
NGBASE-T Link Segments

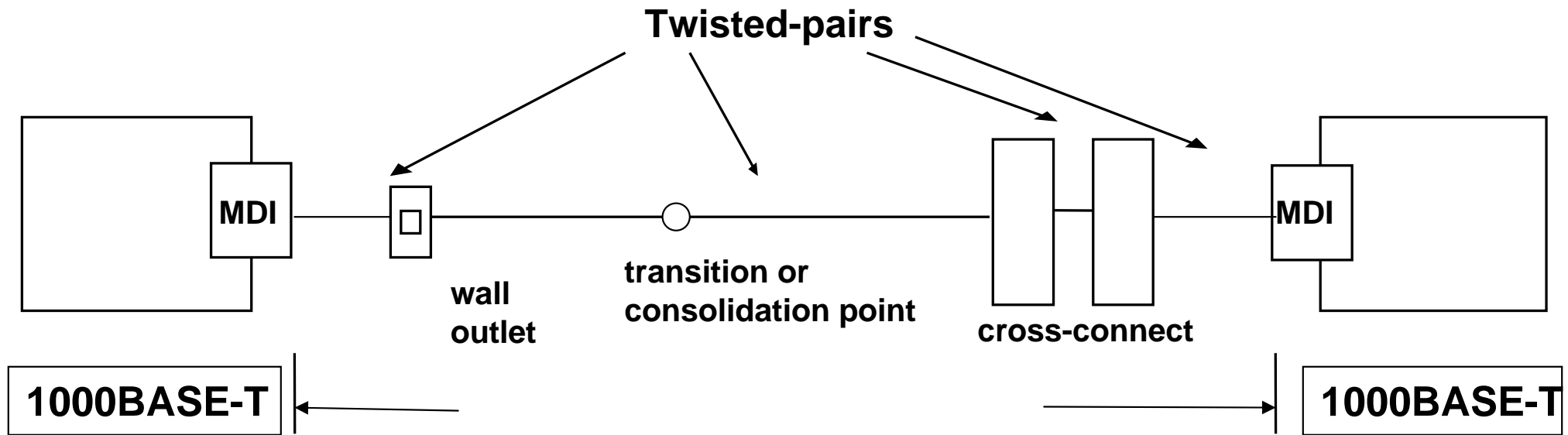
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Summary

- **Discussion of link segment characteristics for NGBASE-T**

Twisted Pair Link Segment



Structured cabling ISO/IEC, TR42

1000BASE-T Link transmission and coupling parameters

- Insertion loss, Return loss
- NEXT, FEXT, Multiple Disturber Crosstalk

Link segments

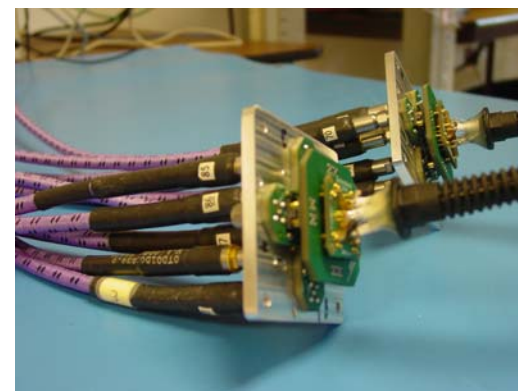
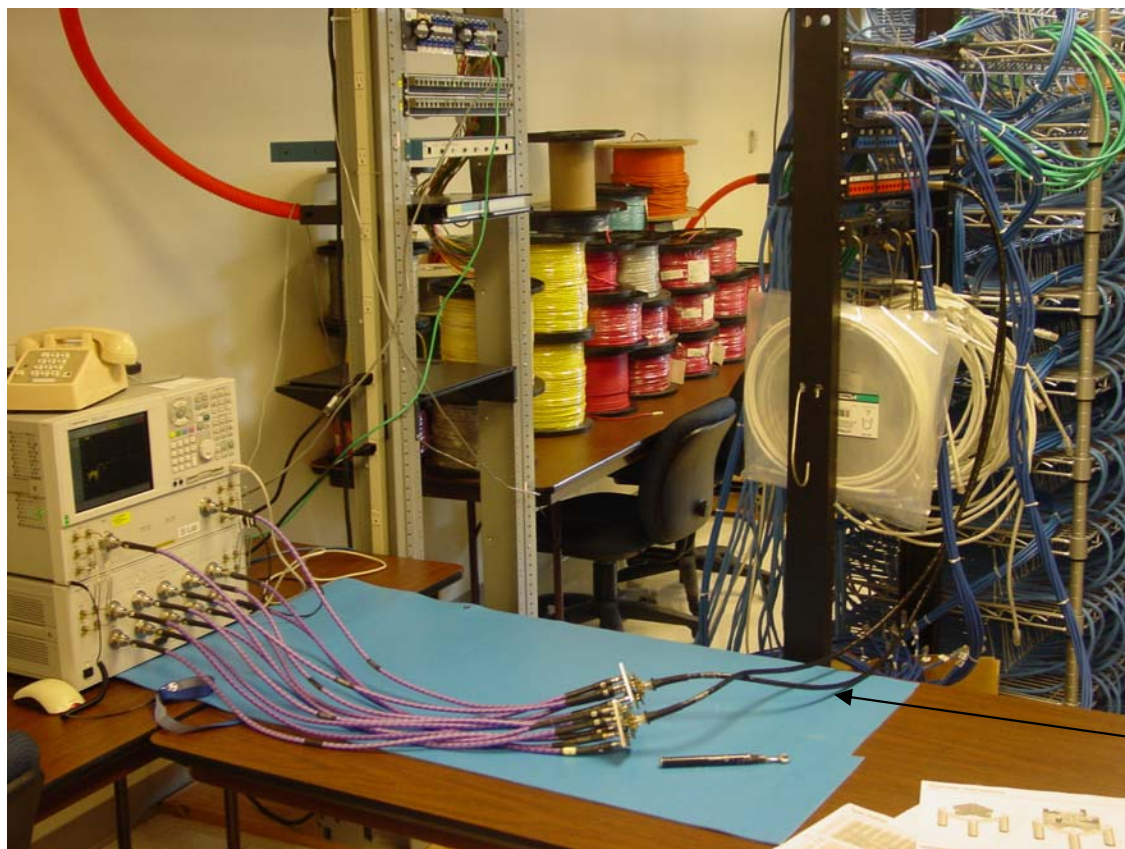
- Topology
 - Transmission and coupling parameters
 - Environmental
-
- Topology
 - Length (up to at least x meters)
 - Number of connectors (x)
-
- Transmission and coupling parameters
 - Insertion loss
 - Link segment noise
 - o Noise within link segment –
 - ✓ return loss
 - ✓ mode conversion (balance)
 - ✓ For link segments $>$ NEXT, FEXT and multiple disturber
 - o Noise coupling between link segments
 - ✓ Alien crosstalk - ANEXT, AFEXT and multiple disturber ANEXT and AFEXT
 - o Mode conversion (balance)

Testing

+Characterization of mode conversion and other balance related parameters of Category 6 and Category 6A cabling by performing single-ended VNA measurements utilizing balunless test fixtures of all 8 conductors of 4-pair cabling at each end for a total of 16 conductors.

