Exploring Effective Return Loss (ERL) as a Means to Improve Channel and Device Specifications v2

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Background and references

- http://www.ieee802.org/3/bs/public/17_07/mellitz_3bs_01a_0717.pdf
- http://www.ieee802.org/3/cd/public/adhoc/archive/mellitz_080217_3cd_02_adhoc.pdf

Agenda

- ERL results for collection of .3cd channels
- Simple experiment with 3 channels
- ERL and COM results
- Recommendation and next steps

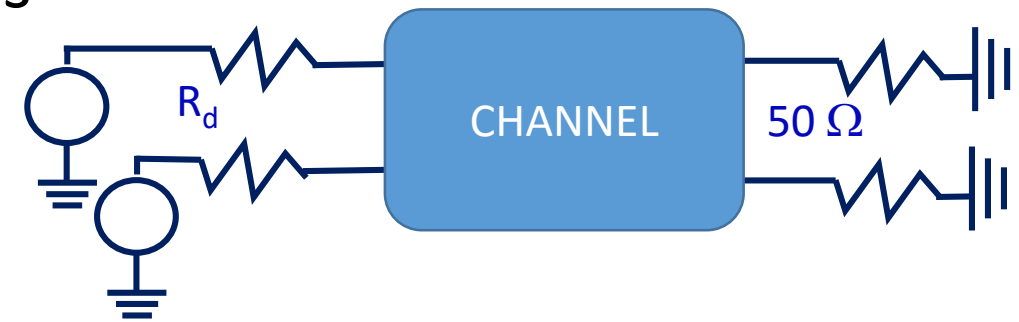
ERL suggests each port/channel has a best termination value.

Channel	ERL11 Z_t (dB)							ERL22 Z_t (dB)						
Z_t- (ohms)->	40	41.85	45	46.5	50	51.15	55	40	41.85	45	46.5	50	51.15	55
"8F--Ch1_10_8F_t"'	-7.8	-8.2	-8.9	-9.3	-9.8	-9.8	-9.3	-8.4	-8.9	-9.7	-10.0	-10.7	-10.7	-10.4
"TEC_STRADAWhisper11p75in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper11p75in_THRU_G14G15-07212016"'	-9.8	-10.4	-11.5	-11.9	-12.8	-12.8	-12.2	-9.5	-10.1	-11.0	-11.5	-12.4	-12.5	-11.9
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_Nom_thru"'	-8.6	-8.8	-8.7	-8.5	-7.9	-7.7	-7.0	-4.3	-4.5	-4.8	-4.9	-5.0	-4.9	-4.6
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_HzLzHz_thru"'	-9.0	-9.4	-9.1	-8.8	-8.1	-7.9	-7.2	-3.6	-3.8	-4.2	-4.4	-4.7	-4.8	-4.7
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_LzHzLz_thru"'	-6.6	-6.8	-6.9	-6.7	-6.3	-6.1	-5.6	-4.2	-4.4	-4.4	-4.4	-4.2	-4.1	-3.7
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_Nom_thru"'	-10.5	-10.9	-10.7	-10.3	-9.5	-9.2	-8.5	-7.5	-7.6	-7.4	-7.2	-6.6	-6.5	-5.9
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_HzLzHz_thru"'	-8.8	-9.1	-9.0	-8.7	-8.1	-7.9	-7.3	-4.6	-4.8	-5.2	-5.2	-5.2	-5.1	-4.8
"mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_LzHzLz_thru"'	-8.0	-8.1	-8.0	-7.8	-7.3	-7.1	-6.5	-6.8	-6.5	-6.0	-5.7	-5.2	-5.1	-4.6
"8F--Ch4_20_8F_t"'	-7.6	-7.9	-8.6	-8.9	-9.4	-9.4	-8.9	-9.7	-10.3	-11.3	-11.7	-12.3	-12.3	-11.6
"TEC_STRADAWhisper27in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper27in_THRU_G14G15_07202016"'	-10.2	-10.9	-12.0	-12.5	-13.5	-13.6	-12.9	-9.8	-10.5	-11.5	-12.0	-12.8	-12.9	-12.2
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_Nom_thru"'	-11.3	-11.7	-11.4	-11.0	-10.0	-9.7	-8.9	-5.5	-5.9	-6.4	-6.6	-6.7	-6.6	-6.2
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_HzLzHz_thru"'	-11.6	-12.0	-11.8	-11.4	-10.4	-10.1	-9.2	-4.6	-4.9	-5.4	-5.6	-6.1	-6.2	-6.3
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_LzHzLz_thru"'	-9.4	-9.7	-9.6	-9.3	-8.5	-8.3	-7.5	-5.8	-6.0	-6.2	-6.1	-5.7	-5.6	-5.1
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_Nom_thru"'	-13.0	-13.5	-13.1	-12.6	-11.5	-11.1	-10.1	-8.7	-9.0	-8.7	-8.4	-7.7	-7.5	-6.8
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_HzLzHz_thru"'	-10.9	-11.3	-11.2	-10.8	-9.9	-9.6	-8.8	-5.5	-5.8	-6.3	-6.4	-6.4	-6.3	-5.9
"mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_LzHzLz_thru"'	-10.9	-11.1	-10.7	-10.4	-9.5	-9.3	-8.5	-8.1	-7.7	-7.1	-6.8	-6.3	-6.1	-5.6
"20dB_HghZ--20dB_HighZ_thru"'	-11.8	-12.6	-14.0	-14.7	-16.3	-16.6	-15.7	-11.6	-12.3	-13.7	-14.4	-15.8	-16.1	-15.2
"20dB_HghZ_Nom_HighZ--20dB_HighZ_Nom_HighZ_thru"'	-12.8	-13.7	-15.2	-16.1	-18.0	-18.3	-17.2	-12.5	-13.4	-14.9	-15.7	-17.5	-17.8	-16.6
"8F--Ch8_30_8F_t"'	-8.3	-8.7	-9.5	-9.8	-10.4	-10.4	-9.8	-10.0	-10.6	-11.6	-12.0	-12.8	-12.8	-11.9
"TEC_STRADAWhisper40in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper40in_THRU_G14G15_07202016"'	-10.5	-11.2	-12.3	-12.9	-14.0	-14.1	-13.3	-10.1	-10.7	-11.8	-12.3	-13.2	-13.3	-12.5
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_Nom_thru"'	-12.1	-12.6	-12.3	-11.8	-10.7	-10.4	-9.4	-5.6	-6.0	-6.5	-6.8	-6.9	-6.8	-6.3
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_HzLzHz_thru"'	-12.5	-12.9	-12.6	-12.1	-11.0	-10.7	-9.7	-4.8	-5.1	-5.6	-5.8	-6.4	-6.5	-6.5
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_LzHzLz_thru"'	-10.3	-10.8	-10.6	-10.3	-9.3	-9.1	-8.2	-6.0	-6.3	-6.5	-6.4	-5.9	-5.8	-5.3
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_Nom_thru"'	-14.1	-14.7	-14.3	-13.7	-12.3	-11.9	-10.8	-9.1	-9.4	-9.1	-8.7	-8.0	-7.8	-7.1
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_LzHzLz_thru"'	-12.2	-12.4	-11.9	-11.5	-10.5	-10.2	-9.2	-8.4	-8.0	-7.4	-7.1	-6.5	-6.3	-5.8
"mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_HzLzHz_thru"'	-11.7	-12.2	-12.0	-11.6	-10.6	-10.3	-9.4	-5.8	-6.2	-6.7	-6.8	-6.8	-6.7	-6.2
"30dB_HghZ_Nom_HighZ--30dB_HighZ_Nom_HighZ_thru"'	-13.1	-14.0	-15.7	-16.5	-18.6	-19.1	-17.5	-13.0	-14.0	-15.6	-16.4	-18.4	-18.8	-17.2
"30dB_HighZ--30dB_HighZ_thru"'	-12.0	-12.8	-14.2	-14.9	-16.5	-16.9	-15.7	-12.0	-12.7	-14.0	-14.7	-16.3	-16.7	-15.5

