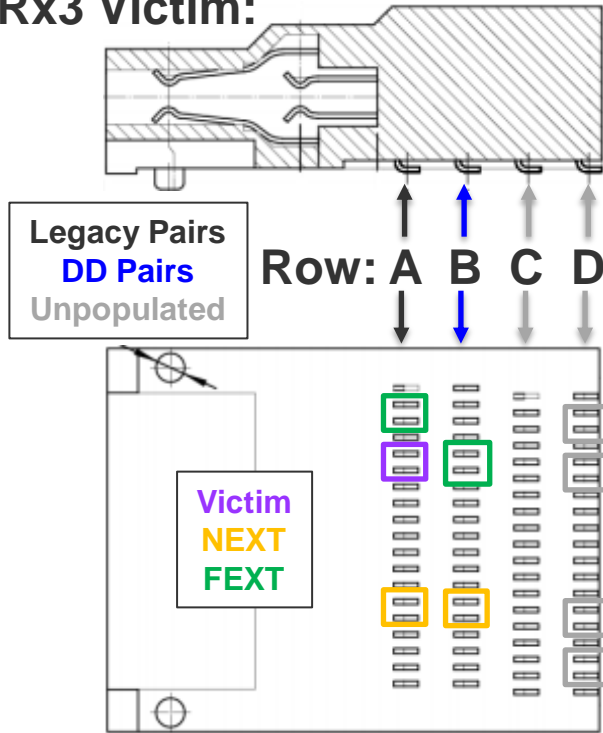
Crosstalk: Measured Data

- Due to the nature of the POC connectors, full crosstalk results were not available
- Some crosstalk measurements were duplicated to simulate crosstalk in Row C
- See next slide for pinout information

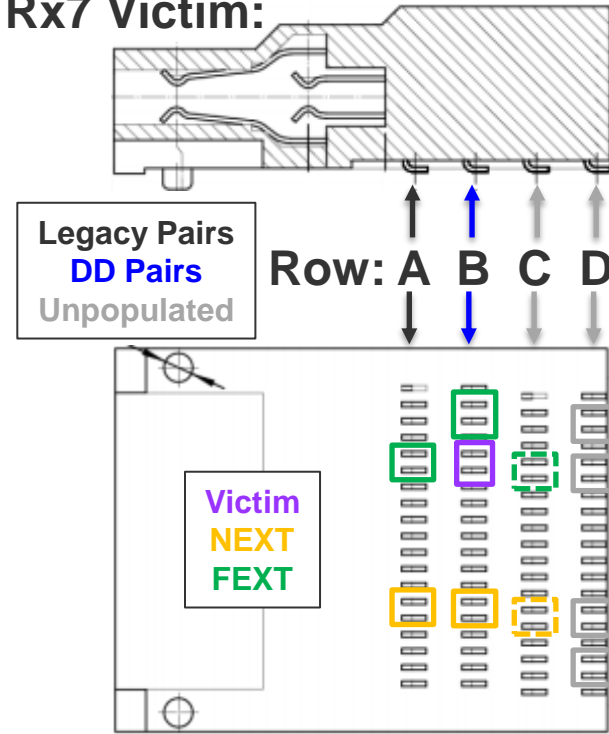
Crosstalk: Measured Data

SOLID = Measured data
D-A-S-H-E-D = "Simulated" data

Rx3 Victim:



Rx7 Victim:



ICN Stop Frequency:

Max Values	Simulated			Measured		
Victim	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}
f _{stop} = 40 GHz	0.516	1.536	1.594	0.487	1.920	1.901
f _{stop} = 50 GHz	0.554	1.569	1.646	0.509	1.919	1.995

Parameter	Value
f _b	53.125 GHz
f _r	0.75 x f _b
f _{min}	0.05 GHz
f _{max}	40 GHz
A _{nt} , A _{ft}	600 mV
T _{nt} , T _{ft}	6.16 ps
ICN _{NEXT} Limit	1.5 mV*
ICN _{FEXT} Limit	4.2 mV*
ICN _{Total} Limit	4.4 mV*