+Measurements performed at the University of New Hampshire Interoperability Test Labs (UNH-IOL) on test configurations consisting of category 6 and category 6A cabling channels and permanent links. The cabling test configurations were constructed with cables and connectors from multiple suppliers provided by Anixter and individual suppliers; at least ten different suppliers were used. The measurements were performed from 10 MHz-10 GHz utilizing an Agilent 12 port measurement test system consisting of a 2 port PNA [E8362B (10 MHz-20 GHz)] and a 10 port multiport test set [U3022A E 10 (300 KHz -26.5 GHz)] and balunless test fixtures designed to interface with the VNA [Optical Cable Corporation (OCC) SMA test head assembly]. Measurement data analysis performed utilizing Agilent's Physical Layer Test System (PLTS).

Equipment connection to patch panels

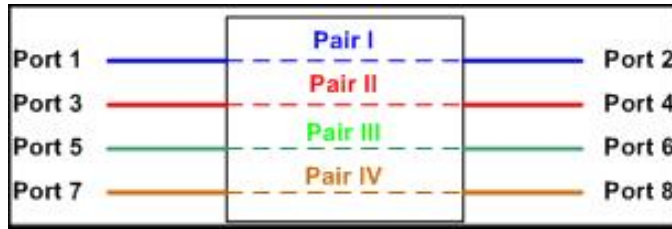


Test fixtures - OCC

**Connection to patch panels
1.25 m Fluke permanent link
adapter**

S-Parameters and dm, cm and mixed mode parameters

DUT



Green cells – currently specified parameters
 White and yellow cells – parameters to be investigated
 Top table – s-parameter designations
 Bottom table – TIA TR42- naming conventions

S	Port 1	Port 3	Port 5	Port 7	Port 2	Port 4	Port 6	Port 8	Port 1	Port 3	Port 5	Port 7	Port 2	Port 4	Port 6	Port 8		
	dd	dd	dd	dd	dd	dd	dd	dd	cd	cd	cd	cd	cd	cd	cd	cd		
Port 1	dd	Sdd11	Sdd13	Sdd15	Sdd17	Sdd12	Sdd14	Sdd16	Sdd18	Sdc11	Sdc13	Sdc15	Sdc17	Sdc12	Sdc14	Sdc16	Sdc18	cd
Port 3	dd	Sdd31	Sdd33	Sdd35	Sdd37	Sdd32	Sdd34	Sdd36	Sdd38	Sdc31	Sdc33	Sdc35	Sdc37	Sdc32	Sdc34	Sdc36	Sdc38	cd
Port 5	dd	Sdd51	Sdd53	Sdd55	Sdd57	Sdd52	Sdd54	Sdd56	Sdd58	Sdc51	Sdc53	Sdc55	Sdc57	Sdc52	Sdc54	Sdc56	Sdc58	cd
Port 7	dd	Sdd71	Sdd73	Sdd75	Sdd77	Sdd72	Sdd74	Sdd76	Sdd78	Sdc71	Sdc73	Sdc75	Sdc77	Sdc72	Sdc74	Sdc76	Sdc78	cd
Port 2	dd	Sdd21	Sdd23	Sdd25	Sdd27	Sdd22	Sdd24	Sdd26	Sdd28	Sdc21	Sdc23	Sdc25	Sdc27	Sdc22	Sdc24	Sdc26	Sdc28	cd
Port 4	dd	Sdd41	Sdd43	Sdd45	Sdd47	Sdd42	Sdd44	Sdd46	Sdd48	Sdc41	Sdc43	Sdc45	Sdc47	Sdc42	Sdc44	Sdc46	Sdc48	cd
Port 6	dd	Sdd61	Sdd63	Sdd65	Sdd67	Sdd62	Sdd64	Sdd66	Sdd68	Sdc61	Sdc63	Sdc65	Sdc67	Sdc62	Sdc64	Sdc66	Sdc68	cd
Port 8	dd	Sdd81	Sdd83	Sdd85	Sdd87	Sdd82	Sdd84	Sdd86	Sdd88	Sdc81	Sdc83	Sdc85	Sdc87	Sdc82	Sdc84	Sdc86	Sdc88	cd
Port 1	dc	Scd11	Scd13	Scd15	Scd17	Scd12	Scd14	Scd16	Scd18	Scc11	Scc13	Scc15	Scc17	Scc12	Scc14	Scc16	Scc18	cc
Port 3	dc	Scd31	Scd33	Scd35	Scd37	Scd32	Scd34	Scd36	Scd38	Scc31	Scc33	Scc35	Scc37	Scc32	Scc34	Scc36	Scc38	cc
Port 5	dc	Scd51	Scd53	Scd55	Scd57	Scd52	Scd54	Scd56	Scd58	Scc51	Scc53	Scc55	Scc57	Scc52	Scc54	Scc56	Scc58	cc
Port 7	dc	Scd71	Scd73	Scd75	Scd77	Scd72	Scd74	Scd76	Scd78	Scc71	Scc73	Scc75	Scc77	Scc72	Scc74	Scc76	Scc78	cc
Port 2	dc	Scd21	Scd23	Scd25	Scd27	Scd22	Scd24	Scd26	Scd28	Scc21	Scc23	Scc25	Scc27	Scc22	Scc24	Scc26	Scc28	cc
Port 4	dc	Scd41	Scd43	Scd45	Scd47	Scd42	Scd44	Scd46	Scd48	Scc41	Scc43	Scc45	Scc47	Scc42	Scc44	Scc46	Scc48	cc
Port 6	dc	Scd61	Scd63	Scd65	Scd67	Scd62	Scd64	Scd66	Scd68	Scc61	Scc63	Scc65	Scc67	Scc62	Scc64	Scc66	Scc68	cc
Port 8	dc	Scd81	Scd83	Scd85	Scd87	Scd82	Scd84	Scd86	Scd88	Scc81	Scc83	Scc85	Scc87	Scc82	Scc84	Scc86	Scc88	cc