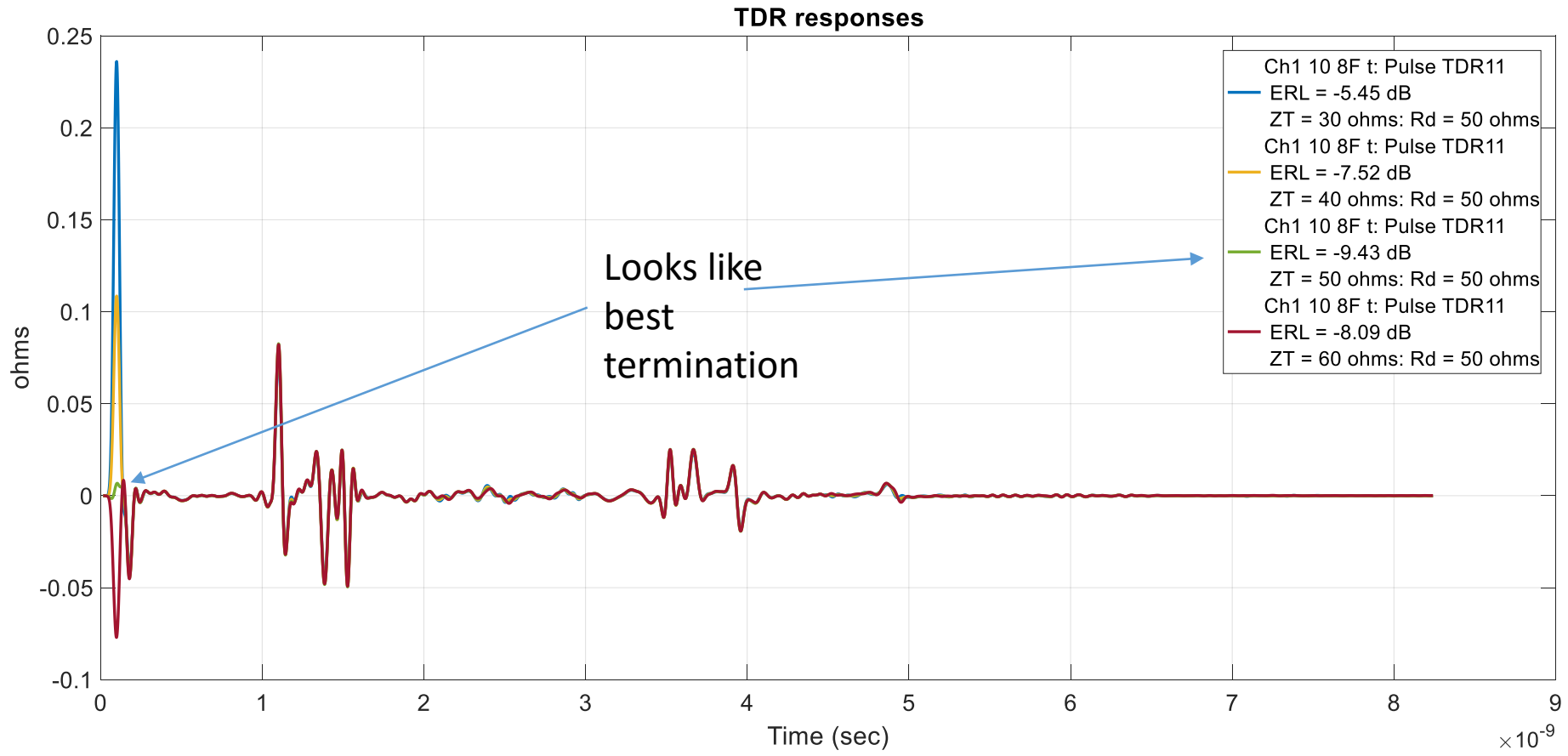
Color barred within a channel for port 1 and 2

Simple experiment

- No full packages
  - Only R_d
- No crosstalk
- Only change R_d Tx (and adjust A_v), R_d Rx = 50 ohms
- Drive impedance (R_d) variation 30 Ω, 40 Ω, 50 Ω, 60 Ω
- PTDR performed with Z_t=R_d variations
- 3 channels
  - CISCO channel Ch1 10 8F t
  - CAVIUM 20dB HighZ Nom HighZ
  - CAVIUM 30dB HighZ Nom HighZ thru

