Comment #74: Variation of COM Parameters for Package Trace and Termination Resistance

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IEEE P802.3cd 50GbE/100GbE/200GbE Task Force
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Background

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- Baseline COM Parameters specify
  - Two values (12mm and 30mm) for zp (package trace length)
  - Lower value (90Ω) than nominal for Zc (package trace impedance)
  - Higher value (55Ω) than nominal for Rd (termination resistance)

- There is a concern that the above combinations does not necessarily cover sufficient corner cases of variation of package trace and termination resistnace

- Hence, I have studied various combinations of variation of the above COM parameters

This presentation is an updated version of hidaka_100516_3cd_adhoc.pdf and hidaka_102616_3cd_adhoc.pdf which were presented at P802.3cd ad hoc call on October 5, 2016 and October 26, 2016

Varied COM Parameters

- The following Eight combinations of values were studied

zp Package trace length	Rd Termination resistance	Zc Package trace impedance
12 mm	45 Ω	90 Ω
		110 Ω
	55 Ω	90 Ω
		110 Ω
30 mm	45 Ω	90 Ω
		110 Ω
	55 Ω	90 Ω
		110 Ω

- The other COM Parameters are almost same as the basline
  - Excepting that fp2 is 25GHz that differs from 26.5625GHz in the baseline
    - It was 25GHz in slide 8 of kareti_083116_3cd_adhoc-v2.
      - All the COM Parameters are shown in a backup slide.

Channels

- 43 Channels were used
  - 10 Cisco Channels (CH1-10)
    - 10 Different Insertion Losses (10~35dB)
  - 15 Intel 100Ω Channels (CH11-25)
    - 5 Different Insertion Losses (10~30dB) x 3 Different Variations of Impedance
  - 15 Intel 85Ω Channels (CH26-40)
    - 5 Different Insertion Losses (10~30dB) x 3 Different Variations of Impedance
  - 3 TE Channels (CH41-43)
    - 3 Different Insertion Losses (10~32dB)

- Channel Data Source
  - Cisco and TE Channels are from P802.3cd Task Force Channel Area
  - Intel Channels are from 50G&NGOATH Stody Group Channel Area

- See backup slides for the details

Cisco Channels (CH1-10): ΔCOM Values

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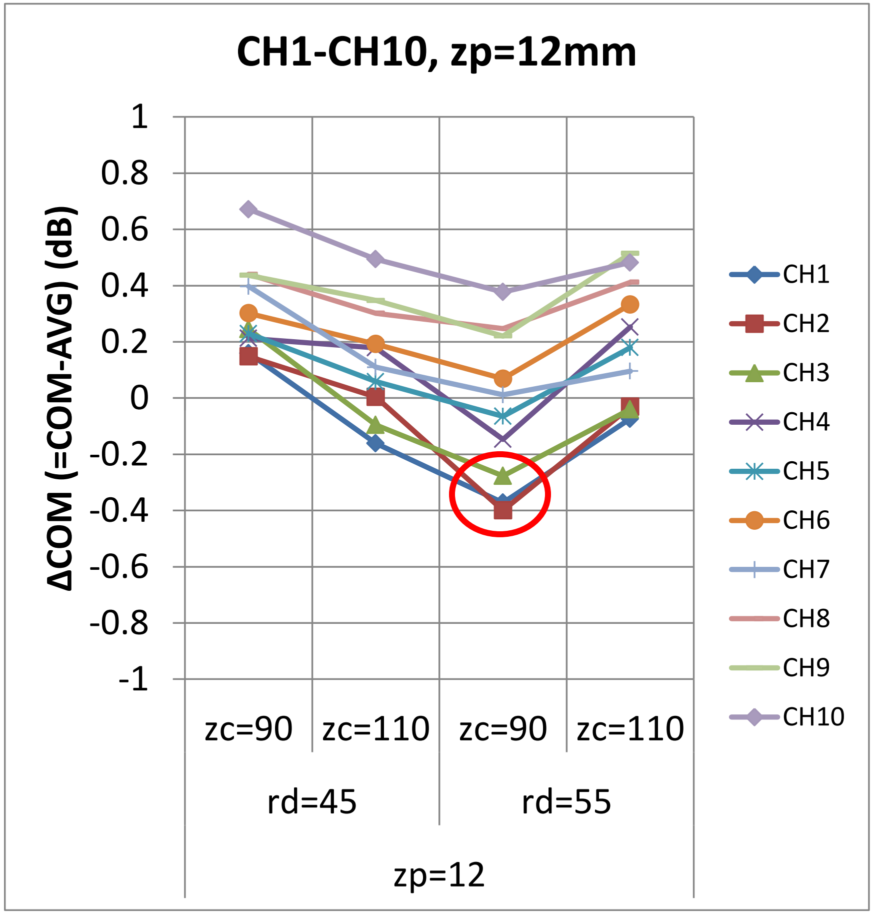
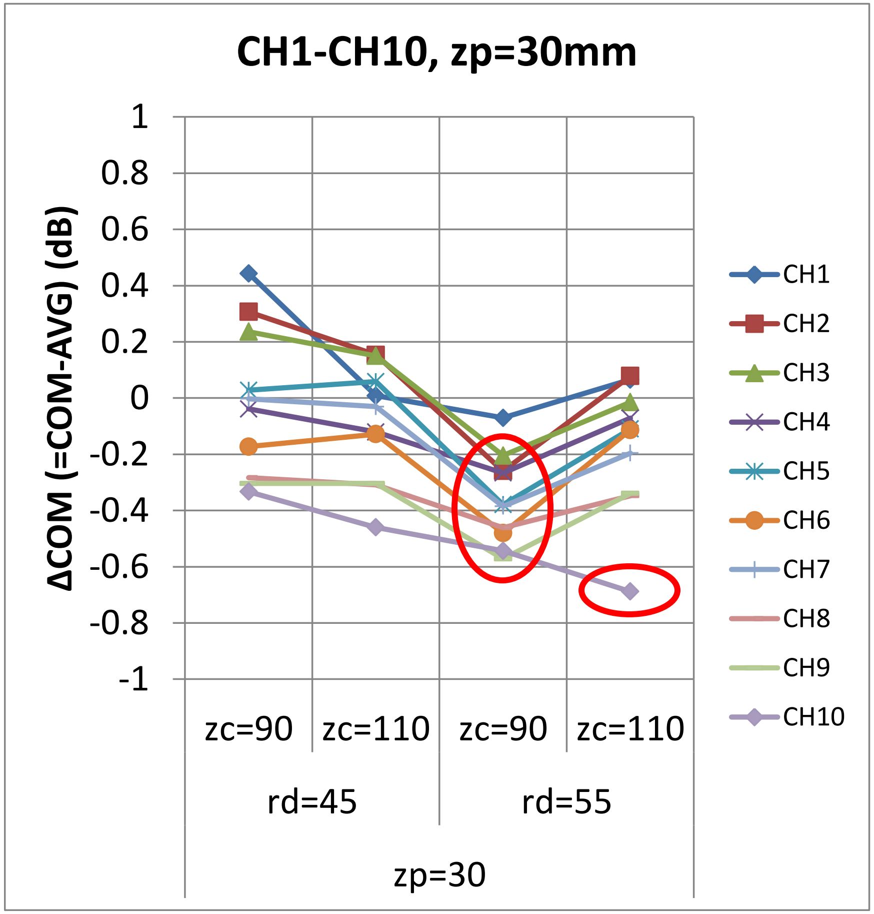
- The worst case is Zc=90Ω & Rd=55Ω or Zc=110Ω & Rd=55Ω
  - Zc=110Ω & Rd=45Ω is better than Zc=90Ω & Rd=55Ω
  - zp=30mm is worse than 12mm except CH1~3 where 12mm is worse





- ΔCOM Value = COM Value minus the average for the 8 combinations of COM parameters.

Intel 100Ω Channels (CH11-25): ΔCOM Values

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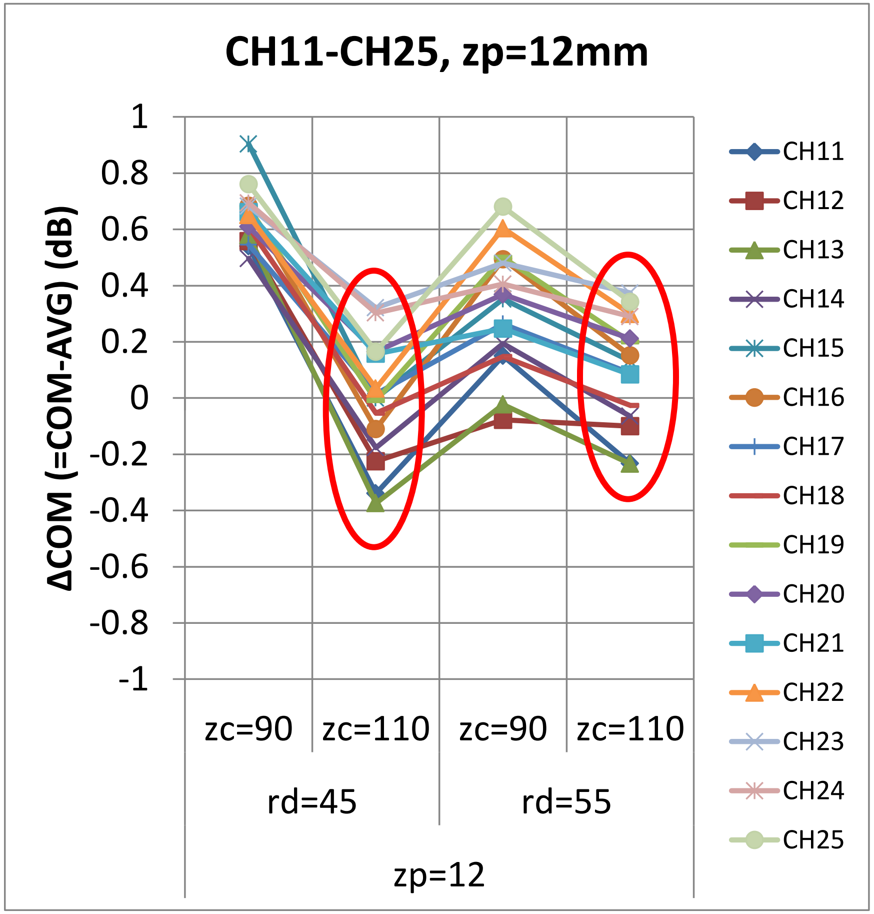
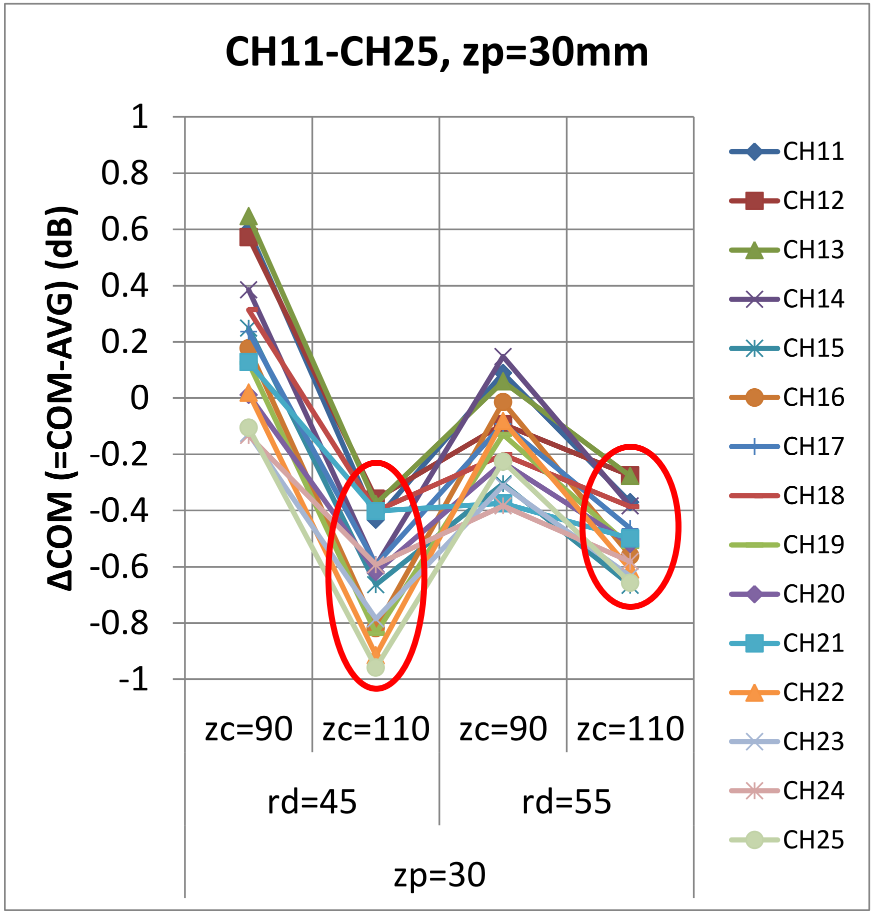
- The worst case is Zc=110Ω & Rd=45Ω or Zc=110Ω & Rd=55Ω
  - Zc=90Ω & Rd=55Ω is better than Zc=110Ω & Rd=45Ω or 55Ω
  - zp=30mm is worse than 12mm





- ΔCOM Value = COM Value minus the average for the 8 combinations of COM parameters.

