40GBASE-T
Cabling channel MDI-to-MDI

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802.3bq (NGBASE-T) Channel Modeling Ad Hoc

•802.3bq 40GBASE-T Channel Modeling Ad Hoc initiated May Interim Brad. Booth (DELL) and Peter. Cibula (INTEL) Channel Modeling Ad Hoc Co-Chairs

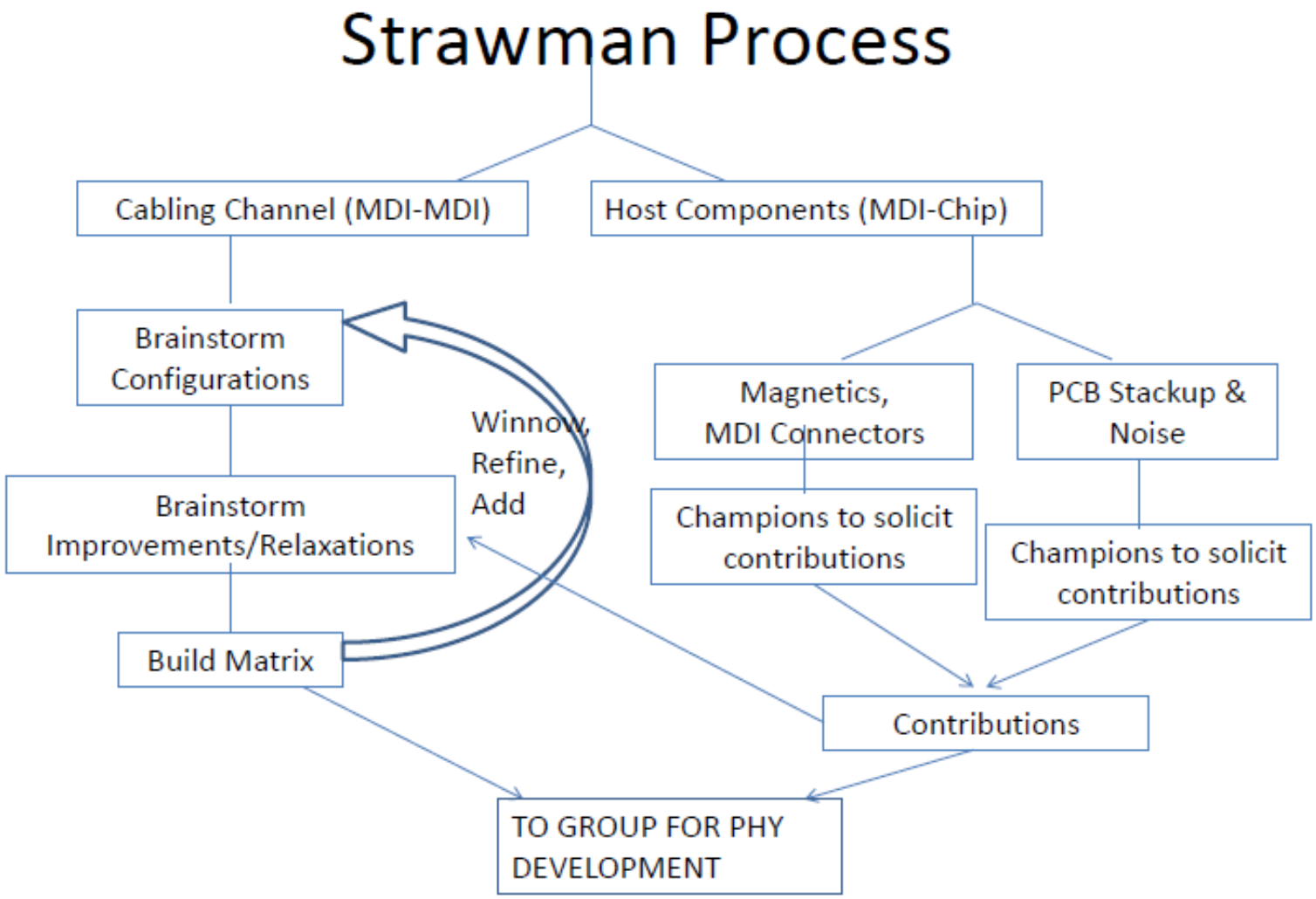
Ad Hoc champions identified to lead critical items;

•Magnetics: Mike Grimwood (Broadcom) and George Zimmerman (affiliated with Commscope) to champion data collection on MDI and isolation path.

•Host PCB: Brad Booth (Dell) and Peter Cibula (Intel) to champion data collection on PCB stackup and noise for 10GBASE-T systems, beginning with their internal teams.

