ERL for Parameter Update

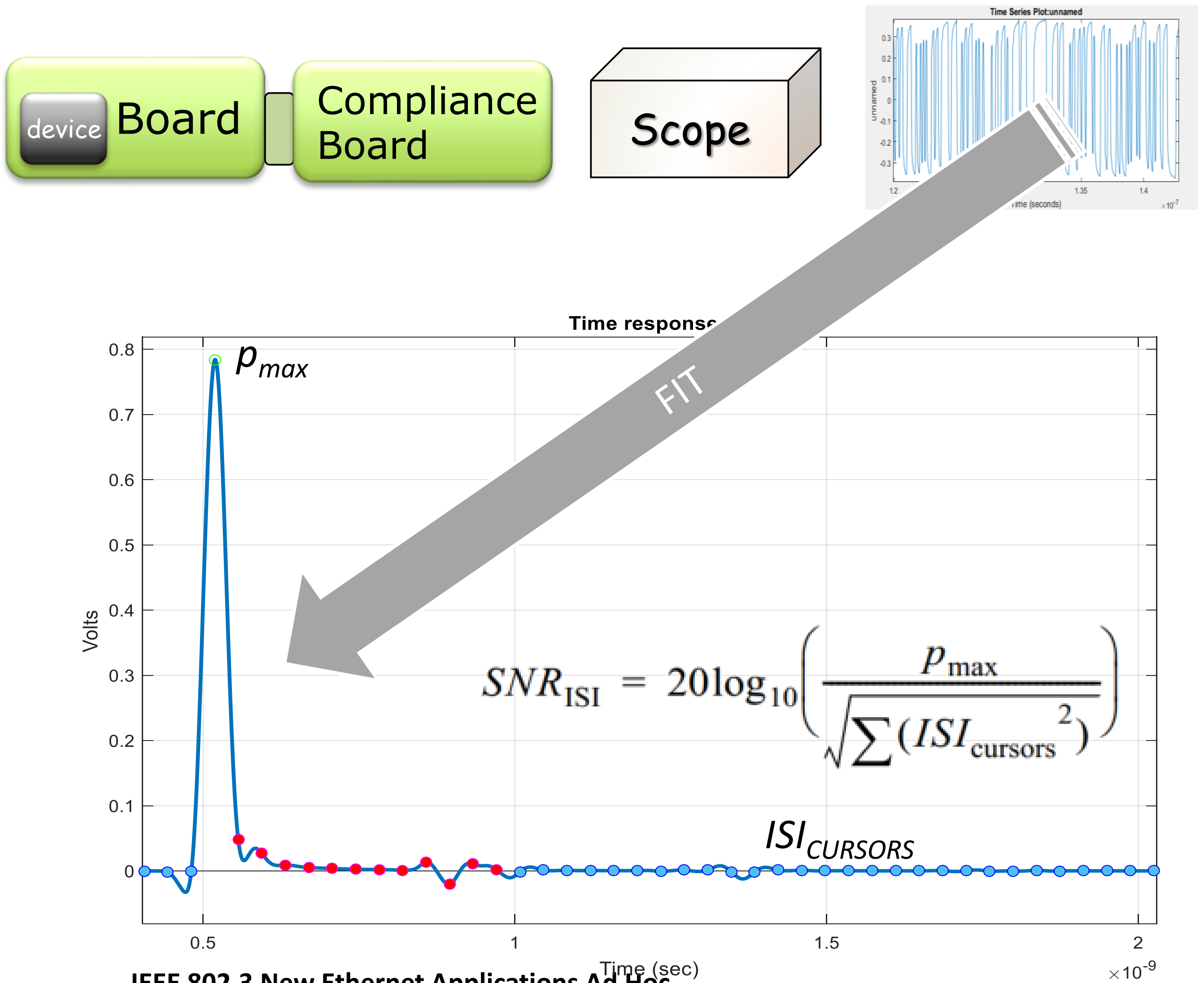
Richard Mellitz, Samtec

02-21-2018

ToC

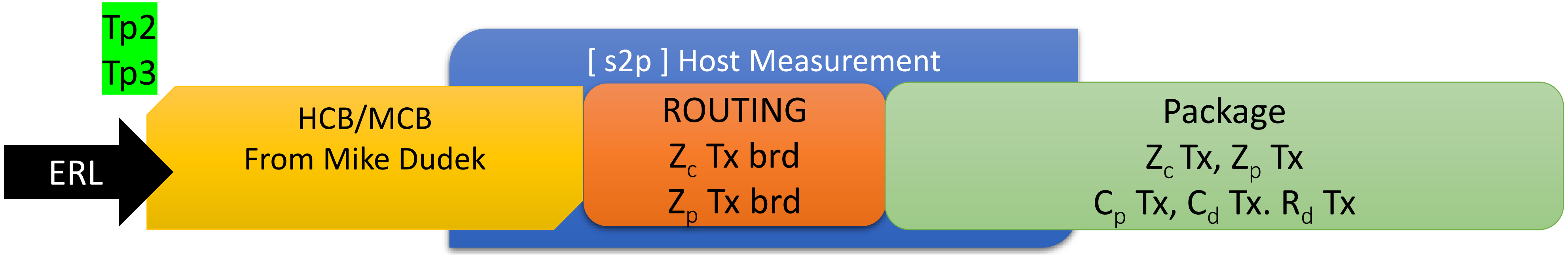
- Review SNR_{ISI}
- Clause 136 host transmitter and receiver
  - DOE experiment
  - SNR_{ISI} comparison
  - ERL_{min} decision
- Clause 136 cable assembly
  - ERL for a variety of cables
- Clause 137 transmitter and receiver
  - DOE experiment
  - SNR_{ISI} comparison
- Clause 137 channel
  - See work from Howard Heck
- Proposal summary

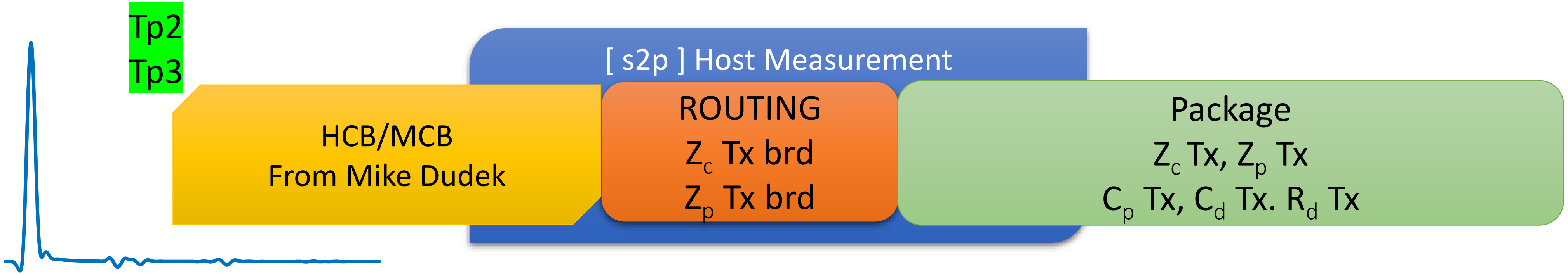
Review SNR_{ISI}



- ❑ SNR_{isi} is determined from a pulse response derived from a measured data pattern response
- ❑ SNR_{ISI} captures reflection outside there reach of a specified DFE
- ❑ In theory its sound good.
  - It misses re-reflections from the rest of the pulse response
  - For devices (CL 136), SNR_{ISI} represents a small amount of noise which is difficult to measure
- ❑ It should correlate to ERL because both are measure reflections.
- ❑ Since reflection are caused from physical channel parameter, both should correlate to them

