





Power Backoff

George Zimmerman, Solarflare




Albert Vareljian, Keyeye

Jose Tellado, Teranetics

Agenda

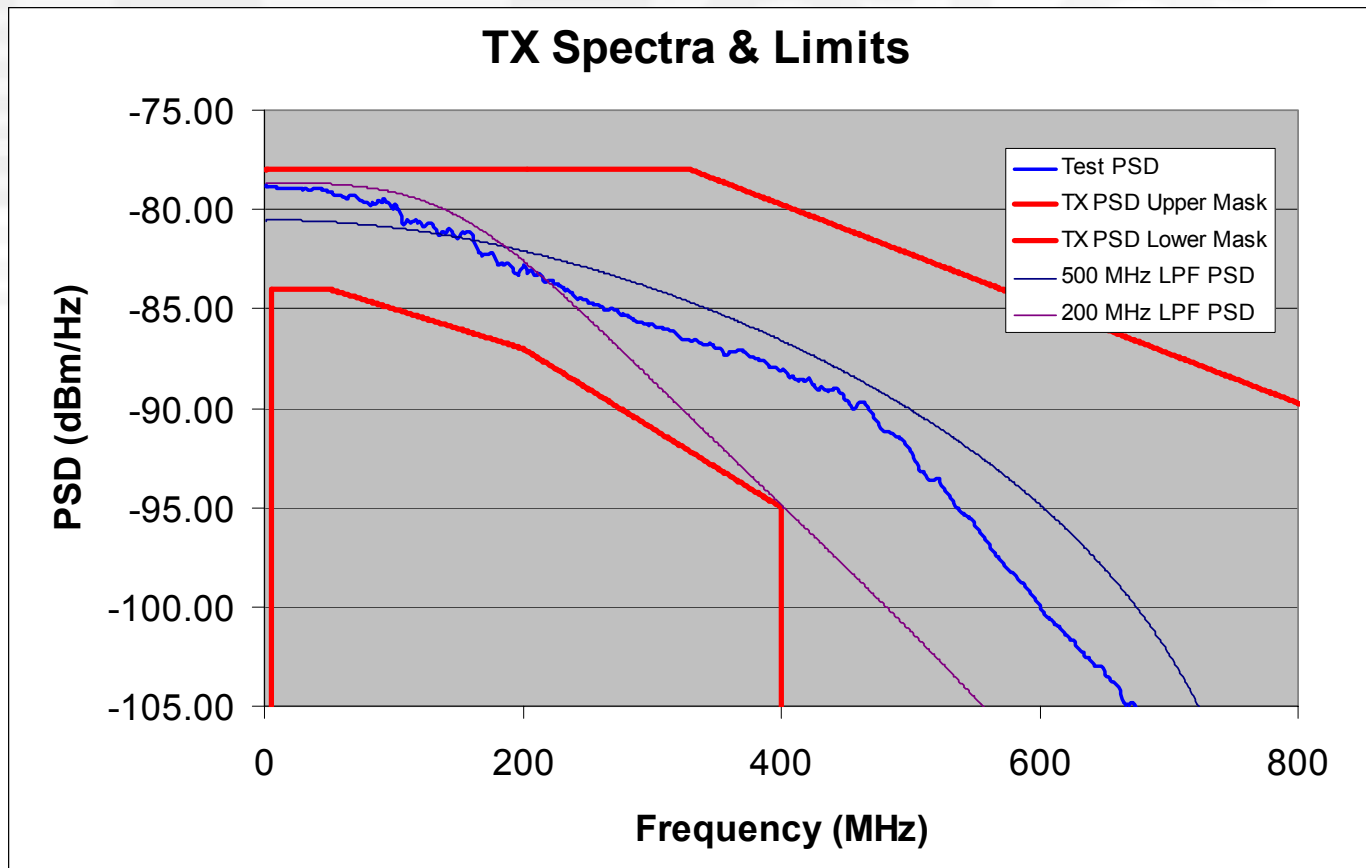
-  Filling in the TBDs
-  Effect of the PSD mask
-  Model refinements
-  Worst-case margins