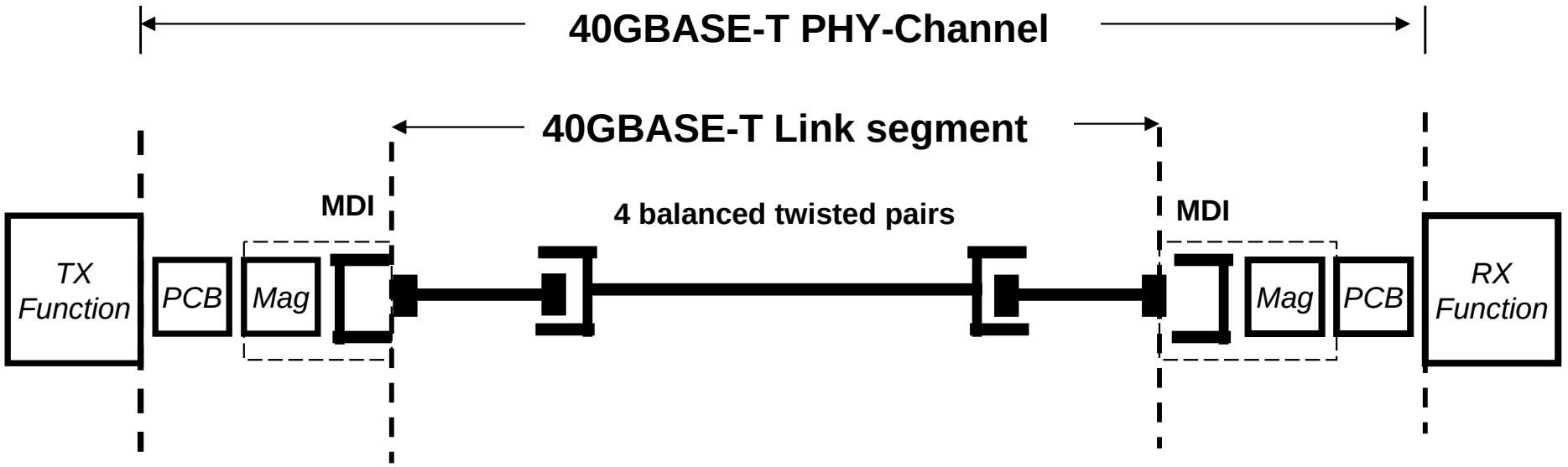
•Cabling: Wayne Larsen (Commscope) and Chris DiMinico to champion the cabling channel MDI-to-MDI efforts outlined on the strawman process slide.

Channel Model Ad Hoc - Proposal for Path Forward



Source: http://www.ieee802.org/3/bq/public/channelmodeling/index.html
Potential Path Forward for Channel Modeling Ad Hoc - updated during meeting zimmerman_02_0513_40GBTah.pdf

40GBASE-T PHY- Channel



To group for modeling to optimize PHY and PHY-channel performance

PHY-Channel

- MDI/Magnetics
- Host PCB
- Link segment - based upon copper media specified by ISO/IEC JTC1/SC25/WG3 and TIA TR42.7
  - –4 pair, balanced twisted-pair copper cabling
  - –Up to 2 connectors
  - –Up to at least 30 meters

