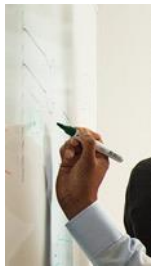

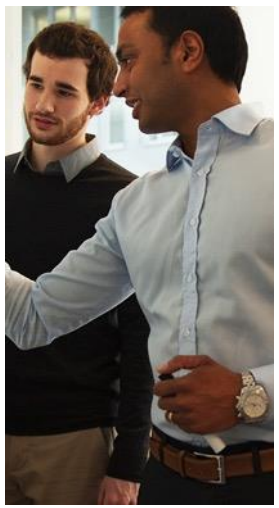

100 Gbps Copper Cable Measurement and S-Parameter File

Nathan Tracy, Bruce Champion

Week of July 15, 2019, Vienna, Austria

Supporters

Greg McSorley, Amphenol

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Rich Mellitz, Samtec

Agenda

- Review of prior presentations and data
- Presentation of measured 2m, 26 AWG OSFP cable assembly data
- S-Parameter file review
- Conclusions

Measured Cable Assembly Analysis, & Simulations: Work Done To Date

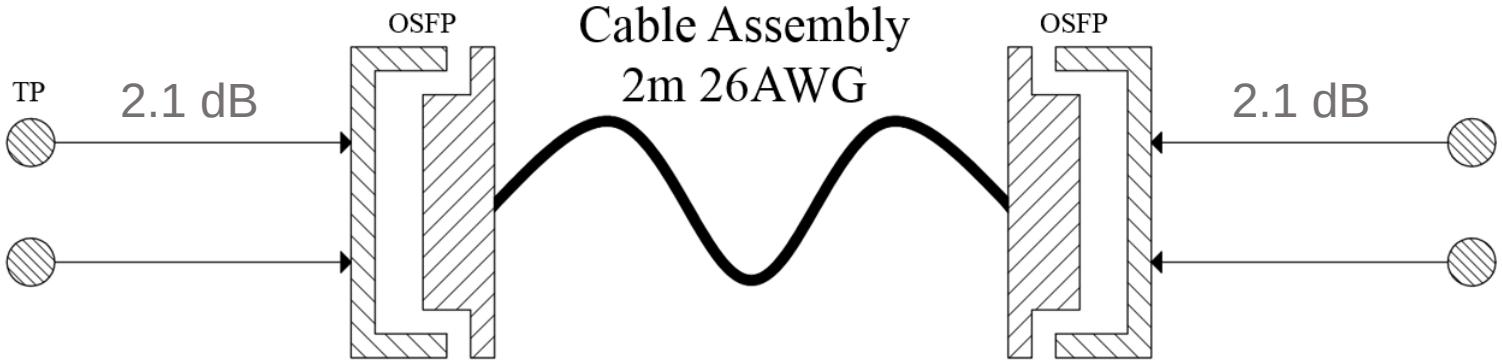
TE has presented cable assembly simulation and measured data previously as our development results have progressed