Intel 85Ω Channels (CH26-40): ΔCOM Values

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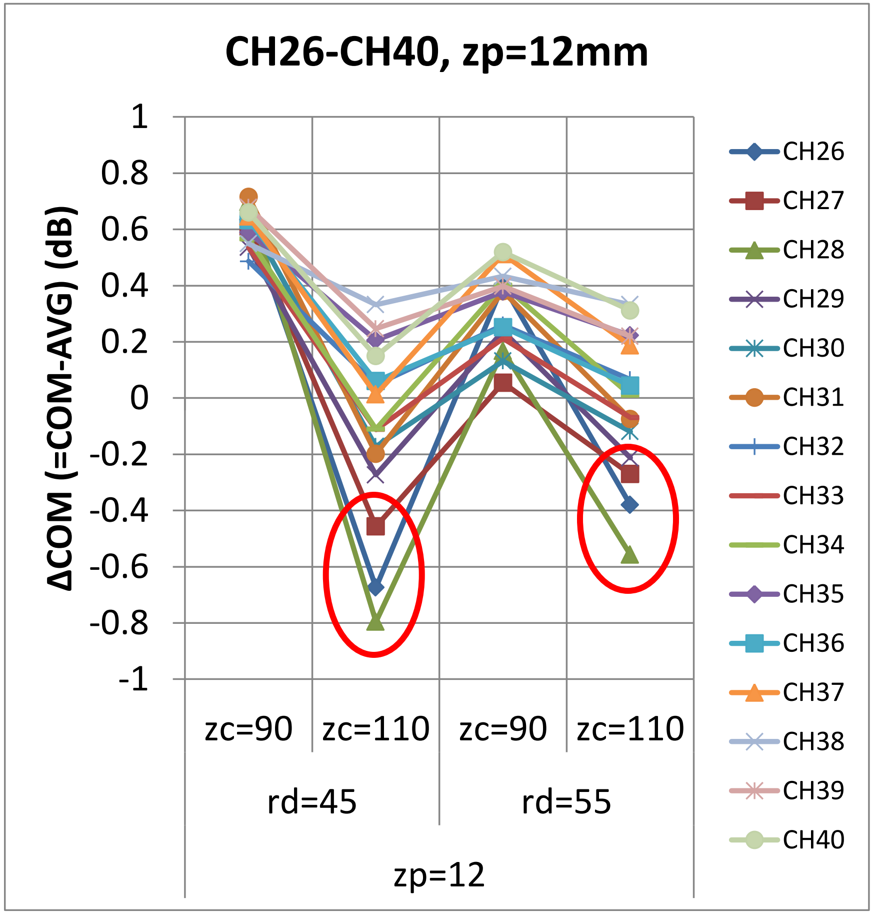
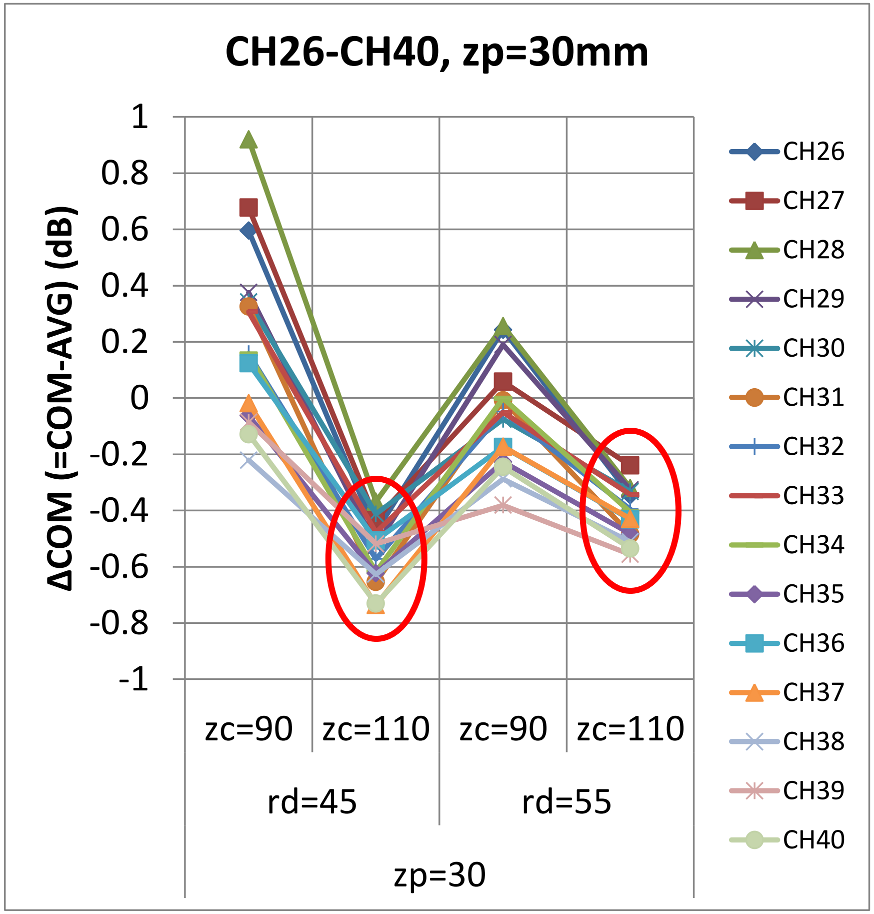
- The worst case is Zc=110Ω & Rd=45Ω or Zc=110Ω & Rd=55Ω
  - Zc=90Ω & Rd=55Ω is better than Zc=110Ω & Rd=45Ω or 55Ω
  - zp=30mm is worse than 12mm except CH26~28 where 12mm is worse

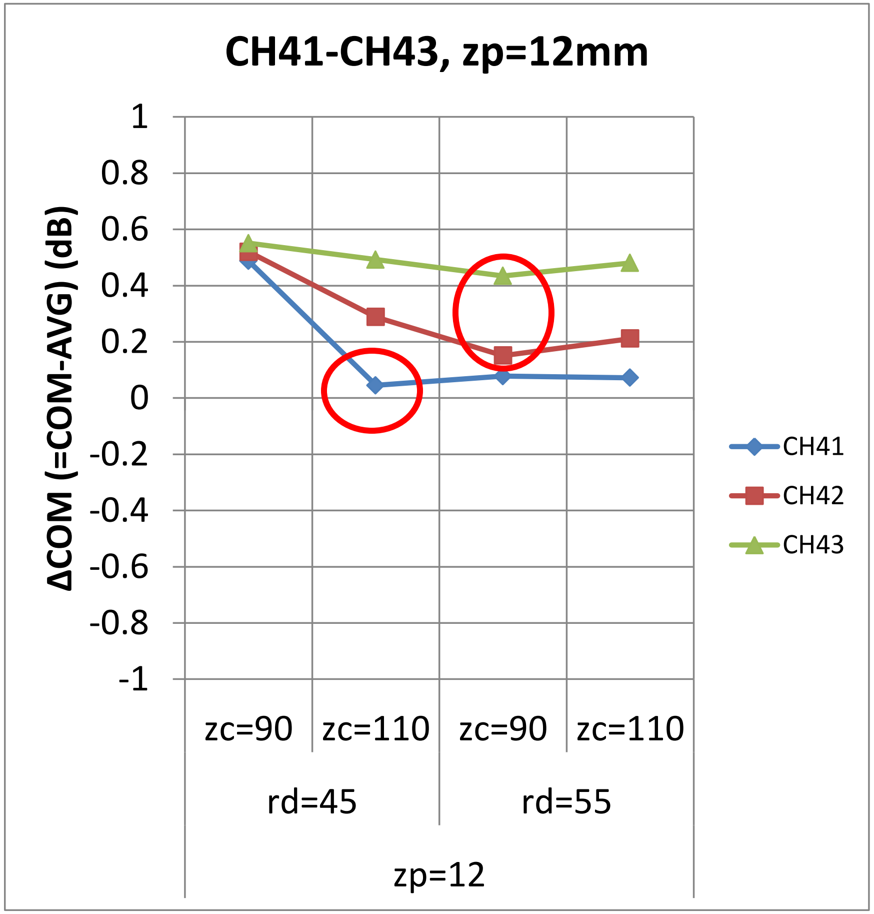


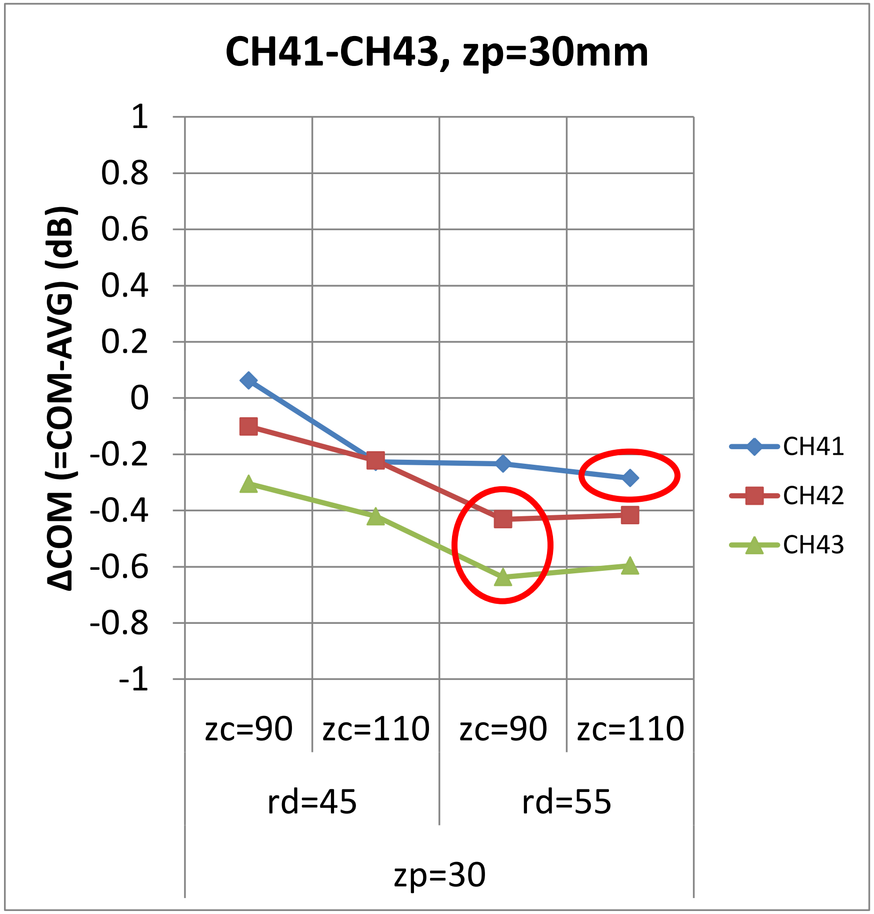


- ΔCOM Value = COM Value minus the average for the 8 combinations of COM parameters.

TE Channels (CH41-43): ΔCOM Values

- The worst case is Zc=90Ω & Rd=55Ω or Zc=110Ω & Rd=55Ω
  - zp=30mm is worse than 12mm
  - For zp=12mm, the worst is Zc=110Ω & Rd=45Ω or Zc=90Ω & Rd=55Ω



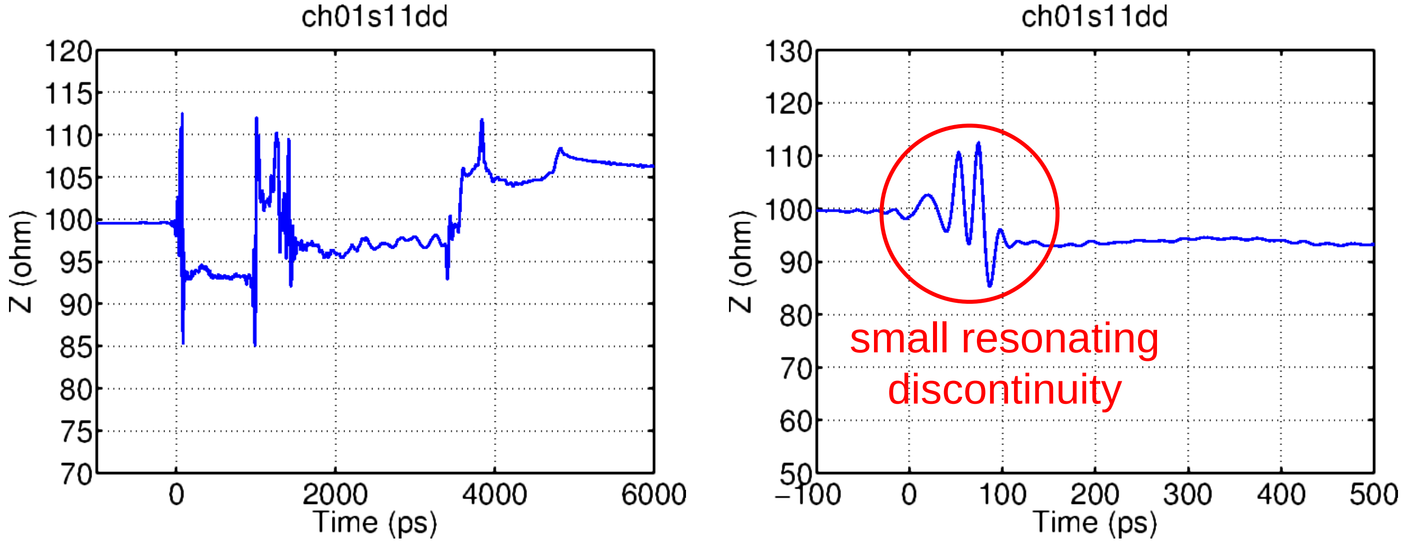


- ΔCOM Value = COM Value minus the average for the 8 combinations of COM parameters.

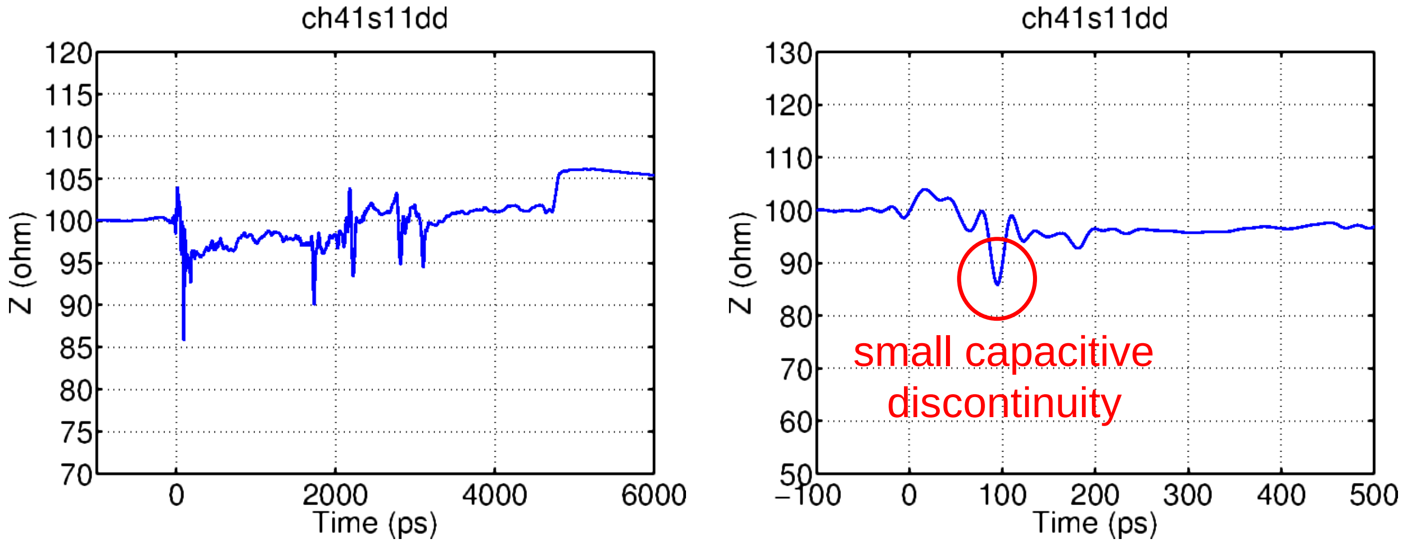
Representative Zdiff Profile of Cisco and TE Channels

- Small resonating or capacitive discontinuities near port entry

Cisco 10dB
(CH1)
S11dd
Port 1



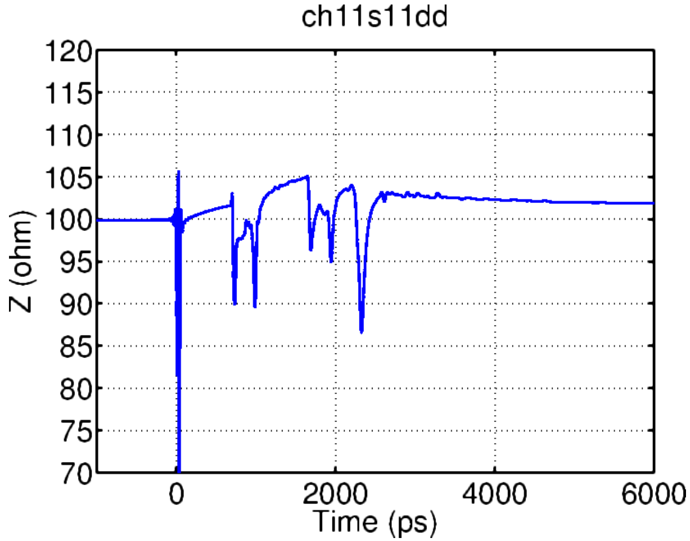
TE 11.75in
(CH41)
S11dd
Port 1

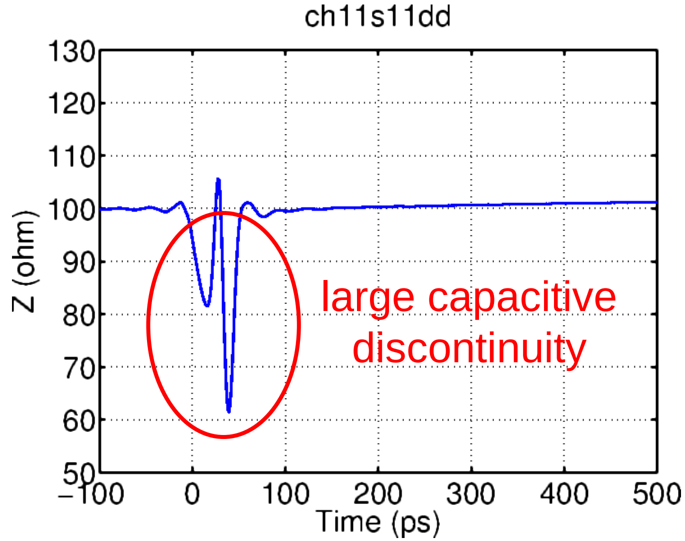


Representative Zdiff Profile of Intel Channels

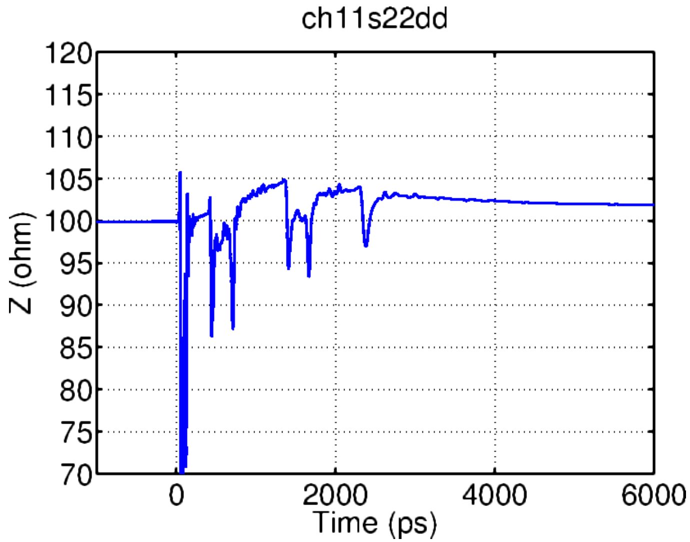
- Large spike-like capacitive discontinuities near port entry