- The ICN values calculated with a 40 GHz stop frequency are roughly the same as those calculated with a 50 GHz stop frequency
- This is due to the decay of the weighting function over this frequency band
- Calculating ICN all the way to 50 GHz has a minimal impact on the results
- Recommendation: For ICN, f_{stop} = 40 GHz
- NOTE: 0.75 x f_b = 39.84 GHz

* No change from 802.3cd spec

ICN Proposal Summary:

▪ Input parameters:

- $f_{\text{start}} = 0.50 \text{ GHz}$
- $f_{\text{stop}} = 40 \text{ GHz}$
- $T_{\text{nt}}, T_{\text{ft}} = 6.16 \text{ ps}$

▪ Limits:

- $\text{ICN}_{\text{NEXT}} \text{ Limit} = 1.50 \text{ mV}$ (same as 802.3cd)
- $\text{ICN}_{\text{FEXT}} \text{ Limit} = 4.20 \text{ mV}$ (same as 802.3cd)
- $\text{ICN}_{\text{Total}} \text{ Limit} = 4.40 \text{ mV}$ (same as 802.3cd)

Summary:

- Proposal to change all existing frequency domain limits to stop at 40 GHz (see [diminico_3ck_01_0120](#))
- Frequency domain limits were proposed for RL & Thru Mode Conversion
- FOM_{ILD} & ICN parameters and limits were proposed

Proposal Summary:

- $f_{\text{stop}} = 40 \text{ GHz}$ for all frequency domain limits

- FOM_{ILD} :

- $T_r = 6.16 \text{ ps}$
- $f_{\text{start}} = 0.05 \text{ GHz}$
- $f_{\text{stop}} = 40 \text{ GHz}$
- $\text{FOM}_{\text{ILD}} \text{ Limit} = 0.18 \text{ dBrms}$

- $\text{SDD11} / \text{SD22} =$

$$\begin{array}{ll} 15 - 0.5f & f < 8 \text{ GHz} \\ 13 - 0.25f & 8 \text{ GHz} \leq f \leq 40 \text{ GHz} \end{array}$$

- $\text{SDC12} / \text{SDC21} =$

$$\begin{array}{ll} 30 - 0.5f & f < 30 \text{ GHz} \\ 15 & 30 \text{ GHz} \leq f \leq 40 \text{ GHz} \end{array}$$

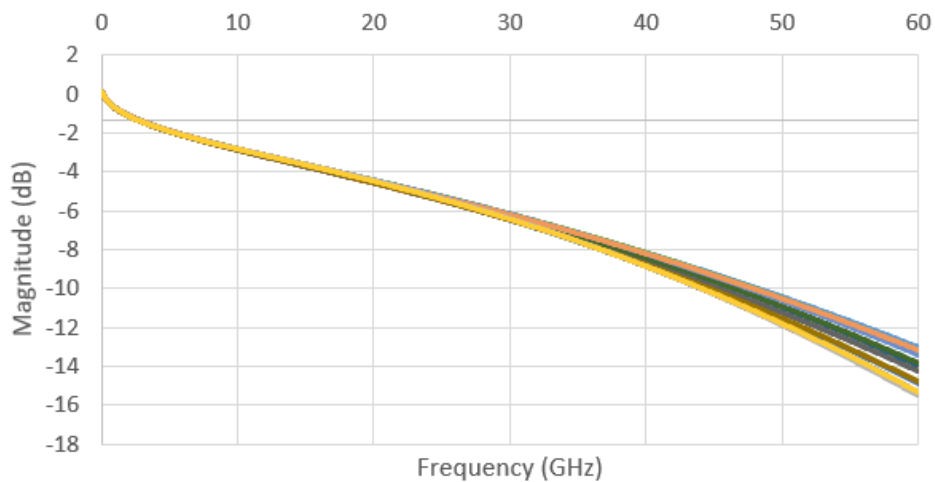
- ICN :

- $f_{\text{start}} = 0.05 \text{ GHz}$
- $f_{\text{stop}} = 40 \text{ GHz}$
- $T_{\text{nt}}, T_{\text{ft}} = 6.16 \text{ ps}$
- $\text{ICN}_{\text{NEXT}} \text{ Limit} = 1.50 \text{ mV}$
- $\text{ICN}_{\text{FEXT}} \text{ Limit} = 4.20 \text{ mV}$
- $\text{ICN}_{\text{Total}} \text{ Limit} = 4.40 \text{ mV}$