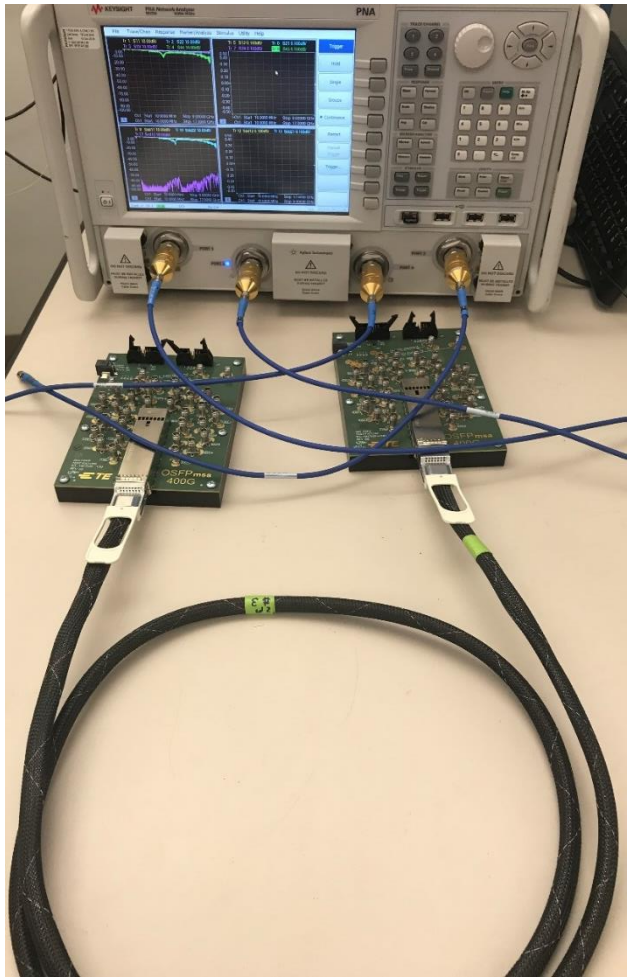
- tracy_100GEL_01a_0318, recommends 30dB loss budget
- tracy_3ck_02a_1118, suggests there is going to be an issue with the 28dB 2m goal
- February 27, 2019 P802.3ck ad hoc, provided simulation and measured results for a number of cables and configurations, projecting a 19.4 to 20.4 dB loss range of loss for 2m cable assemblies
- tracy_3ck_01a_0319, March 2019, presented some of the Feb 27, 2019 data and contributed two new cable assembly channel S-Parameter simulations for a 1.5m 28AWG cable assembly and a 2m 28AWG cable assembly for working group analysis

New Work Being Shared