Experiment: Compare Host ERL and SNR_{ISI} for wide parameter sweep variations





$$SNR_{ISI} = 20\log_{10}\left(\frac{p_{\max}}{\sqrt{\sum (ISI_{cursors}{}^2)}}\right)$$

Swept Parameters

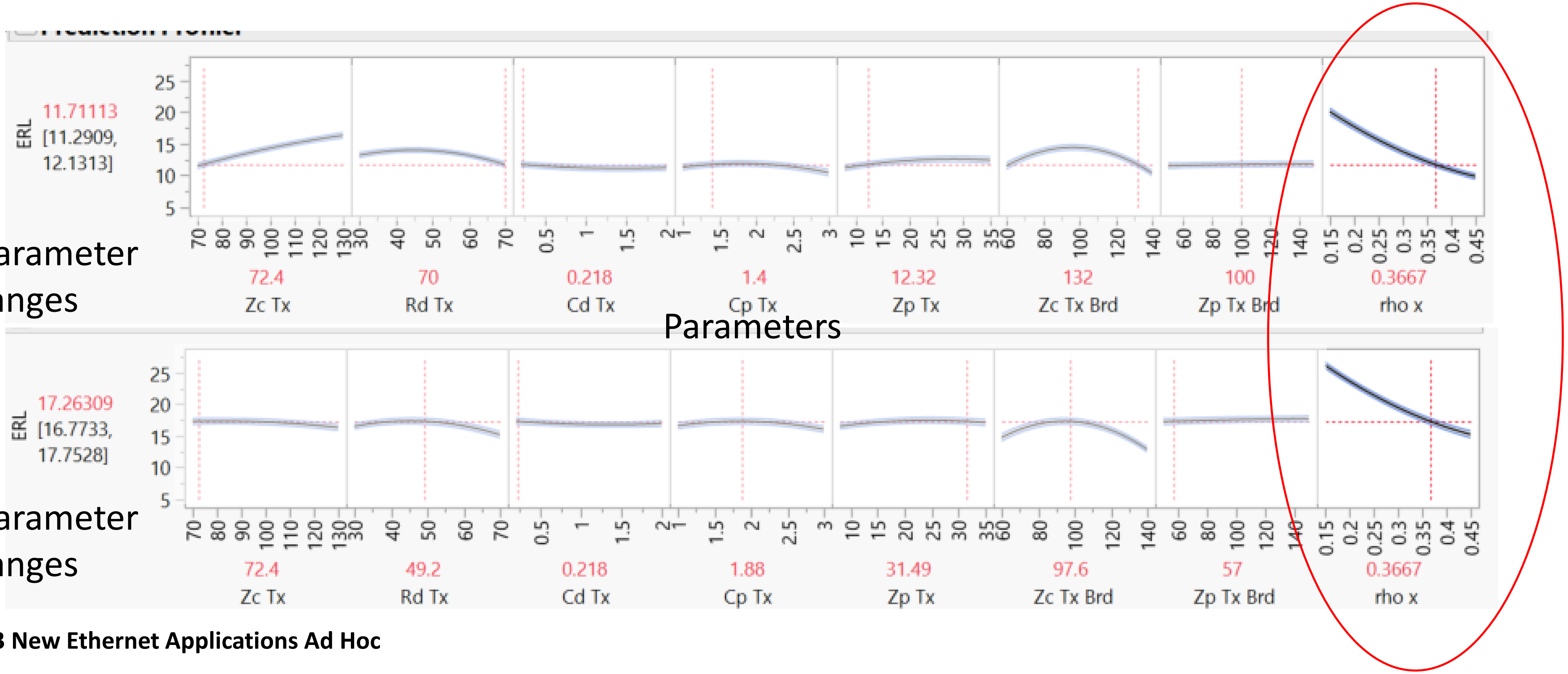
Z_c Tx, Z_p Tx,C_p Tx, C_d Tx. R_d Tx, Z_c Tx brd, Z_p Tx brd

**This is a physical parameter experiment: Ranges we chosen to cause reflections and not to comply with particular standard*

Choose ρ_x =0.44 (which is used in the calculation of ERL)

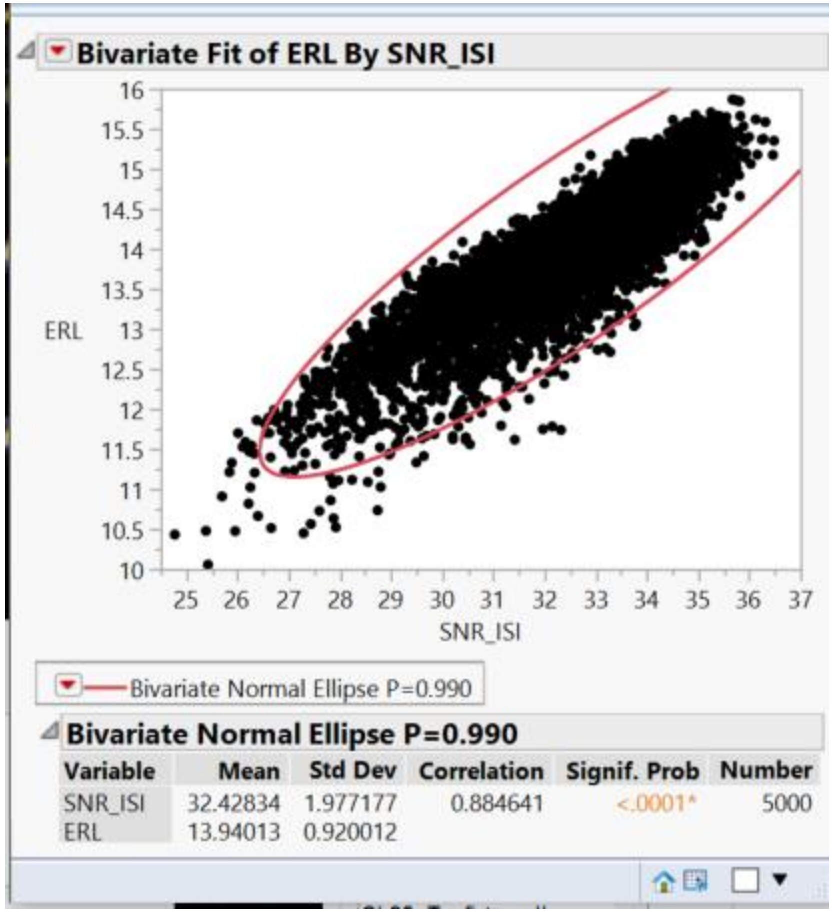
- Dependence on ρ_x does not change with choice for other parameters
- Recommendation: choose one value, ρ_x =.0.44, for all clause and set ERL_{min} to accommodate performance