Channel Model Ad Hoc - Proposal Channel Configurations

Possible Channel Configurations

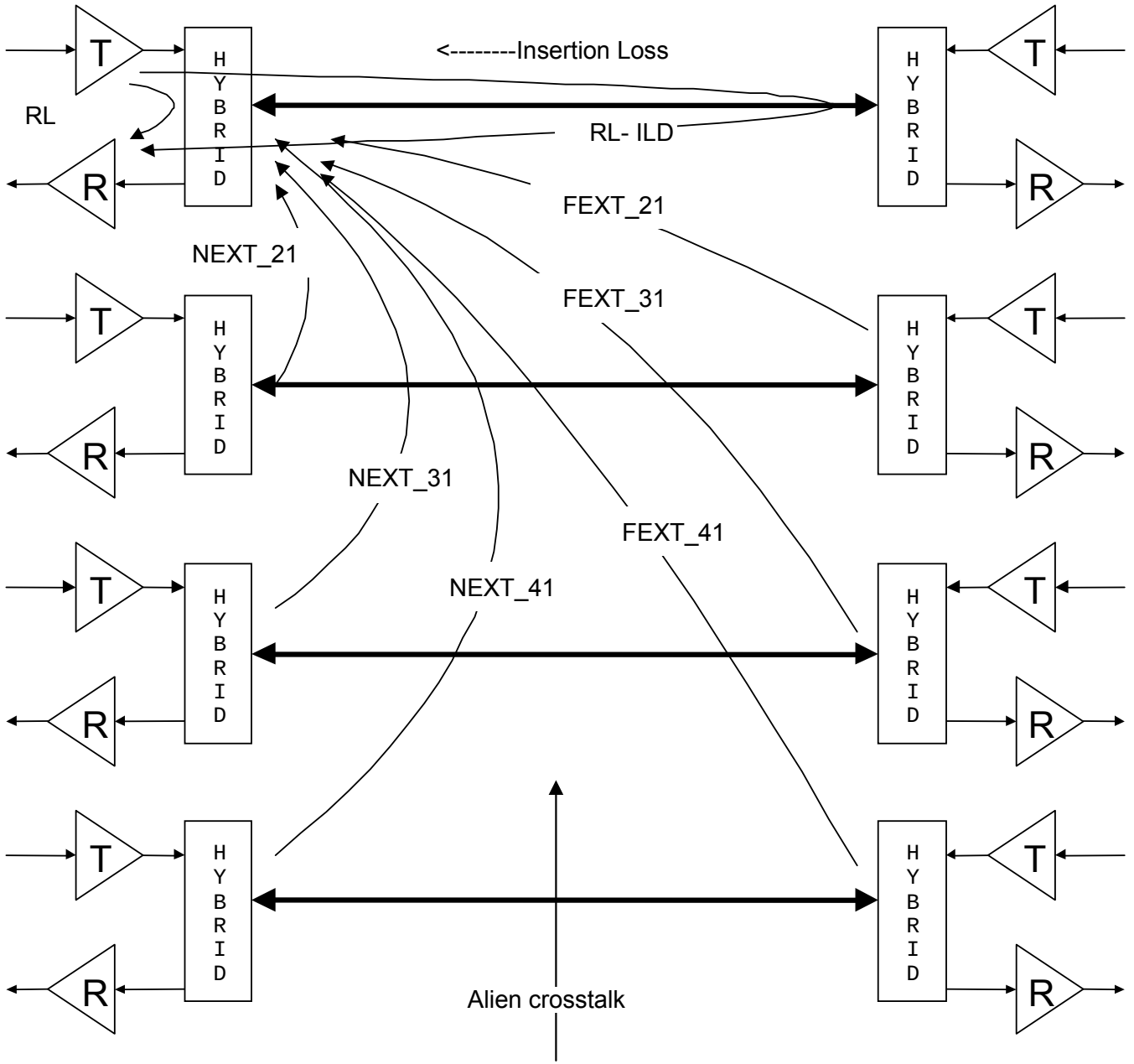
- "X-Axis" – Cable classes
  - A: ISO Class 1, up to 30m (x-y-z)
  - B: ISO Class 2, up to 30m (x-y-z)
  - C: TIA Category 8, up to 30m (x-y-z)
    - Can this be merged with A?
- "Y-Axis" – Topologies/lengths
  - D: Short channels
    - 150mm-3m-150mm ("really short") – Worst case reflection #1
    - 0.5m-3m-0.5m ("pretty short") - Worst case reflection #2
    - 3m - Endpoint to TOR
    - 5m TOR-adjacent
  - E: Other target channels
    - 1m-10m-1m (ISO short reference channel)
    - 30m
    - 30m single patch cord (assuming there is one that meets IL...)
    - 30m asymmetric #1 (1m-26m-3m) – Data center configuration #1
    - 30m asymmetric #3 (1m-24m-5m) – Data center configuration #2
- "Z-Axis" Improvements/Relaxations on A, B, C (reference grimwood_01_0513_40GBT.pdf); "What if" scenarios
  - Improvements
    - 2, 4, 6 dB improved RL
    - 2, 4 dB improved PSNEXT (A,C)
    - Coupling attenuation (Example: Class I/Class II – Contributions show that cabling "far exceeds" current specification)
  - Relaxations
    - Bandwidth (1.6GHz vs. 2.0GHz)
    - Others TBD

Source: http://www.ieee802.org/3/bq/public/channelmodeling/index.html
Potential Path Forward for Channel Modeling Ad Hoc - updated during meeting - zimmerman_02_0513_40GBTah.pdf

Cabling channel characterization

- Identify modeling and measurement test configurations
- Measurements - Testing methodology
  - –VNA – BW, step size, etc…
  - –Test fixtures
  - –File format – Touchstone
- Measurement reporting
  - –Impairments - Differential (mixed mode)
    - +IL, RL, etc…