- 2m, 26 AWG OSFP cable assemblies have been built
- Tested with prototype OSFP MCBs and connectors
- MCB trace loss is slightly below draft specification and is approx. 2.1 dB instead of the draft spec. 2.3 dB
    - Slide 7 shows per channel loss limit adjusted by 0.4 dB to 19.6 dB (vs. proposed 20dB) due to MCB loss being low (2 x 0.2 dB)
    - All S-Parameter data is raw measurement and is not adjusted
- S-Parameter files have been contributed as tracy_3ck_02_0719

2m, 26AWG OSFP Cable: TP1-TP4 Test Data





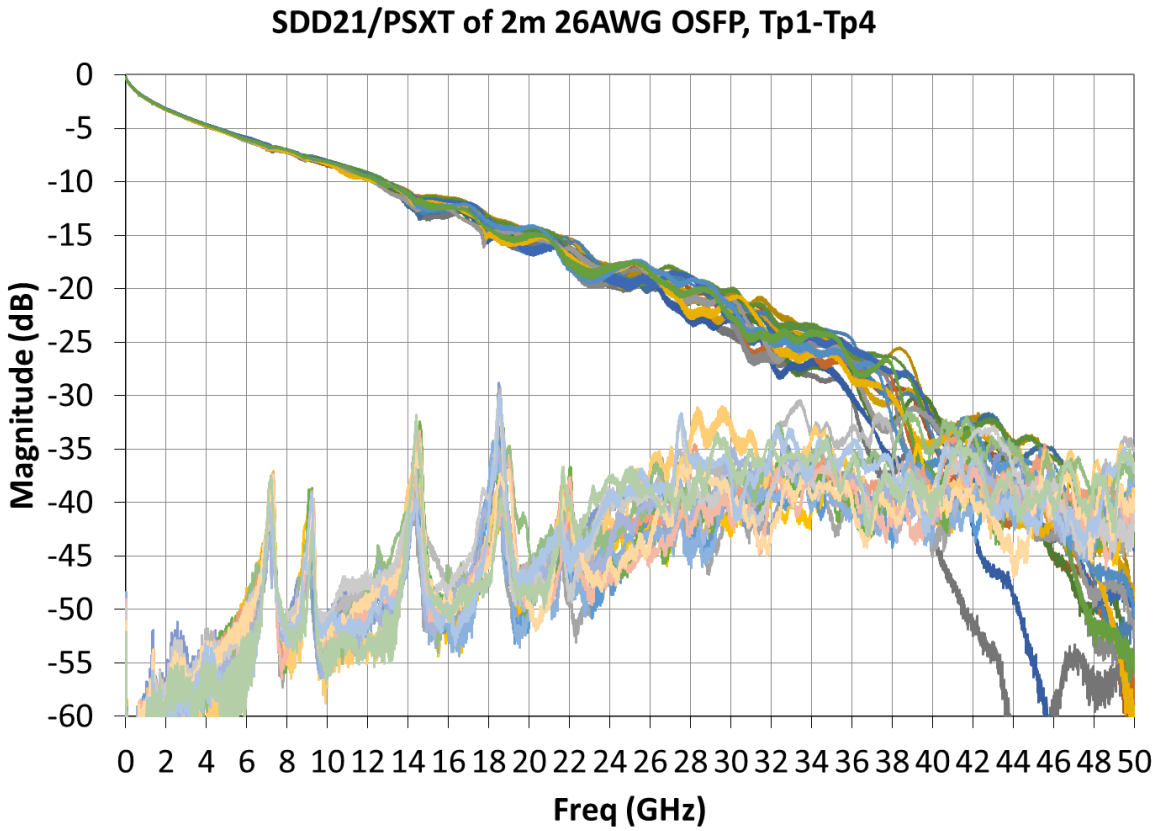
- Data taken from TP1 to TP4
- 10 MHz to 50 GHz
- All Thru files and all XT collected

