Transmitter Specifications and COM for 50GBASE-CR updated

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Introduction

- **The specification methodology for the Copper Cable and backplane clauses creates a closed budget by specifying the cable/backplane with COM and calibrating the Rx Interference Tolerance test with COM.**
- **This relies however on**
  - The specifications for the Tx matching (or being more stringent) than the Tx that is used in COM in the cable/backplane test, or there being a difference between the COM value used to specify the cable and the COM value used for calibrating the RX interference tolerance test.
- **This presentation is an update to the presentation made to the ad-hoc on 1/10 that investigated the performance of the Tx used in COM at TP2 and compared this with the specifications at that point.**
- **It proposes to align the package parameters in the 50GBASE-CR clause with those used in the 50GBASE-KR clause as it is expected that the same ASIC will be used for both, and proposes the use of a 100 Ohm PCB trace in the host (rather than the existing 109.8 Ohm) in order to not encourage cable vendors to tune their cables to a higher impedance to obtain better COM results.**
- **This presentation is related to comments i-161, i-162, and i-163**

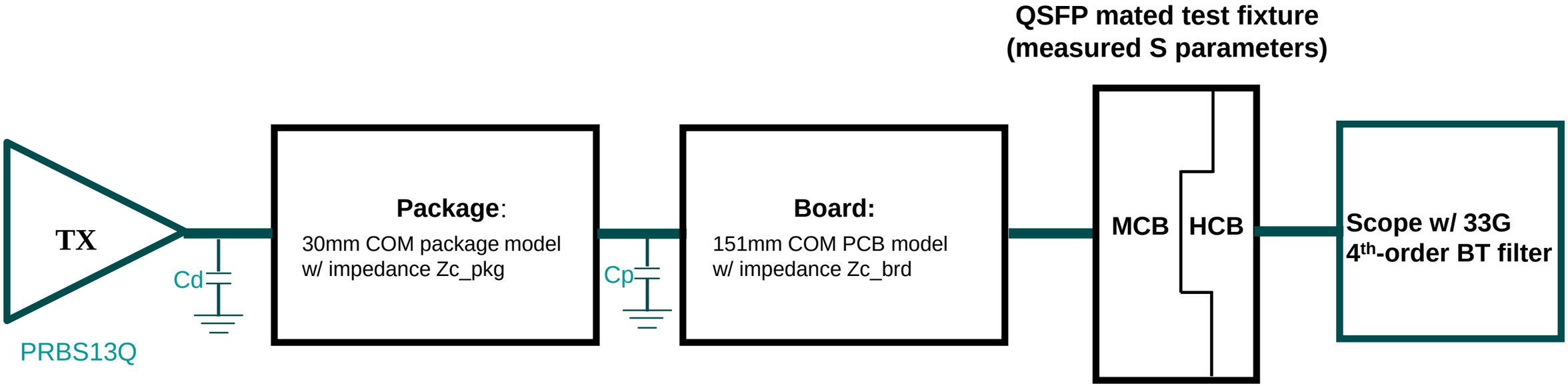
Differences to ad-hoc presentation.

- Corrected the proposal as sent to the reflector where there were typos and an omission.
- Added some additional information, including COM results on two additional cables.
- Clarified some wording.

Methodology

- The COM channel up to the Tx test points was duplicated as close as possible in Matlab.
- The output waveform at the test point was generated in Matlab using Tx with Av=0.4V and using the risetime used in COM. Absolute voltages can be scaled for other values of Av.
- The resulting waveform was then analyzed using the Tx test methodology to determine the Tx parameters which are compared with the Tx specifications. The effect of RLM was also investigated. Nv=13 was used to calculate Vf the steady state voltage to align with 120D and 50GBASE-KR.
- This was repeated changing the transmitter package to match the one being specified in 50GBASE-KR and using a 100 Ohm Host PCB trace impedance.
- COM was also calculated for five representative cables using both the parameters in draft 3.0 and these changed parameters.

Transmitter simulation block diagram at TP2



Transmitter plus package, board, QSFP mated test fixture and 33GHz 4th-order BT filter

53.125Gbs PAM4 transmitter characteristics @ TP2 w/o TX equalization: measured w/ 4th order 33GHz BT filter

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		Simulated PRBS13Q @ TP2									
Parameters	**D3.0 SPEC (Table 136-11) and Table 136-16**	Gaussian TX Filter Risetime 12ps; 30mm package; 151mm pcb; Cd 0.18pF; Cp 0.11pF; Av 0.4V									**Units**
Rd	55	55			50			50			ohm
Zc_pkg	90	90			95			95			ohm
Zc_brd	109.8	109.8			109.8			100			ohm
|EB+EC|		0	0	0.1	0	0	0.1	0	0	0.1	N/A
Rlm	>=0.95	0.947	0.997	0.947	0.947	0.997	0.947	0.947	0.997	0.947	N/A
Sigma-e		0.094	0.093	1.498	0.099	0.098	1.582	0.093	0.092	1.587	mV
Vf (steady-state voltage)	0.34V=< Vf <=0.6V	0.341	0.341	0.341	0.359	0.359	0.359	0.36	0.36	0.36	V
Pmax (Linear fit pulse peak)		0.165	0.165	0.165	0.174	0.174	0.174	0.174	0.174	0.174	V
Differential Peak to Peak Voltage	<=1.2	0.653	0.654	0.654	0.69	0.69	0.69	0.692	0.692	0.692	V
Pmax/Vf	>=0.49	0.482	0.482	0.482	0.484	0.484	0.483	0.484	0.484	0.484	N/A
SNR_{isi}	36.8	31.196	31.208	31.19	32.098	32.091	32.09	32.238	32.229	32.23	dB
SNDR (@ Sigman = 0)		64.86	64.976	40.814	64.85	64.965	40.815	65.476	65.597	40.823	dB
SNDR (TX_SNR=32.5dB)	>=33.3	32.497	32.498	31.903	32.497	32.498	31.903	32.498	32.498	31.904	dB