Signal impairments



40GBASE-T Cabling channel MDI-MDI

40GBASE-T link segment

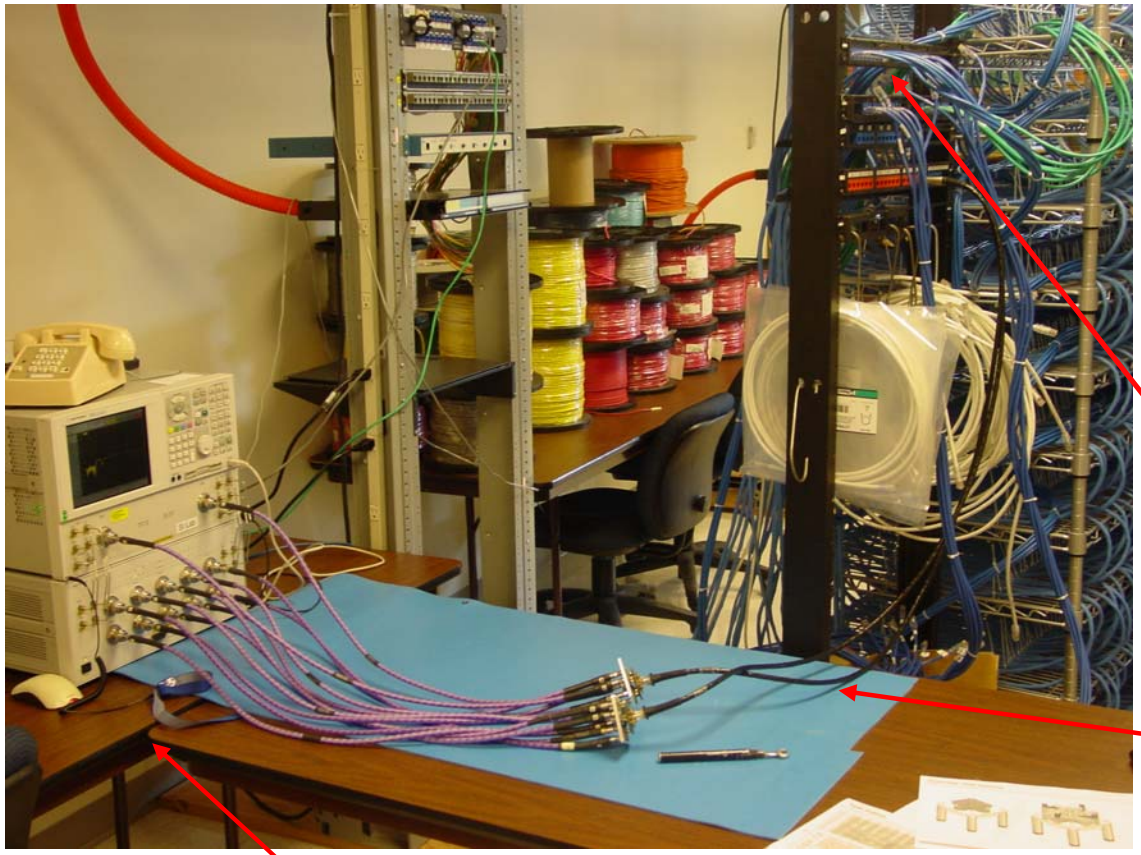
- Transmission and coupling parameters
  - Insertion loss
  - Link segment noise
    - o Noise within link segment –
      - ✓ return loss
      - ✓ mode conversion (balance)
      - ✓ For link segments > NEXT, FEXT and multiple disturber
    - o Noise coupling between link segments
      - ✓ Alien crosstalk - ANEXT, AFEXT and multiple disturber ANEXT and AFEXT
    - o Mode conversion (balance)

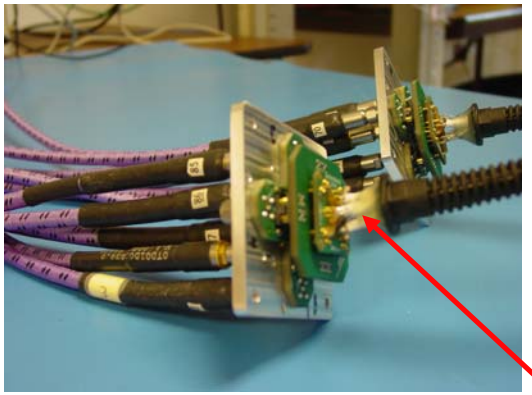
Cabling parameters

Transmission parameters	Coupling parameters (within Link segments)	Coupling parameters (between Link segments)	Balance parameters
Insertion Loss	Near-End crosstalk (NEXT) loss	Alien Near-End crosstalk loss (ANEXT)	Transverse conversion loss (TCL) – SCD11
Differential characteristic impedance	Multiple disturber near-end crosstalk (MDNEXT) loss	Multiple Disturber Alien Far-End crosstalk loss (MDANEXT)	Longitudinal conversion loss (LCL) –SDC11
Return Loss	Far-End crosstalk (FEXT) loss Specified as equal level FEXT (ELFEXT)	Alien Near-End crosstalk loss (AFEXT)	Transverse conversion transmission loss (TCTL) – SCD12
Propagation Delay	Multiple disturber Far-end crosstalk (MDFEXT) loss Specified as MDELFEXT (ELFEXT)	Multiple Disturber Alien Far-End crosstalk loss (MDAFEXT) Specified as power sum (PSAELFEXT)	Longitudinal conversion transmission loss (LCTL) – SDC12
Delay Skew		Specified as power sum (PSAELFEXT)	