Filling in the TBDs

-  PBO levels are sensitive to the PSD Mask
-  PSD mask will need to be refined in comments
-  Assumptions here represent realistic transformer/line interface designs and PSDs from the majority of 10GBASE-T presentations

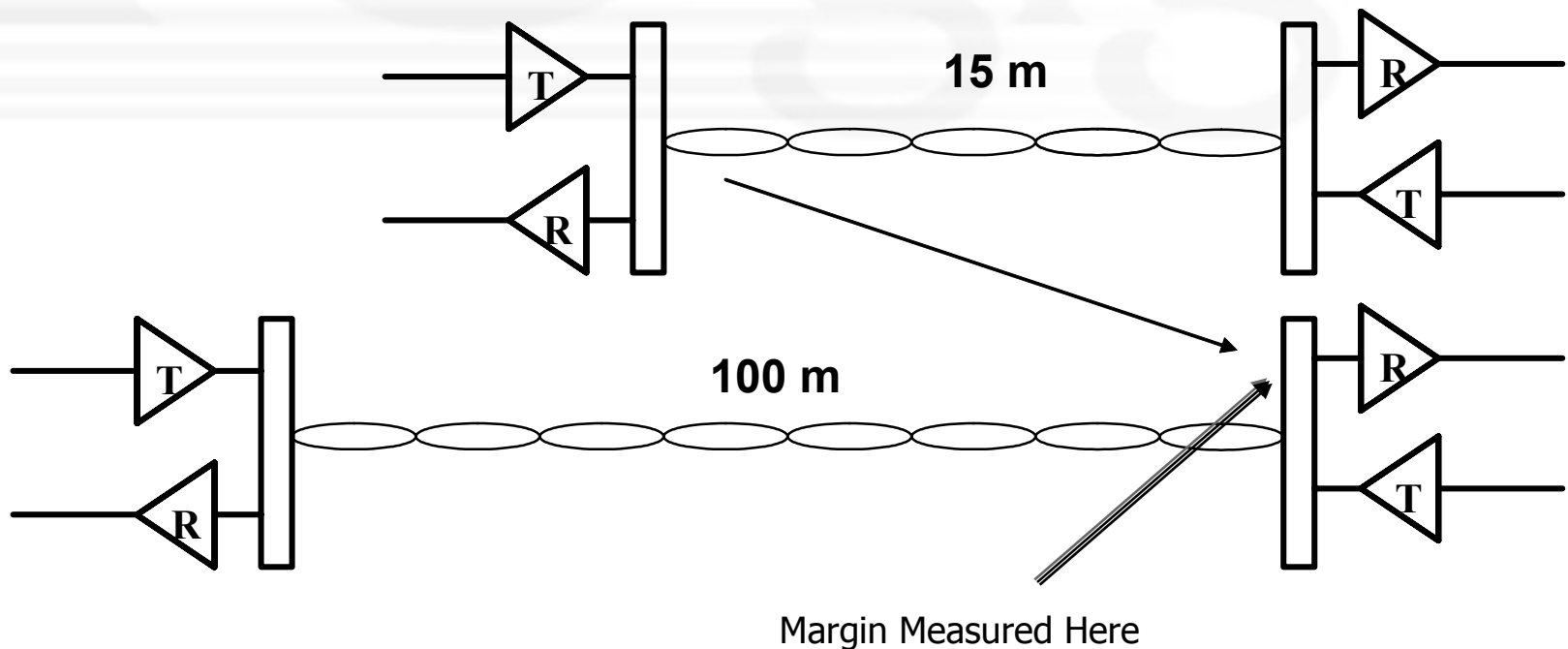
Transmit PSD

 Use Test PSD between limits of PSD mask



Model

- 🚗 Co-located Victim & Disturber
- 🚗 Coupling Models as per D1.4



How Much Power Backoff is Needed?