Parameter ranges



Parameter ranges

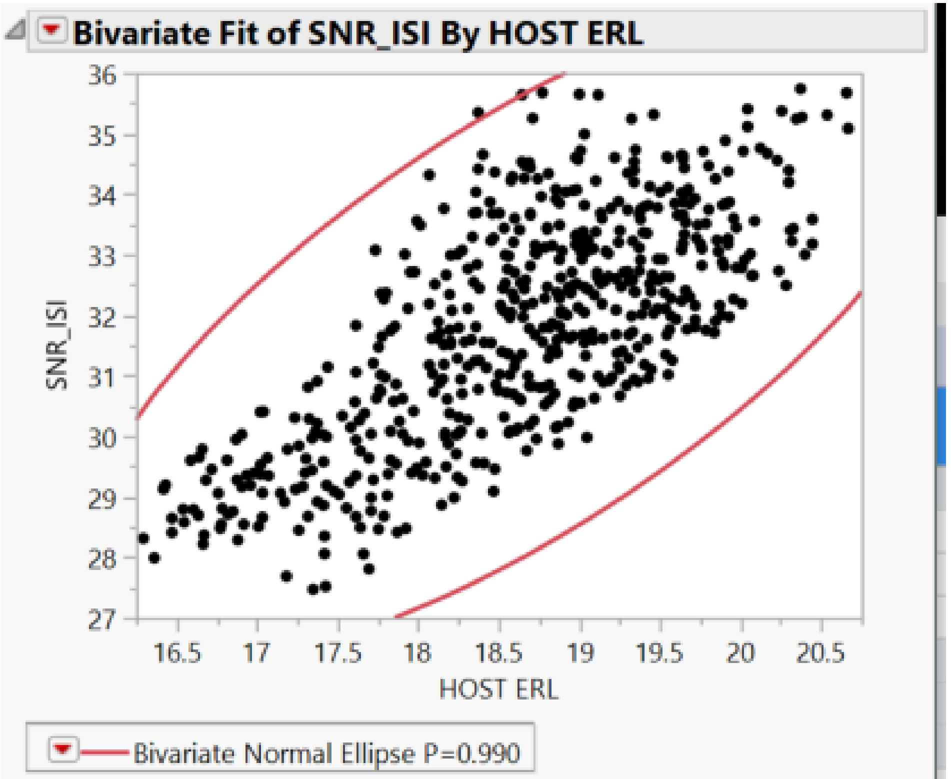
SNR$_{ISI}$ and ERL are correlated as expected … both are measure of reflections



Zc Tx	Rd Tx	Cd Tx	Cp Tx	Zp Tx	Zc Tx Brd	Zp Tx Brd	rho x	ERL	SNR_ISI
113.03	56.07	1.70	2.42	14.72	96.88	104.92	0.44	14.68	33.73
99.09	58.46	0.99	2.50	19.58	123.62	119.54	0.44	13.81	32.15
109.21	63.78	0.62	1.97	16.57	102.66	65.31	0.44	14.89	35.55
105.20	63.08	1.31	1.94	17.75	84.43	118.15	0.44	14.08	32.27
103.93	61.12	1.29	2.76	14.23	102.01	112.75	0.44	14.02	33.72
112.20	48.16	0.44	1.41	19.75	99.92	116.23	0.44	15.61	35.47
76.71	50.23	1.29	1.80	18.32	127.14	70.25	0.44	12.87	30.44
95.68	56.97	0.88	1.34	21.09	84.88	132.07	0.44	14.60	32.81
105.81	42.26	0.73	1.86	21.50	130.94	106.99	0.44	13.34	31.00
79.35	42.76	1.13	2.69	18.56	120.03	61.22	0.44	12.99	31.81
76.56	56.36	0.99	1.77	30.88	77.00	66.23	0.44	13.71	30.81
76.47	38.45	1.30	1.84	26.35	82.31	65.85	0.44	14.67	33.62
92.27	42.65	0.71	2.13	13.88	126.12	67.52	0.44	13.12	32.06
97.58	36.15	1.32	1.52	23.80	102.03	131.30	0.44	14.75	34.94
115.02	63.52	1.42	1.46	23.41	97.88	83.39	0.44	14.53	34.03
88.30	47.11	1.46	1.99	23.08	105.44	114.00	0.44	15.37	34.53
123.89	35.82	0.43	1.39	25.29	91.43	127.37	0.44	13.40	33.42
93.12	54.90	1.75	1.78	13.11	111.76	115.10	0.44	14.77	34.28
79.25	46.22	1.37	2.06	25.23	76.50	124.15	0.44	14.65	32.36
110.84	64.10	1.63	2.02	25.16	76.31	83.49	0.44	12.72	29.27
88.14	42.36	0.38	1.65	23.27	120.90	95.39	0.44	14.51	33.35
107.28	39.26	0.60	2.70	17.69	69.85	109.83	0.44	12.14	27.88
109.48	38.13	0.42	2.72	20.22	69.74	99.09	0.44	11.85	27.44
121.80	38.65	0.85	2.21	23.33	114.84	87.33	0.44	13.49	33.03
78.04	48.06	1.44	1.75	15.01	106.94	85.04	0.44	14.81	34.59
108.43	43.77	1.12	2.35	16.63	77.06	110.33	0.44	13.48	30.53
87.73	50.96	0.65	2.39	23.59	130.66	67.96	0.44	12.68	29.88
122.97	60.28	0.74	1.74	19.74	101.59	92.51	0.44	15.39	35.49
110.81	43.87	0.76	1.25	23.49	102.38	100.26	0.44	14.80	34.65

First 30 points of a 5000 point sweep

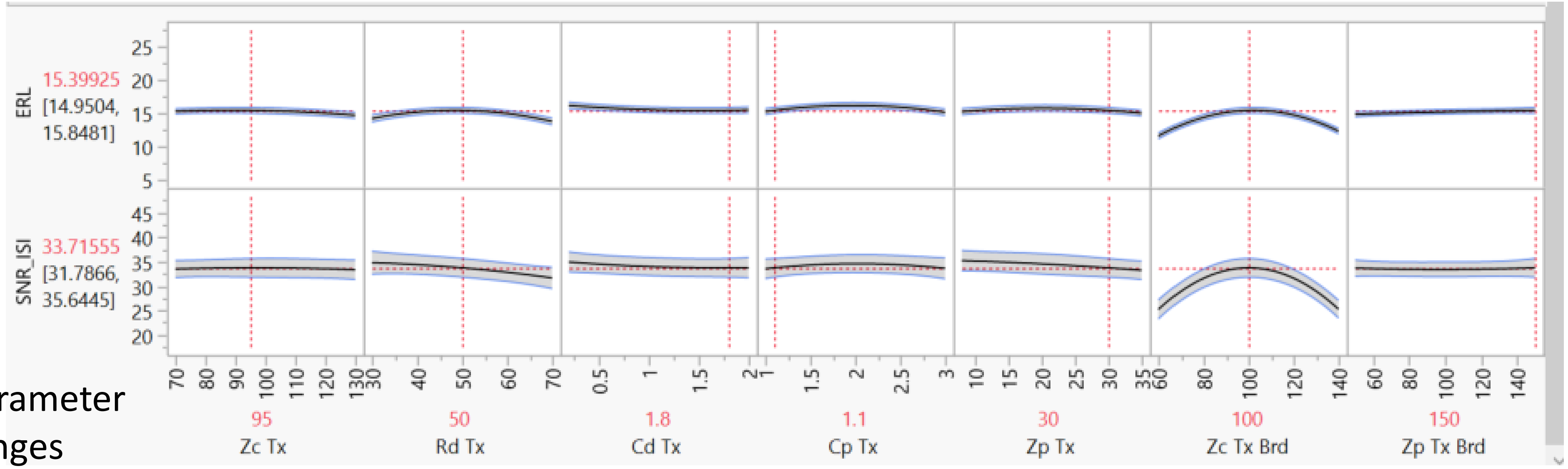
Alex Rysin (Mellanox) shows correlation between SNR_{ISI} and ERL