Port naming

UNH-IOL





Test fixtures - OCC

Cable pairs

Patch panel ports

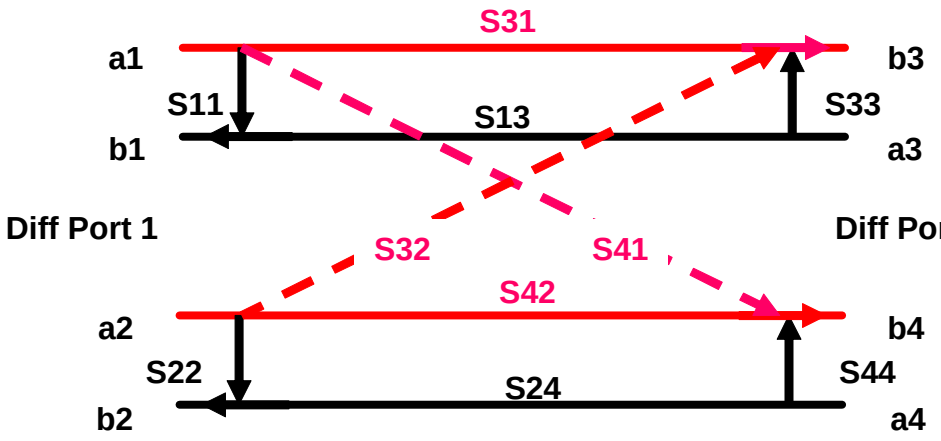
Patch cord connection to cabling

VNA - single ended ports

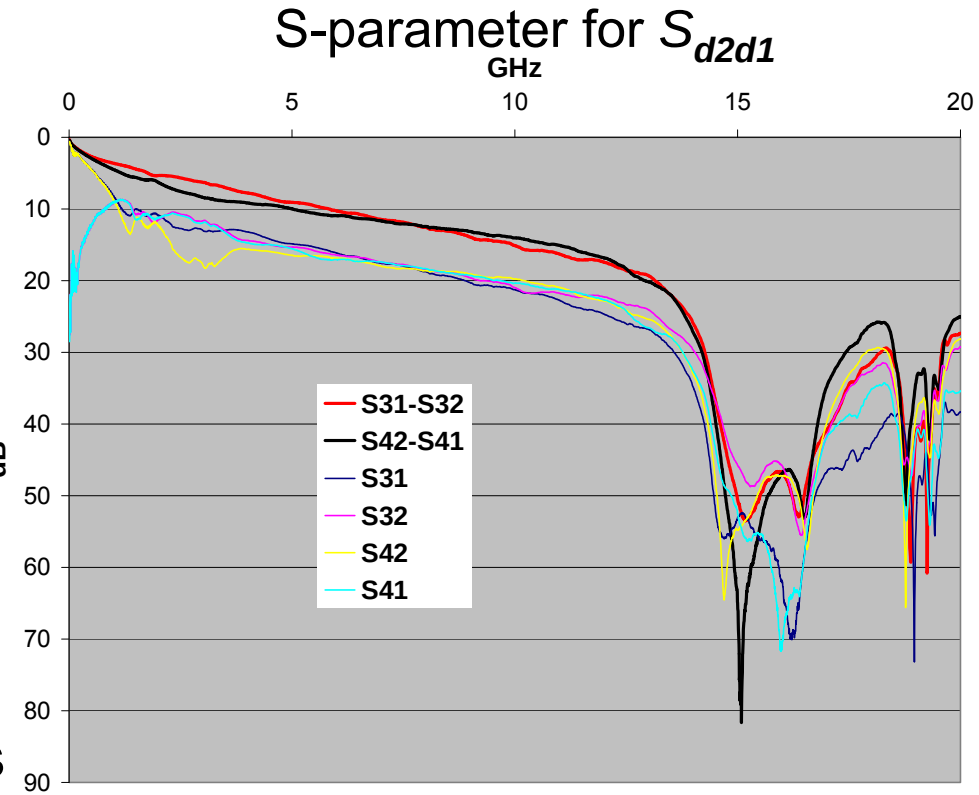
Differential insertion loss

•The differential insertion loss between differential port 1 and differential port 2 is composed of four measurement terms representing the single-ended loss of each half of the differential circuit (i.e. S31 and S42) as well as the single-ended conversion loss terms between each half of the differential circuit (i.e., S32 and S41).