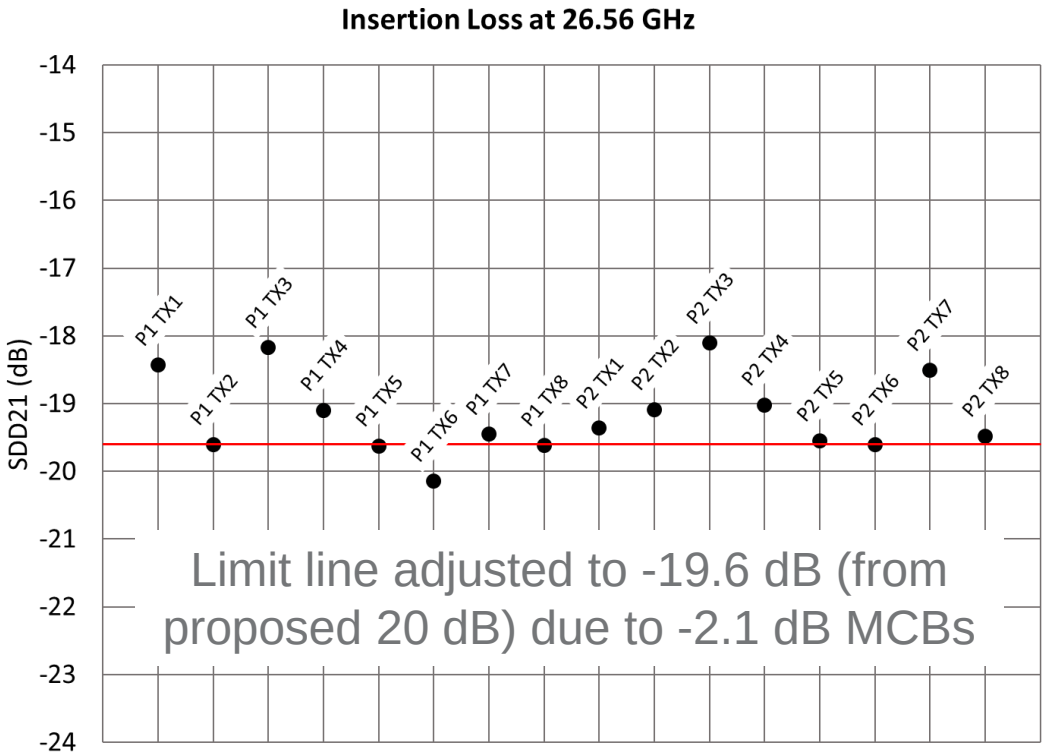
OSFP Pin Map

Pin #	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31
	G	Tx1+	Tx1-	G	Tx3+	Tx3-	G	Tx5+	Tx5-	G	Tx7+	Tx7-	G	SB	SB	SB	SB	G	Rx8-	Rx8+	G	Rx6-	Rx6+	G	Rx4-	Rx4+	G	Rx2-	Rx2+	G
	G	Tx2+	Tx2-	G	Tx4+	Tx4-	G	Tx6+	Tx6-	G	Tx8+	Tx8-	G	SB	SB	SB	SB	G	Rx7-	Rxy+	G	Rx5-	Rx5+	G	Rx3-	Rx3+	G	Rx1-	Rx1+	G
Pin #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

2m, 26AWG OSFP Cable: TP1-TP4 Test Data

- Test data taken using 2.1dB MCBs (Chart on bottom right compensated for this by adjusting limit line by 0.4 dB)
- PSXT includes all aggressors (7 FEXT & 8 NEXT)
- Resonances in crosstalk are from receptacle connector (improvements in development)





IL, COM, ERL

Longer host

Used COM 2.70 script
Config file shown later

- Cd = 120 fF
- Ls = 120 pH
- Cb = 30 fF
- 16 fixed taps with 2 banks of 4 up to 80 UI

PCB Length = 102.7 mm*

* Improvements expected with less PCB trace

Case 1

- z_p (Tx) = 12mm
- z_p (Rx) = 12mm

Case 2

- z_p (Tx) = 31mm
- z_p (Rx) = 29mm

	IL at 26.56 GHz	COM Case 1	COM Case 2	ERL 11	ERL 22
P1_Tx1	-18.432	4.408	3.363	10.084	9.824
P1_Tx2	-19.602	3.688	2.569	9.040	9.846
P1_Tx3	-18.171	4.731	3.768	10.586	11.172
P1_Tx4	-19.097	4.524	3.453	8.610	9.889
P1_Tx5	-19.622	3.795	2.890	10.955	10.701
P1_Tx6	-20.143	4.237	3.086	9.556	10.383
P1_Tx7	-19.452	3.904	2.938	10.437	8.804
P1_Tx8	-19.619	3.890	2.902	9.314	10.089
P2_Tx1	-19.359	4.867	3.728	10.867	10.949
P2_Tx2	-19.086	4.510	3.440	10.153	10.478
P2_Tx3	-18.107	4.852	3.863	10.533	11.116
P2_Tx4	-19.017	4.408	3.440	9.562	10.100
P2_Tx5	-19.548	3.688	2.865	10.612	9.458
P2_Tx6	-19.607	3.999	3.086	10.604	11.060
P2_Tx7	-18.508	3.768	2.938	10.449	9.696
P2_Tx8	-19.479	3.836	2.950	9.854	10.117

Data is not adjusted for low MCB loss. IL is “as measured” and COM / ERL is calculated based on measured data

IL, COM, ERL

Shorter host

Used COM 2.70 script
Config file shown later

- Cd = 120 fF
- Ls = 120 pH
- Cb = 30 fF
- 16 fixed taps with 2 banks of 4 up to 80 UI