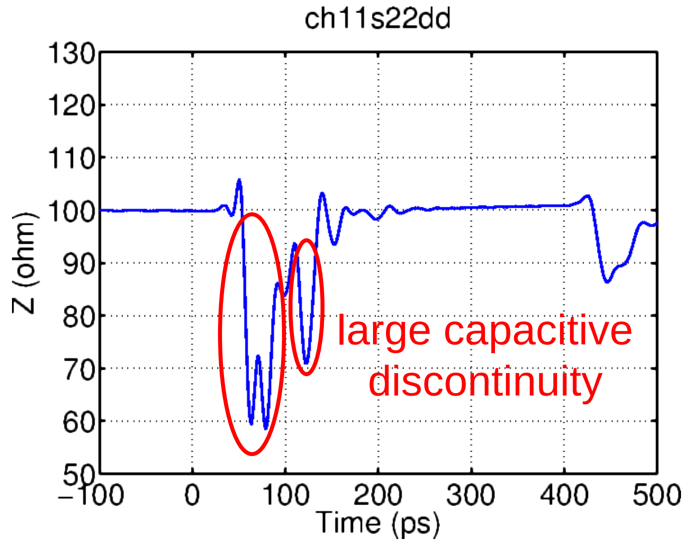
Intel 100Ω
10dB Nom
(CH11)
S11dd
Port 1





Intel 100Ω
10dB Nom
(CH11)
S22dd
Port 2





Effect on Tx amplitude and Tx SNDR

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- There was a concern that if we change Rd and Zc, Tx-related COM parameters such as Av, Afe, Ane and SNR_{TX} may have to be changed consistently, because Tx output amplitude and Tx SNDR may be also affected by package parameters

- Hence, I have conducted additional study

- As a result, I have concluded that the effect on Tx amplitude and Tx SNDR is rather small for Tx model in COM
  - This is because Tx model in COM does not have the voltage-dividing effect of termination resistor in real Tx circuit
  - The result was presented at P802.3cd ad hoc call on October 26, 2016
    - The result is included in the backup slide

Conclusion

- The current values of Rd (55Ω) & Zc (90Ω) do not cover the worst case.
  - In the worst case, the COM value may be degraded by up to ~1dB.

- The following test cases are recommended to cover the worst case:

COM Parameter	Test Cases						Unit
	#1	#2	#3	#4	#5	#6	
zp (Package trace length)	12			30			mm
Rd (Termination resistance)	45	55		45	55		Ω
Zc (Package trace impedance)	110	90	110	110	90	110	Ω

  - We may drop test cases of zp=12mm, because zp=12mm is the worst only for 10dB channels, where COM is high enough.

- All the test cases are not necessarily to be tested for all the time.
  - Once the worst case is identified, we may focus on the worst case, because the worst case is quite often same for similar channels.
    - The worst case is different for quite different channels.

Options

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Option A

COM Parameter	TC1	TC2	TC3	TC4	TC5	TC6	Unit
zp (Package trace length)	12			30			mm
Rd (Termination resistance)	45	55		45	55		Ω
Zc (Package trace impedance)	110	90	110	110	90	110	Ω

Option B

COM Parameter	TC1	TC2	TC3	Unit
zp (Package trace length)	30			mm
Rd (Termination resistance)	45	55		Ω
Zc (Package trace impedance)	110	90	110	Ω

Option C (No Change)

COM Parameter	TC1	TC2	Unit
zp (Package trace length)	12	30	mm
Rd (Termination resistance)	55		Ω
Zc (Package trace impedance)	90		Ω

Back up Slides

- COM Parameters in this study
- Simulation for Effect on Tx amplitude and SNDR
- Channel Data Source
- Channel Characteristics
- Absolute COM Values
- Select Channel Zdiff Profile

COM Parameters in This Study

- This table is same as slide 8 of kareti_083116_3cd_adhoc-v2.
  - f_p2 is 25GHz. It is 26.5625GHz in the baseline kareti_3cd_01a_0916.
  - Circled parameters were varied in this study.

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	26.5625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.8e-4 1.8e-4]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[30]	mm	[test cases]
z_p (NEXT)	[12]	mm	[test cases]
z_p (FEXT)	[30]	mm	[test cases]
z_p (RX)	[30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.25:0.05:0]		[min:step:max]
c(-2)	[0.0:0.025:0.1]		[min:step:max]
c(1)	[-0.25:0.05:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	10.625	GHz	
f_p1	10.625	GHz	
f_p2	25	GHz	
A_v	0.45	V	
A_fe	0.45	V	
A_ne	0.63	V	
L	4		
M	32		
N_b	12	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.64E-08	V^2/GHz	
SNR_TX	32.5	dB	
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	logical	0, 1, 2

g_DC_HP	[-6:1:0]	dB	[min:step:max]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM50_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 2 3 4]	
RUNTAG	_CDAUI-8	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	1.30E-02	ns
T_r_filter_type	1	logical
T_r_meas_point	0	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical
COM_CONTRIBUTION	0	logical
CDR_OVERSAMPLED	0	logical

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	90	Ohm

Table 92–12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	110	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

Sim Parameters for Tx amplitude and SNDR

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- The following 10 combinations of parameters were simulated

Case	zp Package trace length	Rd Termination resistance	Zc Package trace impedance
#1	12 mm	45 Ω	90 Ω
#2			110 Ω
#3		55 Ω	90 Ω
#4			110 Ω
#5	30 mm	45 Ω	90 Ω
#6			110 Ω
#7		55 Ω	90 Ω
#8			110 Ω
#9	12 mm	50 Ω	100 Ω
#10	30 mm		

- The original conditions were #3 and #7
- The proposed conditions were #2/#3/#4 and #6/#7/#8

Sim Model for Tx amplitude and SNDR

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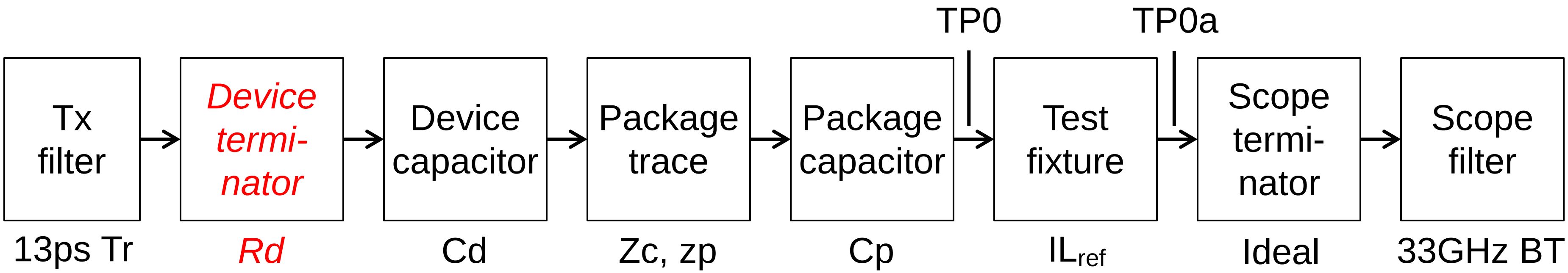

- Tx filter: $S_{21} = (\mathrm{EQ93A{-}46} | T_r = 13\mathrm{ps}, \beta = 2)$ (i.e. 13ps 20-80% Tr)
- Device terminator: $S_{21} = 1, S_{22} = \frac{Rd - 50\Omega}{Rd + 50\Omega}$ (i.e. same as Tx in COM)
  - *No effect of impedance matching on amplitude* (i.e. only effect on reflection)
- Device capacitor: $S = (\mathrm{EQ93A{-}8} | C = C_d)$
- Package trace: $S = \left(\mathrm{EQ93A{-}13{,}14} \middle| \mathrm{Table93A{-}3\ except\ } Z_c, z_p\right)$
- Package capacitor: $S = \left(\mathrm{EQ93A{-}8} \middle| C = C_p\right)$
- Test fixture: $|S_{21}| = 10^{-(\mathrm{EQ93{-}1})/20}, \angle S_{21} = \mathrm{minimum\ phase}(|S_{21}|)$
- Scope terminator: $S_{21} = 1, S_{11} = 0$ (i.e. ideal)
- Scope filter: 4-th order Bessel-Thomson LPF with 33GHz 3dB BW
  - $\omega_0 = 98.2896714244743 5\ \mathrm{G\ rad/s}$

Effect on v_f (Np=200)

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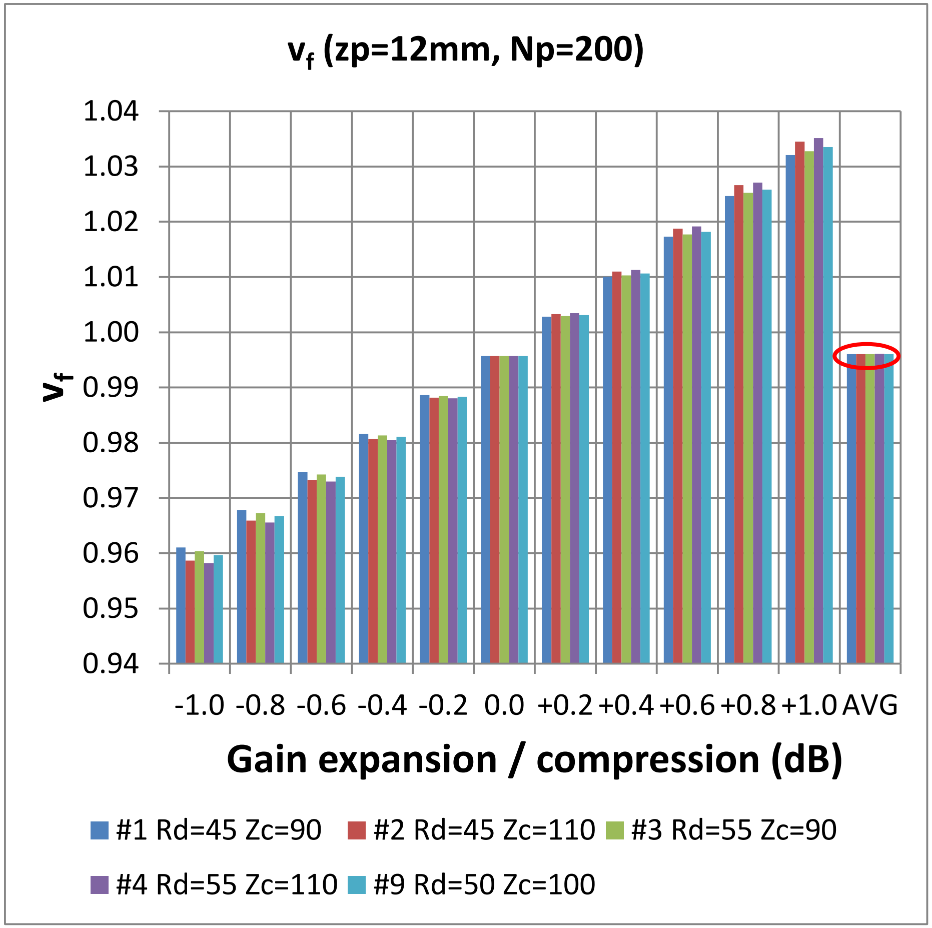
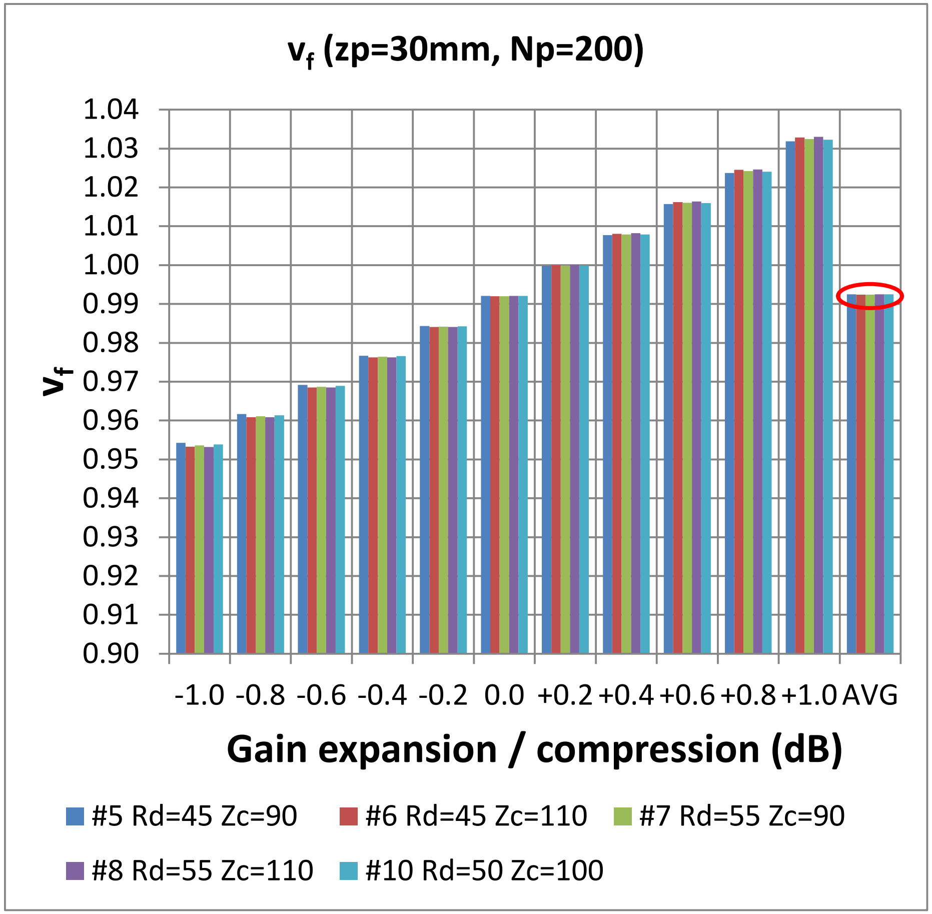
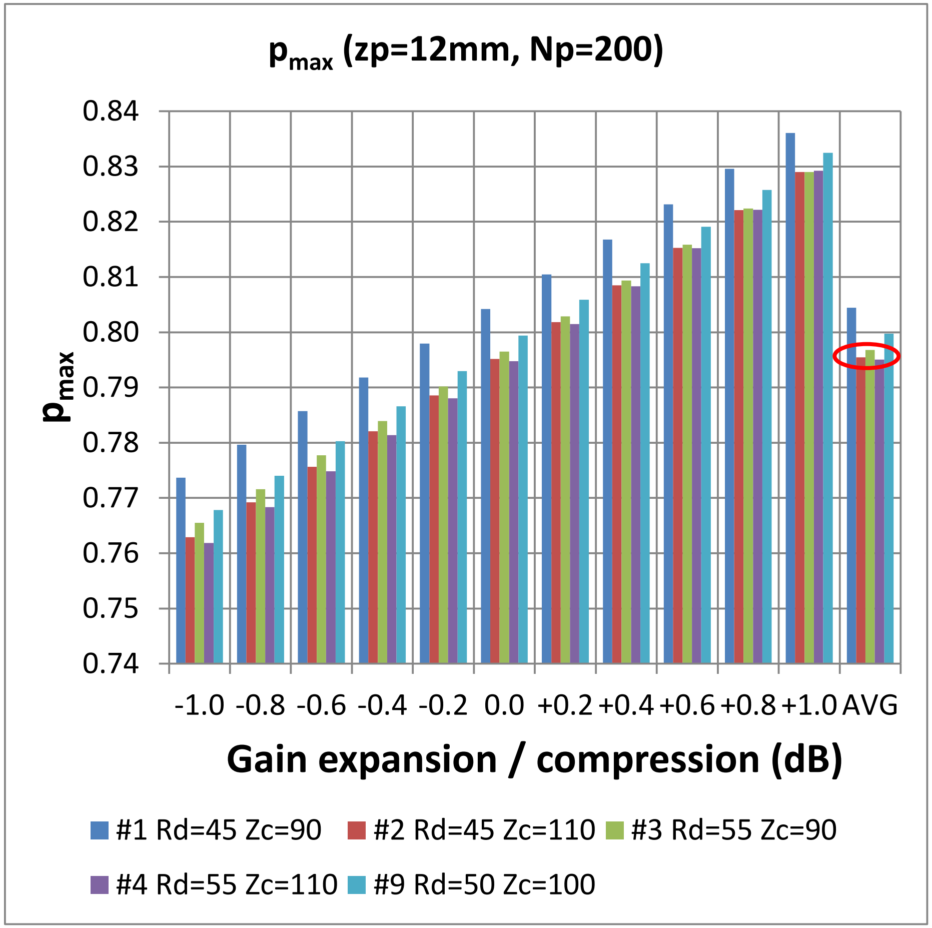
- The effect of Rd and Zc on v_f is very small