Bivariate Normal Ellipse P=0.990

Variable	Mean	Std Dev	Correlation	Signif. Prob	Number
HOST ERL	18.64484	0.919438	0.728089	<.0001*	560
SNR_ISI	31.81056	1.837705			

ERL is correlated to physical parameters slightly better than SNR_{ISI}



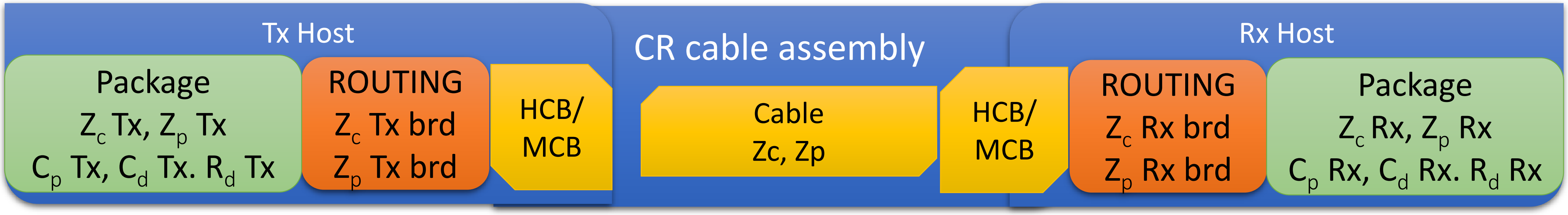
RSqrd=1

RSqrd=0.89

Parameter ranges

Parameters

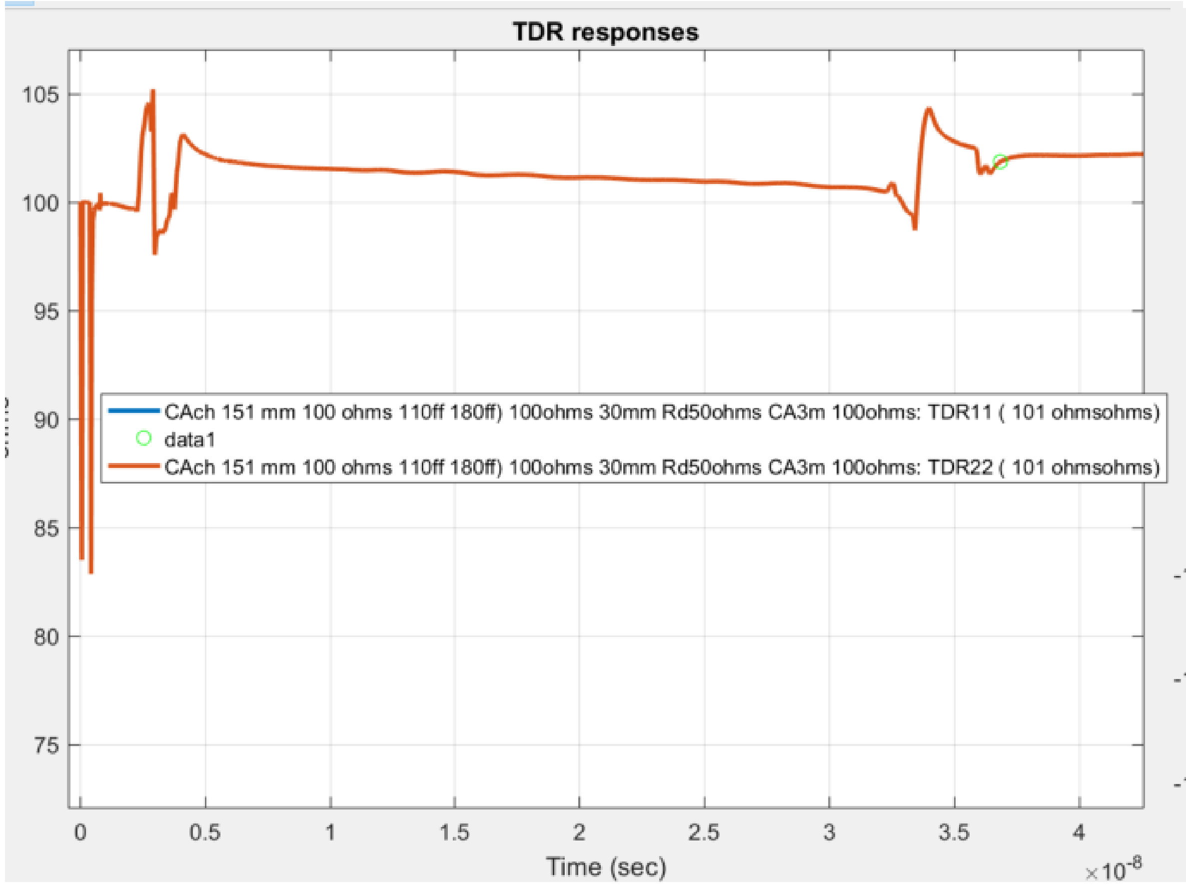
Setup: COM computation with synthesized cable (full channel Die to Die)