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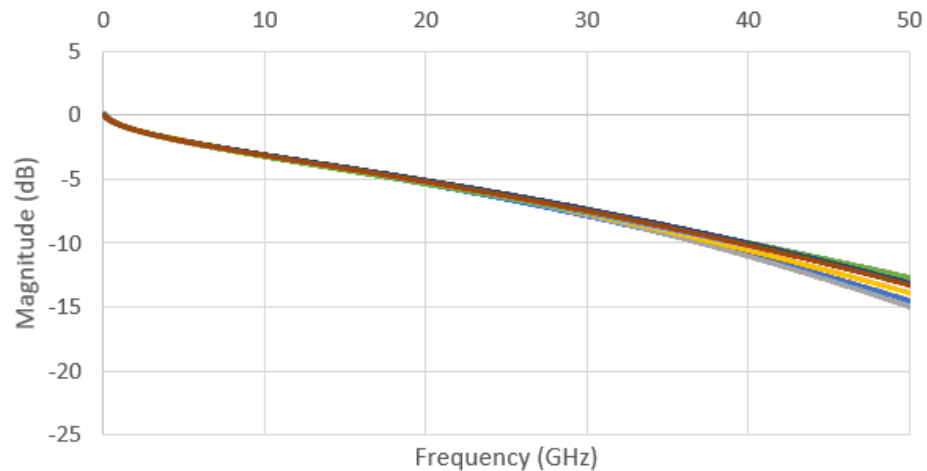
L_{fit} : $f_{stop} = 40$ GHz

Simulated Data:



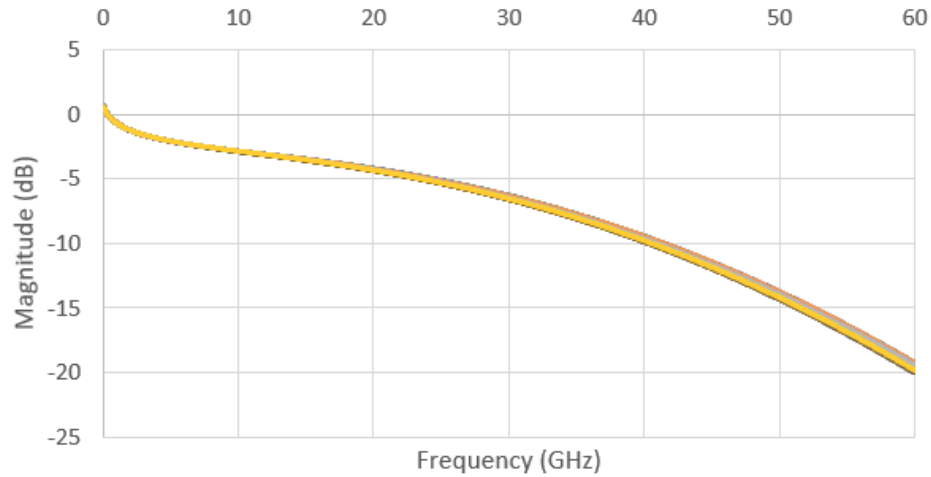
These plots are included for reference

Measured Data:



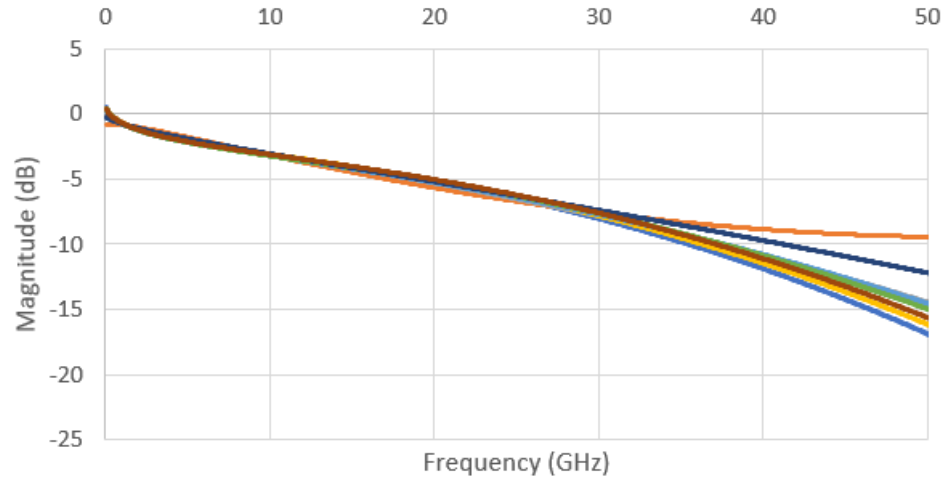
$IL_{fit}: f_{stop} = 50 \text{ GHz}$

Simulated Data:



These plots are included for reference

Measured Data:



Simulated ILD: Coefficients

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$f_{\text{stop}} = 40 \text{ GHz}$	a_0	-0.331	-0.283	-0.318	-0.352	-0.250	-0.295	-0.406	-0.425	-0.293	-0.334	-0.353	-0.311	-0.310	-0.260	-0.421	-0.399
	a_1	1.134	1.066	1.094	1.135	0.990	1.050	1.220	1.245	1.079	1.136	1.136	1.083	1.071	1.004	1.242	1.212
	a_2	-0.066	-0.043	-0.056	-0.067	-0.025	-0.043	-0.094	-0.104	-0.047	-0.066	-0.067	-0.052	-0.049	-0.029	-0.104	-0.092
	a_4	0.003	0.002	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.003
$f_{\text{stop}} = 50 \text{ GHz}$	a_0	-1.052	-1.088	-1.092	-1.135	-1.166	-1.211	-1.047	-1.048	-1.095	-1.050	-1.141	-1.105	-1.209	-1.157	-1.017	-1.055
	a_1	2.065	2.108	2.089	2.142	2.167	2.226	2.045	2.042	2.117	2.062	2.149	2.105	2.228	2.155	2.004	2.056
	a_2	-0.329	-0.337	-0.335	-0.349	-0.355	-0.372	-0.325	-0.326	-0.340	-0.327	-0.350	-0.339	-0.373	-0.351	-0.316	-0.328
	a_4	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

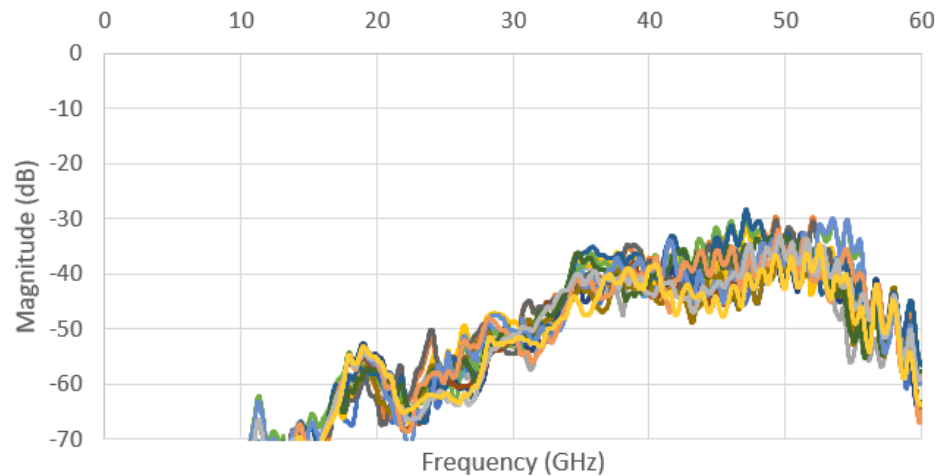
Measured ILD: Coefficients

		5	6	7	8	13	14	15	16
$f_{\text{stop}} = 40 \text{ GHz}$	a_0	-0.369	-0.211	-0.427	-0.232	-0.215	-0.179	-0.295	-0.298
	a_1	1.148	0.936	1.237	0.938	0.943	0.911	1.044	1.044
	a_2	-0.039	0.023	-0.079	0.007	0.025	0.035	-0.022	-0.014
	a_4	0.003	0.002	0.004	0.003	0.002	0.002	0.003	0.003
$f_{\text{stop}} = 50 \text{ GHz}$	a_0	-0.867	0.964	-0.183	-0.755	-0.554	-0.753	0.098	-0.830
	a_1	1.815	-0.552	0.938	1.627	1.392	1.662	0.558	1.747
	a_2	-0.233	0.432	0.001	-0.191	-0.104	-0.179	0.108	-0.218
	a_4	0.007	-0.004	0.003	0.006	0.004	0.005	0.001	0.006