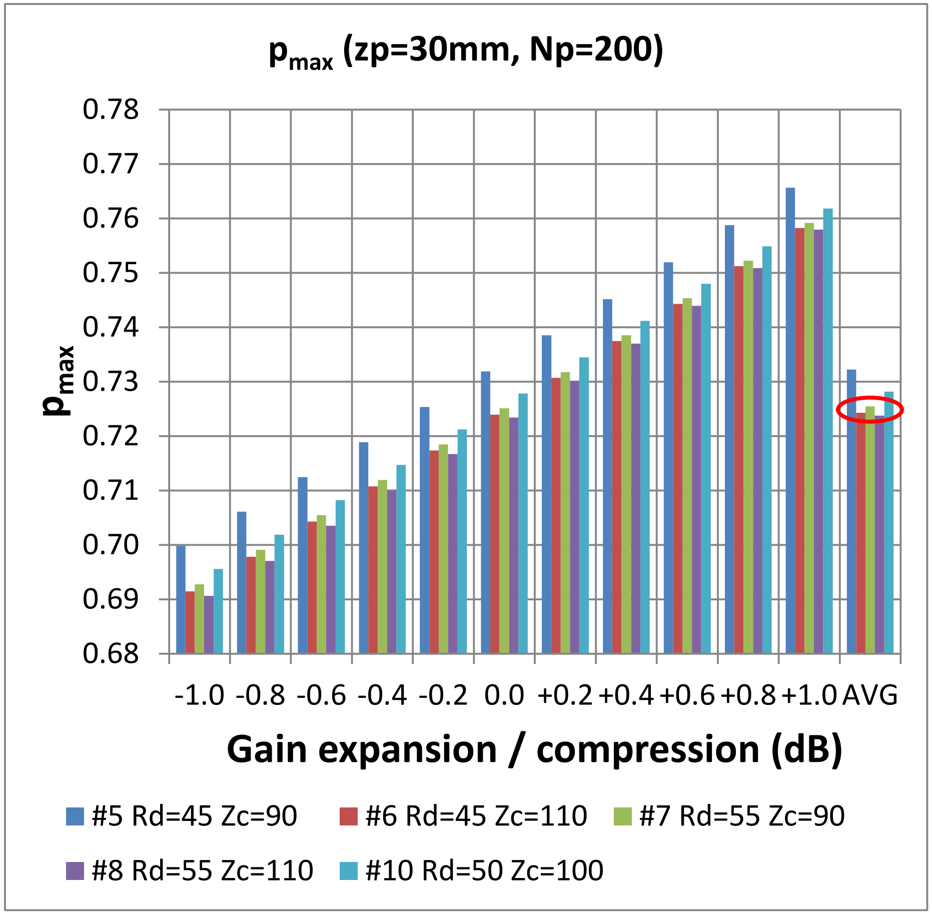




Effect on p_{max} (Np=200)

- The effect of Rd and Zc on p_{max} is very small





Effect on the Ratio of p_{max} to v_f (Np=200)

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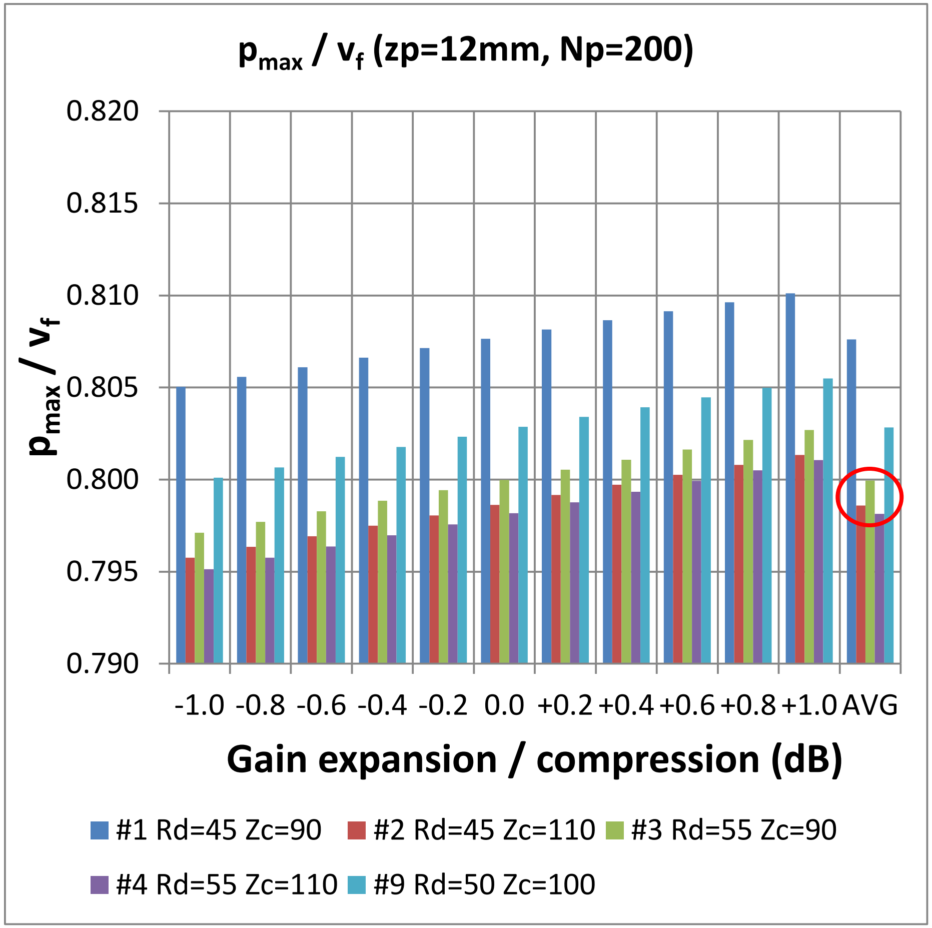
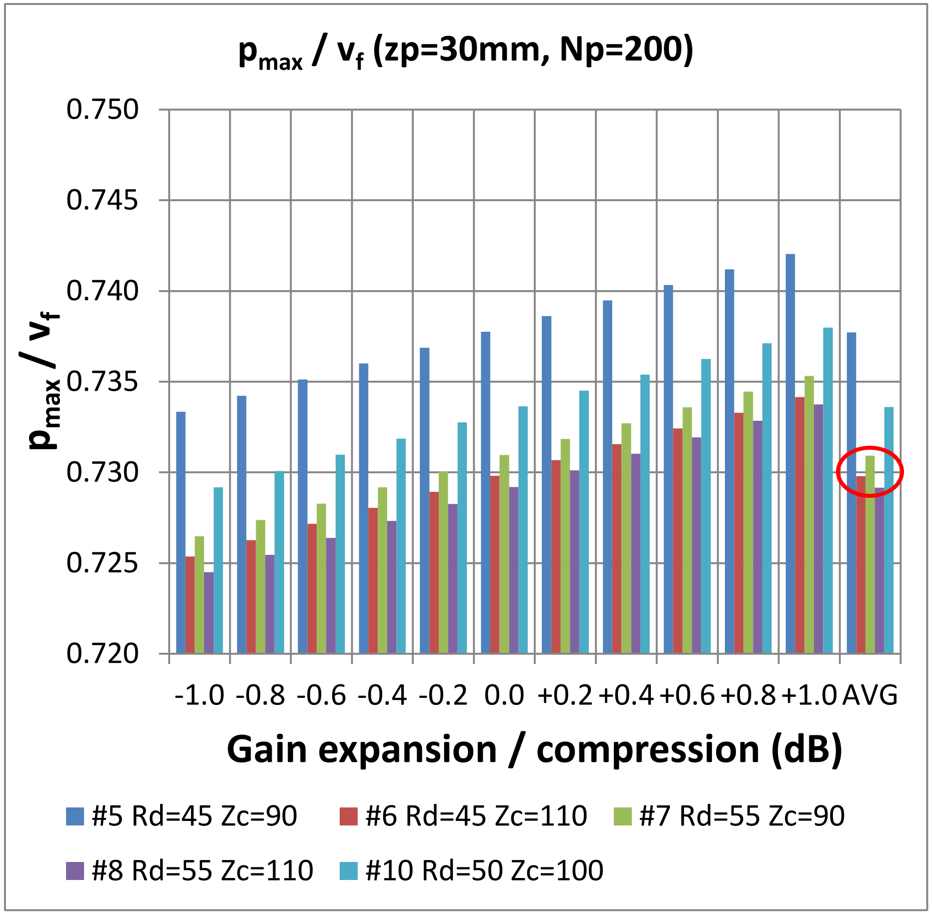
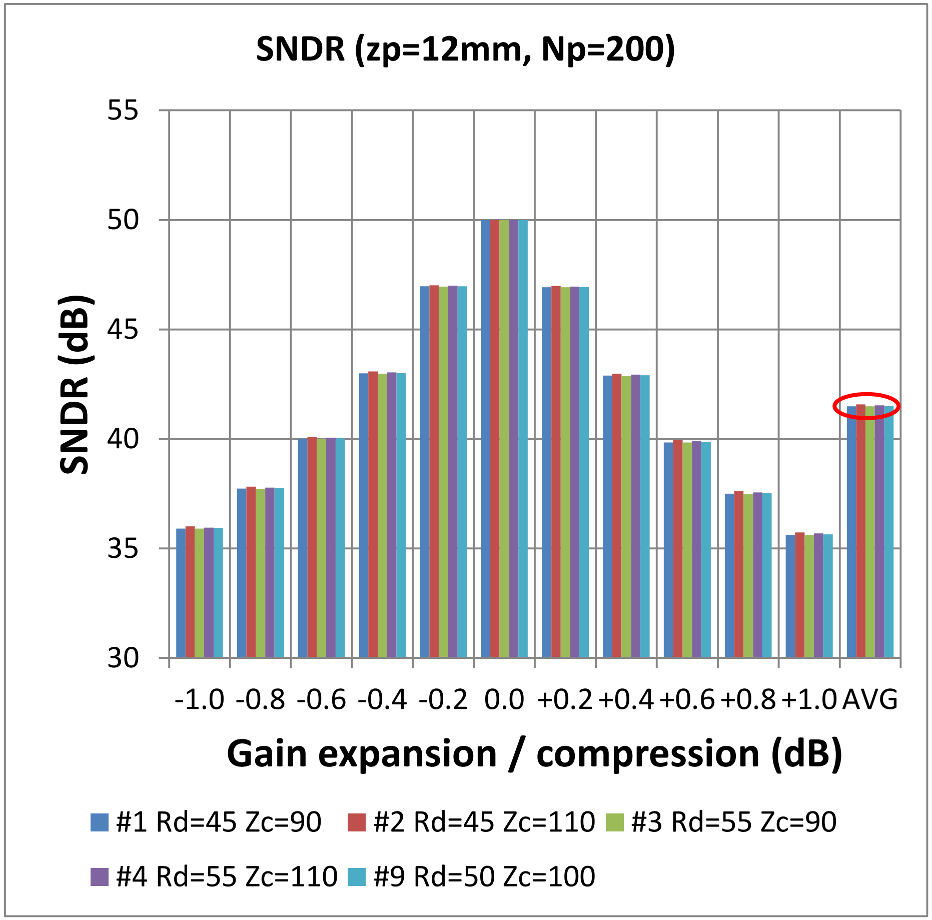
- The effect of Rd and Zc on the ratio of p_{max} to v_f is rather small between proposed conditions (#2/3/4, #6/7/8)

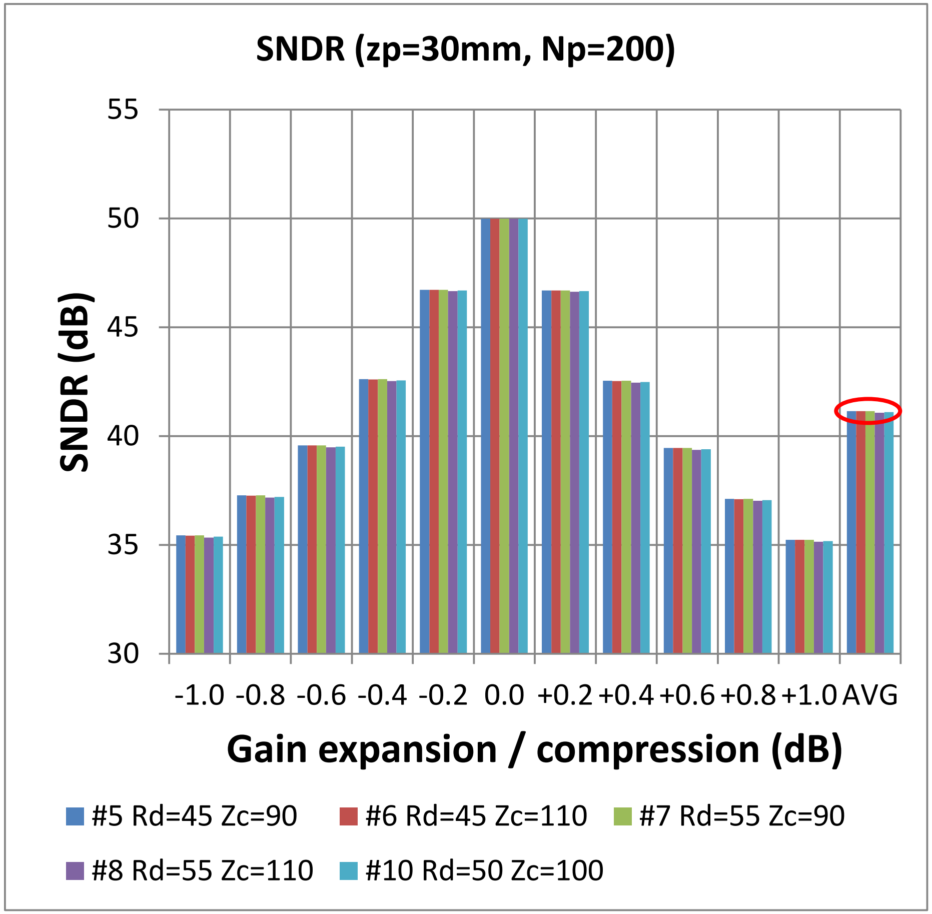




Effect on SNDR (Np=200)