	Port 1	Port 3	Port 5	Port 7	Port 2	Port 4	Port 6	Port 8	Port 1	Port 3	Port 5	Port 7	Port 2	Port 4	Port 6	Port 8		
	dd	dd	dd	dd	dd	dd	dd	dd	dc	dc	dc	dc	dc	dc	dc	dc		
Port 1	dd	RLdd11	NEXTdd13	NEXTdd15	NEXTdd17	ILdd12	FEXTdd14	FEXTdd16	FEXTdd18	LCLdc11	NEXTdc13	NEXTdc15	NEXTdc17	LCTLdc12	FEXTdc14	FEXTdc16	FEXTdc18	dc
Port 3	dd	NEXTdd31	RLdd33	NEXTdd35	NEXTdd37	FEXTdd32	ILdd34	FEXTdd36	FEXTdd38	NEXTdc31	LCLdc33	NEXTdc35	NEXTdc37	NEXTdc32	LCTLdc34	FEXTdc36	FEXTdc38	dc
Port 5	dd	NEXTdd51	NEXTdd53	RLdd55	NEXTdd57	FEXTdd52	FEXTdd54	ILdd56	FEXTdd58	NEXTdc51	NEXTdc53	LCLdc55	NEXTdc57	FEXTdc52	FEXTdc54	LCTLdc56	FEXTdc58	dc
Port 7	dd	NEXTdd71	NEXTdd73	NEXTdd75	RLdd77	FEXTdd72	FEXTdd74	FEXTdd76	ILdd78	NEXTdc71	NEXTdc73	NEXTdc75	LCLdc77	FEXTdc72	FEXTdc74	FEXTdc76	LCTLdc78	dc
Port 2	dd	ILdd21	FEXTdd23	FEXTdd25	FEXTdd27	RLdd22	NEXTdd24	NEXTdd26	NEXTdd28	LCTLdc21	FEXTdc23	FEXTdc25	FEXTdc27	LCLdc22	NEXTdc24	NEXTdc26	NEXTdc28	dc
Port 4	dd	FEXTdd41	ILdd43	FEXTdd45	FEXTdd47	NEXTdd42	RLdd44	NEXTdd46	NEXTdd48	FEXTdc41	LCTLdc43	FEXTdc45	FEXTdc47	FEXTdc42	LCLdc44	NEXTdc46	NEXTdc48	dc
Port 6	dd	FEXTdd61	FEXTdd63	ILdd65	FEXTdd67	NEXTdd62	NEXTdd64	RLdd66	NEXTdd68	FEXTdc61	FEXTdc63	LCTLdc65	FEXTdc67	NEXTdc62	NEXTdc64	LCLdc66	NEXTdc68	dc
Port 8	dd	FEXTdd81	FEXTdd83	FEXTdd85	ILdd87	NEXTdd82	NEXTdd84	NEXTdd86	RLdd88	FEXTdc81	FEXTdc83	FEXTdc85	LCTLdc87	NEXTdc82	NEXTdc84	NEXTdc86	LCLdc88	dc
Port 1	cd	TCLcd11	NEXTcd13	NEXTcd15	NEXTcd17	TCTLcd12	FEXTcd14	FEXTcd16	FEXTcd18	RLcc11	NEXTcc13	NEXTcc15	NEXTcc17	ILcc12	FEXTcc14	FEXTcc16	FEXTcc18	cc
Port 3	cd	NEXTcd31	TCLcd33	NEXTcd35	NEXTcd37	FEXTcd32	TCTLcd34	FEXTcd36	FEXTcd38	NEXTcc31	RLcc33	NEXTcc35	NEXTcc37	FEXTcc32	ILcc34	FEXTcc36	FEXTcc38	cc
Port 5	cd	NEXTcd51	NEXTcd53	TCLcd55	NEXTcd57	FEXTcd52	FEXTcd54	TCTLcd56	FEXTcd58	NEXTcc51	NEXTcc53	RLcc55	NEXTcc57	FEXTcc52	FEXTcc54	ILcc56	FEXTcc58	cc
Port 7	cd	NEXTcd71	NEXTcd73	NEXTcd75	TCLcd77	FEXTcd72	FEXTcd74	FEXTcd76	TCTLcd78	NEXTcc71	NEXTcc73	NEXTcc75	RLcc77	FEXTcc72	FEXTcc74	FEXTcc76	ILcc78	cc
Port 2	cd	TCTLcd21	FEXTcd23	FEXTcd25	FEXTcd27	TCLcd22	NEXTcd24	NEXTcd26	NEXTcd28	ILcc21	FEXTcc23	FEXTcc25	FEXTcc27	RLcc22	NEXTcc24	NEXTcc26	NEXTcc28	cc
Port 4	cd	FEXTcd41	TCTLcd43	FEXTcd45	FEXTcd47	NEXTcd42	TCLcd44	NEXTcd46	NEXTcd48	FEXTcc41	ILcc43	FEXTcc45	FEXTcc47	NEXTcc42	RLcc44	NEXTcc46	NEXTcc48	cc
Port 6	cd	FEXTcd61	FEXTcd63	TCTLcd65	FEXTcd67	NEXTcd62	NEXTcd64	TCLcd66	NEXTcd68	FEXTcc61	FEXTcc63	ILcc65	FEXTcc67	NEXTcc62	NEXTcc64	RLcc66	NEXTcc68	cc
Port 8	cd	FEXTcd81	FEXTcd83	FEXTcd85	TCTLcd87	NEXTcd82	NEXTcd84	NEXTcd86	TCLcd88	FEXTcc81	FEXTcc83	FEXTcc85	ILcc87	NEXTcc82	NEXTcc84	NEXTcc86	RLcc88	cc