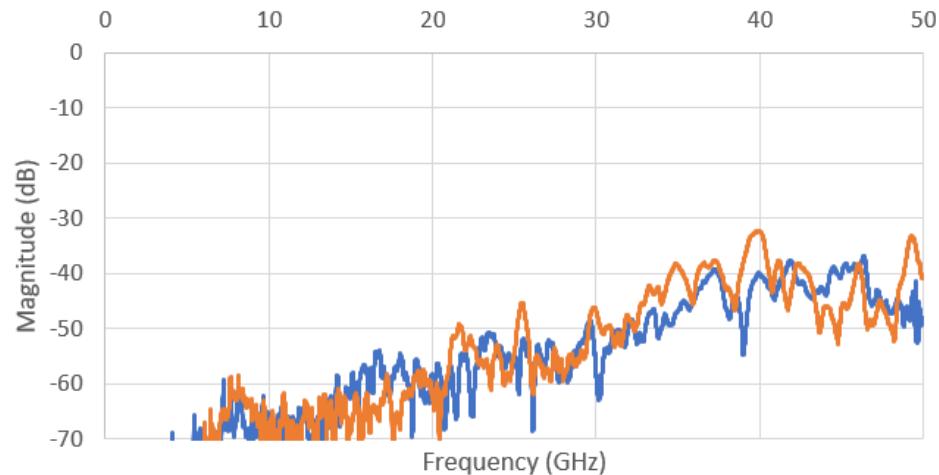
PSNEXT:

These plots are included for reference

Simulated Data:

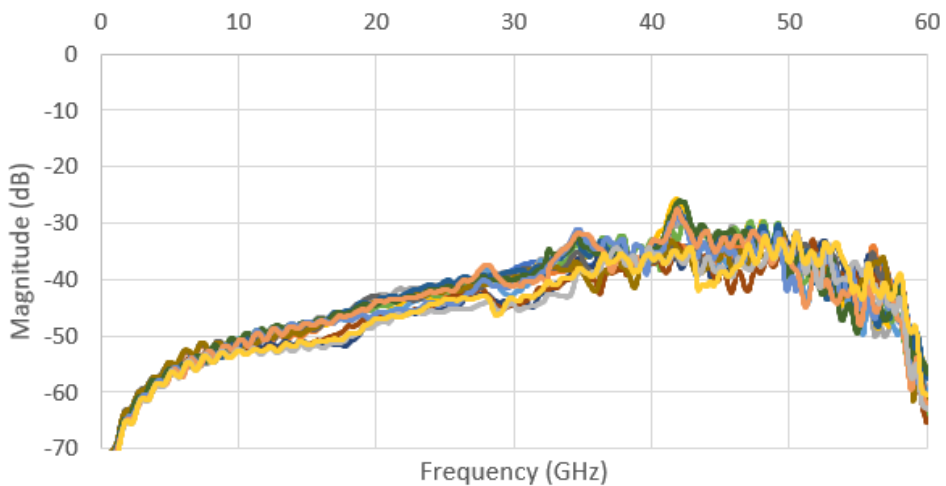


Measured Data:



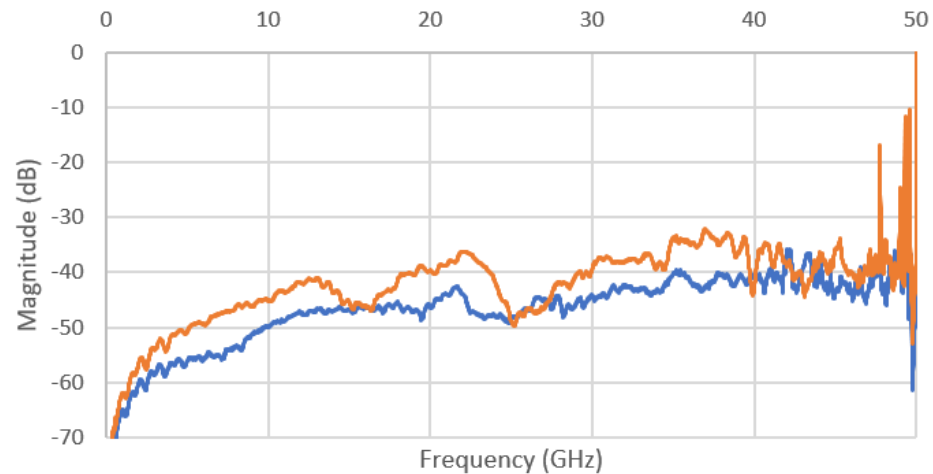
PSFEXT:

Simulated Data:



These plots are included for reference

Measured Data:



ICN:

Key:
 Legacy Pair
 DD Pair
 Proposed Value

Parameter	Value
f_b	53.125 GHz
f_r	0.75 x f_b
f_{min}	0.05 GHz
f_{max}	40 GHz
A_{nt}, A_{ft}	600 mV
T_{nt}, T_{ft}	6.16 ps
ICN _{NEXT} Limit	1.5 mV*
ICN _{FEXT} Limit	4.2 mV*
ICN _{Total} Limit	4.4 mV*

* No change from 802.3cd spec

NOTE: $0.75 \times f_b = 39.84 \text{ GHz}$

Victim	Simulated			Measured		
	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}
1 (Tx1)	0.349	1.394	1.437			
2 (Tx3)	0.440	1.283	1.356			
3 (Tx5)	0.405	1.536	1.588			
4 (Tx7)	0.495	1.411	1.495			
5 (Tx6)	0.403	1.389	1.447			
6 (Tx8)	0.453	1.394	1.466			
7 (Tx2)	0.344	1.004	1.061			
8 (Tx4)	0.391	1.008	1.081			
9 (Rx4)	0.460	1.393	1.467			
10 (Rx2)	0.337	1.308	1.351			
11 (Rx8)	0.516	1.508	1.594			
12 (Rx6)	0.450	1.457	1.525			
13 (Rx7)	0.412	1.343	1.405	0.487	1.920	1.981
14 (Rx5)	0.370	1.449	1.495			
15 (Rx3)	0.394	0.924	1.004	0.346	1.044	1.099
16 (Rx1)	0.327	0.999	1.051			
MAX	0.516	1.536	1.594	0.487	1.920	1.981

ICN:

Key:
Legacy Pair
DD Pair
Proposed Value

Parameter	Value
f_b	53.125 GHz
f_r	0.75 x f_b
f_{\min}	0.05 GHz
f_{\max}	50 GHz
A_{nt}, A_{ft}	600 mV
T_{nt}, T_{ft}	6.16 ps
ICN _{NEXT} Limit	1.5 mV*
ICN _{FEXT} Limit	4.2 mV*
ICN _{Total} Limit	4.4 mV*

* No change from 802.3cd spec

NOTE: $0.75 \times f_b = 39.84 \text{ GHz}$

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Victim	Simulated			Measured		
	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}	ICN _{NEXT}	ICN _{FEXT}	ICN _{Total}
1 (Tx1)	0.367	1.414	1.461			
2 (Tx3)	0.462	1.306	1.386			
3 (Tx5)	0.432	1.569	1.627			
4 (Tx7)	0.521	1.475	1.564			
5 (Tx6)	0.422	1.431	1.491			
6 (Tx8)	0.495	1.426	1.510			
7 (Tx2)	0.365	1.025	1.088			
8 (Tx4)	0.404	1.027	1.103			
9 (Rx4)	0.482	1.411	1.491			
10 (Rx2)	0.348	1.327	1.372			
11 (Rx8)	0.554	1.550	1.646			
12 (Rx6)	0.480	1.514	1.588			
13 (Rx7)	0.440	1.378	1.447	0.509	1.919	1.995
14 (Rx5)	0.398	1.490	1.542			
15 (Rx3)	0.406	0.946	1.029	0.365	1.051	1.113
16 (Rx1)	0.344	1.018	1.075			
MAX	0.554	1.569	1.646	0.509	1.919	1.995