- The effect of Rd and Zc on SNDR is very small





Cisco Channels (CH1-10)

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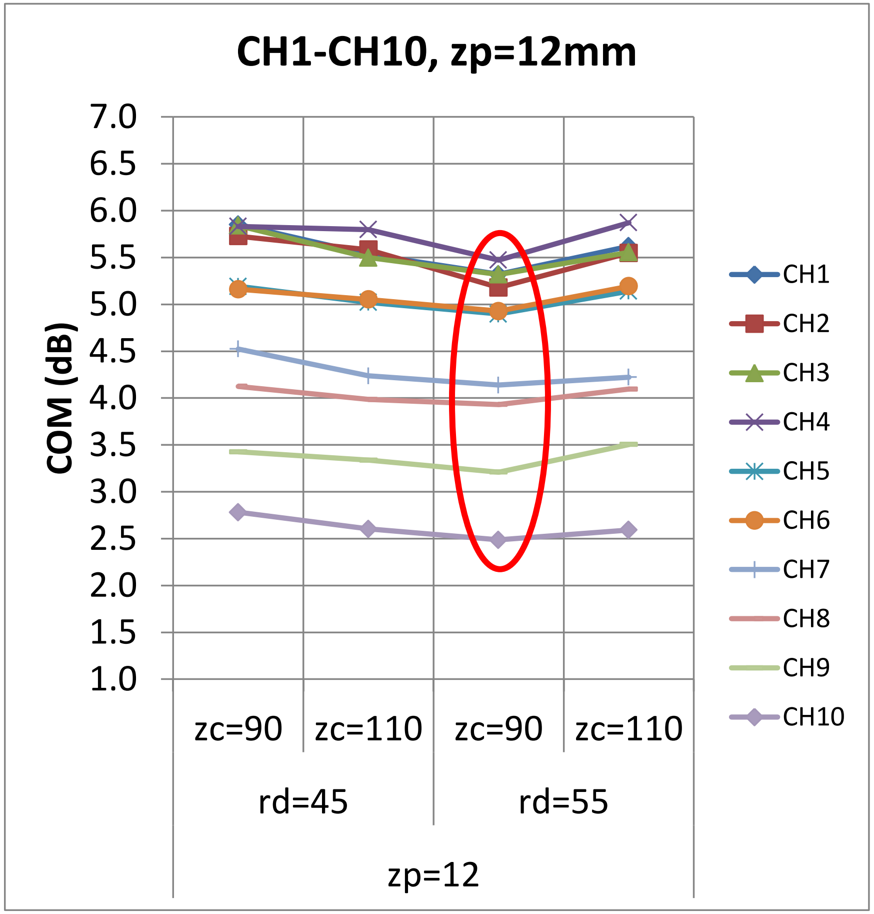
- Data source (in P802.3cd TF Channel Data Area)
  - http://www.ieee802.org/3/cd/public/channel/Cisco_Backplane_channel_data.zip
- Characteristics
  - Insertion Loss @ Nyquist : 10.7876dB (CH1) ~ 34.9828dB (CH10)
  - Crosstalk : 5 FEXT + 3 NEXT

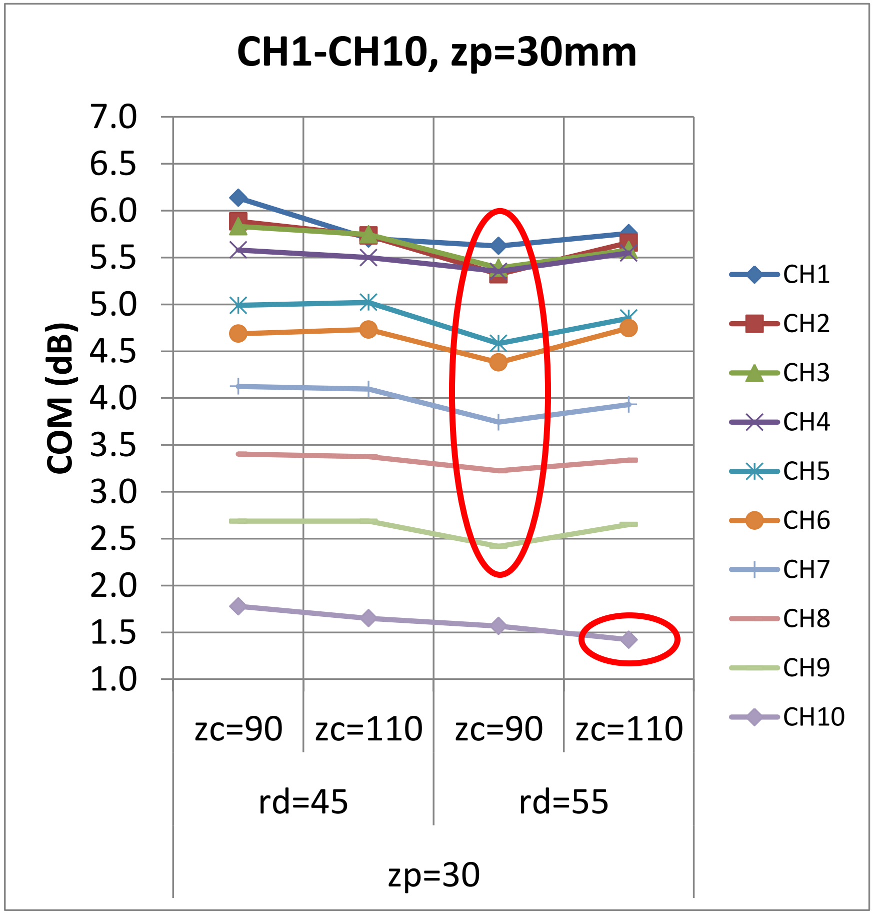
	IL (dB)	FOM_ILD	ICN (mV)
CH1	10.7876	0.31042	1.2534
CH2	12.4579	0.30047	1.1147
CH3	17.3145	0.28196	0.81725
CH4	20.874	0.31335	0.72664
CH5	22.3474	0.28224	0.69128

	IL (dB)	FOM_ILD	ICN (mV)
CH6	25.3573	0.3028	0.64907
CH7	27.6685	0.31005	0.60807
CH8	30.1441	0.30382	0.57276
CH9	32.859	0.31247	0.55667
CH10	34.9828	0.34579	0.54711

Cisco Channels (CH1-10): COM Values

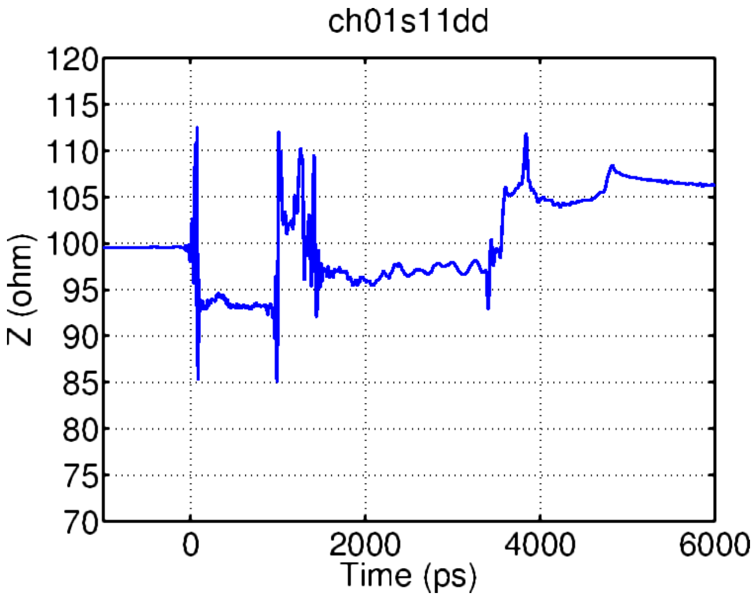
- The worst case is Zc=90Ω & Rd=55Ω or Zc=110Ω & Rd=55Ω
  - Zc=110Ω & Rd=45Ω is better than Zc=90Ω & Rd=55Ω
  - zp=30mm is worse than 12mm except CH1~3 where 12mm is worse