PAM4 Levels: L0=-1;L1=(-1+EB)/3;L2=(1+EC)/3;L3=1

Linear fitting: Dp=3;Nb=12;Np=200;Nv=13

Conclusions on waveform simulations.

- The values of SNDR and SNRisi in draft 3.0 would fail the Transmitter used in COM and are therefore more stringent than they need to be.
- The calculations used Nv=13 (same as 120D.3.1.4 and clause 137 by reference). As defined in draft 3.0 the value of Nv would be infinite so that should be changed.
- The Pmax/Vf ratio is not significantly affected by the various changes and the existing value of 0.49 does not need to be changed. (comment i-161) (provided Nv=13 is used).
- The value of Vf in draft 3.0 isn't appropriate for the value of 0.45 for Av. Av and Vf should be changed based on the values of Rd and Av used (and Nv) to better correlate to each other and to the 50GBASE-KR specification.

COM results

			802.3by COM						802.3cd/D3.0 COM					
	Loss (dB) @ 12.89 GHz	Loss (dB) @ 13.28 GHz	CA-25G-N		CA-25G-S		CA-25G-L		Table 136-15 Rd=55 Zc_pkg=90 Zc_brd=109.8		Table 137-5 Rd=50 Zc_pkg=95 Zc_brd=109.8		Table 137-5 Rd=50 Zc_pkg=95 Zc_brd=100	
			Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
TE QSFP to QSFP 3m 25 AWG	15.35	15.42	3.35	2.56	4.69	3.88	6.70	6.00	5.05	4.60	5.04	4.54	5.40	4.82
FCI QSFP to Quad SFP 3m 26 AWG	17.59	17.73	2.57	1.58	4.18	3.24	6.21	5.33	4.34	3.80	4.39	3.62	4.54	3.72
Molex zQSFP to zQSFP 3m 26AWG	14.12	14.41	4.16	3.22	5.56	4.63	7.56	6.63	6.06	5.42	6.04	5.32	6.23	5.55
Amphenol QSFP to QSFP 3m 26AWG	14.42	14.74	3.63	2.93	5.07	4.15	6.99	6.33	5.43	5.00	5.55	5.02	5.80	5.18
TE QSFP to Quad SFP 3m 28 AWG	16.61	17.16	3.11	2.00	4.44	3.39	6.60	5.58	4.90	4.31	4.85	4.11	4.99	4.21

Max Allowed Cable loss in draft 3.0 at 13.28GHz is 17.16dB.

Overall Conclusions.

- The draft 3.0 cable COM specification is more relaxed than that for the 25GBASE-CR-N and 25GBASE-CR-S cables implying that some tightening would be possible while maintaining the 3meter objective.
- Changing the parameters to match the 50GBASE-KR specification and the host PCB to 100 Ohm is desirable but doing just that would relax the cable specification further. Also it would require tighter specifications on the Tx than the existing worst case values making it difficult to make host Tx's.
- Note that there isn't any margin for Tx host noise (or impedance mismatch if the PCB is changed to 100 Ohm) as neither are included in the COM calculations.
- The next slide lists the proposed changes that will close the budget, correcting existing issues and making the desired changes.