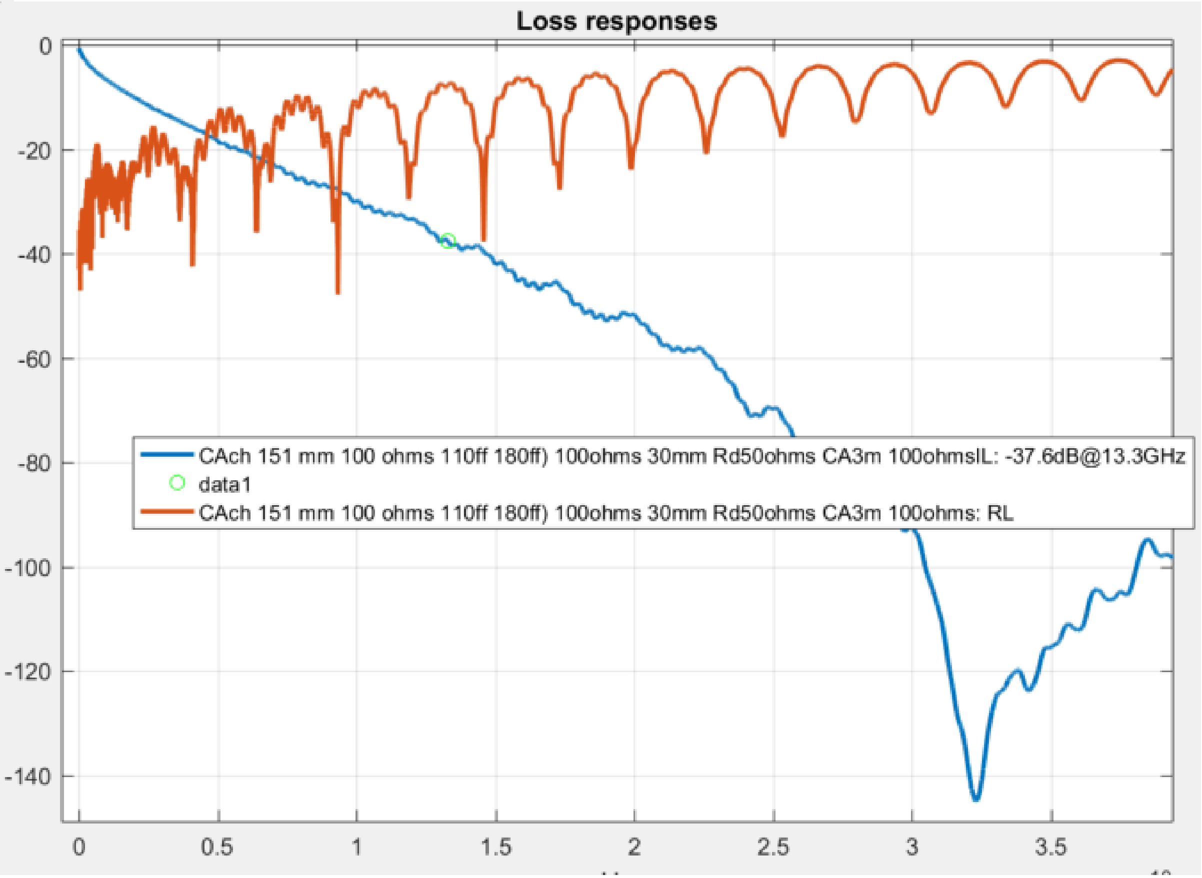


(No crosstalk)

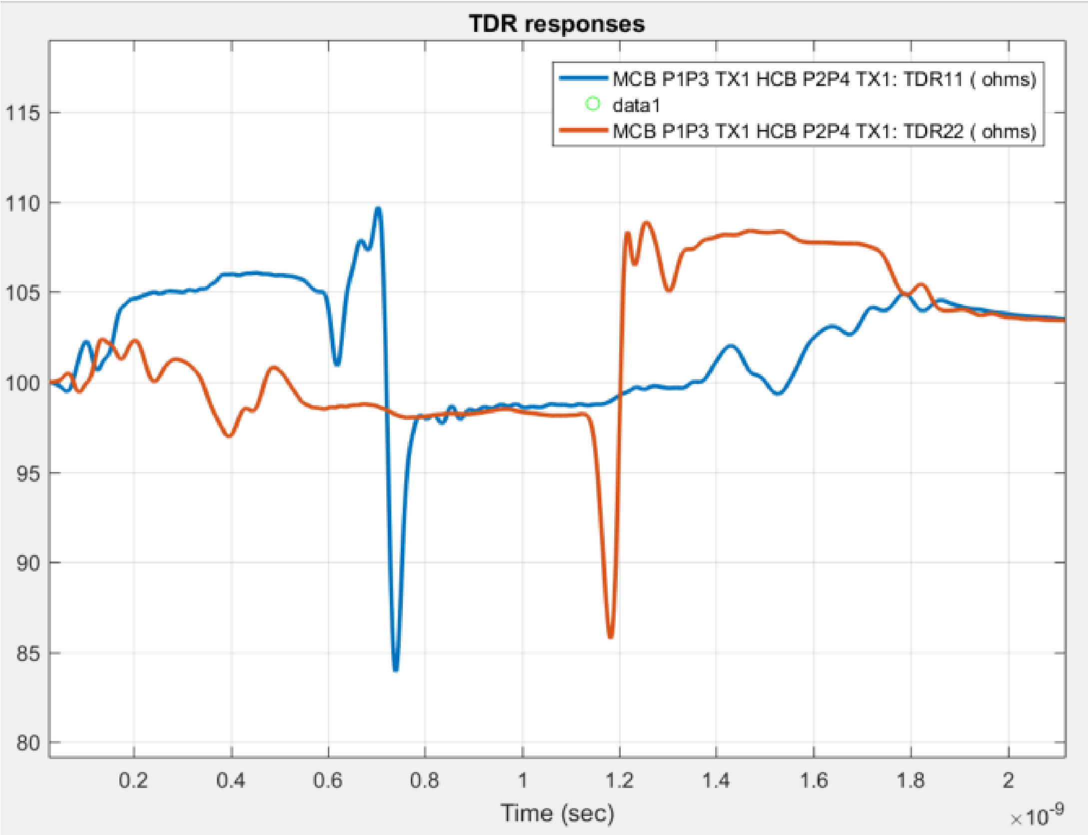
- MCB/HCB from Mike Dudek
- Test fixture differences will affect required margin
- Host and cable use the same test fixture

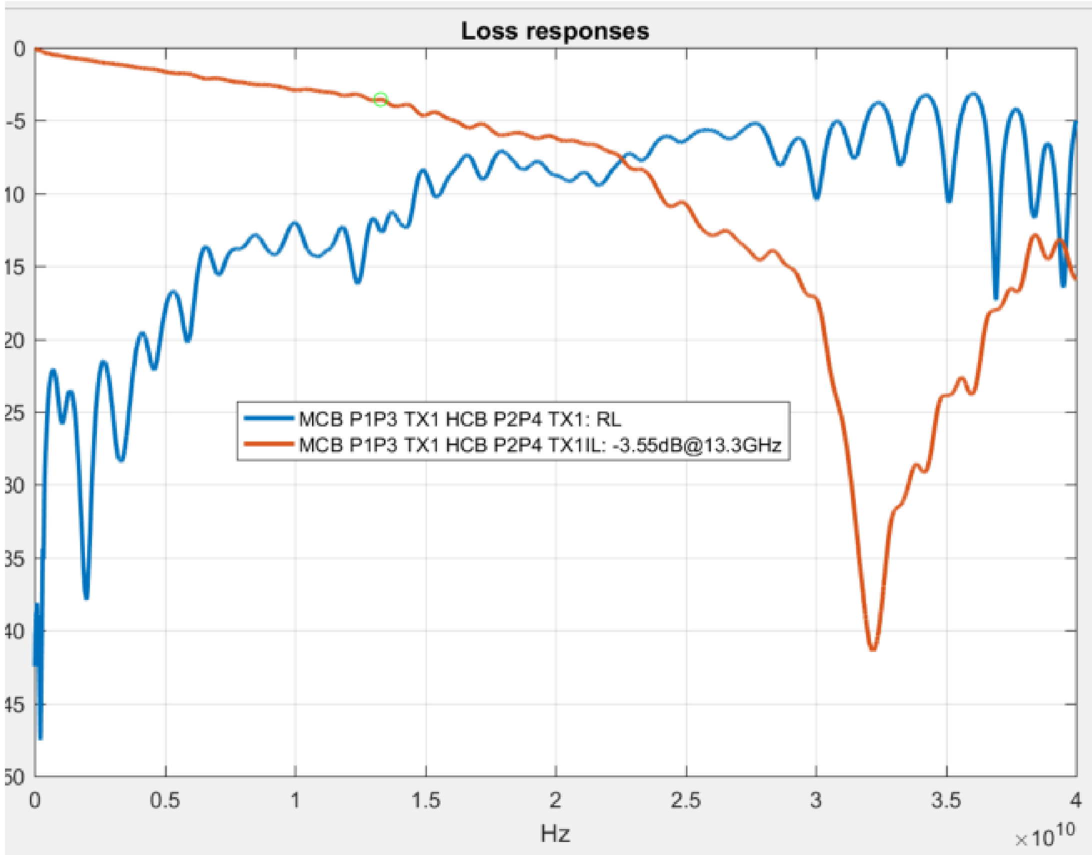
Example of Die to Die TDR and Loss Responses for full cable channel