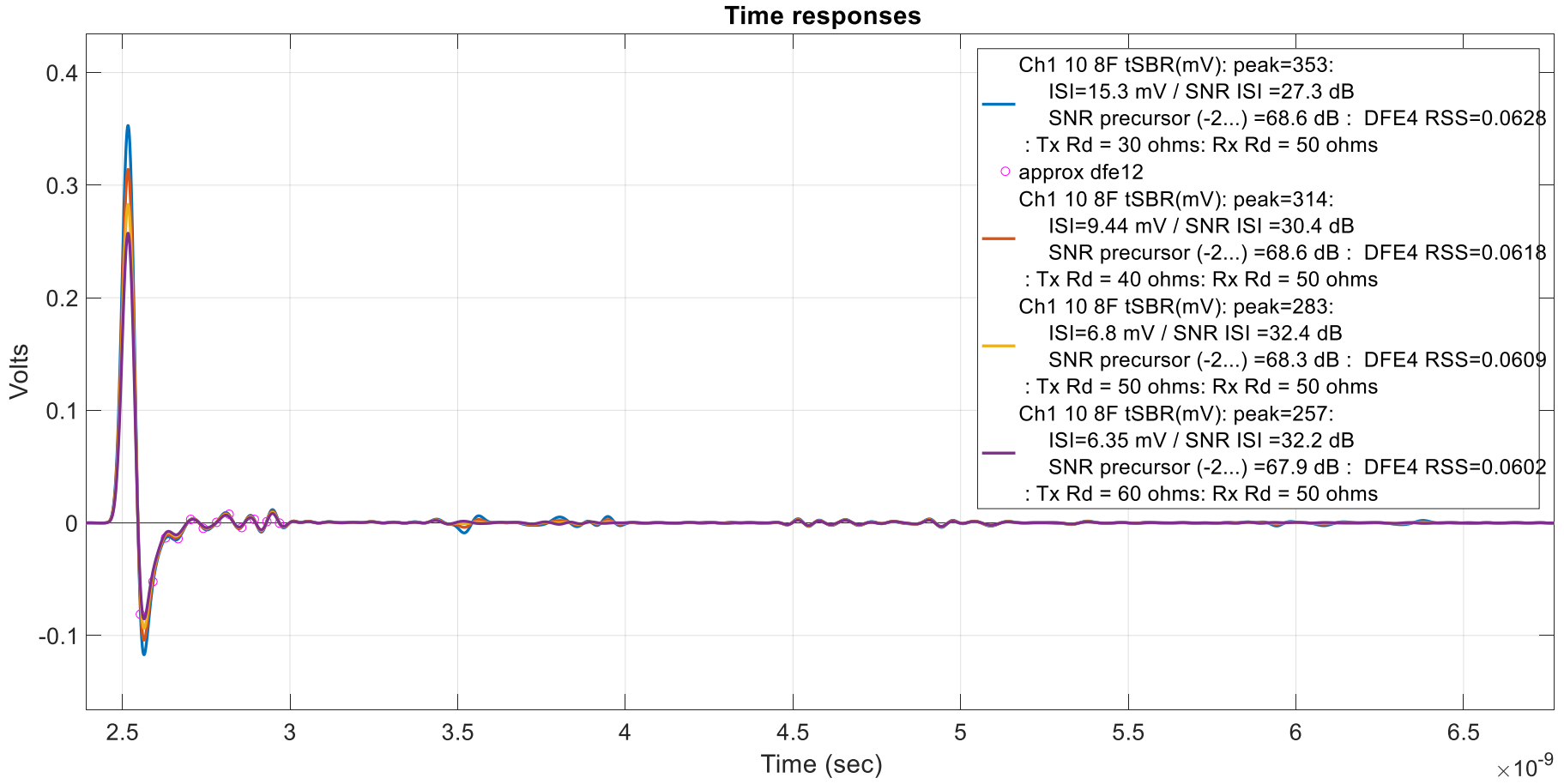


PTDR: CISCO channel Ch1 10 8F t w/ Z_t variation

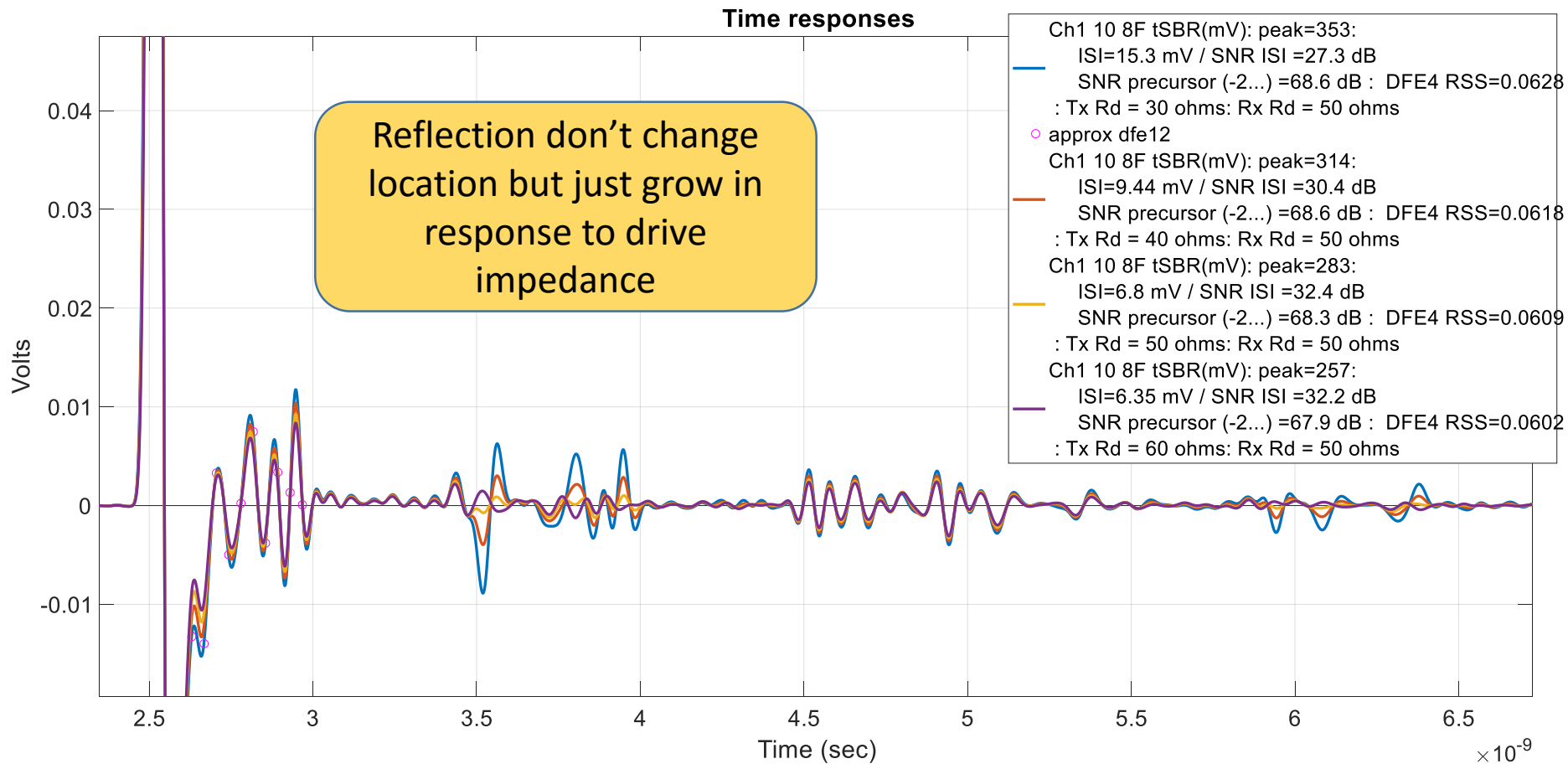


(Rd) variation

Pulse Response: CISCO channel Ch1 10 8F t w/ R_d variation



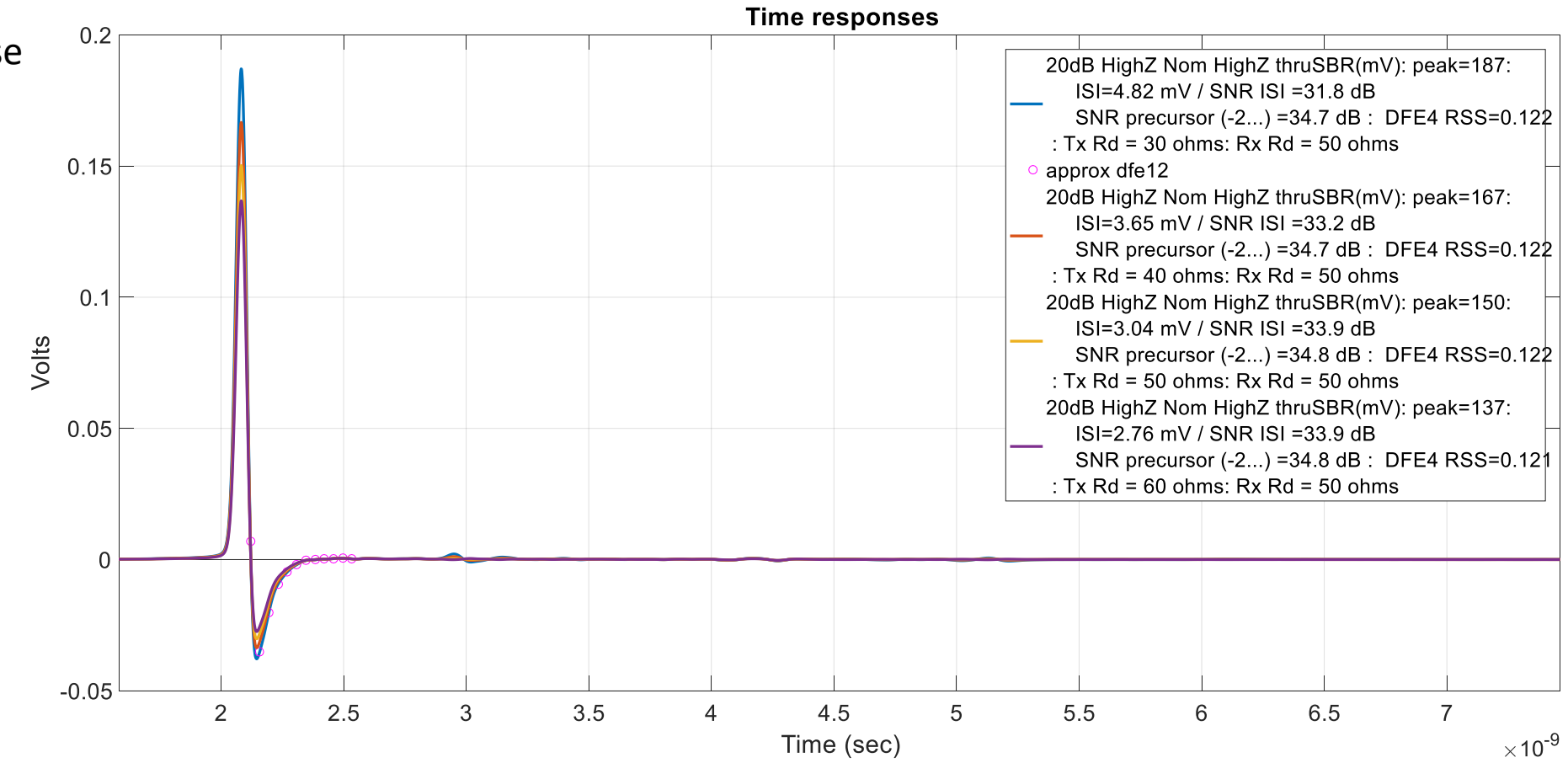
Pulse Response CISCO channel Ch1 10 8F t zoom w/ R_d variation