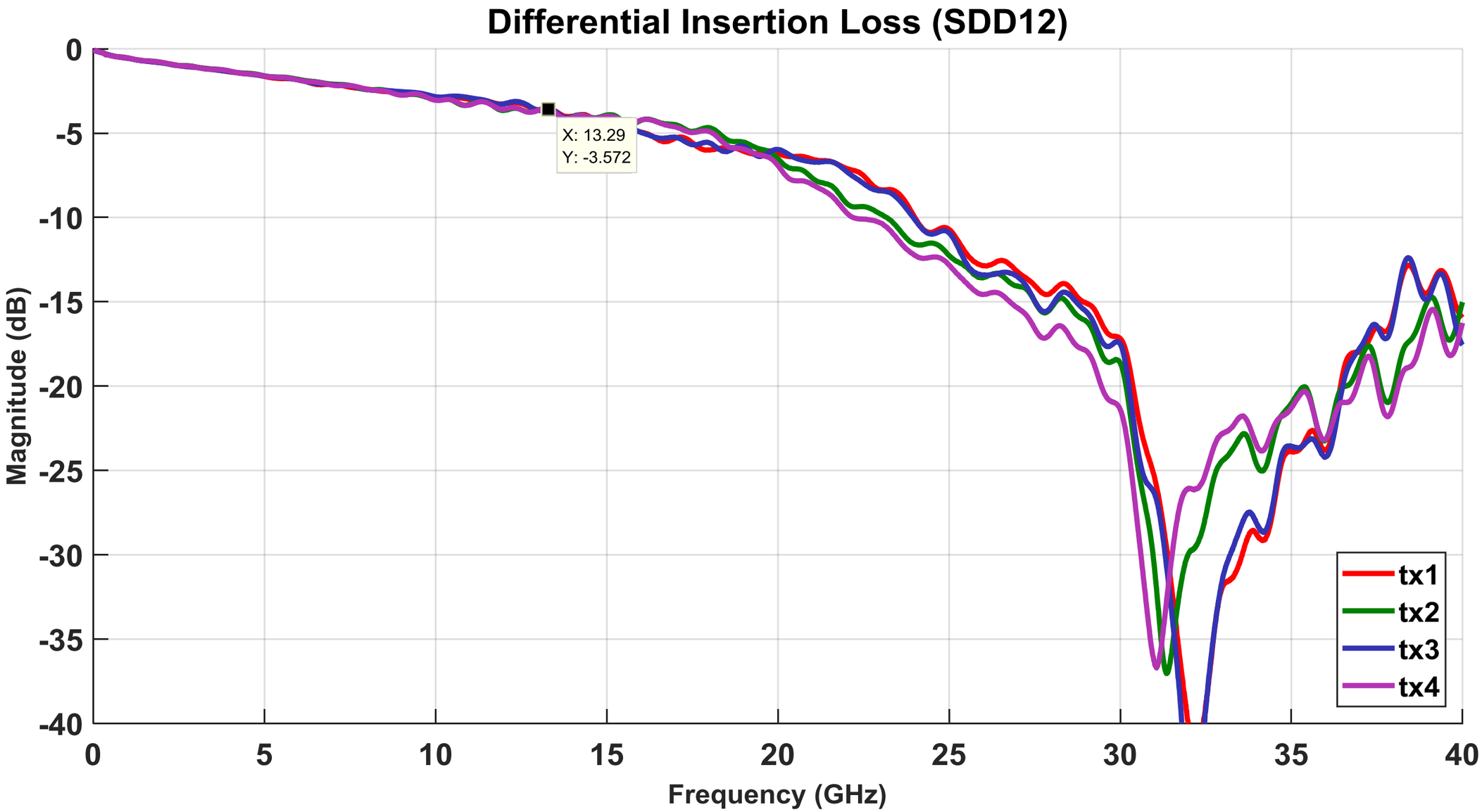
Proposed Changes. (These supercede those in my comments and has corrections since the ad-hoc)

- COM parameters
  - RD=50 Ohms (was 55)
  - Zc package = 95 Ohm (was 90 Ohm)
  - Av/Afe= 0.415 (was 0.45)
  - Ane=0.604 (was 0.63)
  - Add an exception that Zc for the PCB = 100 Ohm (on page 236 line 39 change “parameter values given in Table 92-12” to “parameter values given in Table 92-12 except that Zc=100 Ohm” (was 109.8 Ohm)
- COM pass/fail criterion 3.3dB for Cable test (was 3.0dB), 3.0dB for interference calibration (no change).
- TX specifications
  - Add a sentence to 136.9.3.1.2 stating that Nv=13. (was effectively infinite)
  - Vf(min) = 0.354V (was 0.34V)
  - SNRisi=31.2dB (was 36.8dB)
  - SNDR=32dB (was 33.3dB)