Disturbance into a 100m link defines limiting case

- Co-terminated receivers, Cat 6a cabling
- Full-power ANEXT into 100m victim receiver
- Maximum of 14 dB power backoff required
- PBO schedule designed by cutting through 0.5 dB loss point

IEEE_nominal_DSQ 100m - full power ANEXT, 100m victim, Model 1





100 meter Cat6e victim receiver		Variable length Cat6e disturber								
Sum of Margin		Disturber Backoff								
Disturber Length		0	2	4	6	8	10	12	14	16
10		-3.07	-1.49	-0.03	1.28	2.42	3.36	4.10	4.66	5.06
20		-3.01	-1.41	0.05	1.37	2.50	3.44	4.16	4.71	5.10
30		-1.96	-0.44	0.94	2.14	3.15	3.94	4.55	4.98	5.29
40		-0.61	0.78	2.01	3.03	3.85	4.48	4.93	5.25	5.46
50		0.77	1.98	3.00	3.82	4.45	4.91	5.23	5.45	5.60
60		2.01	3.00	3.81	4.43	4.89	5.22	5.44	5.59	5.69
70		3.02	3.81	4.42	4.88	5.20	5.43	5.58	5.69	5.75
80		3.80	4.40	4.86	5.19	5.42	5.57	5.68	5.75	5.79
90		4.38	4.83	5.16	5.40	5.56	5.67	5.74	5.79	5.82
100		4.80	5.14	5.38	5.55	5.66	5.73	5.78	5.81	5.83

(PRIOR) Proposed Power Backoff Schedule

-  Controlled by received power at MDI
-  Adjusts for disturbers with higher power transmitters or excess low frequency energy
-  Less aggressive than prior presentation

Length(m)	Far End Power at MDI	Backoff (dB)
0-25	>+0.3	14
25-35	+0.3 to -1.1	12
35-45	-1.1 to -2.3	10
45-55	-2.3 to -3.3	8
55-65	-3.3 to -4.2	6
65-75	-4.2 to -5.0	4
75-85	-5.0 to -5.7	2
>85	<-5.7	0

Compromise Power Backoff Schedule

-  Controlled by received power at MDI
-  Receivers shall control PBO within one PBO step, defined as a table row below
-  Less aggressive than prior presentation
-  Represents compromise for less power backoff, stronger signals at MDI

Length(m)	Far End Power at MDI	Backoff (dB)
0-25	>+0.3	10
25-35	+0.3 to -1.1	10
35-45	-1.1 to -2.3	8
45-55	-2.3 to -3.3	6
55-65	-3.3 to -4.2	4
65-75	-4.2 to -5.0	2
75-85	-5.0 to -5.7	0
>85	<-5.7	0

Analysis Model

- Based on IEEE Study Group Models
 - Same concepts as Sept 2003 MATLAB code
 - Residuals modeled from measured transfer functions with cancellation applied, not as AWGN floor
- Includes measurement data and implementation effects, per PHY Proposals
 - July 2004 multi-vendor proposals
 - Models for ADCs, DACs (10 ENOB, 9 ENOB)
 - Actual residuals after cancellation
 - 55 dB echo, 40 dB NEXT, 25 dB FEXT
 - 150dBm/Hz background
 - RX noise, ADC, DAC, forward echo, baud-sampling included

(PRIOR) Cat 6a Margin Analysis:

- Analysis model tweaked to give worst numbers vs. reach
- Constant full-power 100m ANEXT (4.2 dBm)
- ANEXT/AELFEXT independent of length (Model 1 levels)
- Covers short into long and long into short cases
- Green: Greater than 4 dB, Yellow: within 1 dB, Red: >1 dB loss (no red)

SCHEDULE 3 - 100m Cat6a, Cat7 IL (Model 1), ANEXT power = full power, Median Tx PSD