Modal plots: CISCO channel Ch1 10 8F. This channel has great COM margin even with crosstalk and full packages but fails RL mask

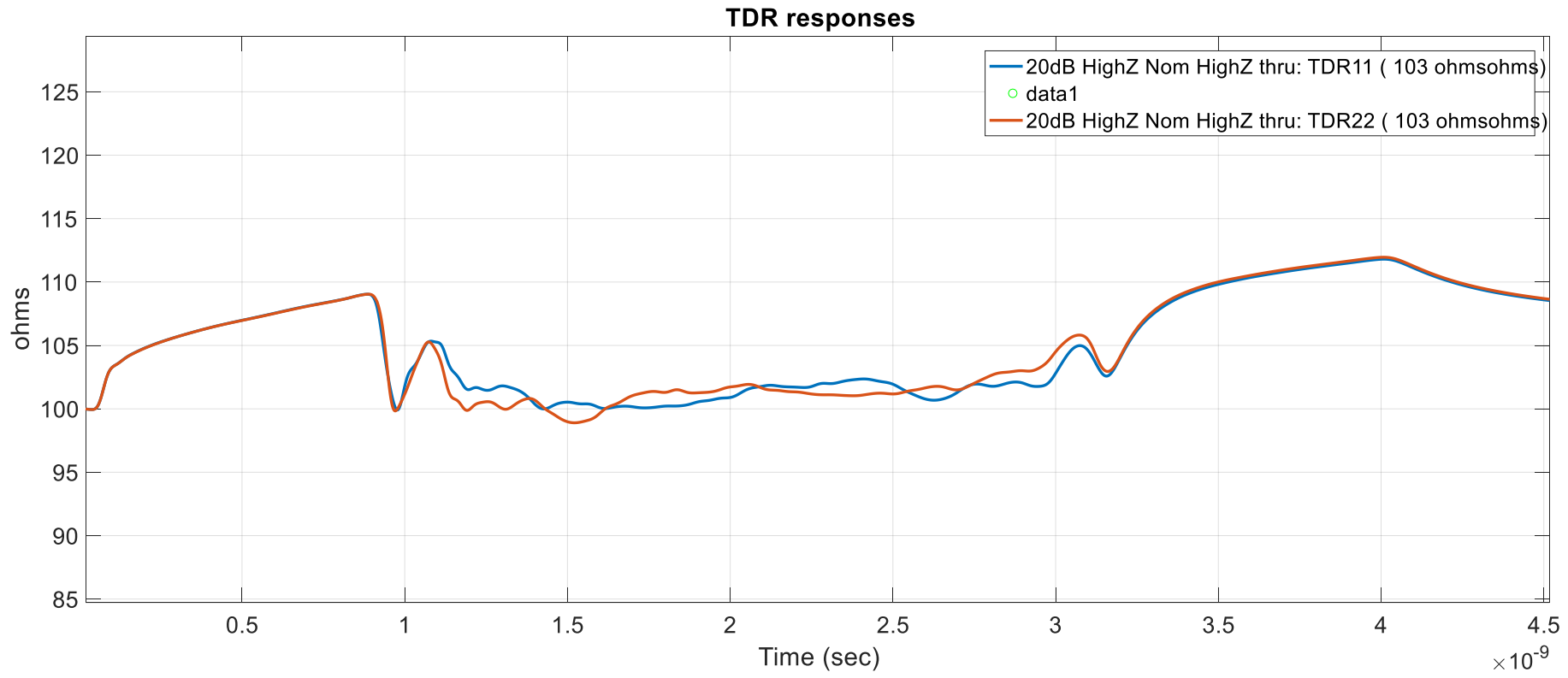
Pulse response: CAVIUM 20dB HighZ Nom HighZ channel w/ Z_t variation