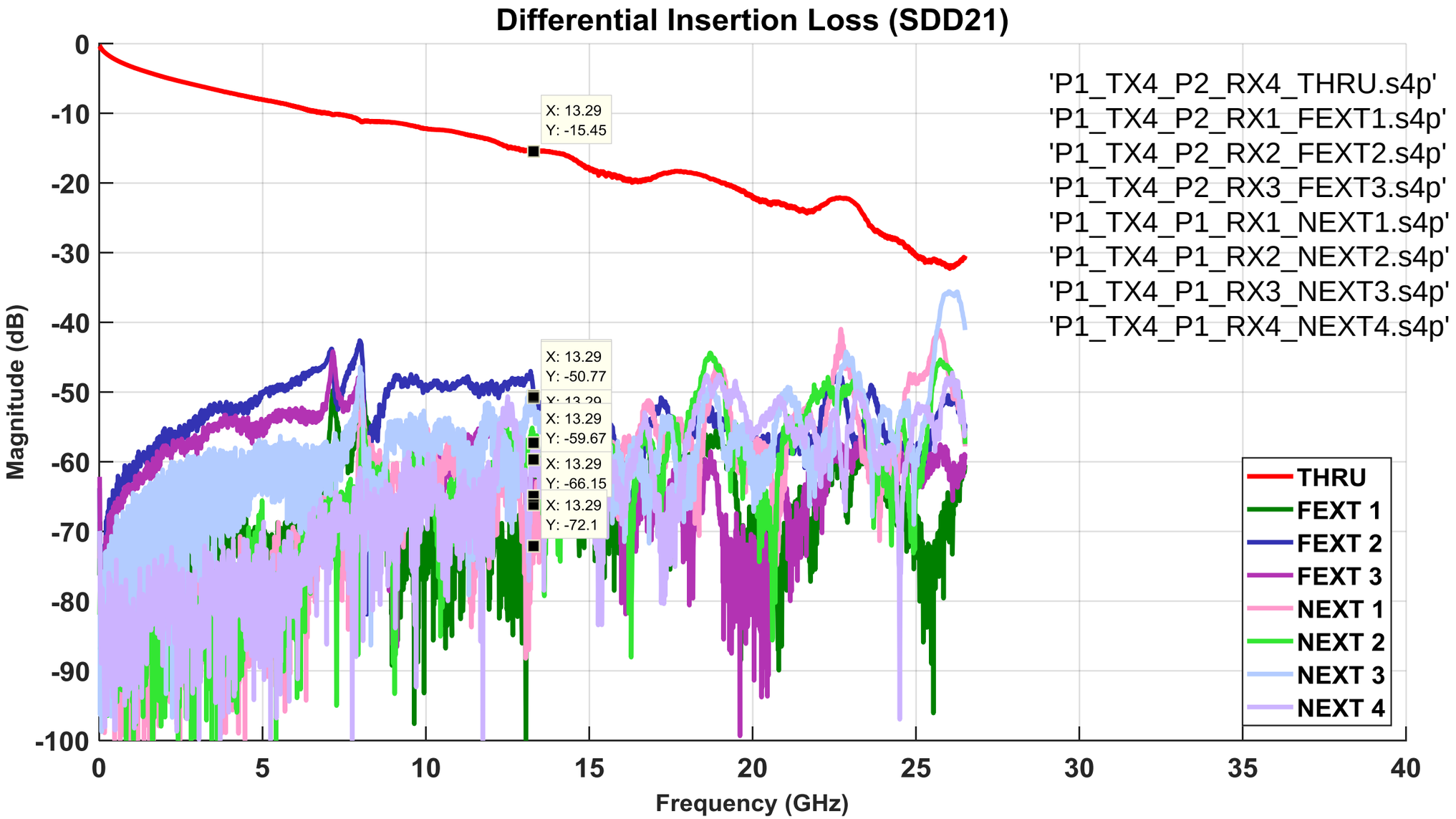
Back-up.

Channel performance.