MIN 3.98 MAX 12.54 MED 9.92 AVG 9.49

Sum of Margin	Victim Length																
Disturber Length		25	26	35	36	45	46	55	56	65	66	75	76	85	86	100	
	25	10.41	11.55	10.71	12.04	10.35	11.75	9.72	11.16	8.96	10.39	8.11	9.50	7.18	8.50	4.81	
	26	10.14	11.28	10.32	11.67	9.92	11.34	9.27	10.73	8.51	9.96	7.67	9.08	6.74	8.09	4.40	
	35	10.55	11.67	10.64	11.98	10.26	11.67	9.62	11.06	8.85	10.29	8.00	9.40	7.07	8.40	4.71	
	36	10.33	11.47	10.27	11.60	9.80	11.24	9.14	10.61	8.37	9.83	7.53	8.95	6.61	7.97	4.27	
	45	10.65	11.77	10.81	12.12	10.21	11.64	9.56	11.01	8.79	10.23	7.94	9.34	7.01	8.34	4.65	
	46	10.47	11.61	10.49	11.82	9.78	11.20	9.08	10.55	8.30	9.76	7.45	8.88	6.53	7.90	4.19	
	55	10.72	11.84	10.93	12.24	10.36	11.77	9.52	10.98	8.75	10.19	7.89	9.30	6.96	8.30	4.60	
	56	10.57	11.70	10.65	11.98	9.98	11.40	9.06	10.52	8.25	9.72	7.40	8.83	6.48	7.85	4.14	
	65	10.77	11.89	11.02	12.33	10.47	11.88	9.65	11.09	8.71	10.16	7.85	9.26	6.92	8.26	4.56	
	66	10.64	11.77	10.77	12.10	10.13	11.55	9.23	10.69	8.23	9.69	7.36	8.80	6.44	7.81	4.09	
	75	10.80	11.92	11.07	12.39	10.55	11.96	9.74	11.18	8.81	10.25	7.80	9.22	6.87	8.22	4.51	
	76	10.68	11.81	10.85	12.18	10.23	11.66	9.35	10.81	8.37	9.82	7.33	8.75	6.39	7.76	4.04	
	85	10.82	11.94	11.11	12.43	10.60	12.01	9.80	11.24	8.87	10.31	7.88	9.28	6.82	8.17	4.46	
	86	10.71	11.84	10.90	12.24	10.30	11.73	9.43	10.89	8.46	9.91	7.43	8.85	6.34	7.71	3.98	
	100	10.88	11.99	11.23	12.54	10.77	12.17	10.00	11.44	9.10	10.54	8.13	9.53	7.09	8.42	4.58	

Transmitter PSD variation

- Adjusted for use with 200 MHz 2nd order LPF at 5.2 dBm
- Changes lengths at which transitions occur
- Cat 6a example shown (full power ANEXT)
- Margins still robust

SCHEDULE 3 - 100m Cat6a, Cat7 IL (Model 1), ANEXT power = full power. High Power 5.2 200 MHz LPF

MIN 3.03 MAX 12.28 MED 10.50 AVG 10.23

Sum of Margin	Victim Length															
Disturber Length		28	29	36	37	44	45	52	53	60	61	66	67	72	73	100
28		10.32	11.47	10.62	11.88	10.61	11.93	10.45	11.80	10.20	11.55	10.37	11.70	10.50	11.79	4.84
29		10.04	11.20	10.27	11.55	10.23	11.57	10.06	11.42	9.80	11.17	9.97	11.32	10.11	11.42	4.43
36		10.37	11.51	10.50	11.77	10.48	11.81	10.30	11.66	10.05	11.41	10.22	11.56	10.35	11.65	4.68
37		10.12	11.27	10.14	11.41	10.05	11.41	9.86	11.25	9.60	10.99	9.78	11.14	9.92	11.24	4.22
44		10.42	11.55	10.55	11.81	10.35	11.70	10.17	11.54	9.91	11.29	10.08	11.43	10.22	11.53	4.53
45		10.18	11.33	10.21	11.49	9.92	11.26	9.69	11.09	9.42	10.82	9.60	10.98	9.75	11.08	4.03
52		10.45	11.59	10.59	11.85	10.40	11.72	10.05	11.43	9.78	11.17	9.95	11.31	10.09	11.41	4.39
53		10.22	11.38	10.26	11.54	9.98	11.33	9.56	10.94	9.26	10.67	9.44	10.83	9.59	10.94	3.86
60		10.47	11.61	10.62	11.88	10.42	11.76	10.07	11.44	9.65	11.05	9.82	11.20	9.96	11.30	4.25
61		10.25	11.41	10.30	11.58	10.02	11.37	9.60	10.99	9.12	10.52	9.28	10.68	9.43	10.80	3.68
66		10.42	11.57	10.55	11.82	10.33	11.67	9.96	11.34	9.52	10.91	9.58	10.97	9.73	11.08	3.99
67		10.18	11.35	10.20	11.50	9.90	11.26	9.46	10.86	8.97	10.38	9.00	10.40	9.14	10.52	3.37
72		10.36	11.52	10.46	11.75	10.22	11.57	9.84	11.22	9.38	10.78	9.43	10.82	9.47	10.84	3.71
73		10.10	11.29	10.09	11.40	9.76	11.14	9.31	10.72	8.80	10.22	8.83	10.24	8.84	10.23	3.03
100		10.74	11.86	11.03	12.28	10.95	12.27	10.69	12.05	10.34	11.72	10.46	11.80	10.53	11.84	4.54