Test matrix

S	Port A								Port B								
	Port 1 dd	Port 3 dd	Port 5 dd	Port 7 dd	Port 2 dd	Port 4 dd	Port 6 dd	Port 8 dd	Port 1 cd	Port 3 cd	Port 5 cd	Port 7 cd	Port 2 cd	Port 4 cd	Port 6 cd	Port 8 cd	
Port 1 dd	Sdd11	Sdd13	Sdd15	Sdd17	Sdd12	Sdd14	Sdd16	Sdd18	Sdc11	Sdc13	Sdc15	Sdc17	Sdc12	Sdc14	Sdc16	Sdc18	cd
Port 3 dd	Sdd31	Sdd33	Sdd35	Sdd37	Sdd32	Sdd34	Sdd36	Sdd38	Sdc31	Sdc33	Sdc35	Sdc37	Sdc32	Sdc34	Sdc36	Sdc38	cd
Port 5 dd	Sdd51	Sdd53	Sdd55	Sdd57	Sdd52	Sdd54	Sdd56	Sdd58	Sdc51	Sdc53	Sdc55	Sdc57	Sdc52	Sdc54	Sdc56	Sdc58	cd
Port 7 dd	Sdd71	Sdd73	Sdd75	Sdd77	Sdd72	Sdd74	Sdd76	Sdd78	Sdc71	Sdc73	Sdc75	Sdc77	Sdc72	Sdc74	Sdc76	Sdc78	cd
Port 2 dd	Sdd21	Sdd23	Sdd25	Sdd27	Sdd22	Sdd24	Sdd26	Sdd28	Sdc21	Sdc23	Sdc25	Sdc27	Sdc22	Sdc24	Sdc26	Sdc28	cd
Port 4 dd	Sdd41	Sdd43	Sdd45	Sdd47	Sdd42	Sdd44	Sdd46	Sdd48	Sdc41	Sdc43	Sdc45	Sdc47	Sdc42	Sdc44	Sdc46	Sdc48	cd
Port 6 dd	Sdd61	Sdd63	Sdd65	Sdd67	Sdd62	Sdd64	Sdd66	Sdd68	Sdc61	Sdc63	Sdc65	Sdc67	Sdc62	Sdc64	Sdc66	Sdc68	cd
Port 8 dd	Sdd81	Sdd83	Sdd85	Sdd87	Sdd82	Sdd84	Sdd86	Sdd88	Sdc81	Sdc83	Sdc85	Sdc87	Sdc82	Sdc84	Sdc86	Sdc88	cd
Port 1 dc	Scd11	Scd13	Scd15	Scd17	Scd12	Scd14	Scd16	Scd18	Scc11	Scc13	Scc15	Scc17	Scc12	Scc14	Scc16	Scc18	cc
Port 3 dc	Scd31	Scd33	Scd35	Scd37	Scd32	Scd34	Scd36	Scd38	Scc31	Scc33	Scc35	Scc37	Scc32	Scc34	Scc36	Scc38	cc
Port 5 dc	Scd51	Scd53	Scd55	Scd57	Scd52	Scd54	Scd56	Scd58	Scc51	Scc53	Scc55	Scc57	Scc52	Scc54	Scc56	Scc58	cc
Port 7 dc	Scd71	Scd73	Scd75	Scd77	Scd72	Scd74	Scd76	Scd78	Scc71	Scc73	Scc75	Scc77	Scc72	Scc74	Scc76	Scc78	cc
Port 2 dc	Scd21	Scd23	Scd25	Scd27	Scd22	Scd24	Scd26	Scd28	Scc21	Scc23	Scc25	Scc27	Scc22	Scc24	Scc26	Scc28	cc
Port 4 dc	Scd41	Scd43	Scd45	Scd47	Scd42	Scd44	Scd46	Scd48	Scc41	Scc43	Scc45	Scc47	Scc42	Scc44	Scc46	Scc48	cc
Port 6 dc	Scd61	Scd63	Scd65	Scd67	Scd62	Scd64	Scd66	Scd68	Scc61	Scc63	Scc65	Scc67	Scc62	Scc64	Scc66	Scc68	cc
Port 8 dc	Scd81	Scd83	Scd85	Scd87	Scd82	Scd84	Scd86	Scd88	Scc81	Scc83	Scc85	Scc87	Scc82	Scc84	Scc86	Scc88	cc

Pin	Port A	Port B
1,2	1	2
3,6	3	4
4,5	5	6
7,8	7	8

Measurement 1 ---
144 out of 256 cells (blue)

Pin	Port A	Port B
1,2	1	2
3,6	3	4
4,5	5	6
7,8	7	8

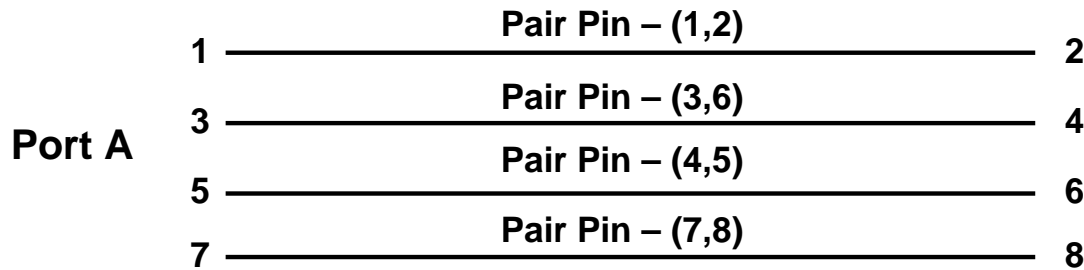
Measurement 2 ---
80 out of 256 (red)