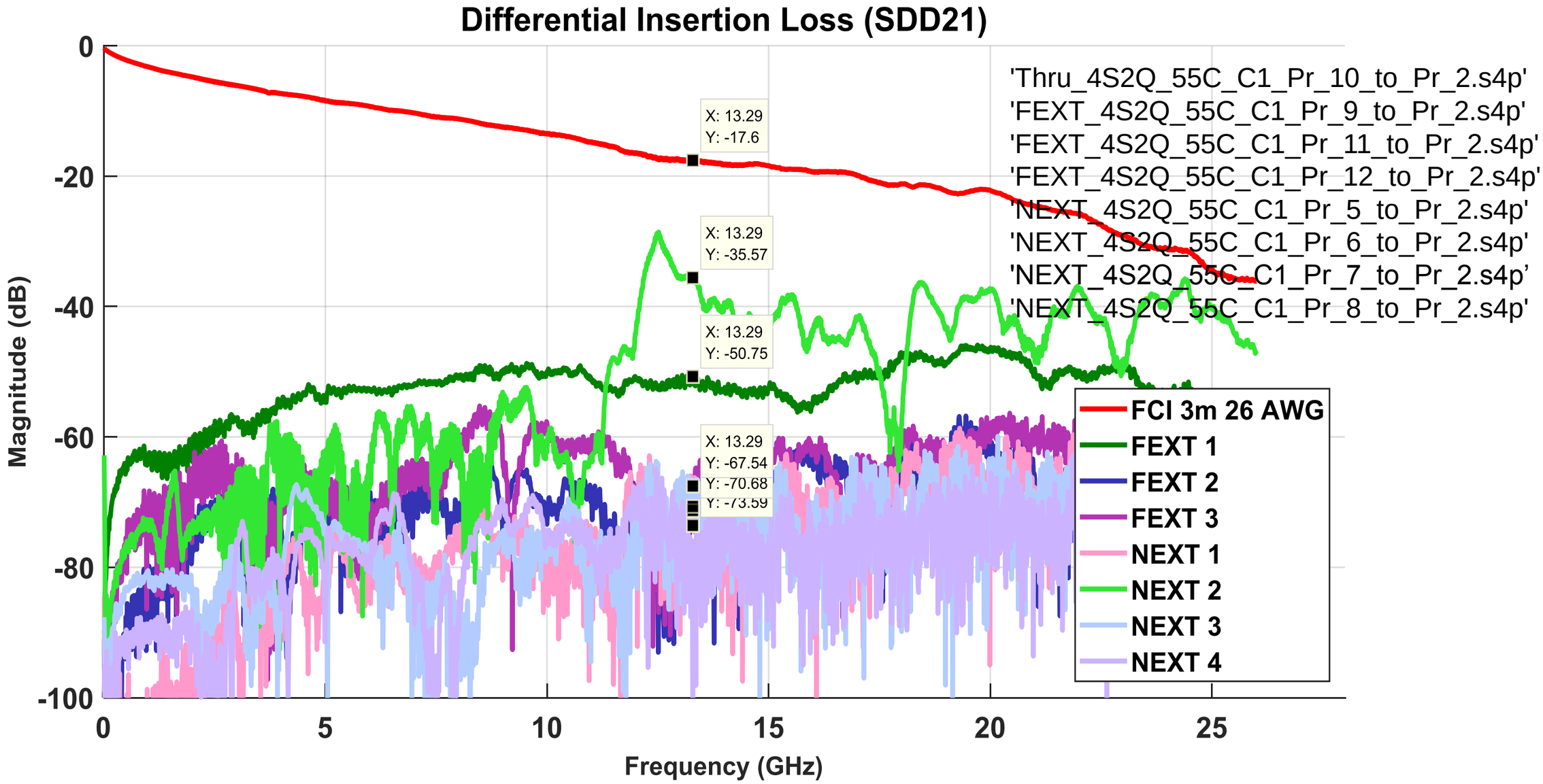
QSFP mated test fixture



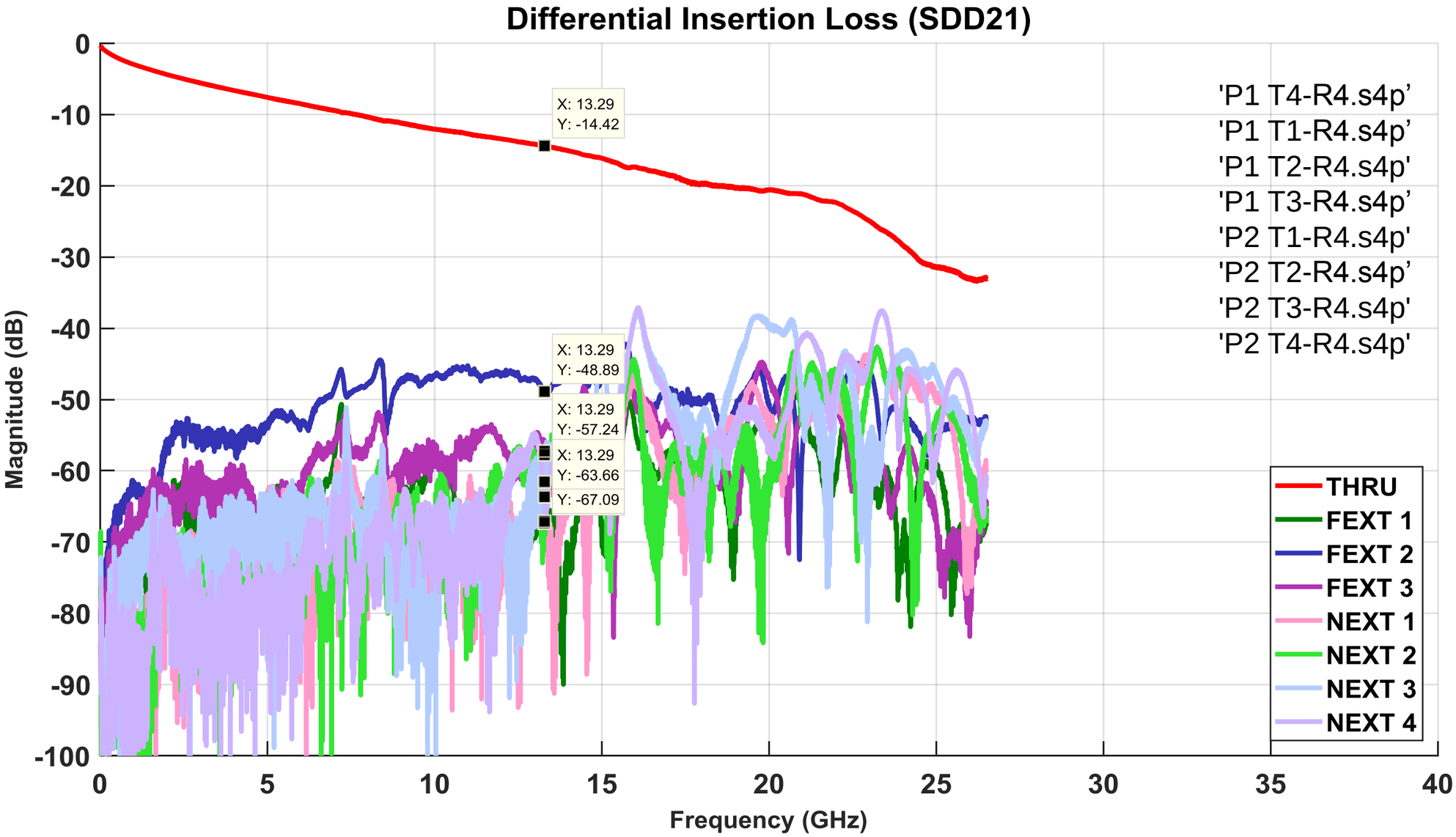