Note: Pulse A_v are adjusted when running COM

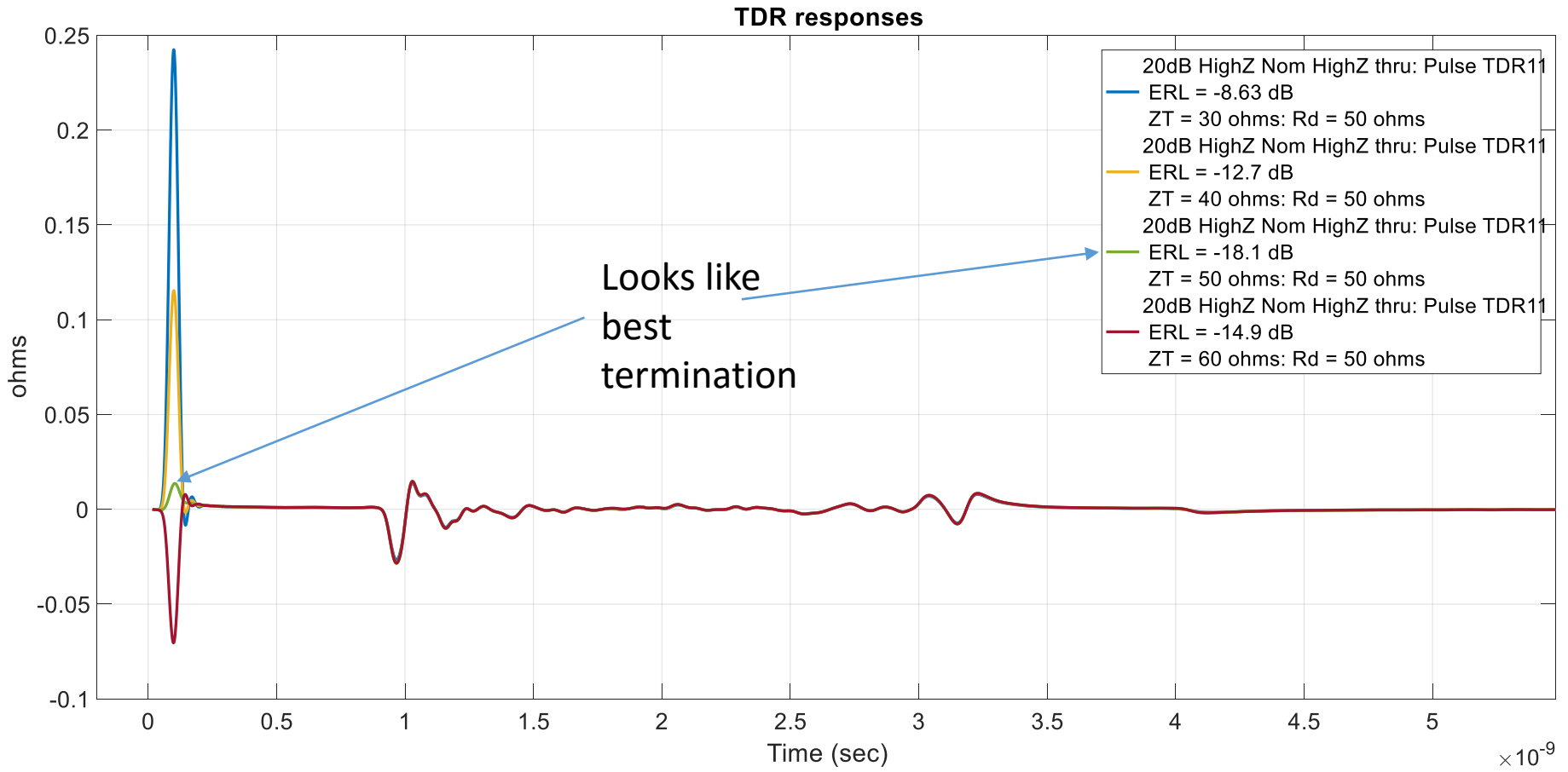


Pulse response: CAVIUM 20dB HighZ Nom HighZ channel ZOOM w/ R_d variation

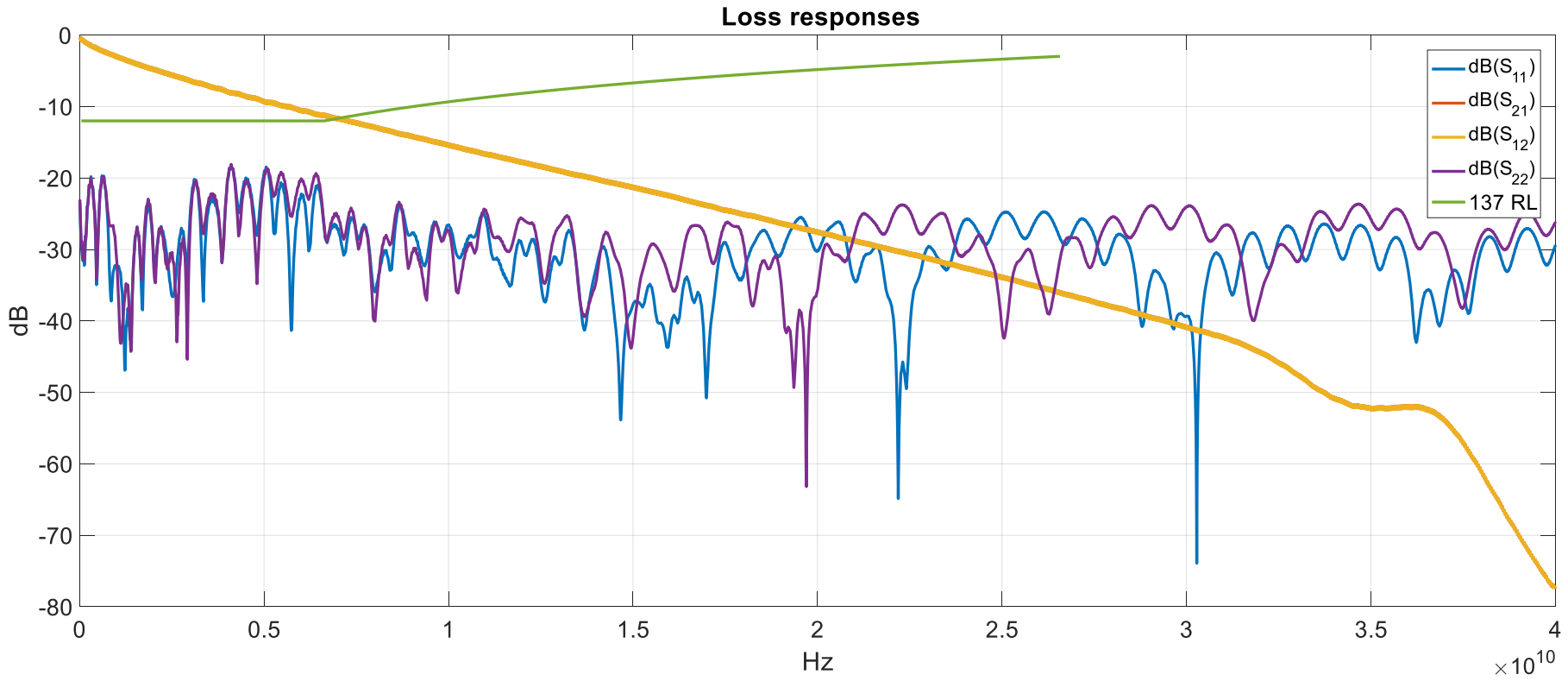
TDR: CAVIUM 20dB HighZ Nom HighZ channel



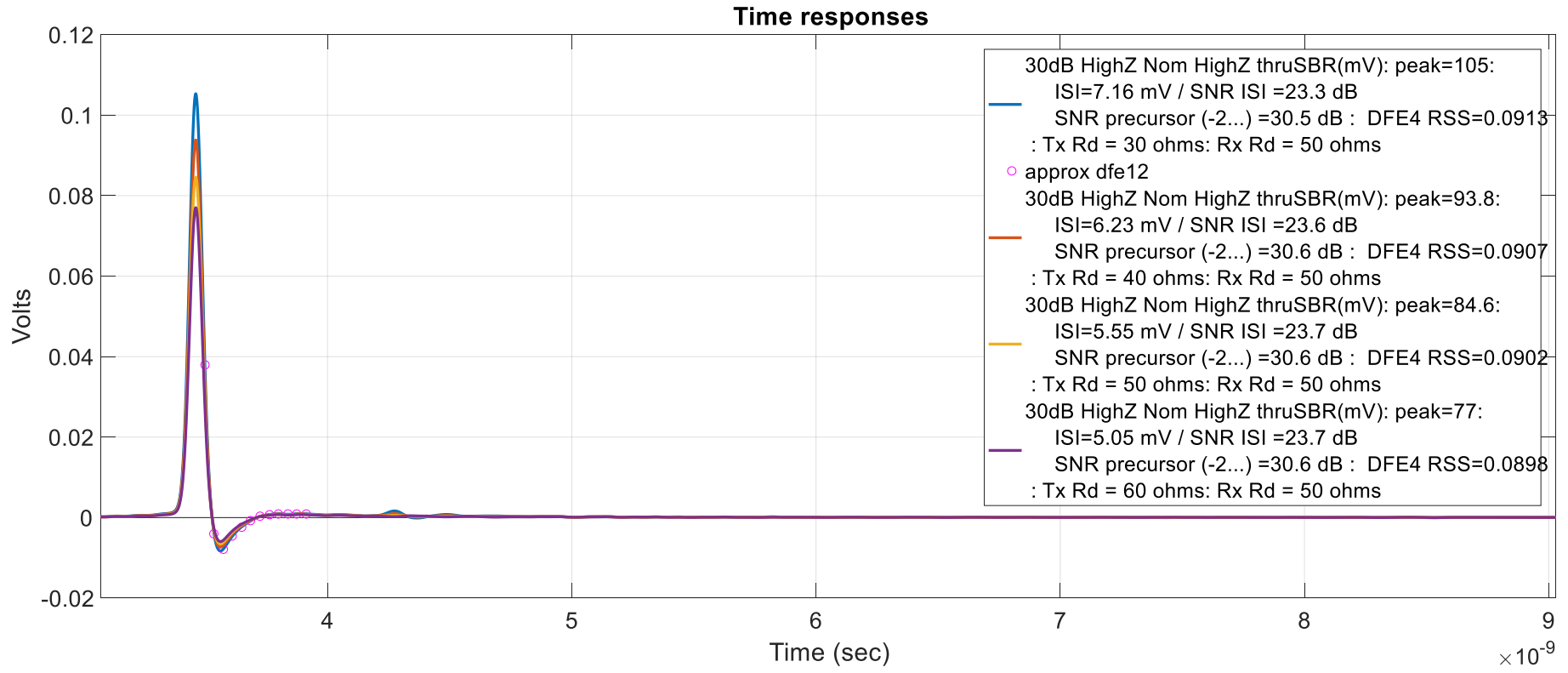
PTDR: 20dB HighZ Nom HighZ w/ Z_t variation