PCB Length = 92.7 mm

Case 1

- z_p (Tx) = 12mm
- z_p (Rx) = 12mm

Case 2

- z_p (Tx) = 31mm
- z_p (Rx) = 29mm

	IL at 26.56 GHz	COM Case 1	COM Case 2	ERL 11	ERL 22
P1_Tx1	-18.432	4.657	3.596	10.084	9.824
P1_Tx2	-19.602	3.782	2.902	9.040	9.846
P1_Tx3	-18.171	4.928	4.041	10.586	11.172
P1_Tx4	-19.097	4.702	3.755	8.610	9.889
P1_Tx5	-19.622	3.972	3.248	10.955	10.701
P1_Tx6	-20.143	4.365	3.375	9.556	10.383
P1_Tx7	-19.452	3.986	3.299	10.437	8.804
P1_Tx8	-19.619	4.096	3.160	9.314	10.089
P2_Tx1	-19.359	5.130	4.082	10.867	10.949
P2_Tx2	-19.086	4.792	3.702	10.153	10.478
P2_Tx3	-18.107	5.067	4.027	10.533	11.116
P2_Tx4	-19.017	4.642	3.755	9.562	10.100
P2_Tx5	-19.548	3.958	3.110	10.612	9.458
P2_Tx6	-19.607	4.110	3.236	10.604	11.060
P2_Tx7	-18.508	3.849	3.198	10.449	9.696
P2_Tx8	-19.479	3.945	3.160	9.854	10.117

COM Settings

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	[45 45]	Ohm	[TX RX]
A_v	0.39	V	vp/vf=.694
A_fe	0.39	V	vp/vf=.694
A_ne	0.578	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.5		min
c(-1)	[-0.3:0.02:0]		[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	16	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
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	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	1	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3000	
beta_x	2.53E+09	
rho_x	**0.25**	
fixture delay time	0	s
TDR_W_TXPKG	0	
N_bx	24	UI
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
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_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

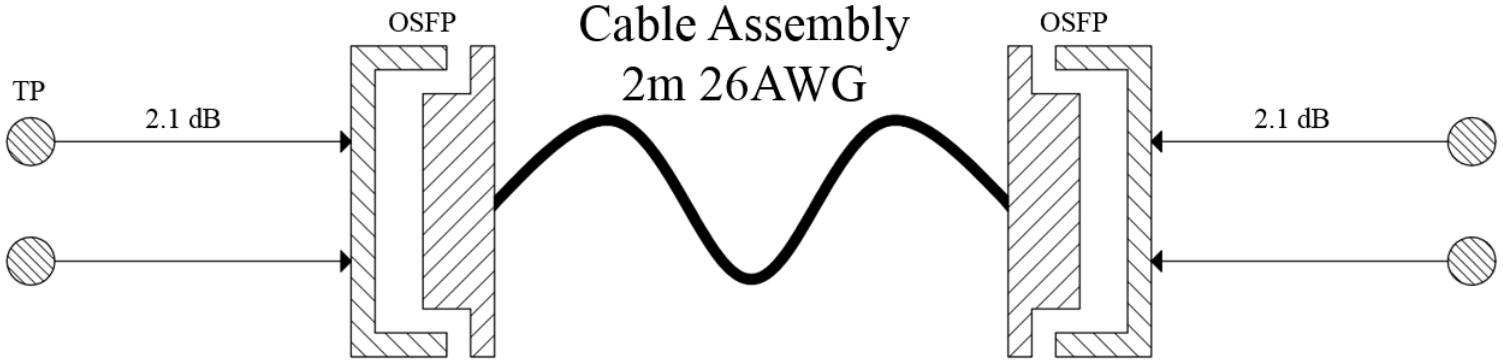
Table 92–12 parameters 5.2dB at 26.56GHz		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 0.000599 0.0001022]*	1.286 dB/in or 0.0506 dB/mm at 100 ohms
board_tl_tau	*6.200E-03*	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	*102.7*	mm
z_bp (NEXT)	*102.7*	mm
z_bp (FEXT)	*102.7*	mm
z_bp (RX)	*102.7*	mm

Floating Tap Control		
N_bg	**2**	**0 1 2 or 3 groups**
N_bf	*4*	taps per group
N_f	80	UI span for floating taps
bmaxg	0.1	max DFE value for floating taps