Effect of AFEXT disturbers mis-adjusting

- AFEXT is one power step (2dB) higher than nominal
- If $PBO_nominal > 0$, $PBO = PBO_nominal - 2dB$
- Includes a full PBO interval overlap (4 dB power difference worst case)
- Minimal margin losses

SCHEDULE 3 - 100m Cat6a, Cat7 IL (Model 1), ANEXT power = full power, Median Tx PSD, AFEXT + 2dB
 MIN 3.38 MAX 12.54 MED 9.43 AVG 9.08

Sum of Margin	Victim Length																
Disturber Length		25	26	35	36	45	46	55	56	65	66	75	76	85	86	100	
25		10.08	11.25	10.29	11.63	9.88	11.31	9.23	10.69	8.47	9.92	7.63	9.04	6.71	8.06	4.37	
26		9.69	10.86	9.74	11.12	9.29	10.74	8.62	10.10	7.86	9.33	7.02	8.46	6.12	7.50	3.79	
35		10.29	11.43	10.19	11.55	9.75	11.19	9.09	10.56	8.32	9.78	7.48	8.90	6.56	7.92	4.22	
36		9.97	11.13	9.67	11.02	9.14	10.60	8.46	9.95	7.68	9.16	6.85	8.29	5.94	7.33	3.62	
45		10.44	11.57	10.42	11.76	9.69	11.14	9.02	10.49	8.25	9.71	7.40	8.83	6.48	7.85	4.14	
46		10.17	11.33	9.97	11.32	9.11	10.55	8.38	9.87	7.60	9.08	6.75	8.21	5.85	7.25	3.53	
55		10.54	11.67	10.60	11.93	9.91	11.33	8.98	10.46	8.20	9.67	7.35	8.78	6.43	7.80	4.09	
56		10.31	11.47	10.20	11.55	9.39	10.83	8.36	9.84	7.55	9.04	6.70	8.16	5.79	7.20	3.47	
65		10.61	11.75	10.72	12.05	10.07	11.49	9.16	10.62	8.15	9.63	7.30	8.74	6.43	7.84	4.04	
66		10.42	11.57	10.37	11.72	9.59	11.04	8.60	10.08	7.53	9.01	6.66	8.12	5.75	7.16	3.43	
75		10.66	11.79	10.81	12.14	10.18	11.61	9.29	10.75	8.30	9.75	7.25	8.70	6.33	7.71	3.99	
76		10.48	11.64	10.49	11.84	9.74	11.19	8.77	10.25	7.72	9.20	6.64	8.08	5.70	7.12	3.38	
85		10.69	11.82	10.87	12.20	10.26	11.69	9.38	10.84	8.40	9.85	7.36	8.79	6.27	7.66	3.93	
86		10.71	11.84	10.90	12.24	10.30	11.73	9.43	10.89	8.46	9.91	7.43	8.85	6.34	7.71	3.98	
100		10.88	11.99	11.23	12.54	10.77	12.17	10.00	11.44	9.10	10.54	8.13	9.53	7.09	8.42	4.58	