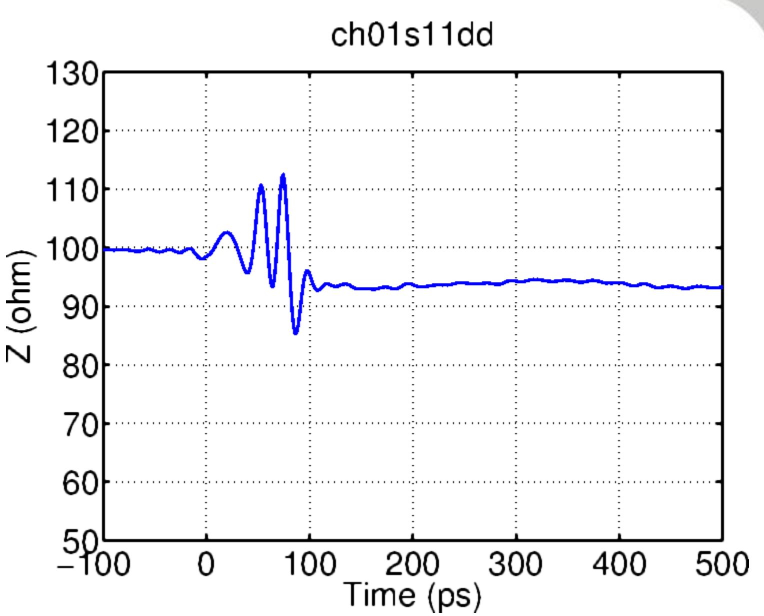




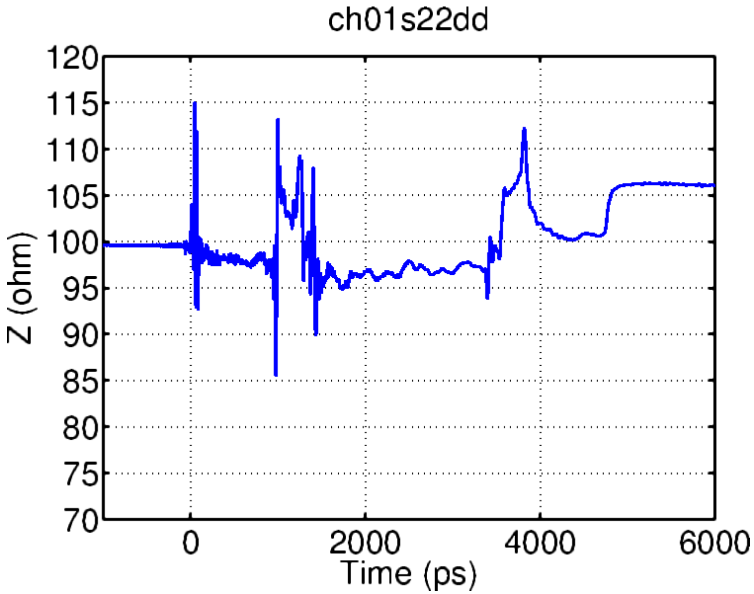
Cisco 10dB Channel (CH1): Zdiff Profile

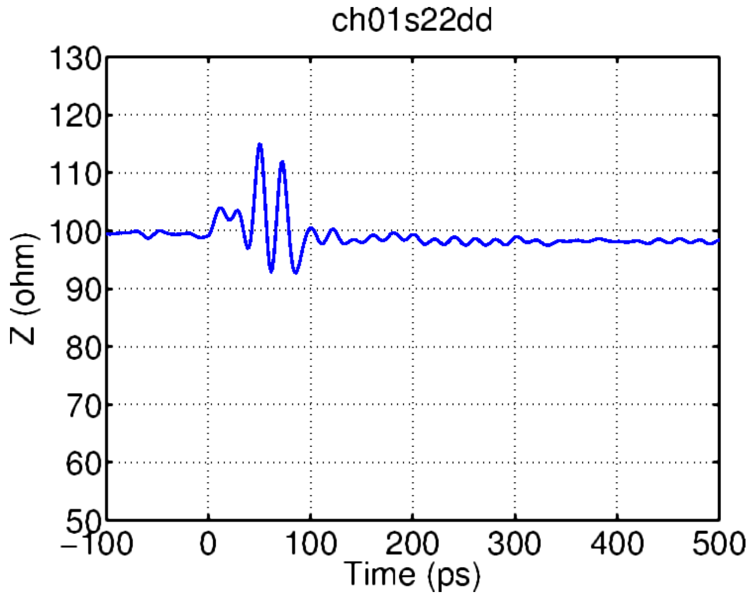
S11dd





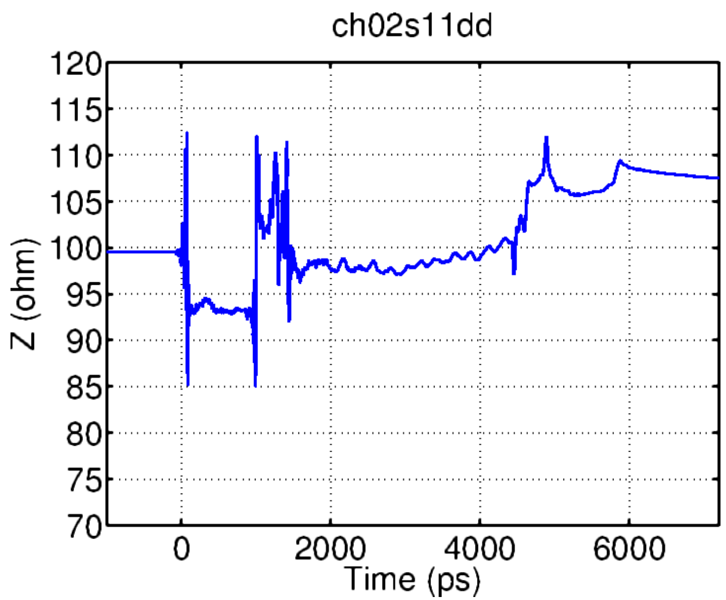
S22dd

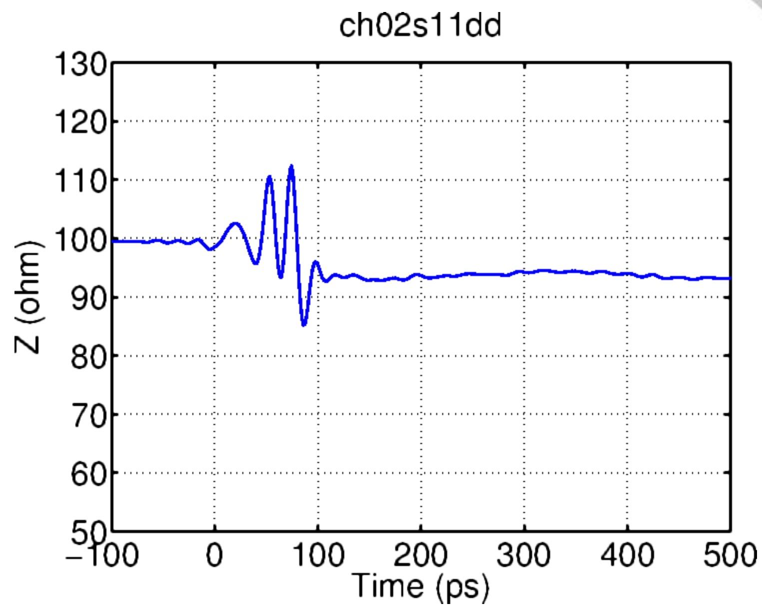




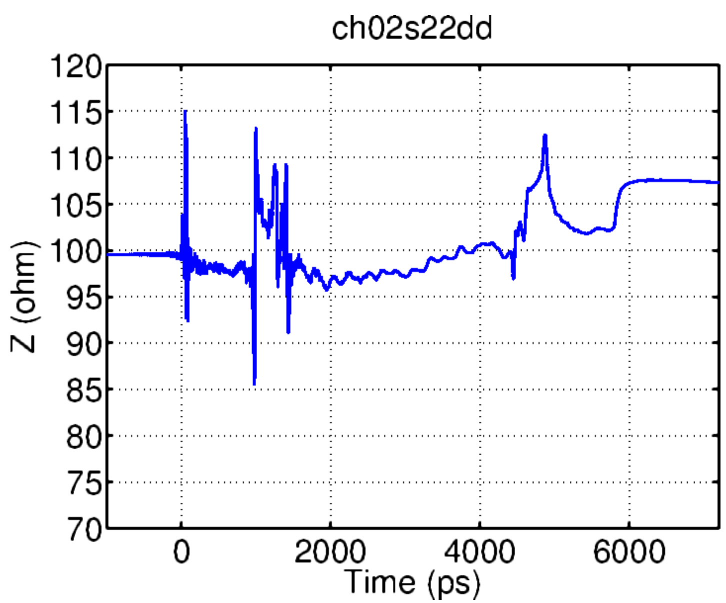
Cisco 12dB Channel (CH2): Zdiff Profile

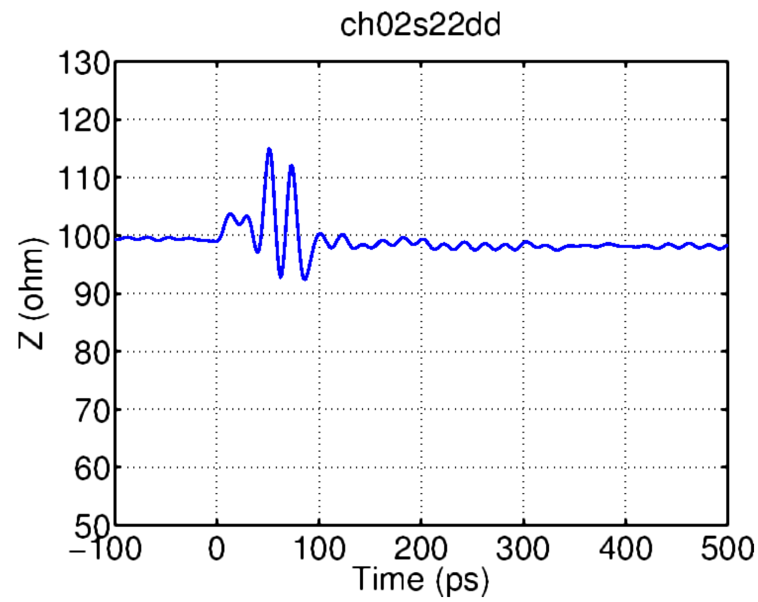
S11dd





S22dd





Cisco 17dB Channel (CH3): Zdiff Profile

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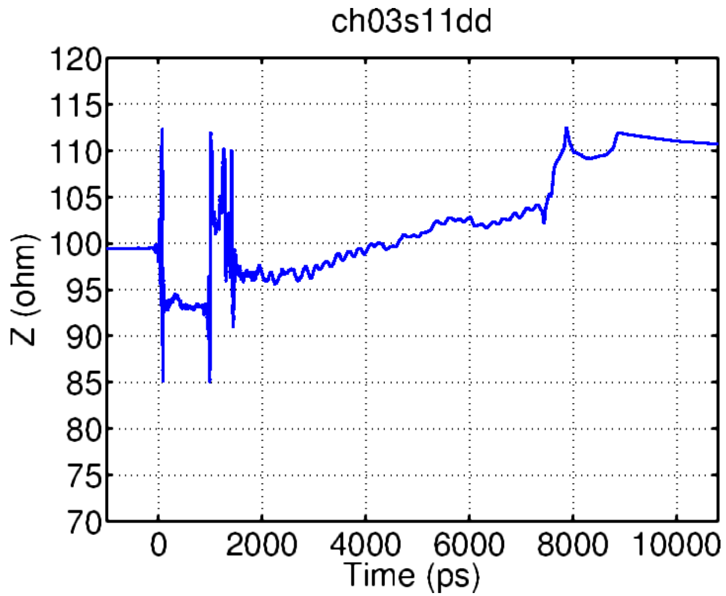
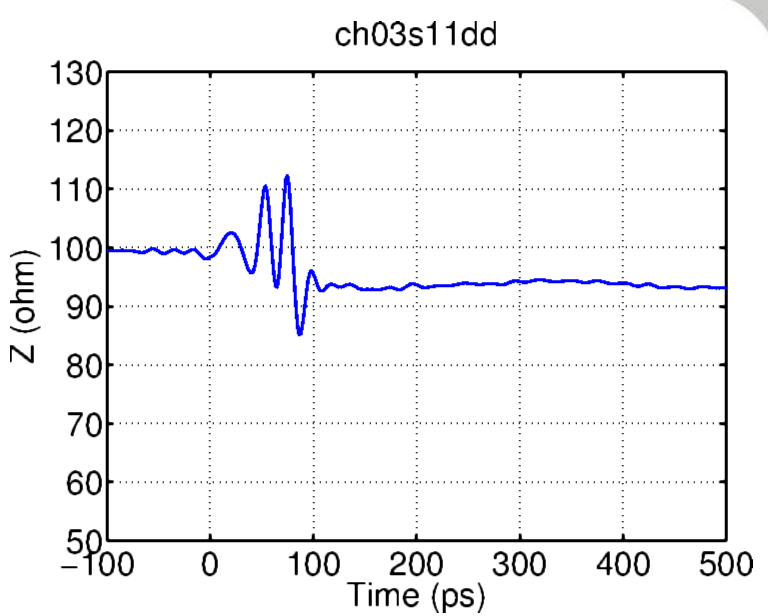
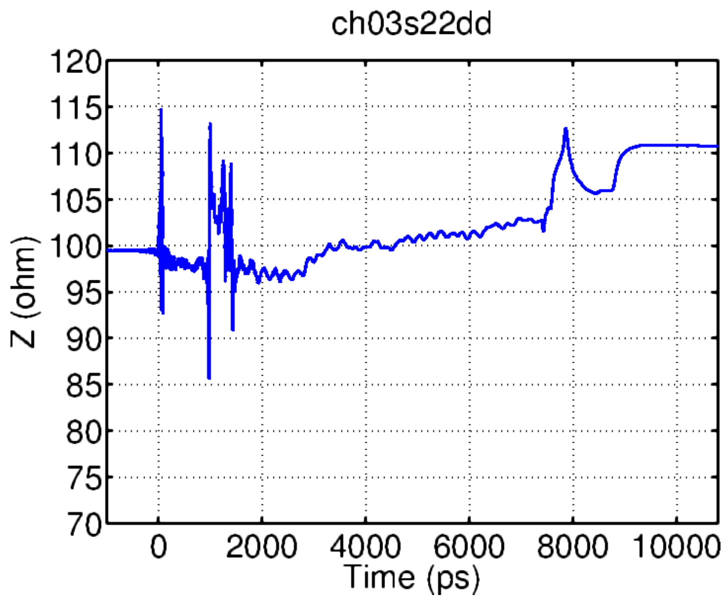
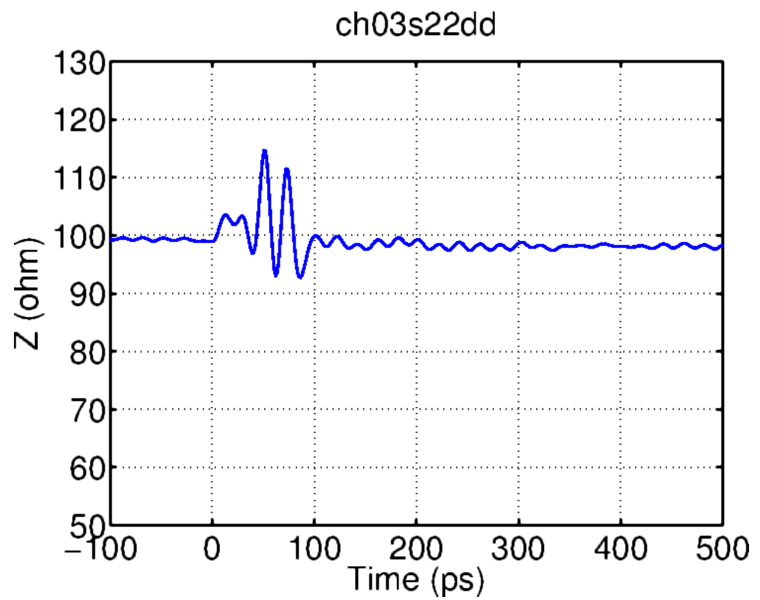
S11dd





S22dd





Cisco 30dB Channel (CH8): Zdiff Profile

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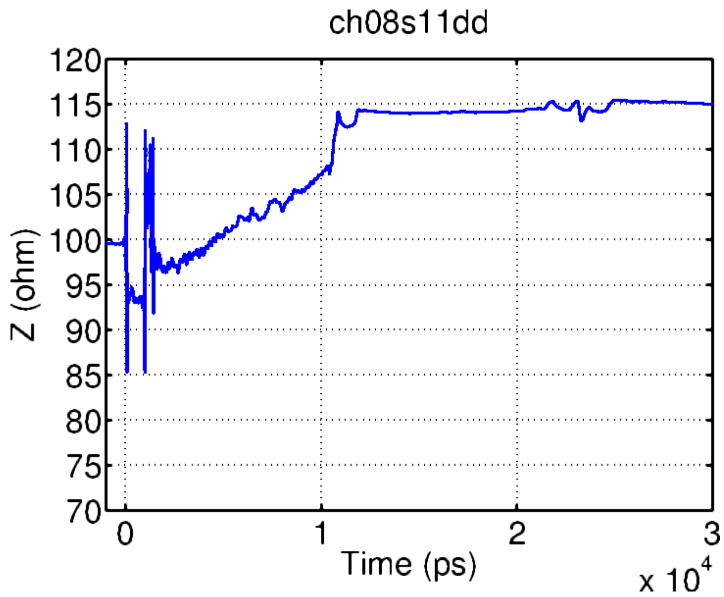
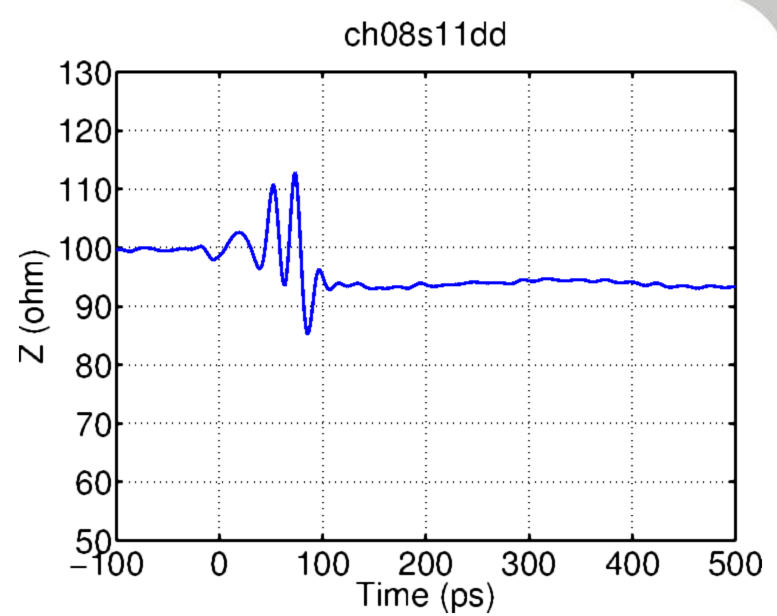
S11dd





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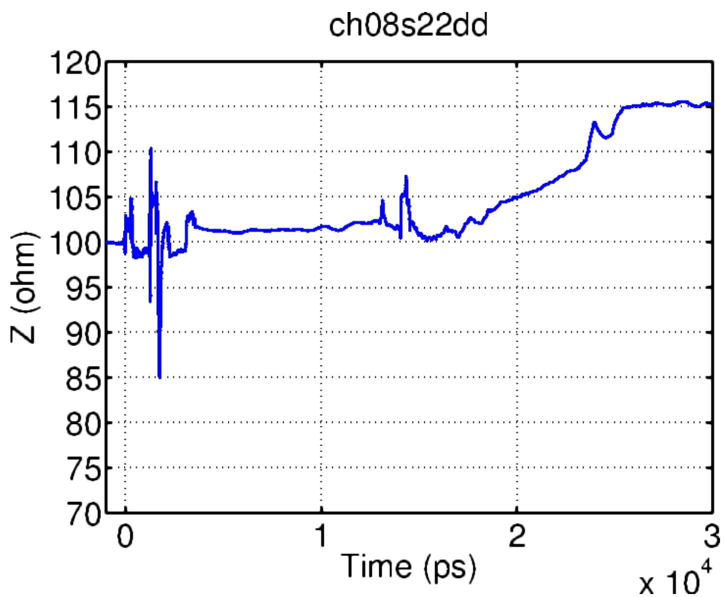
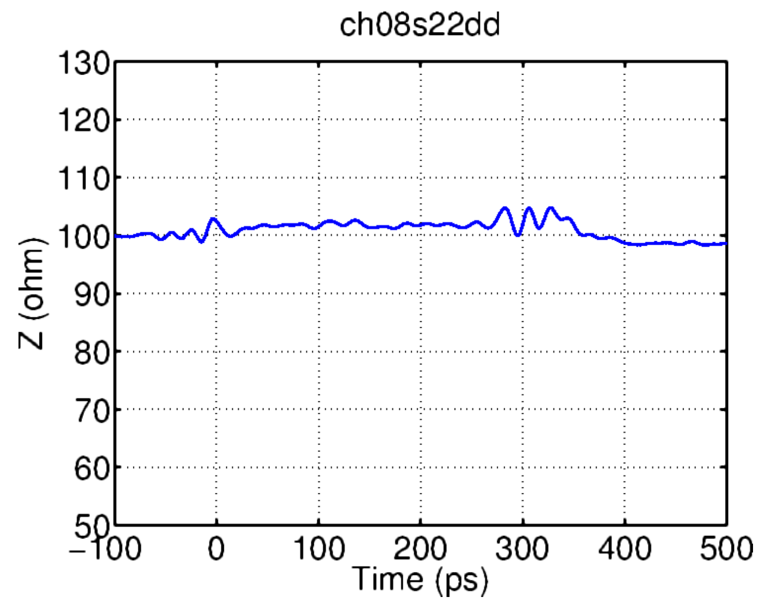
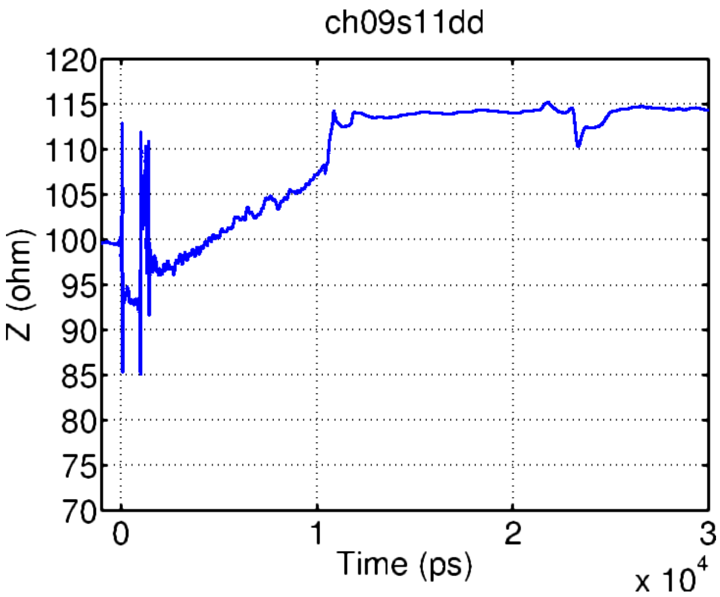