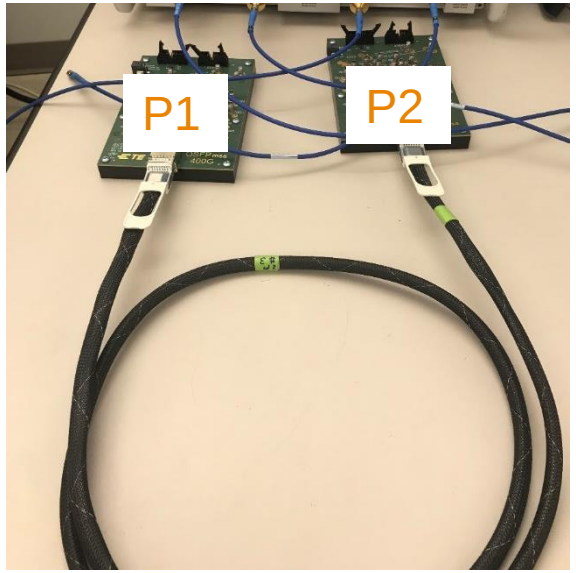
yellow indicates WIP

Comments on *tracy_3ck_02_0719* S-Parameter File

Test Data
- 256, .s4p touchstone files shared
  - Data is Tp1 to Tp4 associated with tracy_3ck_01a_0719
  - 16 lanes each having 1 Thru and 15 XT files
  - Each lane is in its separate folder (see next slide)
  - 10MHz to 50 GHz



File Naming
- Each side of assembly is represented by P1 or P2
- Example Thru:
  - P1_Tx1_P2_Rx1