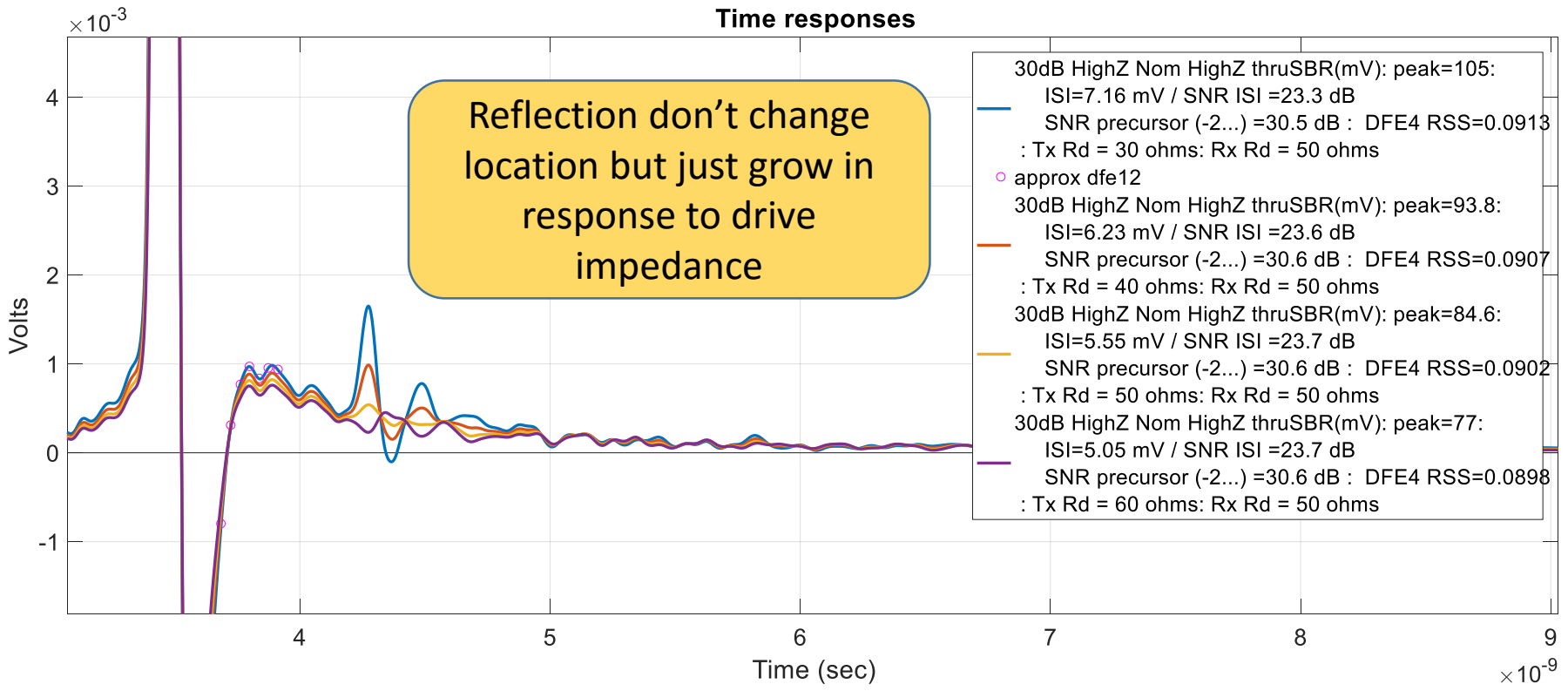
Modal plots: 20dB HighZ Nom HighZ



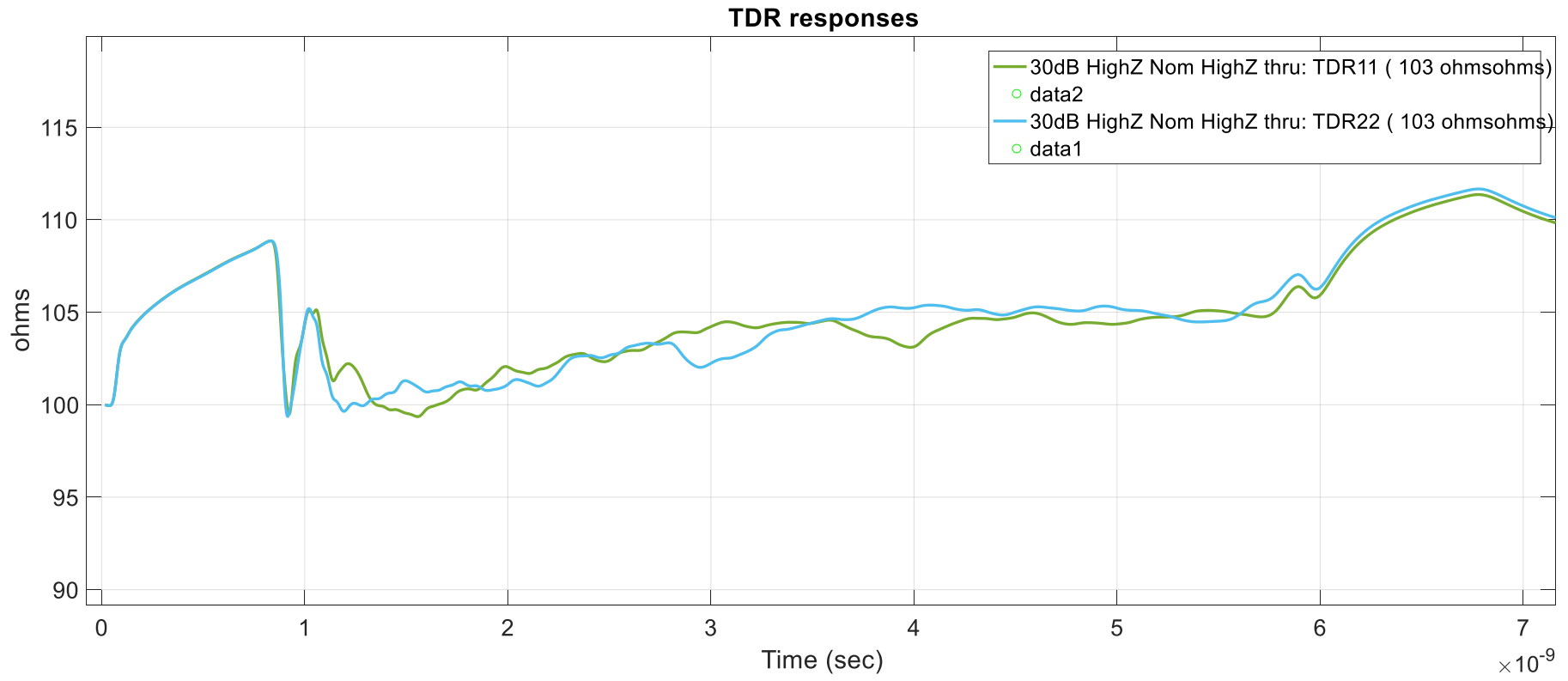
Pulse response CAVIUM 30dB HighZ Nom HighZ thru w/ Z_t variation