TE QSFP to QSFP cable 3m 25awg cable



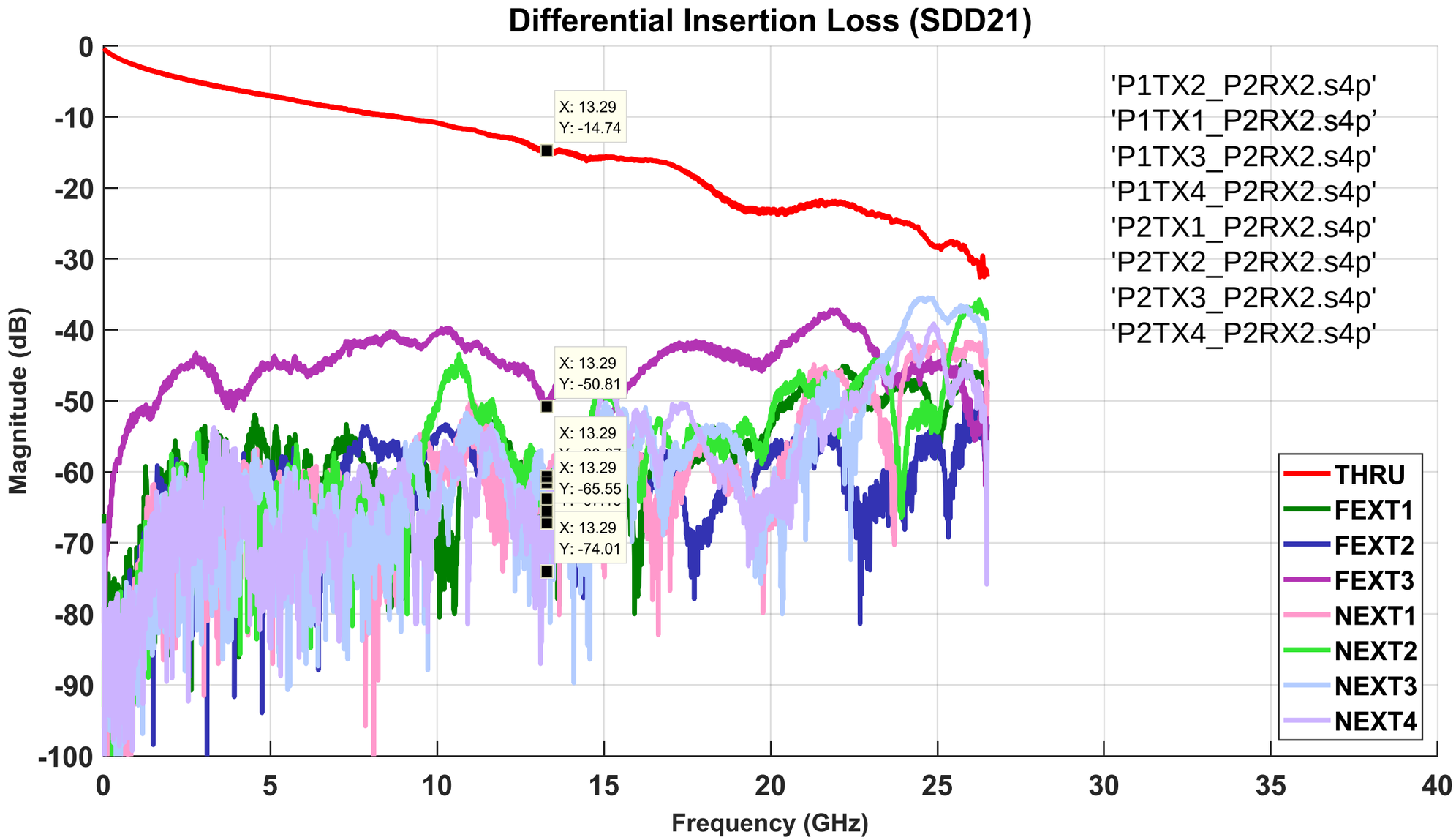
FCI QSFP to Quad SFP 3m 26 AWG cable at 55C