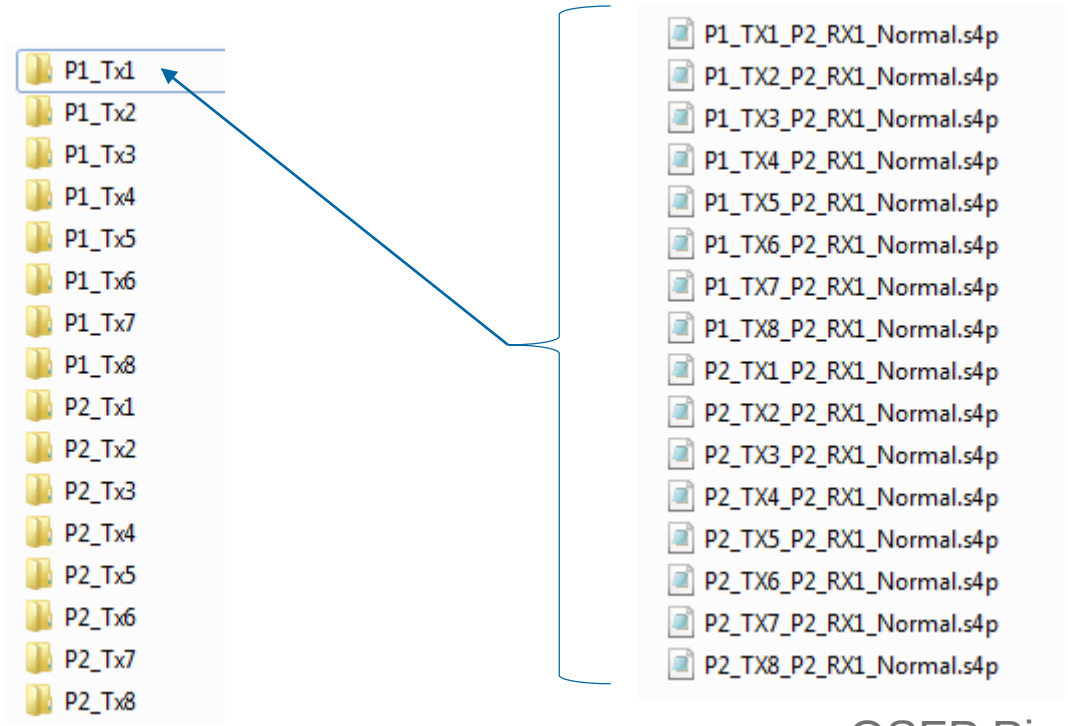
OSFP Pin Map

Pin #	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31
	G	Tx1+	Tx1-	G	Tx3+	Tx3-	G	Tx5+	Tx5-	G	Tx7+	Tx7-	G	SB	SB	SB	SB	G	Rx8-	Rx8+	G	Rx6-	Rx6+	G	Rx4-	Rx4+	G	Rx2-	Rx2+	G
	G	Tx2+	Tx2-	G	Tx4+	Tx4-	G	Tx6+	Tx6-	G	Tx8+	Tx8-	G	SB	SB	SB	SB	G	Rx7-	Rxy+	G	Rx5-	Rx5+	G	Rx3-	Rx3+	G	Rx1-	Rx1+	G
Pin #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Comments on *tracy_3ck_02_0719* S-Parameter File

Each lane in its own folder

Files have P1/P2 designation

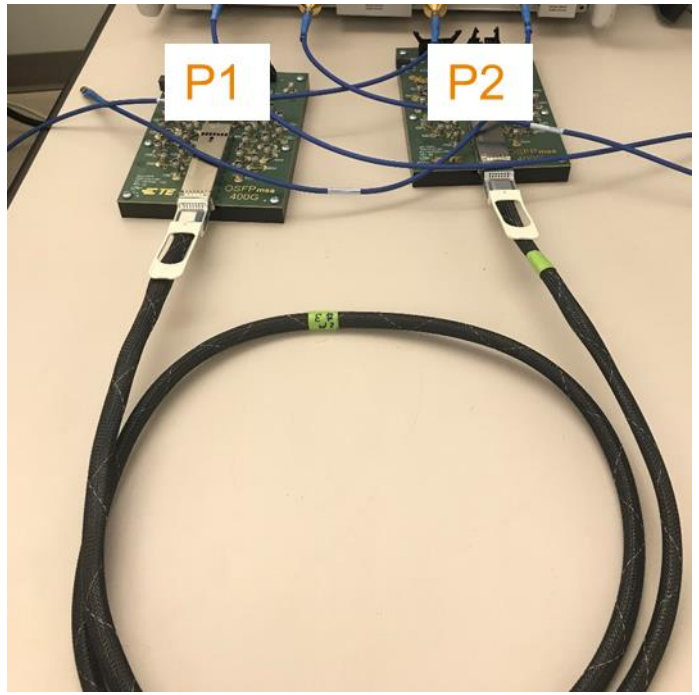


Example Thru/FEXT/NEXT

Thru:
P1_Tx1_P2_Rx1_Normal.s4p

FEXT:
P1_Tx2_P2_Rx1_Normal.s4p

NEXT:
P2_Tx1_P2_Rx1_Normal.s4p



OSFP Pin Map

Pin #	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31
	G	Tx1+	Tx1-	G	Tx3+	Tx3-	G	Tx5+	Tx5-	G	Tx7+	Tx7-	G	SB	SB	SB	SB	G	Rx8-	Rx8+	G	Rx6-	Rx6+	G	Rx4-	Rx4+	G	Rx2-	Rx2+	G
	G	Tx2+	Tx2-	G	Tx4+	Tx4-	G	Tx6+	Tx6-	G	Tx8+	Tx8-	G	SB	SB	SB	SB	G	Rx7-	Rxy+	G	Rx5-	Rx5+	G	Rx3-	Rx3+	G	Rx1-	Rx1+	G
Pin #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Summary

2m, 26 AWG, TP1 to TP4 OSFP cable assembly measured results have been presented and contributed

Based on multiple cables built, we believe this demonstrates performance that is consistent with the inclusion of manufacturing variations

Supports 20dB loss proposal for TP1 to TP4 cable assembly

Requires 29dB for end to end link, TP0 to TP5, to enable the 20dB cable assembly channel

Further performance improvements will be required, but we have time

S-Parameter files included for working group analysis

Recommendation: use this contributed file to get COM configuration narrowed down