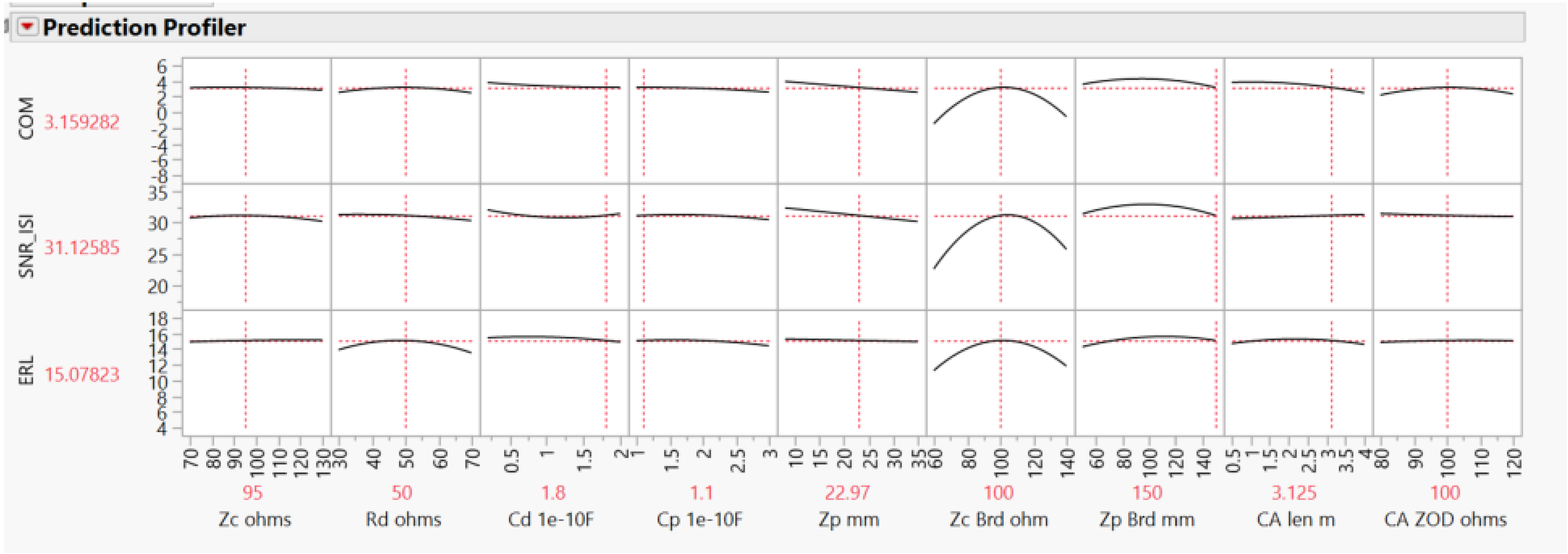


Example of MCB/HCB fixture TDR and Loss Responses (Fixture from Mike Dudek)