Pin	Port A	Port B
1,2	1	2
3,6	3	4
4,5	5	6
7,8	7	8

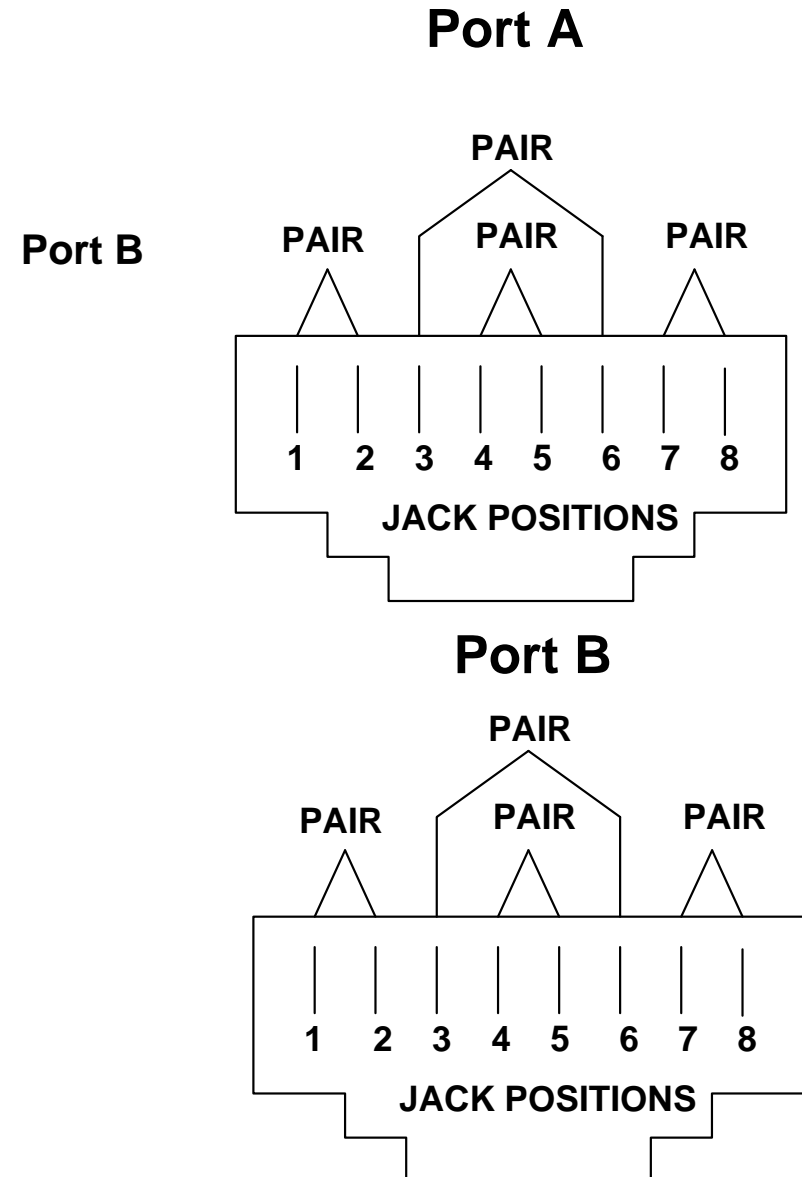
Measurement 3 ---
32 out of 256 (yellow)

Device under test

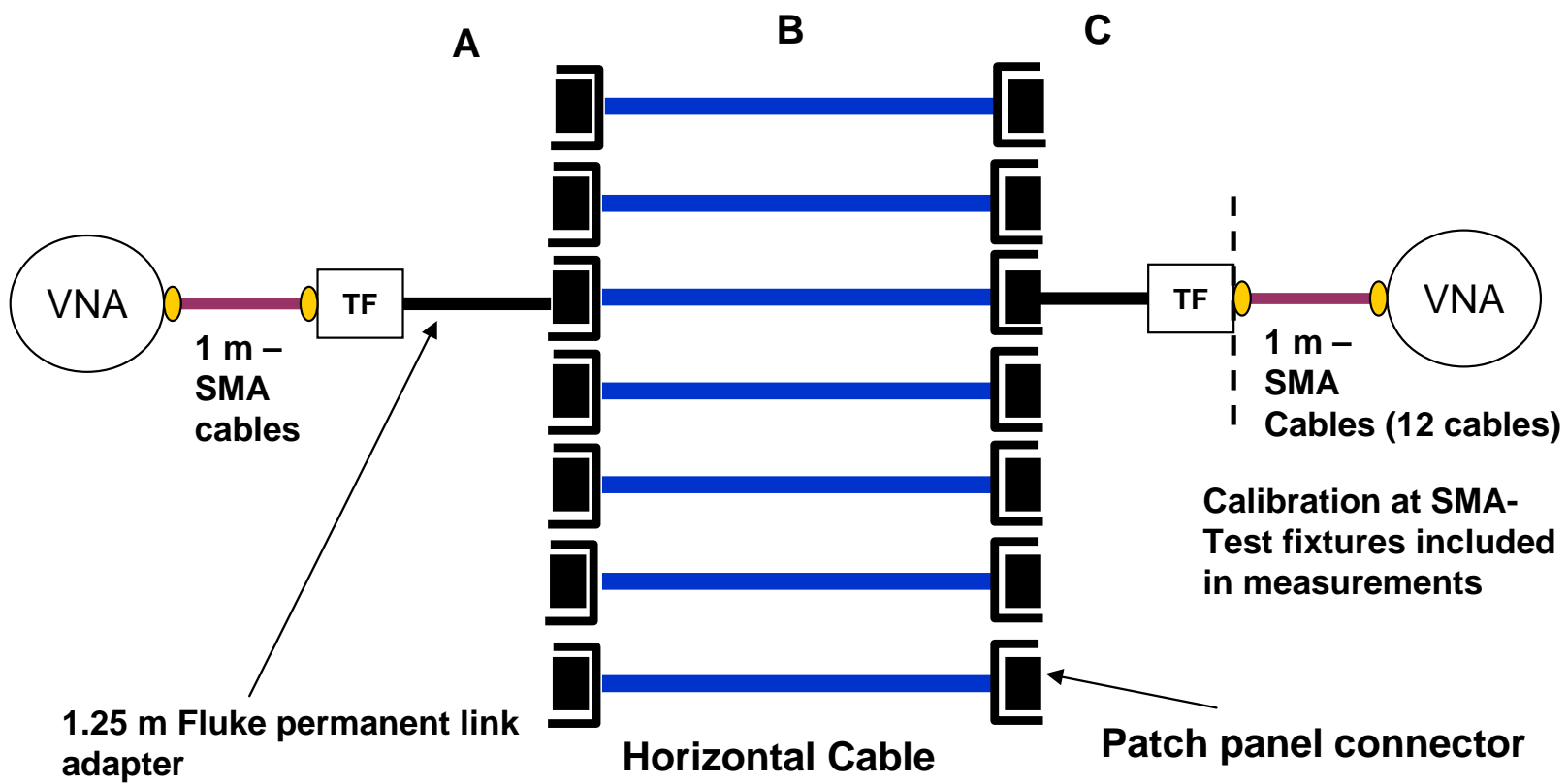
- 12 port VNA connected to both ends of cable pairs under.