COMPROMISE Cat6a Analysis

- Analysis model tweaked to give worst numbers vs. reach
- Constant full-power 100m ANEXT (4.2 dBm)
- ANEXT/AELFEXT independent of length (Model 1 levels)
 - Covers short into long and long into short cases
 - Green: Greater than 4 dB, Yellow: within 1 dB, Red: >1 dB loss (no red)

SCHEDULE 3- Capped at 10dB - 100m Cat6a, Cat7 IL (Model 1), ANEXT power = full power (4.2 dBm)

MIN		3.32		MAX		13.81		MED		11.01		AVG		10.36		
Sum of Margin	Victim Length															
Disturber length		25	26	35	36	45	46	55	56	65	66	75	76	85	86	100
	25	11.86	11.90	11.18	12.47	10.84	12.22	10.23	11.63	9.47	10.86	8.61	9.96	7.65	7.39	3.68
	26	11.92	11.93	11.23	12.51	10.89	12.26	10.27	11.67	9.51	10.90	8.65	10.00	7.70	7.44	3.73
	35	12.35	12.41	11.64	12.91	11.34	12.69	10.73	12.11	9.96	11.33	9.09	10.41	8.12	7.86	4.15
	36	12.14	12.17	11.17	12.43	10.76	12.15	10.12	11.54	9.35	10.76	8.49	9.85	7.54	7.28	3.56
	45	12.47	12.54	11.87	13.11	11.29	12.66	10.67	12.06	9.89	11.27	9.02	10.35	8.04	7.78	4.07
	46	12.29	12.35	11.46	12.72	10.75	12.11	10.06	11.48	9.28	10.69	8.41	9.78	7.46	7.19	3.47
	55	12.54	12.63	12.04	13.27	11.51	12.85	10.63	12.04	9.85	11.24	8.97	10.31	8.00	7.74	4.02
	56	12.40	12.47	11.68	12.94	11.02	12.38	10.06	11.46	9.24	10.65	8.37	9.74	7.41	7.15	3.42
	65	12.60	12.69	12.16	13.39	11.66	13.00	10.81	12.19	9.82	11.21	8.94	10.28	7.96	7.70	3.98
	66	12.48	12.55	11.85	13.10	11.23	12.59	10.29	11.69	9.23	10.63	8.33	9.71	7.37	7.11	3.37
	75	12.63	12.73	12.24	13.47	11.77	13.11	10.94	12.32	9.96	11.33	8.90	10.24	7.92	7.65	3.93
	76	12.53	12.61	11.96	13.22	11.37	12.74	10.46	11.86	9.42	10.81	8.31	9.67	7.33	7.07	3.32
	85	12.66	12.76	12.30	13.53	11.85	13.19	11.03	12.41	10.06	11.43	9.00	10.33	7.87	7.60	3.87
	86	12.67	12.77	12.33	13.56	11.89	13.23	11.08	12.46	10.12	11.49	9.07	10.39	7.93	7.65	3.92
	100	12.76	12.88	12.61	13.81	12.31	13.62	11.61	12.96	10.72	12.06	9.72	11.01	8.62	8.35	4.51

COMPROMISE Class E Margin Analysis

- Constant full-power 55m ANEXT (8 dB PBO)
- ANEXT/AELFEXT independent of Length (Class E levels)
 - Includes 56m Cat6 case to show effect of excess AFEXT power

SCHEDULE 3 - Short range w/PBO Capped at 10dB - 55m Cat6 (Model 2), ANEXT power = max 55m cat 6 power, Median TX PSD
 MIN 3.64 MAX 9.27 MED 6.76 AVG 6.70