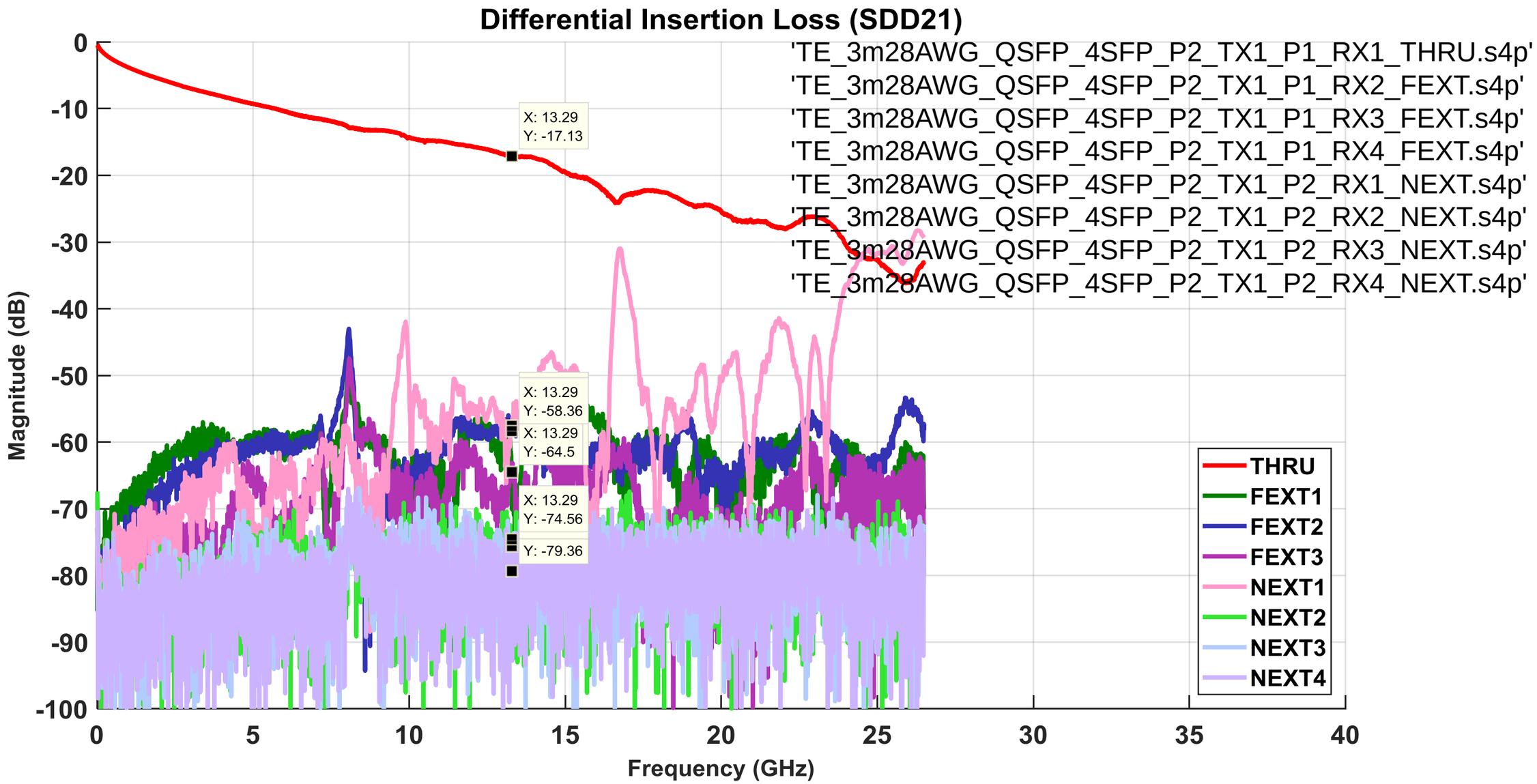
Molex zQSFP to zQSFP 3m 26AWG



Amphenol QSFP to QSFP cable 3m 26awg cable



TE QSFP to Quad SFP cable 3m 28awg cable



802.3cd COM table

802.3cd/D3.0 Table 136-15

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	26.5625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.8e-4 1.8e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX] or selected
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.25:0.05:0]		[min:step:max]
c(-2)	[0:0.025:0.1]		[min:step:max]
c(1)	[-0.25:0.05:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	10.625	GHz	
f_p1	10.625	GHz	
f_p2	53.125	GHz	
A_v	0.45	V	tdr selected
A_fe	0.45	V	tdr selected
A_ne	0.63	V	tdr selected
L	4		
M	32		
N_b	12	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.64E-08	V^2/GHz	
SNR_TX	32.5	dB	tdr selected
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	Value	0, 1, 2
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\D1p3_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_50G_PAM4	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.012	ns
FORCE_TR	1	logical

Non standard control options		
COM_CONTRIBUTION	0	logical
TDR	1	logical
ERL	1	logical
Z_t	50	ohms
ERL_ONLY	1	logical
TR_TDR	0.0189	ns
TDR_duration	5	
TDR_f_BT_3db	19.921875	GHz
TDR_Butterworth	1	logical

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	90	Ohm (tdr sel)

Table 92–12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	110	mm
z_bp (FEXT)	110	mm
z_bp (RX)	151	mm

802.3cd/D3.0 Table 137-5

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	26.5625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.8e-4 1.8e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX] or selected
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.25:0.05:0]		[min:step:max]
c(-2)	[0:0.025:0.1]		[min:step:max]
c(1)	[-0.25:0.05:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	10.625	GHz	
f_p1	10.625	GHz	
f_p2	53.125	GHz	
A_v	0.415	V	tdr selected
A_fe	0.415	V	tdr selected
A_ne	0.604	V	tdr selected
L	4		
M	32		
N_b	12	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.64E-08	V^2/GHz	
SNR_TX	32.5	dB	tdr selected
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	Value	0, 1, 2
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\D1p3_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_50G_PAM4	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.012	ns
FORCE_TR	1	logical

Non standard control options		
COM_CONTRIBUTION	0	logical
TDR	1	logical
ERL	1	logical
Z_t	50	ohms
ERL_ONLY	1	logical
TR_TDR	0.0189	ns
TDR_duration	5	
TDR_f_BT_3db	19.921875	GHz
TDR_Butterworth	1	logical

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	95	Ohm (tdr sel)

Table 92–12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	110	mm
z_bp (FEXT)	110	mm
z_bp (RX)	151	mm