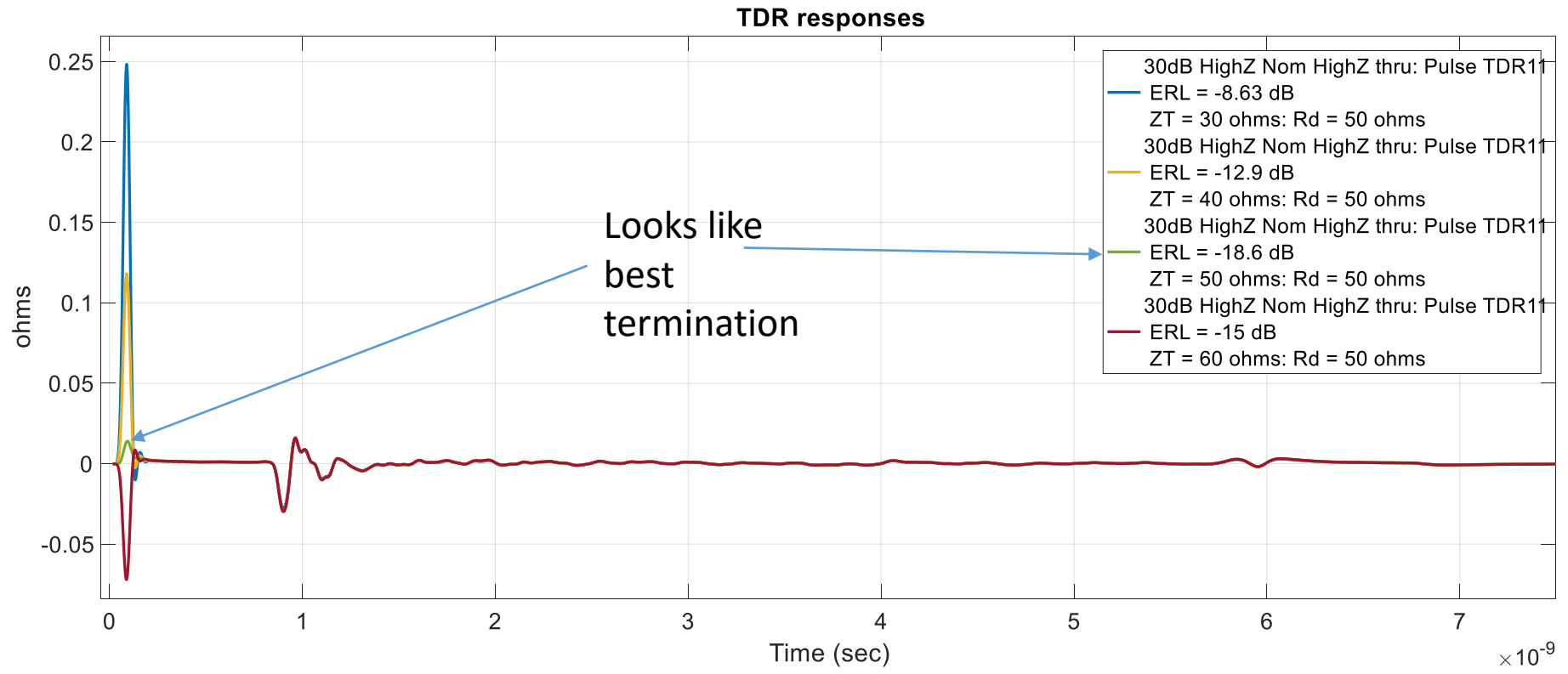
Pulse response CAVIUM 30dB HighZ Nom HighZ thru Zoom w/ R_d variation