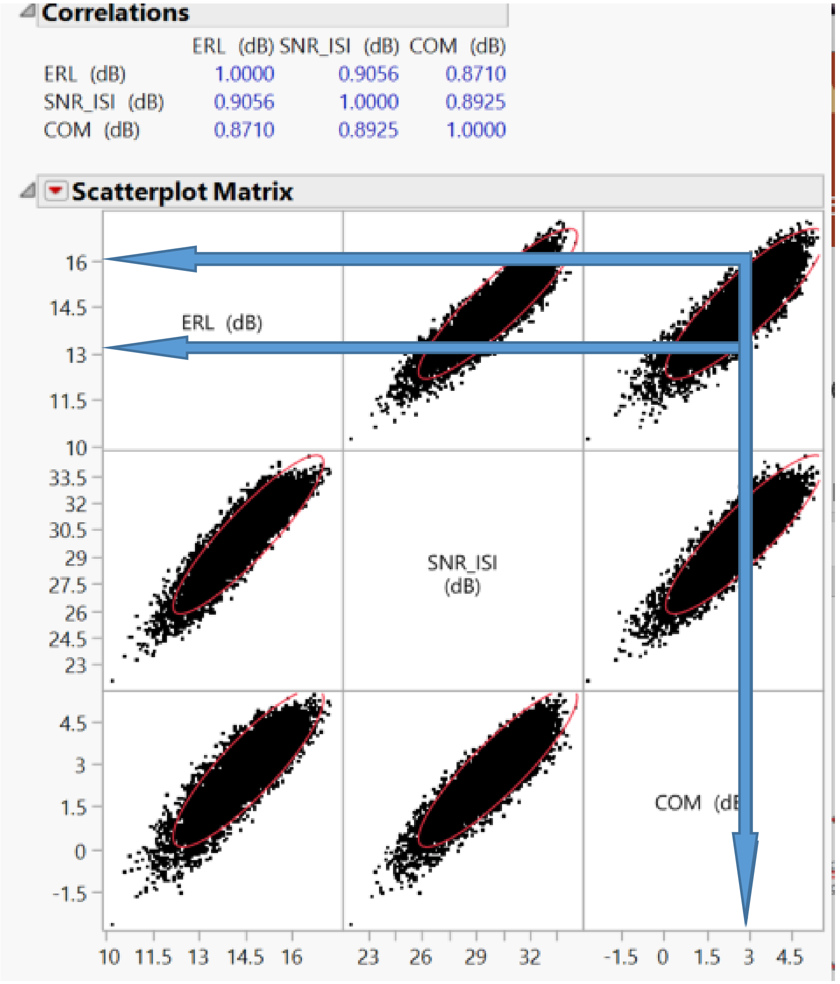




Example of full channel sweep responses showing ranges



Cable COM simulations w/o crosstalk correlates well to SNR_{ISI} and ERL

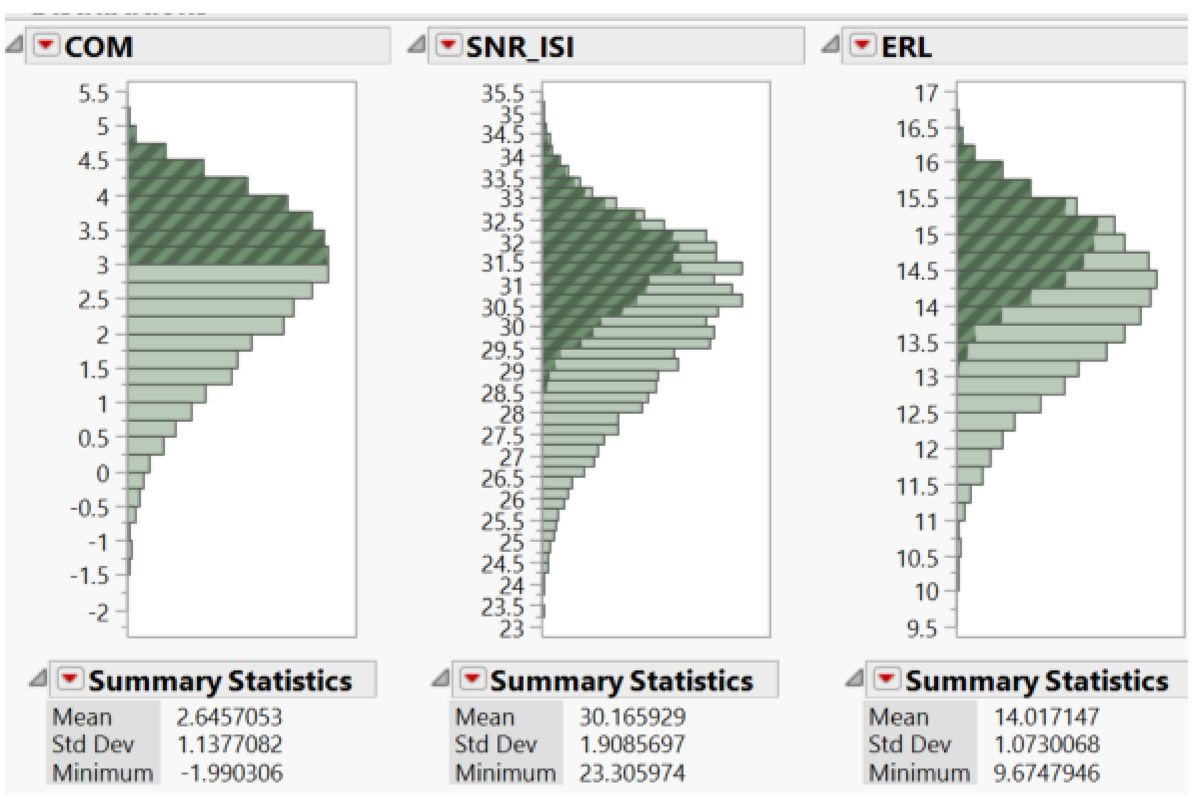


Correlations

	ERL (dB)	SNR_ISI (dB)	COM (dB)
ERL (dB)	1.0000	0.9056	0.8710
SNR_ISI (dB)	0.9056	1.0000	0.8925
COM (dB)	0.8710	0.8925	1.0000

- ❑ SNR_{ISI} may be OK for a Tx host because compared to the Cl 137 Tx $SNR_{ISI.}$
  - ISI noise is much larger for a host
  - It's more measurable
- ❑ SNR_{ISI} does not exist for a Rx Host
- ❑ Recommendation: use ERL_{min} > between 13 and 16 dB for Rx and Tx Hosts.
  - More data to help decide later
- ❑ Replaces SNR_{isi} and Return Loss

Correlation to COM can be use to access how may good parts fail ERL but work OK in a system (and Via Versa)



- Dark areas are all channels which pass COM
- SNR_{ISI} and ERL dark area represent all hosts which pass COM.
- Using $\rho_x = 0.44$
- See next slide for acessement

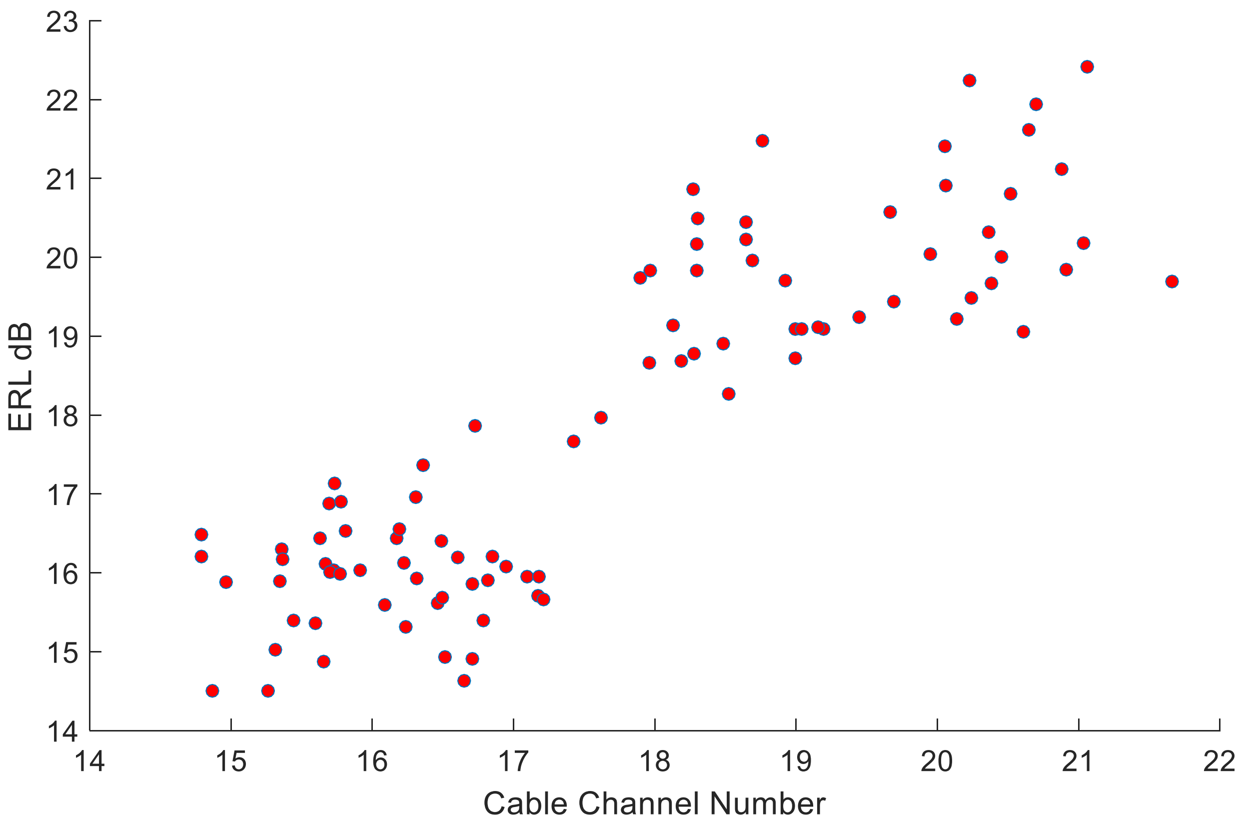
The consensus problem: The spec verses manufacturing scrap

ERL_{min} (dB)	ERL passes but channels fail	ERL fails but channels pass
15	1.3 %	24 %
14.5	5.6 %	12 %
14	15 %	3.7 %
13.5	28 %	0.74 %
13	40 %	0. 06 %

recommendation

Perhaps a straw ballot to decide

ERL for all posted cable is greater than 14 dB (most all pass CR COM)



Summary (Updated ERL_{min} and parameters

- ERL replaces Return Loss and/or SNR_{ISI} for
  1. Devices (KR)
  2. Channels (KR)
  3. Hosts (CR)
  4. Cable Assemblies (CR)

- Use β_x =10.7 GHz, and ρ_x =0.44 , T_{rp} = 0.0189 ns for all clauses

Clause	ERL Min (dB)
136 Tx Host	14.5
136 Rx Host	14.5
136 Cable Assembly	14
137 Tx Device	16.1
137 Rx Device	16.1
137 Channel	11