$$S_{d2d1} = \frac{1}{2}\left(S_{31} - S_{32} + S_{42} - S_{41}\right)$$

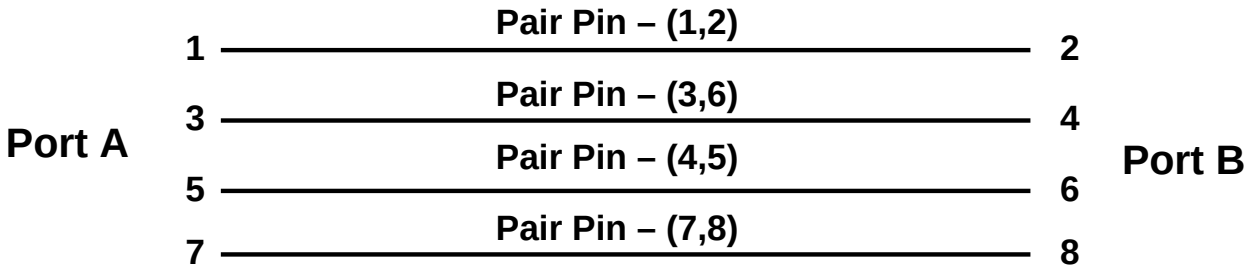


•Single-ended conversion loss terms (S32 and S41) represent the pair unbalances.

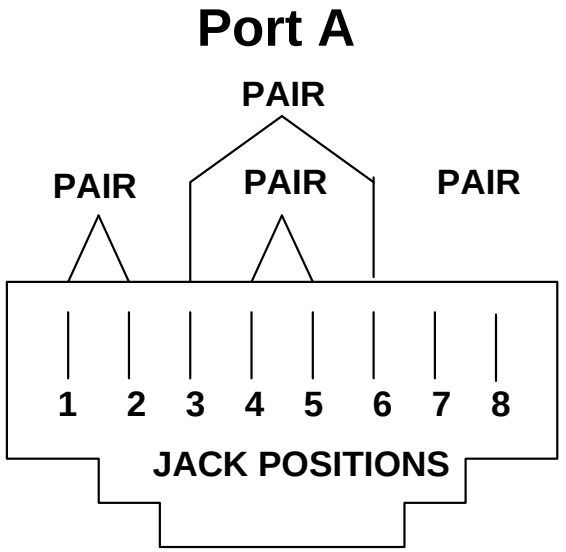


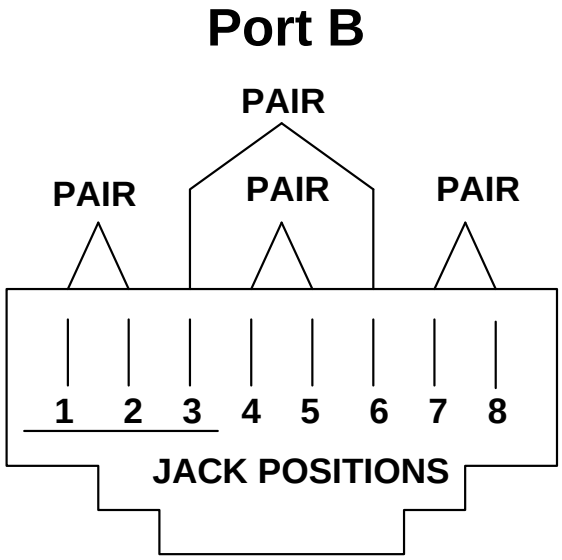
3 meter cable assembly performed utilizing a vector network analyzer (VNA)