Pin	Port A	Port B
1,2	1	2
3,6	3	4
4,5	5	6
7,8	7	8

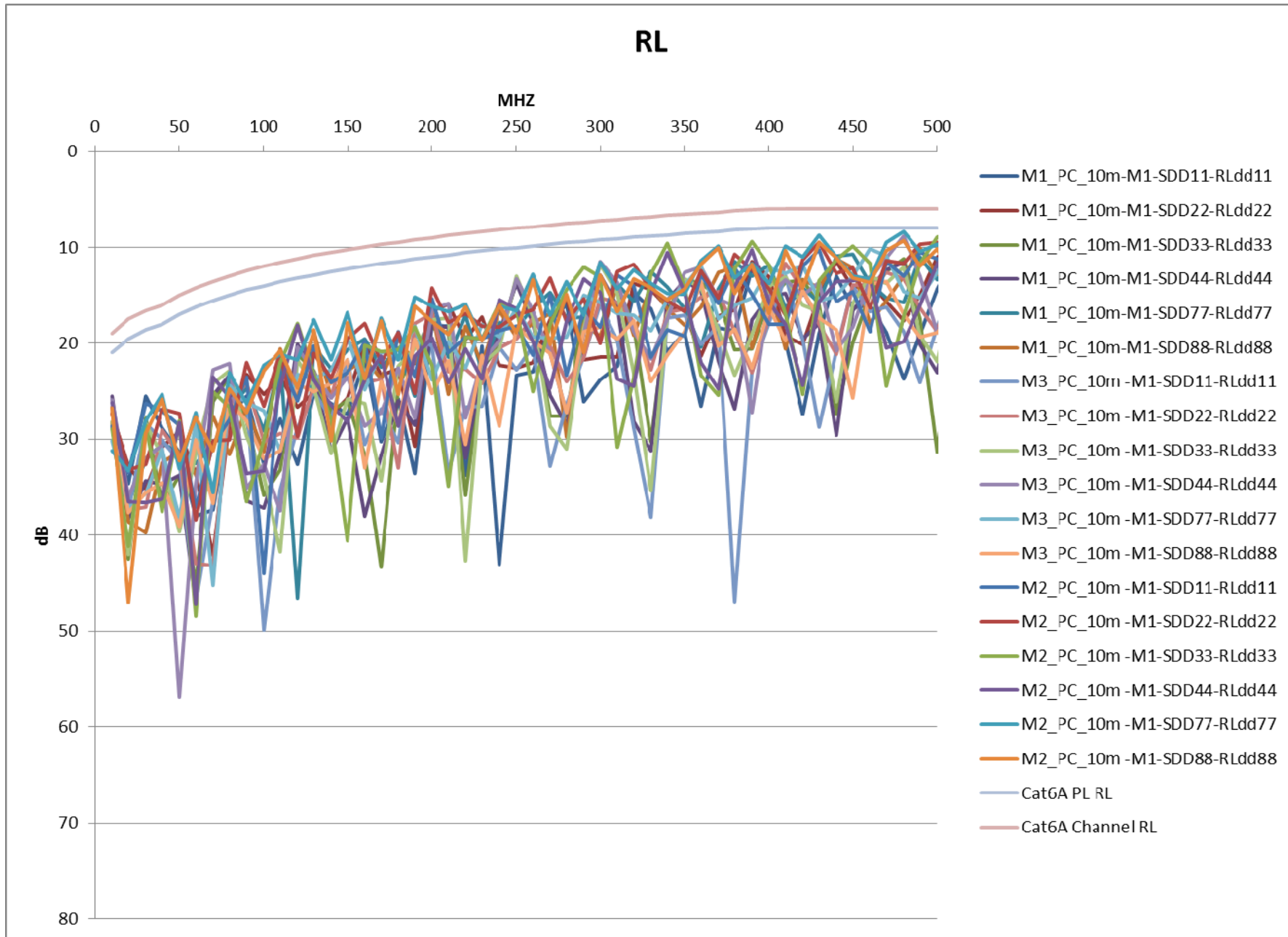


Permanent link testing

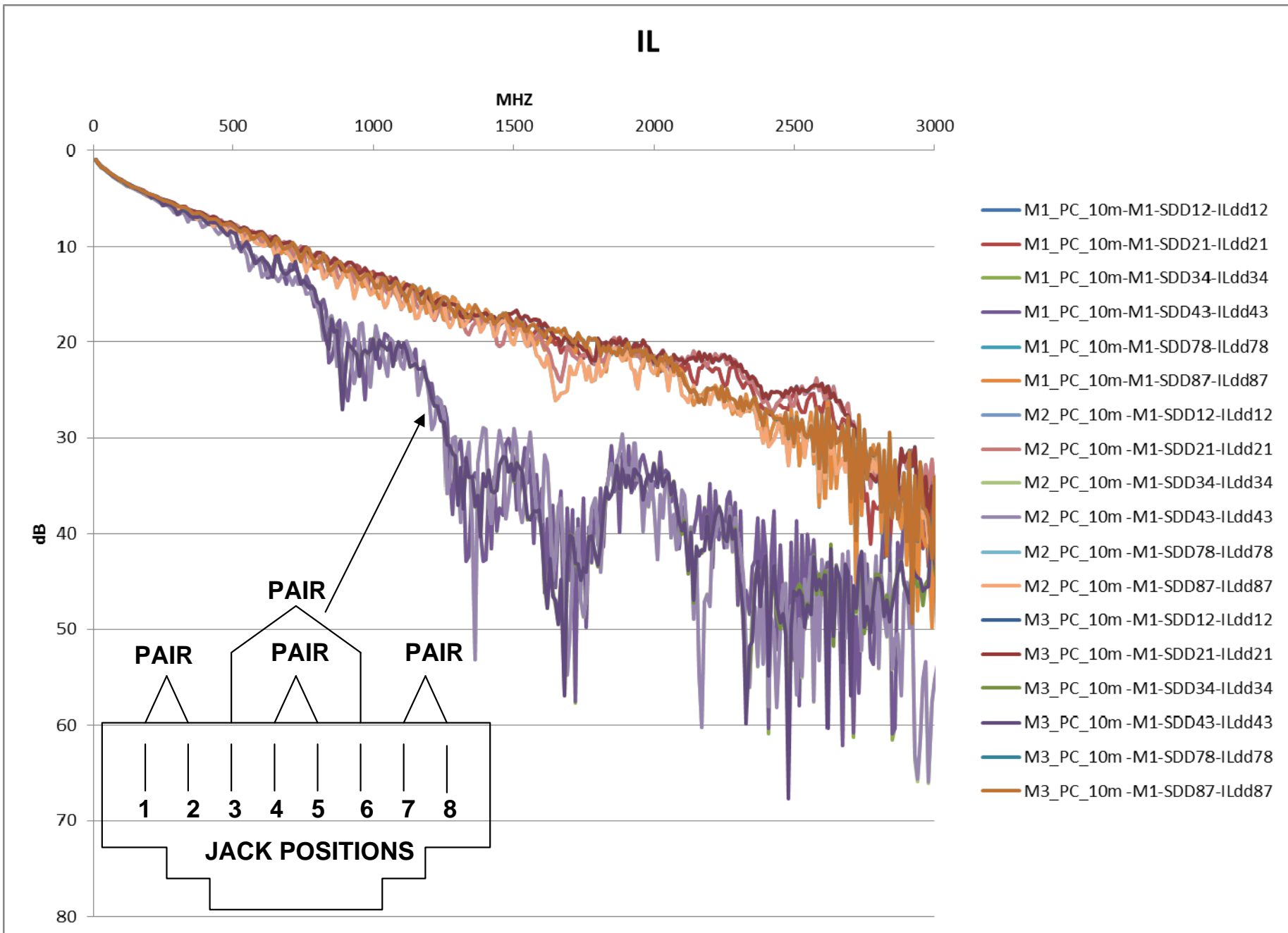


Set-up	A	B	C
Category 6	1.25 m	10 m, 20 m, 30 m, 35 m, 40 m, 50 m	1.25 m
Category 6A	1.25 m	10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m, 100 m	1.25 m
Category 6	1.25 m	70 m [35 m looped back from patch panel]	1.25 m
Category 5e	1.25 m	70 m [35 m looped back from patch panel]	1.25 m