Sum of Margin	Victim Length								
Disturber length	25	26	35	36	45	46	55	56	
25	8.26	8.06	5.82	7.35	4.79	6.36	3.68	5.25	
26	8.35	8.11	5.88	7.41	4.85	6.41	3.74	5.31	
35	8.99	8.79	6.34	7.87	5.32	6.88	4.21	5.78	
36	8.68	8.45	5.85	7.35	4.77	6.34	3.66	5.23	
45	9.16	8.96	6.59	8.09	5.30	6.87	4.19	5.76	
46	8.90	8.69	6.17	7.68	4.80	6.34	3.64	5.22	
55	9.27	9.09	6.76	8.26	5.52	7.06	4.19	5.76	
56	9.06	8.86	6.40	7.91	5.07	6.62	3.68	5.24	









COMPROMISE Scaled Class E Channel Analysis

- ANEXT/AFEXT Scaled with IL per Draft
- IL of longer channel used for ANEXT/AFEXT scaling
- PBO applied to both ANEXT and AFEXT sources per the disturbing channel length

SCHEDULE 3 - PBO Capped at 10dB - variable length (Model 3 & 4), ANEXT power = afextpower, ANEXT, AFEXT constants scale
 MIN 2.63 MAX ##### MED 7.18 AVG 10.41

Sum of Margin	Victim Length															
Disturber length		25	26	35	36	45	46	55	56	65	66	75	76	85	86	100
25		9.45	9.36	7.84	9.28	7.26	8.76	6.56	8.07	6.31	7.95	6.86	8.41	7.11	6.96	4.63
26		9.58	9.42	7.91	9.35	7.34	8.83	6.63	8.14	6.39	8.03	6.94	8.49	7.19	7.04	4.71
35		10.50	10.40	8.59	10.01	8.03	9.52	7.33	8.83	7.12	8.76	7.73	9.26	7.99	7.84	5.49
36		9.43	9.28	7.16	8.59	6.49	8.01	5.75	7.30	5.57	7.26	6.29	7.89	6.70	6.56	4.36
45		10.05	9.95	8.16	9.57	7.18	8.69	6.45	7.98	6.31	8.00	7.13	8.71	7.58	7.44	5.25
46		8.88	8.73	6.66	8.12	5.61	7.12	4.82	6.39	4.71	6.44	5.64	7.28	6.24	6.11	4.08
55		9.29	9.17	7.32	8.77	6.42	7.93	5.41	6.97	5.35	7.09	6.40	8.03	7.07	6.95	4.97
56		8.01	7.84	5.74	7.24	4.78	6.32	3.75	5.31	3.69	5.46	4.84	6.53	5.66	5.55	3.76
65		8.96	8.83	6.98	8.46	6.14	7.66	5.18	6.73	4.19	5.98	5.46	7.15	6.38	6.28	4.57
66		7.83	7.66	5.60	7.11	4.70	6.25	3.72	5.29	2.72	4.29	3.83	5.58	4.90	4.81	3.29
75		9.72	9.63	7.98	9.43	7.21	8.71	6.29	7.82	5.32	6.85	4.32	6.07	5.48	5.40	4.00
76		8.67	8.53	6.64	8.13	5.79	7.33	4.85	6.41	3.87	5.43	2.87	4.42	3.91	3.85	2.63
85		10.42	10.36	8.93	10.34	8.22	9.71	7.34	8.85	6.39	7.90	5.40	6.89	4.38	4.32	3.22
86		10.59	10.54	9.17	10.57	8.48	9.96	7.61	9.11	6.66	8.16	5.67	7.16	4.65	4.36	3.28
100		12.52	12.61	12.16	13.40	11.79	13.14	11.05	12.44	10.15	11.52	9.15	10.48	8.06	7.79	3.92

Conclusion

-  Adopt COMPROMISE Power Backoff Schedule for initial ballot (see slide 8)
 -  Based on measured MDI power to compensate for PSD and transmitter power variation
 -  Line lengths for reference only
 -  Shown to keep margins balanced across line lengths
 -  Shown to allow for TX power variation
 -  Shown to allow for TX PSD variation
 -  Robust margins shown in simulation environment with all impairments
 -  Compromise to allow higher received signal power at MDI for short and long lines, improving EMI susceptibility