List of cables tested

List of Cable tested for ERL with ρ_x=0.44

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\7_Victim-P2_TX3_SFPend\TE_3m28AWG_QSFP_4SFP_P2_TX3_P1_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\6_Victim-P2_TX2_SFPend\TE_3m28AWG_QSFP_4SFP_P2_TX2_P1_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\5_Victim-P2_TX1_SFPend\TE_3m28AWG_QSFP_4SFP_P2_TX1_P1_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\4_Victim-P1_TX4_QSFPend\TE_3m28AWG_QSFP_4SFP_P1_TX4_P2_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\3_Victim-P1_TX3_QSFPend\TE_3m28AWG_QSFP_4SFP_P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\2_Victim-P1_TX2_QSFPend\TE_3m28AWG_QSFP_4SFP_P1_TX2_P2_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\1_Victim-P1_TX1_QSFPend\TE_3m28AWG_QSFP_4SFP_P1_TX1_P2_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_26AWG_MaxLossExample_15p96dB\TE_QSFP_QSFP_3m_26AWG_MaxLossExample_15p96dB\P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_25AWG_MaxLossExample_15p25dB\TE_QSFP_QSFP_3m_25AWG_MaxLossExample_15p25dB\P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_24AWG_MaxLossExample_14p47dB\TE_QSFP_QSFP_3m_24AWG_MaxLossExample_14p47dB\P2_TX3_P1_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_26AWG_MaxLossExample_15p96dB\TE_QSFP_QSFP_3m_26AWG_MaxLossExample_15p993dB\TE_QSFP_QSFP_3m_26AWG_MaxLossExample_15p993dB\P2_TX1_P1_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_24AWG_MaxLossExample_14p49dB\TE_QSFP_QSFP_3m_24AWG_MaxLossExample_14p49dB\P1_TX2_P2_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_QSFP_3m_25AWG_MaxLossExample_15p35dB\TE_QSFP_QSFP_3m_25AWG_MaxLossExample_15p35dB\P1_TX4_P2_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\3_Victim-P1_TX3_QSFPend\TE_3m26AWG_QSFP_4SFP_P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\3_Victim-P1_TX3_QSFPend\TE_3m24AWG_QSFP_4SFP_P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\3_Victim-P1_TX3_QSFPend\TE_2m26AWG_QSFP_4SFP_P1_TX3_P2_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\8_Victim-P2_TX4_SFPend\TE_3m24AWG_QSFP_4SFP_P2_TX4_P1_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\7_Victim-P2_TX3_SFPend\TE_3m24AWG_QSFP_4SFP_P2_TX3_P1_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\6_Victim-P2_TX2_SFPend\TE_3m24AWG_QSFP_4SFP_P2_TX2_P1_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\5_Victim-P2_TX1_SFPend\TE_3m24AWG_QSFP_4SFP_P2_TX1_P1_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\4_Victim-P1_TX4_QSFPend\TE_3m24AWG_QSFP_4SFP_P1_TX4_P2_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\2_Victim-P1_TX2_QSFPend\TE_3m24AWG_QSFP_4SFP_P1_TX2_P2_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_24AWG\1_Victim-P1_TX1_QSFPend\TE_3m24AWG_QSFP_4SFP_P1_TX1_P2_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\8_Victim-P2_TX4_SFPend\TE_2m26AWG_QSFP_4SFP_P2_TX4_P1_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\7_Victim-P2_TX3_SFPend\TE_2m26AWG_QSFP_4SFP_P2_TX3_P1_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\6_Victim-P2_TX2_SFPend\TE_2m26AWG_QSFP_4SFP_P2_TX2_P1_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\5_Victim-P2_TX1_SFPend\TE_2m26AWG_QSFP_4SFP_P2_TX1_P1_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\4_Victim-P1_TX4_QSFPend\TE_2m26AWG_QSFP_4SFP_P1_TX4_P2_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\2_Victim-P1_TX2_QSFPend\TE_2m26AWG_QSFP_4SFP_P1_TX2_P2_RX2_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_2m_26AWG\1_Victim-P1_TX1_QSFPend\TE_2m26AWG_QSFP_4SFP_P1_TX1_P2_RX1_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\8_Victim-P2_TX4_SFPend\TE_3m26AWG_QSFP_4SFP_P2_TX4_P1_RX4_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\7_Victim-P2_TX3_SFPend\TE_3m26AWG_QSFP_4SFP_P2_TX3_P1_RX3_THRU.s4p

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\6_Victim-P2_TX2_SFPend\TE_3m26AWG_QSFP_4SFP_P2_TX2_P1_RX2_THRU.s4p

List of Cable tested for ERL cont'd

C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\5_Victim-P2_TX1_SFPend\TE_3m26AWG_QSFP_4SFP_P2_TX1_P1_RX1_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\4_Victim-P1_TX4_QSFPend\TE_3m26AWG_QSFP_4SFP_P1_TX4_P2_RX4_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\2_Victim-P1_TX2_QSFPend\TE_3m26AWG_QSFP_4SFP_P1_TX2_P2_RX2_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_26AWG\1_Victim-P1_TX1_QSFPend\TE_3m26AWG_QSFP_4SFP_P1_TX1_P2_RX1_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\8_Victim-P2_TX4_SFPend\TE_3m30AWG_QSFP_4SFP_P2_TX4_P1_RX4_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\7_Victim-P2_TX3_SFPend\TE_3m30AWG_QSFP_4SFP_P2_TX3_P1_RX3_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\6_Victim-P2_TX2_SFPend\TE_3m30AWG_QSFP_4SFP_P2_TX2_P1_RX2_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\5_Victim-P2_TX1_SFPend\TE_3m30AWG_QSFP_4SFP_P2_TX1_P1_RX1_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\4_Victim-P1_TX4_QSFPend\TE_3m30AWG_QSFP_4SFP_P1_TX4_P2_RX4_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\3_Victim-P1_TX3_QSFPend\TE_3m30AWG_QSFP_4SFP_P1_TX3_P2_RX3_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\2_Victim-P1_TX2_QSFPend\TE_3m30AWG_QSFP_4SFP_P1_TX2_P2_RX2_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_30AWG\1_Victim-P1_TX1_QSFPend\TE_3m30AWG_QSFP_4SFP_P1_TX1_P2_RX1_THRU.s4p
C:\Users\richardm\Documents\channels\ieee802p3by\Tyco\TE_QSFP_4SFP_3m_28AWG\8_Victim-P2_TX4_SFPend\TE_3m28AWG_QSFP_4SFP_P2_TX4_P1_RX4_THRU.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_5\Link_5\Thru_Link_5_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_4\Link_4\Thru_Link_4_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_3\Link_3\Thru_Link_3_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_2\Link_2\Thru_Link_2_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_1\Link_1\Thru_Link_1_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Amphenol_Link_6\Link_6\Thru_Link_6_C1_Pr_22_to_Pr_6.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P2 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P2 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P2 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P2 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P1 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P1 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P1 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_0p5m_32awg\.5m 32awg\THRUS\P1 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P2 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P2 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P2 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P2 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P1 T1-R1.s4p

\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P1 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P1 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_26awg\1m 26awg\THRUS\P1 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P2 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P2 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P2 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P1 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P1 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P1 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P1 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_1m_30awg\1m 30awg\THRUS\P2 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P2 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P2 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P2 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P2 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P1 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P1 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P1 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_2m_26awg\2m 26awg\THRUS\P1 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P1 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P1 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P2 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P2 T2-R2.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P2 T3-R3.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P2 T4-R4.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P1 T1-R1.s4p
\\scdc-richardm\Users\richardm\Documents\channels\ieee802p3cd\Molex_zQSFP-zQSFP_3m_26awg\3m 26awg\THRUS\P1 T2-R2.s4p