802.3by COM table

802.3by Table 110-11 CA-25G-N

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	A	B	C	D	E	F	G	H	I	J	K	L
1	**Table 93A-1 parameters**					**I/O control**				**Table 93A–3 parameters**		
2	**Parameter**	**Setting**	**Units**	**Information**		DIAGNOSTICS	1	logical		**Parameter**	**Setting**	**Units**
3	f_b	25.78125	GBd			DISPLAY_WINDOW	1	logical		package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
4	f_min	0.05	GHz			Display frequency domain	1	logical		package_tl_tau	6.141E-03	ns/mm
5	Delta_f	0.01	GHz			CSV_REPORT	1	logical		package_Z_c	78.2	Ohm
6	C_d	[2.5e-4 2.5e-4]	nF	[TX RX]		RESULT_DIR	.\results\test\					
7	z_p select	[1 2]		[test cases to run]		SAVE_FIGURES	0	logical		**Table 92–12 parameters**		
8	z_p (TX)	[12 30]	mm	[test cases]		SAVE_RESP	0	logical		**Parameter**	**Setting**	
9	z_p (NEXT)	[12 12]	mm	[test cases]		Port Order	[1 3 2 4]			board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
10	z_p (FEXT)	[12 30]	mm	[test cases]		RUNTAG	_CR_N			board_tl_tau	6.191E-03	ns/mm
11	z_p (RX)	[12 30]	mm	[test cases]		**Receiver testing**				board_Z_c	109.8	Ohm
12	C_p	[1.8e-4 1.8e-4]	nF	[TX RX]		RX_CALIBRATION	0	logical		z_bp (TX)	151	mm
13	R_0	50	Ohm			Sigma BBN step	5.00E-03	V		z_bp (NEXT)	72	mm
14	R_d	[55 55]	Ohm	[TX RX]		IDEAL_TX_TERM	0	logical		z_bp (FEXT)	72	mm
15	f_r	0.75	*fb							z_bp (RX)	151	mm
16	c(0)	0.62		min								
17	c(-1)	[-0.18:0.02:0]		[min:step:max]		T_r	8.00E-03	ns				
18	c(1)	[-0.38:0.02:0]		[min:step:max]		T_r_meas_point	0	logical				
19	g_DC	[-16:1:0]	dB	[min:step:max]		T_r_filter_type	1	logical				
20	f_z	6.4453125	GHz									
21	f_p1	6.4453125	GHz			**Non standard control options**						
22	f_p2	25.78125	GHz			INC_PACKAGE	1	logical				
23	A_v	0.4	V			IDEAL_RX_TERM	0	logical				
24	A_fe	0.6	V			INCLUDE_CTLE	1	logical				
25	A_ne	0.6	V			INCLUDE_TX_RX_FILTER	1	logical				
26	L	2										
27	M	32										
28	N_b	14	UI									
29	b_max(1)	0.35										
30	b_max(2..N_b)	0.35										
31	sigma_RJ	0.01	UI									
32	A_DD	0.05	UI									
33	eta_0	5.20E-08	V^2/GHz									
34	SNR_TX	29	dB									
35	R_LM	1										
36	DER_0	1.00E-12										
37	**Operational control**											
38	COM Pass threshold	2.2	dB		set to 3 if cable loss than 12 dB							
39	Include PCB	1	Value	0, 1, 2								

802.3by Table 110-11 CA-25G-S

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Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.62		min
c(-1)	[-0.18:0.02:0]		[min:step:max]
c(1)	[-0.38:0.02:0]		[min:step:max]
g_DC	[-13:1:0]	dB	[min:step:max]
f_z	6.4453125	GHz	
f_p1	6.4453125	GHz	
f_p2	25.78125	GHz	
A_v	0.4	V	
A_fe	0.6	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	14	UI	
b_max(1)	0.5		
b_max(2..N_b)	0.5		
sigma_RJ	0.01	UI	
A_DD	0.05	UI	
eta_0	5.20E-08	V^2/GHz	
SNR_TX	29	dB	
R_LM	1		
DER_0	1.00E-08		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	Value	0, 1, 2

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\test\	
SAVE_FIGURES	0	logical
SAVE_RESP	0	logical
Port Order	[1 3 2 4]	
RUNTAG	_CR_S	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	8.00E-03	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical
Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	78.2	Ohm

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

802.3by Table 110-11 CA-25G-L

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Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.62		min
c(-1)	[-0.18:0.02:0]		[min:step:max]
c(1)	[-0.38:0.02:0]		[min:step:max]
g_DC	[-13:1:0]	dB	[min:step:max]
f_z	6.4453125	GHz	
f_p1	6.4453125	GHz	
f_p2	25.78125	GHz	
A_v	0.4	V	
A_fe	0.6	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	14	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0.01	UI	
A_DD	0.05	UI	
eta_0	5.20E-08	V^2/GHz	
SNR_TX	29	dB	
R_LM	1		
DER_0	1.00E-05		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	Value	0, 1, 2

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\test\	
SAVE_FIGURES	0	logical
SAVE_RESP	0	logical
Port Order	[1 3 2 4]	
RUNTAG	_CR_L	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	8.00E-03	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical
Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	78.2	Ohm

Table 92–12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

References for cable s parameters

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