Return loss

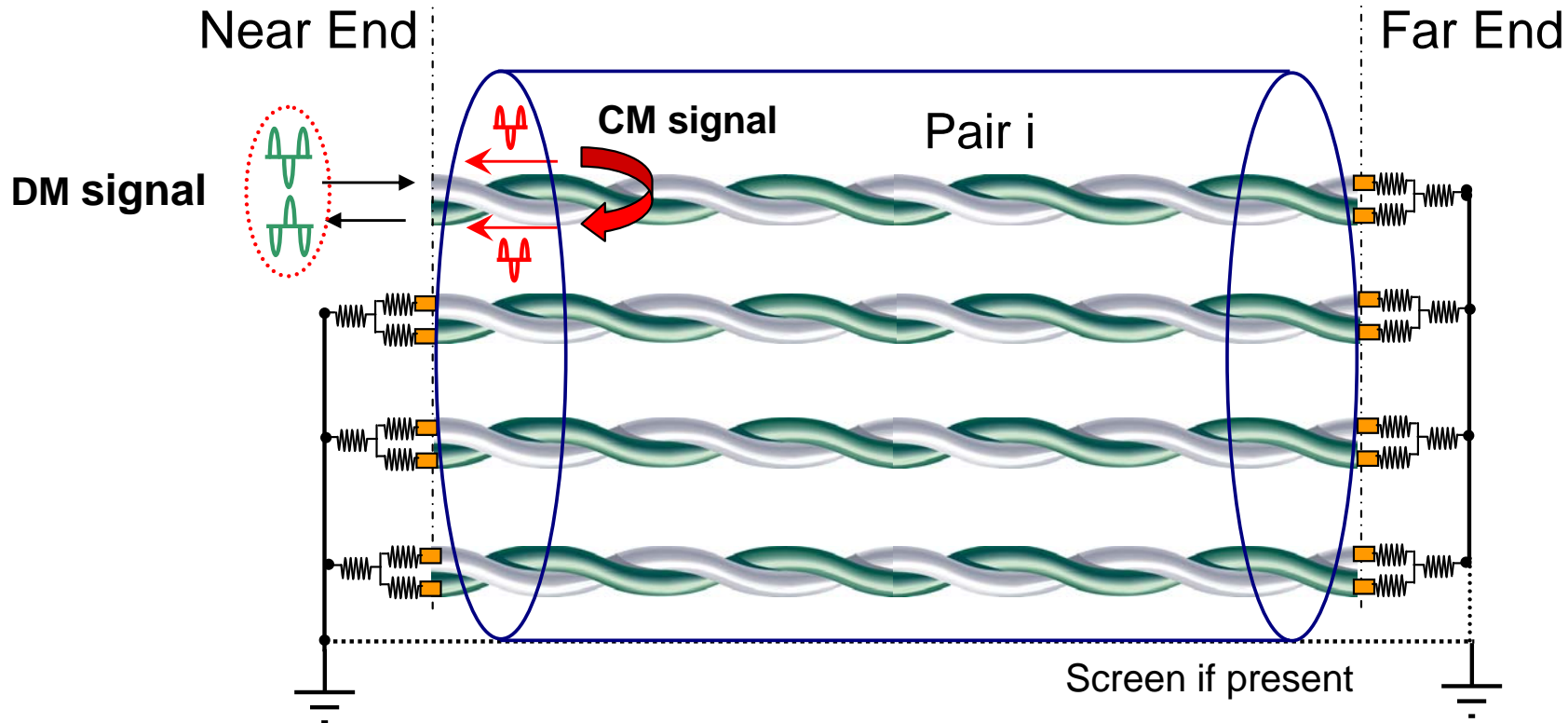


IL to 3 GHz



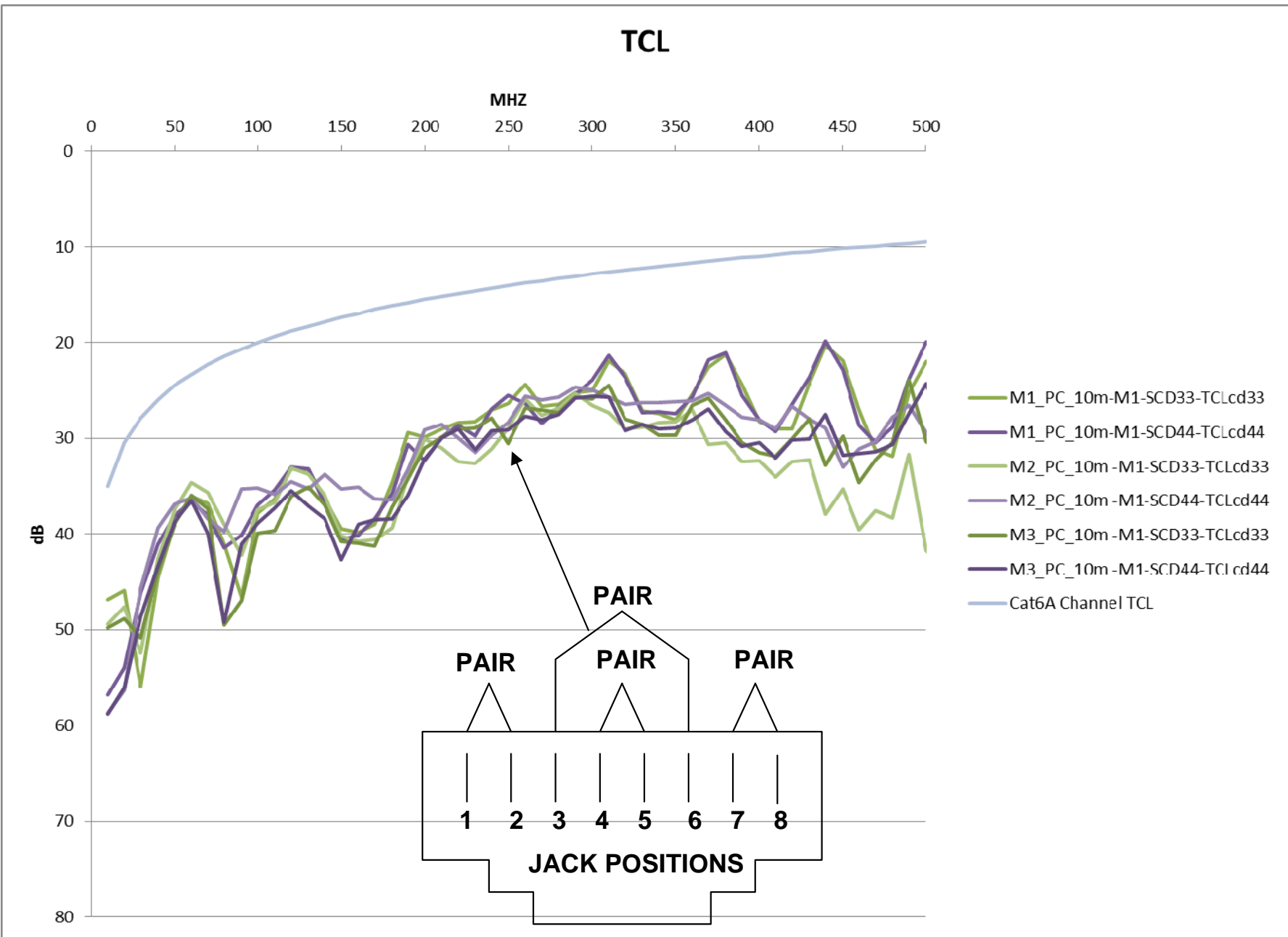
Mode Conversion: TCL

CM signals

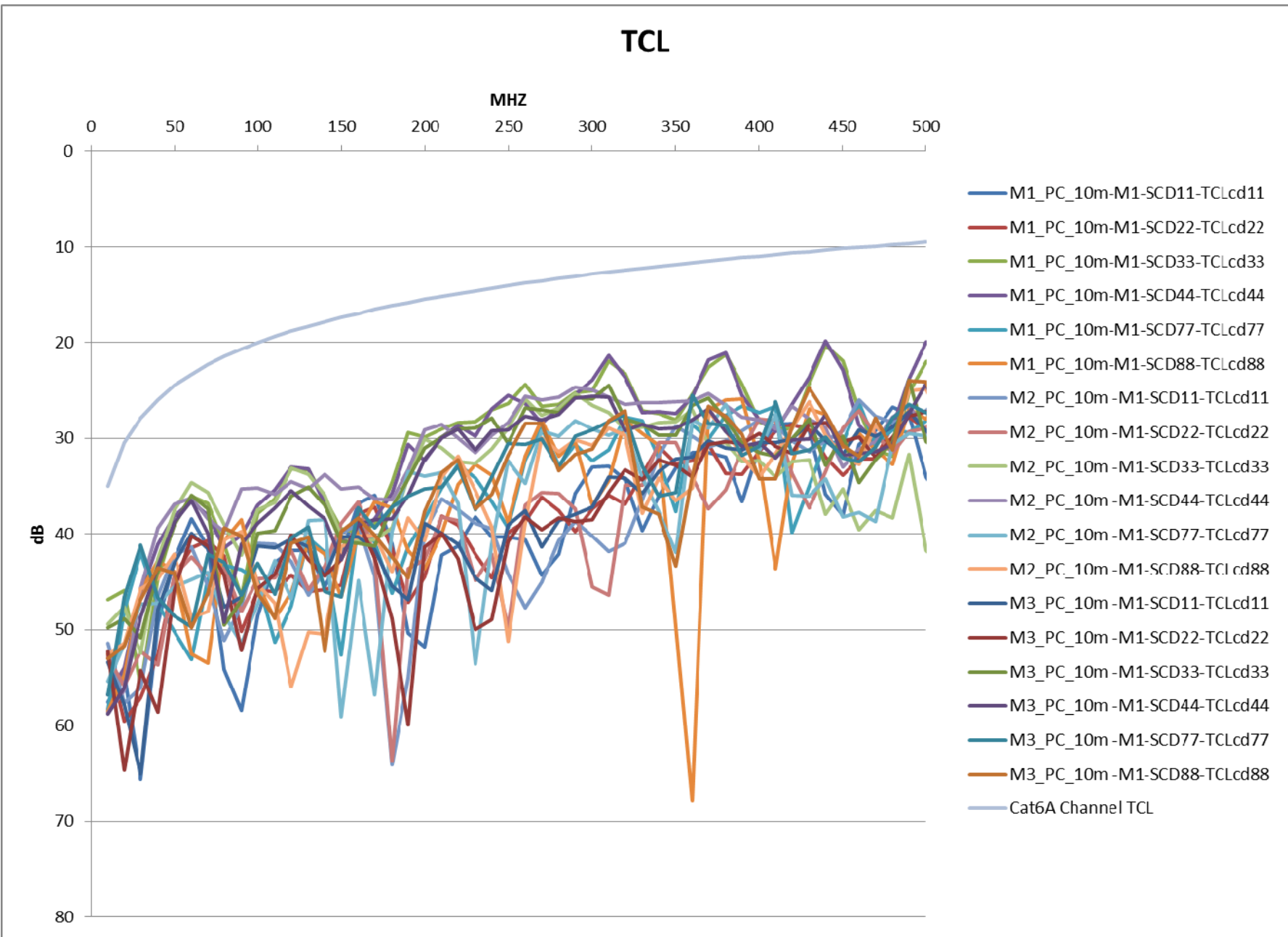


Mode conversion within a pair at the same end is defined as Transverse Conversion Loss (TCL)

Transverse Conversion Loss (TCL) – Pin 3-6



Transverse Conversion Loss (TCL)



Summary

- **Discussion of link segment characteristics for NGBASE-T**
 - **Insertion loss**