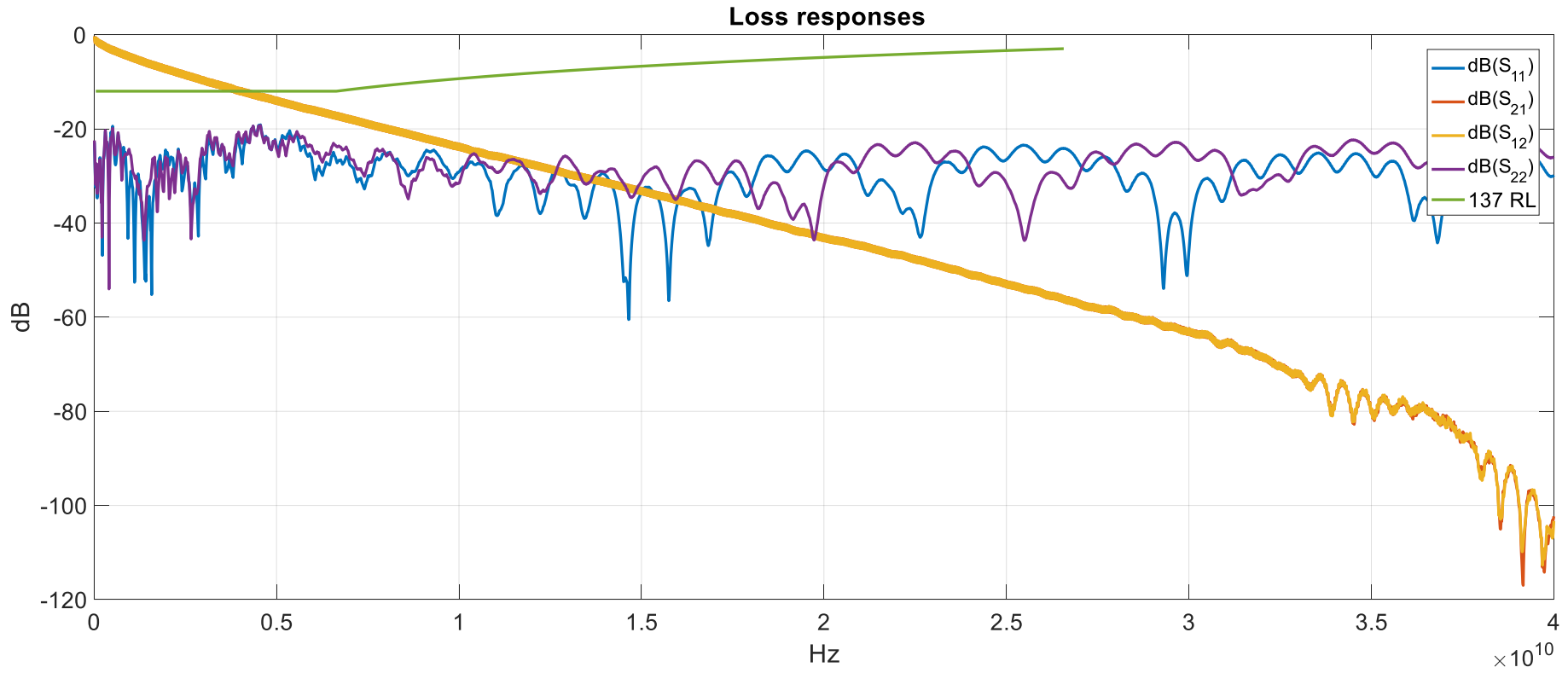
TDR: CAVIUM 30dB HighZ Nom HighZ thru



PTDR: CAVIUM 30dB HighZ Nom HighZ thru w/ Z_t variation



Modal plots CAVIUM 30dB HighZ Nom HighZ thru

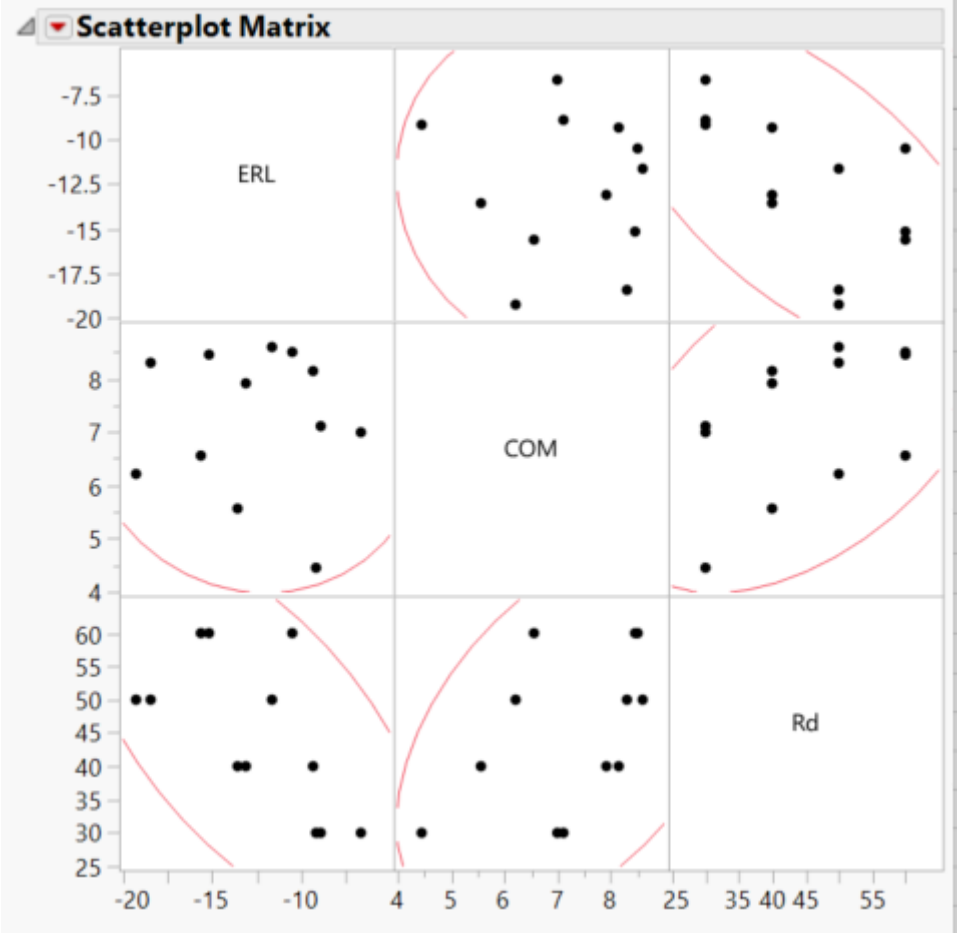


ERL vs COM vs Rd

	ERL (dB)	COM (dB)	Rd Tx (ohms)	Rd Rx (ohms)
CISCO channel Ch1 10 8F t	-6.6	7.00	30	50
	-9.3	8.15	40	50
	-11.6	8.60	50	50
	-10.5	8.50	60	50
CAVIUM 20dB HighZ Nom HighZ	-8.9	7.11	30	50
	-13.1	7.92	40	50
	-18.4	8.30	50	50
	-15.2	8.45	60	50
CAVIUM 30dB HighZ Nom HighZ thru	-9.1	4.45	30	50
	-13.6	5.56	40	50
	-19.3	6.21	50	50
	-15.6	6.56	60	50

- It looks like RL in not the only factor for COM.
  - The best channel impedance and other channel factors may interplay with the package (device)
  - Awaiting fuller DOE

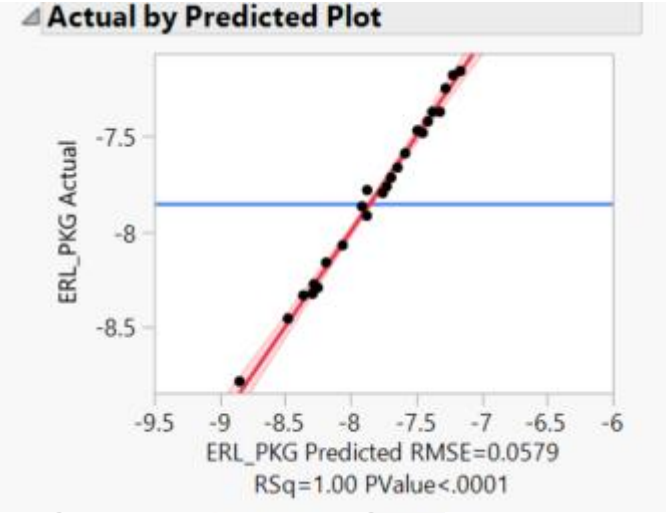
Poor correlation between COM, ERL, and R_d across all channels i.e. $r^2 < 50$ %

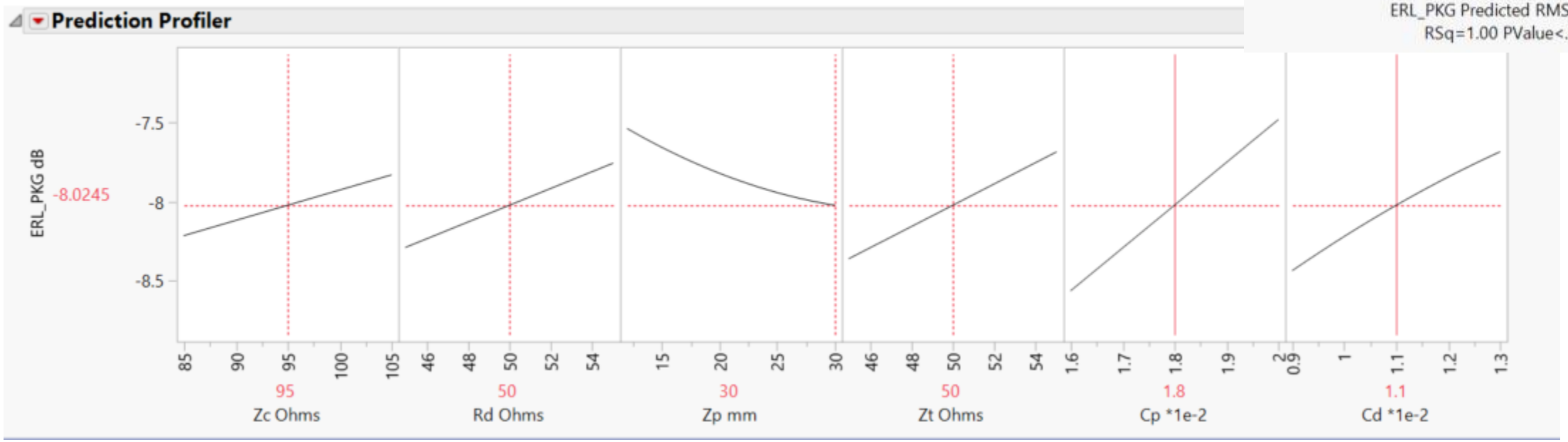


COM and ERL correlate well for a given channel, i.e. $r^2 > 80\ \%$

DOE of Package parameters vs ERL

Very good fit





Recommendation and Next Steps

- Recommend so far: Only apply return loss or ERL spec if COM is less than 3.5 dB
- See if limiting range of package parameters limits COM variability
  - Use ERL to limit package return loss
  - Looking like the device (package) limit would be ERL < -8 dB
- An ERL spec would allow for package trade off within the COM package parameters expected ranges
  - For example, high capacitances and high impedance may not work simultaneously
- Next DOE of package parameters computing COM for all channels
  - Investigate: Would limiting package parameter combination thus ERL limit COM variability?