Port naming



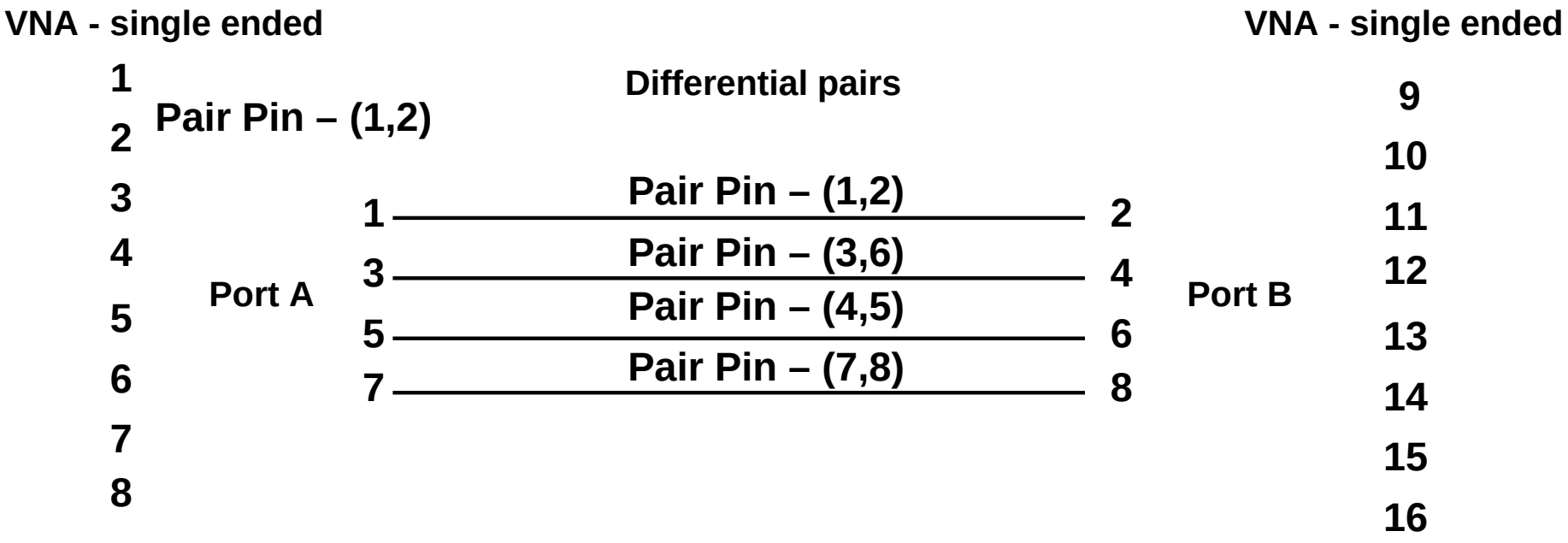
Pin	Port A	Port B
1,2	1	2
3,6	3	4
4,5	5	6
7,8	7	8



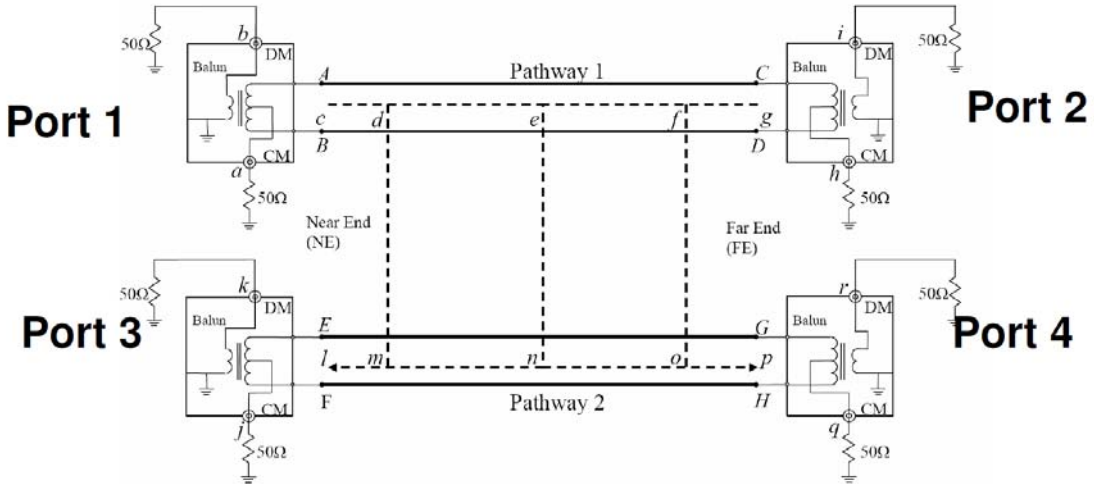


Port naming

- Up to 16 port VNA connected to both ends of cable pairs under.