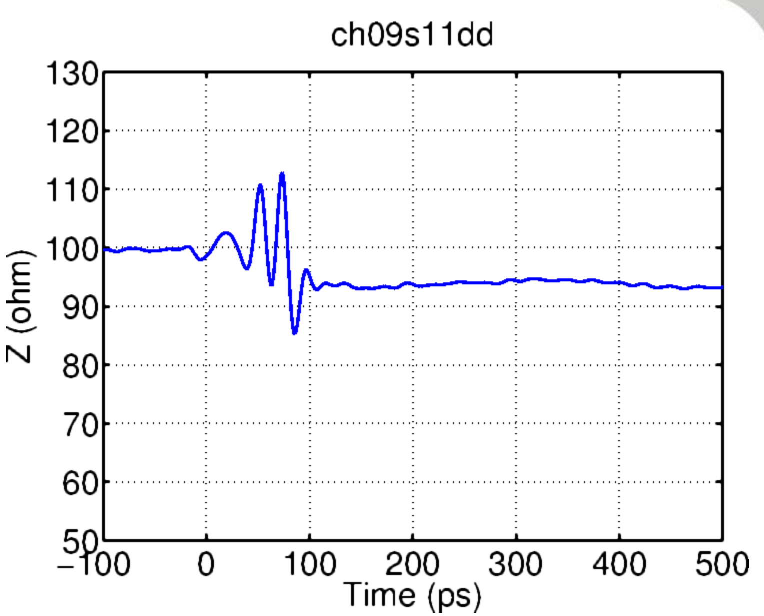


Cisco 33dB Channel (CH9): Zdiff Profile

FUJITSU

S11dd





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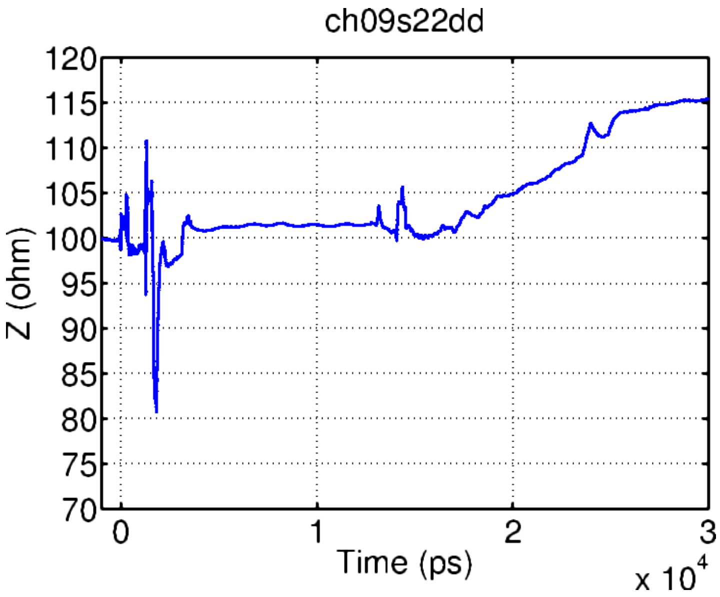
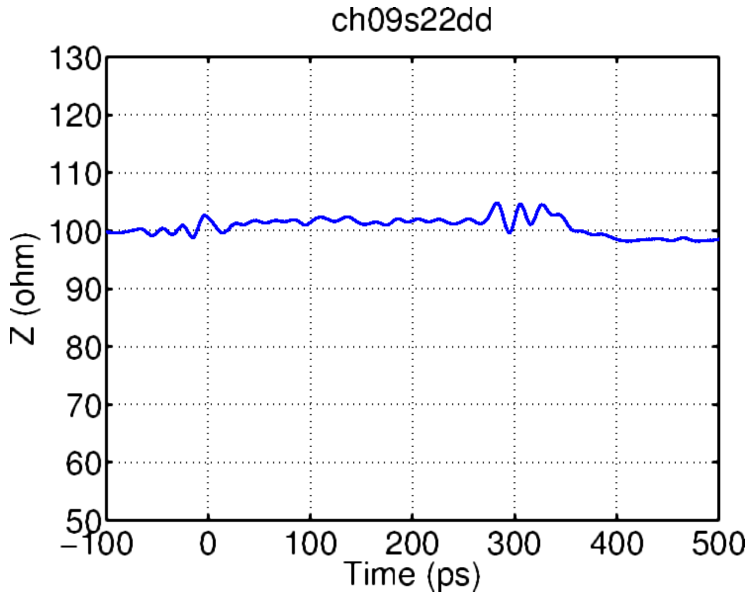
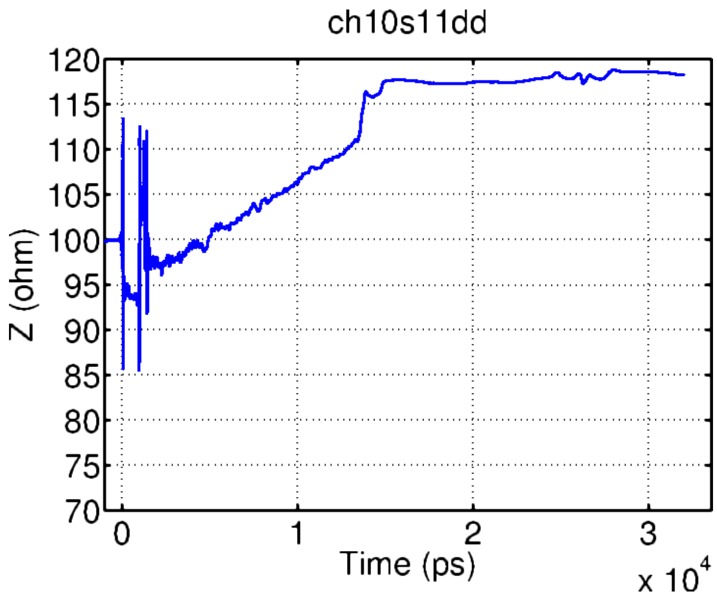


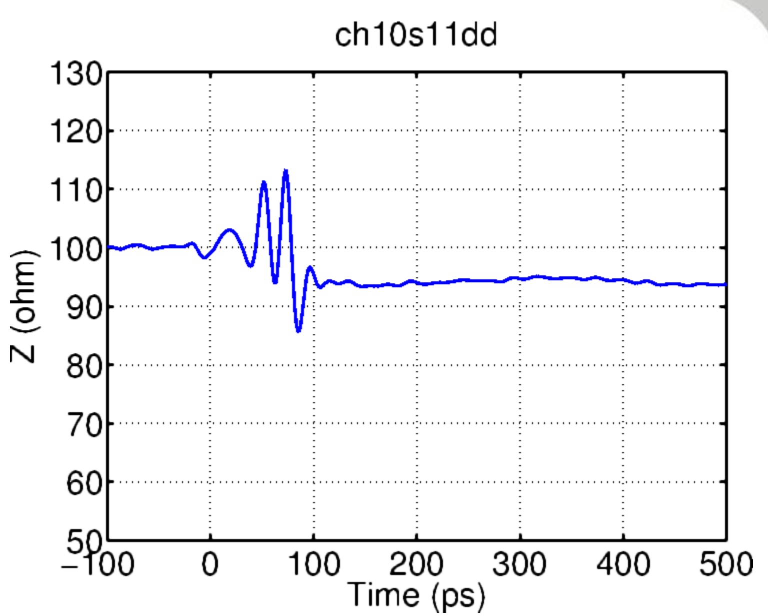


Cisco 35dB Channel (CH10): Zdiff Profile

FUJITSU

S11dd





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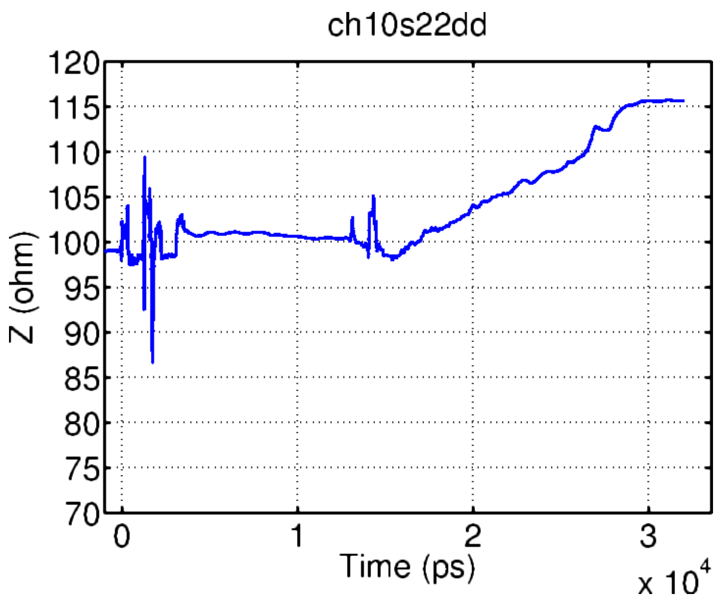
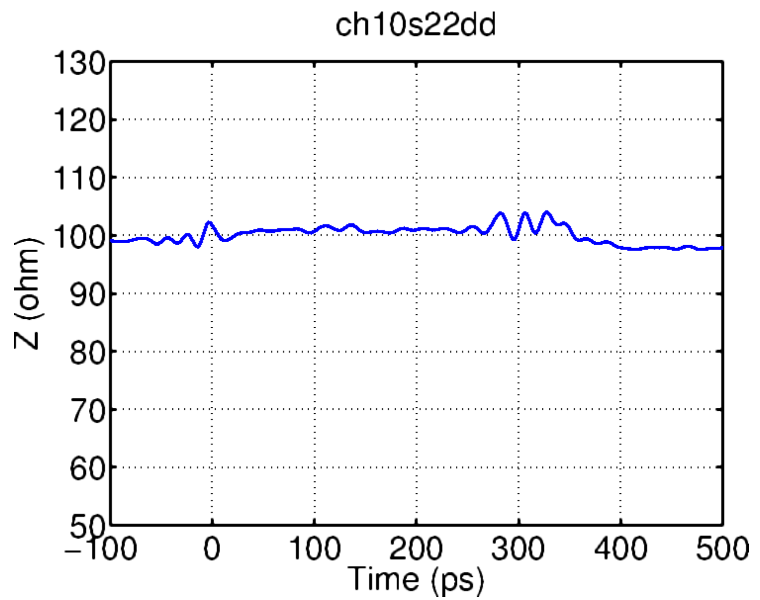




Intel 100Ω Channels (CH11-25)

FUJITSU

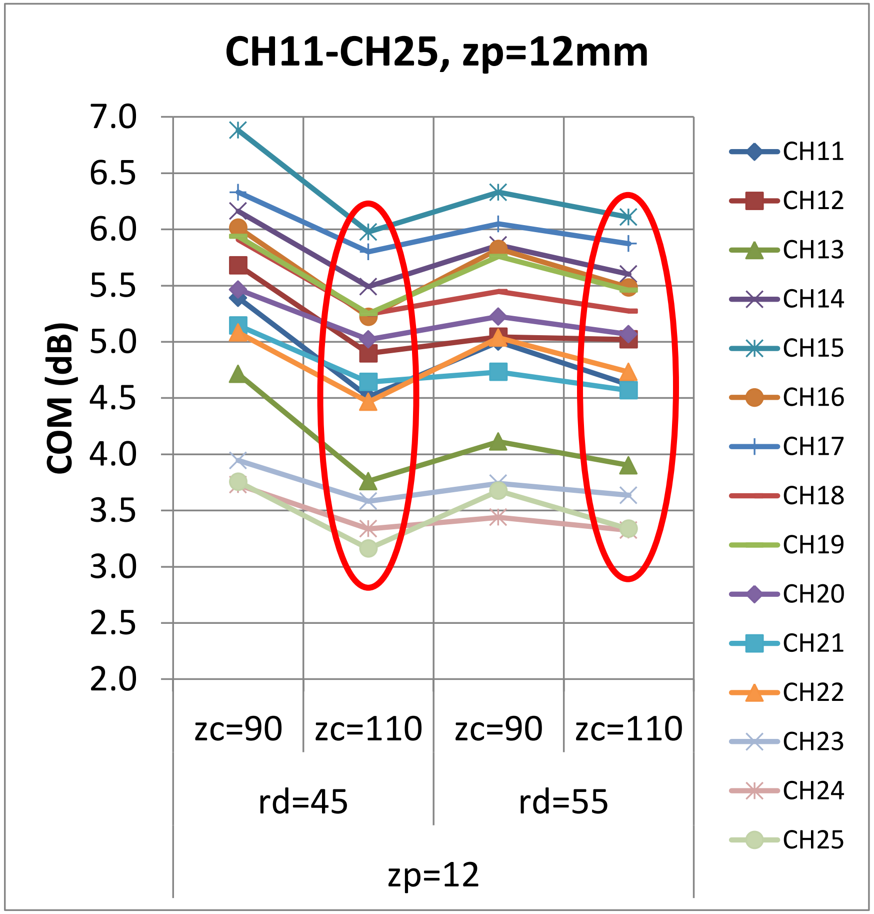
- Data source (in 50G&NGOATH SG Channel Data Area)
  - http://www.ieee802.org/3/50G/public/channel/mellitz_01_021716_??dB_6_channels.zip
- Characteristics
  - http://www.ieee802.org/3/50G/public/adhoc/archive/mellitz_021716_50GE_NGOATH_adhoc.pdf
  - Approximate IL @ Nyquist : 10dB (CH11/12/13) ~ 30dB (CH23/24/25)
  - Crosstalk : 3 FEXT + 4 NEXT

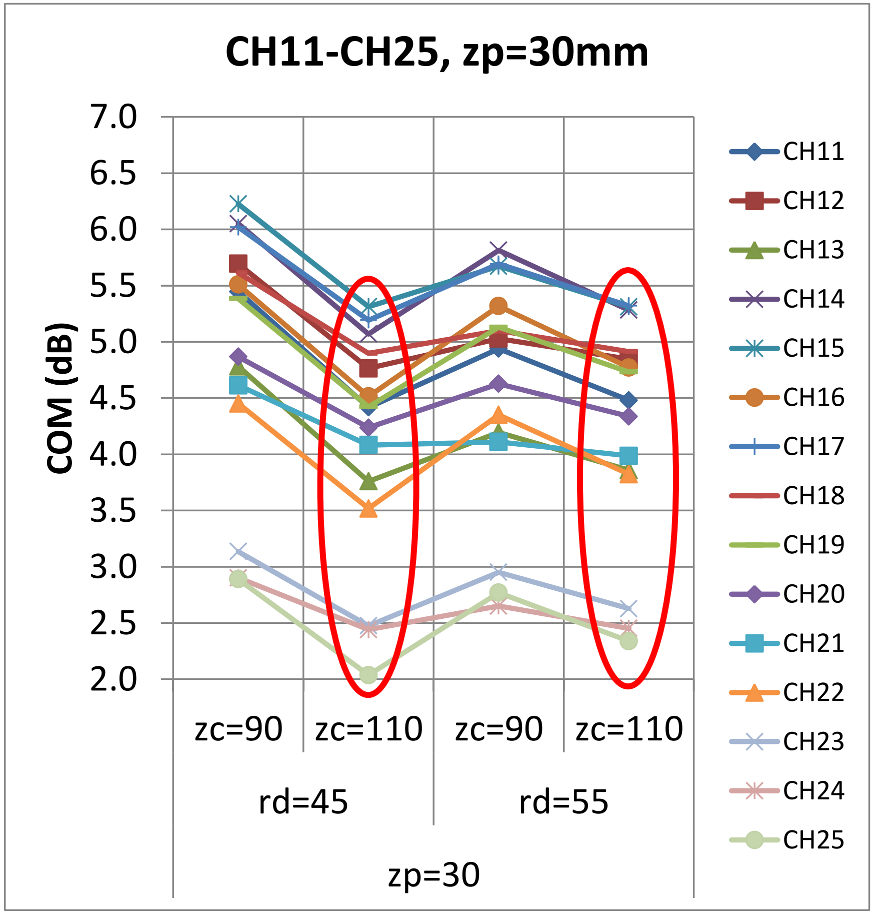
	Corner	IL (dB)	FOM_ILD	ICN(mV)
CH11	Nom	9.7636	0.35085	2.5159
CH12	HzLzHz	9.6743	0.30416	2.5299
CH13	LzHzLz	9.9267	0.33959	2.4796
CH14	Nom	14.8063	0.25593	1.6857
CH15	HzLzHz	15.1217	0.25119	1.6854
CH16	LzHzLz	15.0295	0.27047	1.7122
CH17	Nom	19.9038	0.23598	1.4094
CH18	HzLzHz	19.7834	0.23241	1.4131
CH19	LzHzLz	19.789	0.2501	1.3863