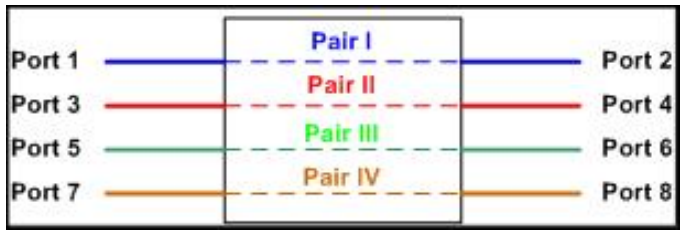
S-parameter to impairment mapping



		Port 1		Port 2		Port 3		Port 4	
Port 1	cc	Scc11	RLcc11	Scc12	ILcc12	Scc13	NEXTcc13	Scc14	FEXTcc14
	cd	Scd11	TCLcd11	Scd12	TCTLcd12	Scd13	NEXTcd13	Scd14	FEXTcd14
	dc	Sdc11	LCLdc11	Sdc12	LCTLdc12	Sdc13	NEXTdc13	Sdc14	FEXTdc14
	dd	Sdd11	RLdd11	Sdd12	ILdd12	Sdd13	NEXTdd13	Sdd14	FEXTdd14
Port 2	cc	Scc21	ILcc21	Scc22	RLcc22	Scc23	FEXTcc23	Scc24	NEXTcc24
	cd	Scd21	TCTLcd21	Scd22	TCLcd22	Scd23	FEXTcd23	Scd24	NEXTcd24
	dc	Sdc21	LCTLdc21	Sdc22	LCLdc22	Sdc23	FEXTdc23	Sdc24	NEXTdc24
	dd	Sdd21	ILdd21	Sdd22	RLdd22	Sdd23	FEXTdd23	Sdd24	NEXTdd24
Port 3	cc	Scc31	NEXTcc31	Scc32	NEXTcc32	Scc33	RLcc33	Scc34	ILcc34
	cd	Scd31	NEXTcd31	Scd32	NEXTcd32	Scd33	TCLcd33	Scd34	TCTLcd34
	dc	Sdc31	NEXTdc31	Sdc32	NEXTdc32	Sdc33	LCLdc33	Sdc34	LCTLdc34
	dd	Sdd31	NEXTdd31	Sdd32	NEXTdd32	Sdd33	RLdd33	Sdd34	ILdd34
Port 4	cc	Scc41	FEXTcc41	Scc42	FEXTcc42	Scc43	ILcc43	Scc44	RLcc44
	cd	Scd41	FEXTcd41	Scd42	FEXTcd42	Scd43	TCTLcd43	Scd44	TCLcd44
	dc	Sdc41	FEXTdc41	Sdc42	FEXTdc42	Sdc43	LCTLdc43	Sdc44	LCLdc44
	dd	Sdd41	FEXTdd41	Sdd42	FEXTdd42	Sdd43	ILdd43	Sdd44	RLdd44

S-Parameters and dm, cm and mixed mode parameters

DUT

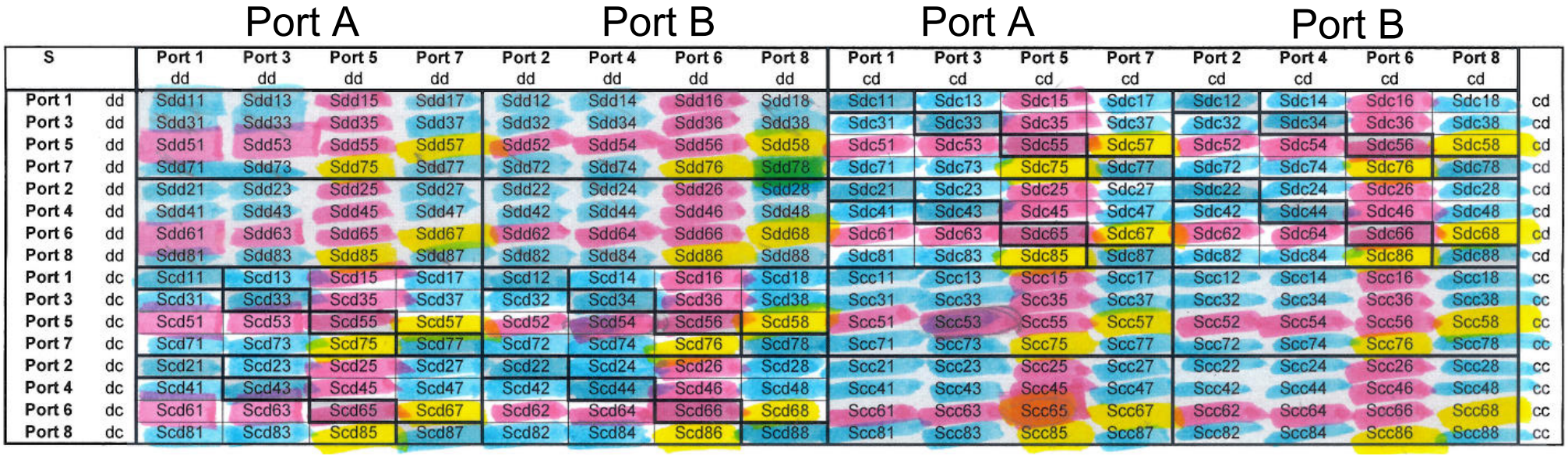


Green cells – currently specified parameters
White and yellow cells – parameters to be investigated
Top table – s-parameter designations
Bottom table – TIA TR42- naming conventions

S		Port 1 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

		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 dc	Port 3 dc	Port 5 dc	Port 7 dc	Port 2 dc	Port 4 dc	Port 6 dc	Port 8 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

12-Port VNA



S		Port A				Port B				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)

Volunteers

- Your name here