	Corner	IL (dB)	FOM_ILD	ICN(mV)
CH20	Nom	24.9191	0.23847	1.2603
CH21	HzLzHz	24.8017	0.22766	1.2846
CH22	LzHzLz	24.8212	0.2604	1.2331
CH23	Nom	29.9563	0.24648	1.1876
CH24	HzLzHz	29.7874	0.22562	1.214
CH25	LzHzLz	29.8354	0.2849	1.1574

Intel 100Ω Channels (CH11-25): COM Values

- The worst case is Zc=110Ω & Rd=45Ω or Zc=110Ω & Rd=55Ω
  - Zc=90Ω & Rd=55Ω is better than Zc=110Ω & Rd=45Ω or 55Ω
  - zp=30mm is worse than 12mm





Intel 100Ω 10dB Nom (CH11): Zdiff Profile

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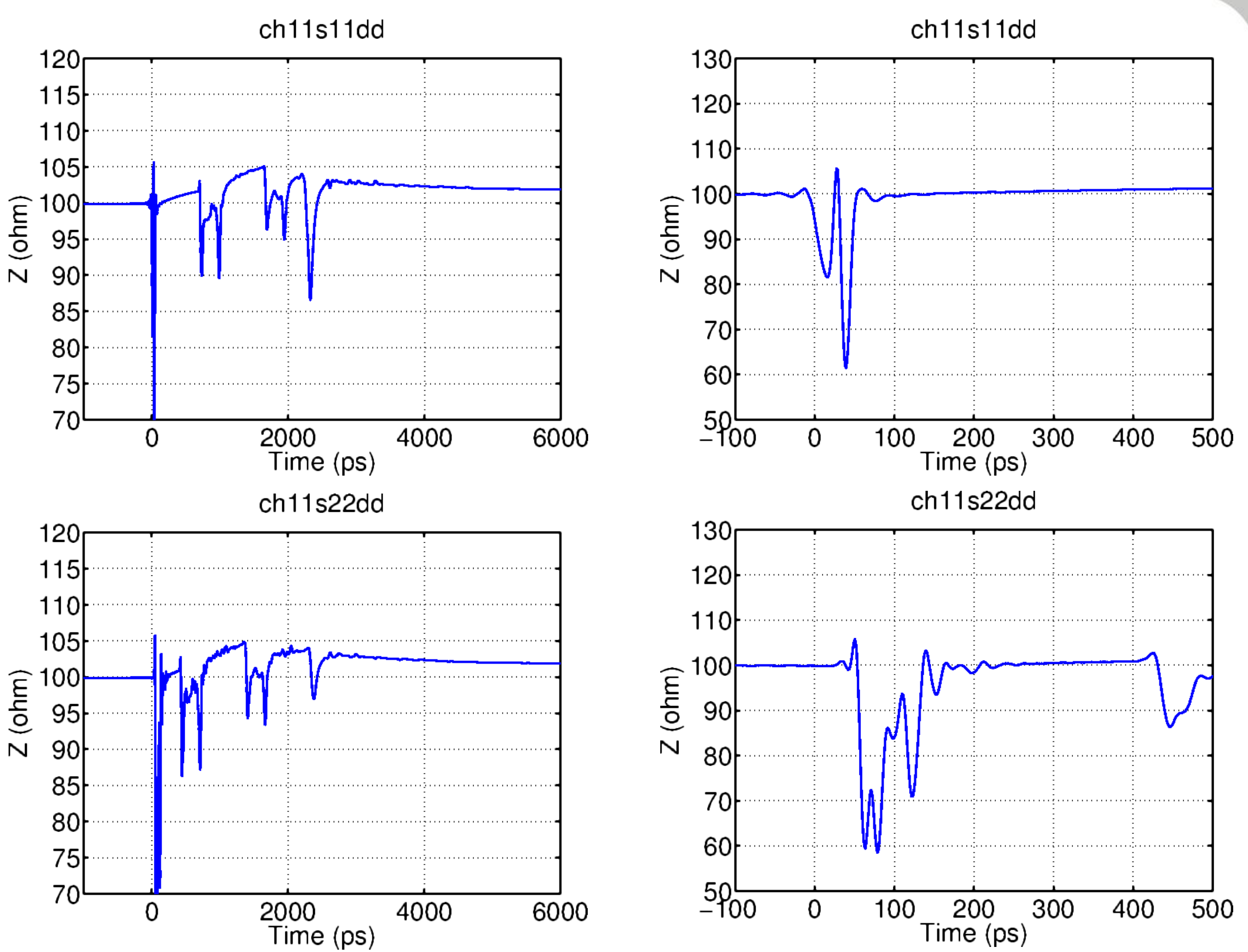
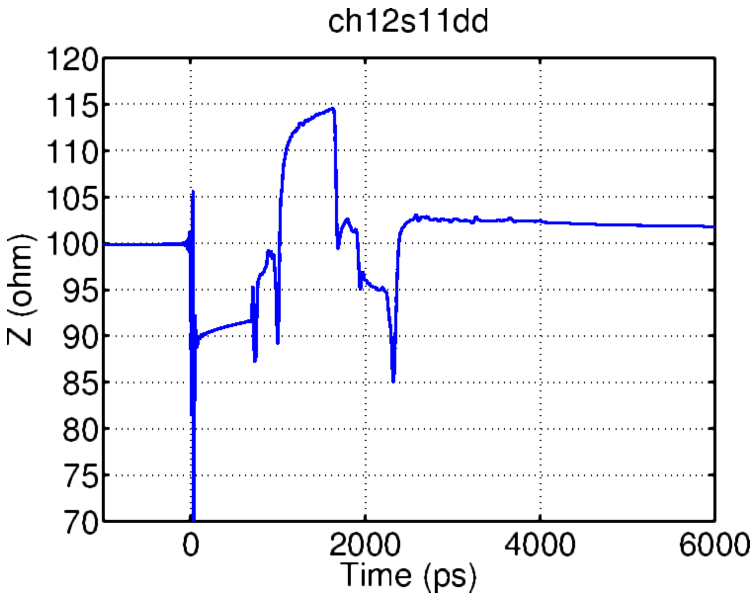
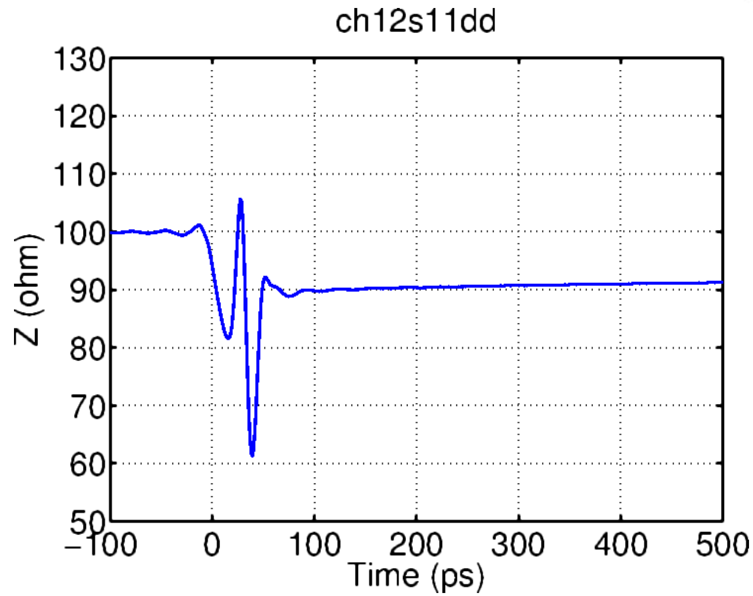


Intel 100Ω 10dB HzLzHz (CH12): Zdiff Profile

FUJITSU

S11dd





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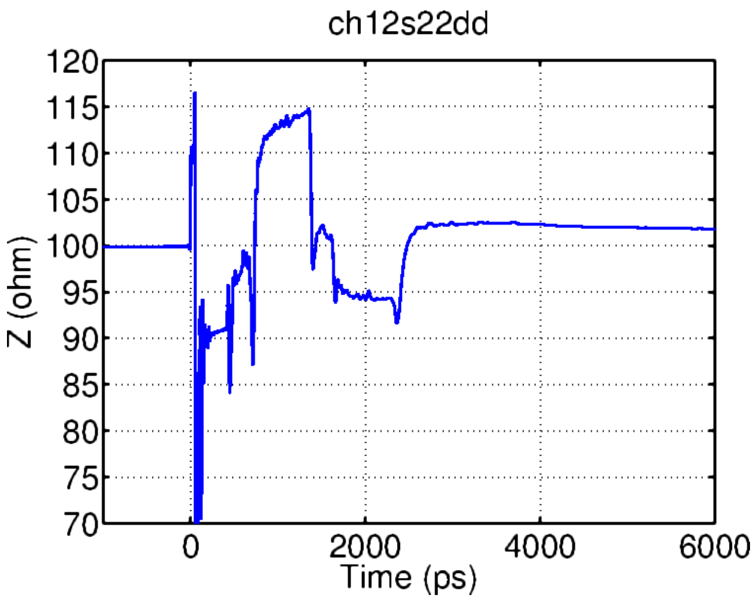
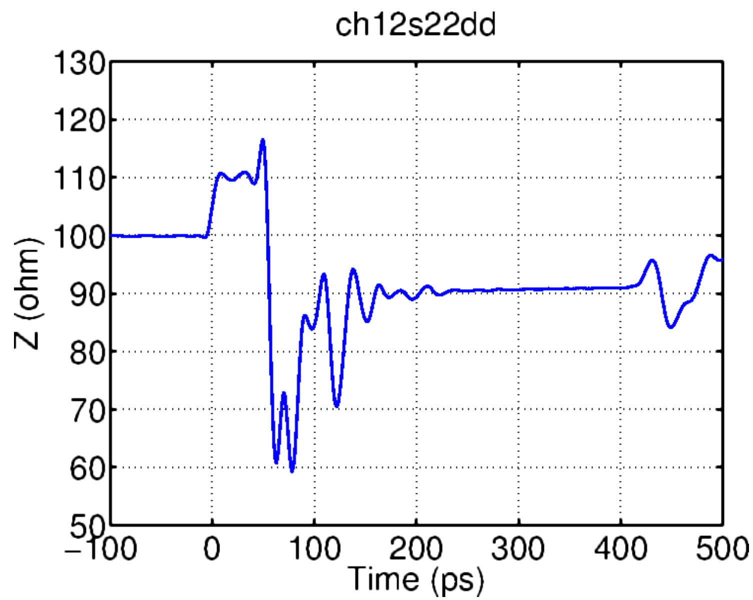
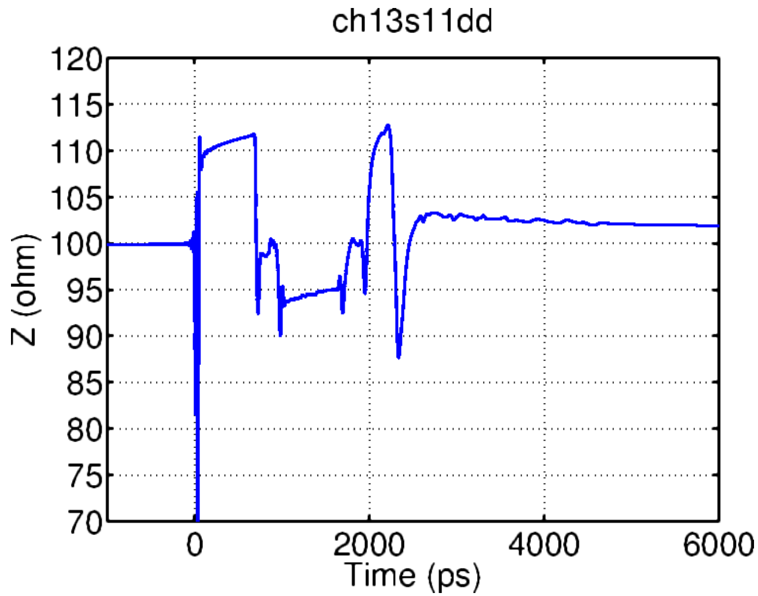


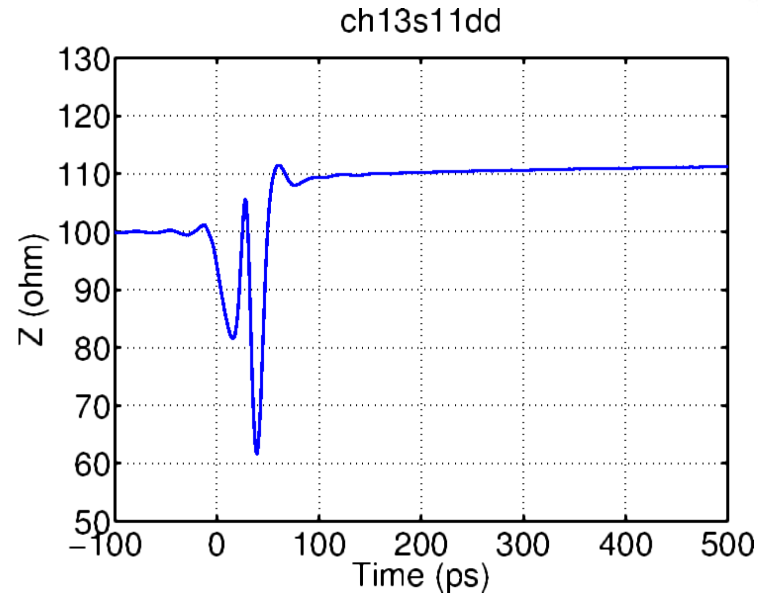


Intel 100Ω 10dB LzHzLz (CH13): Zdiff Profile

FUJITSU

S11dd





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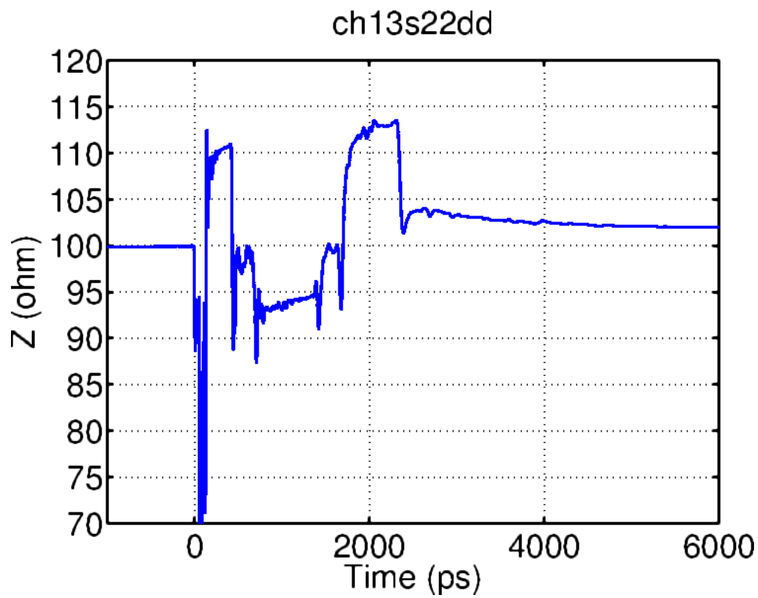
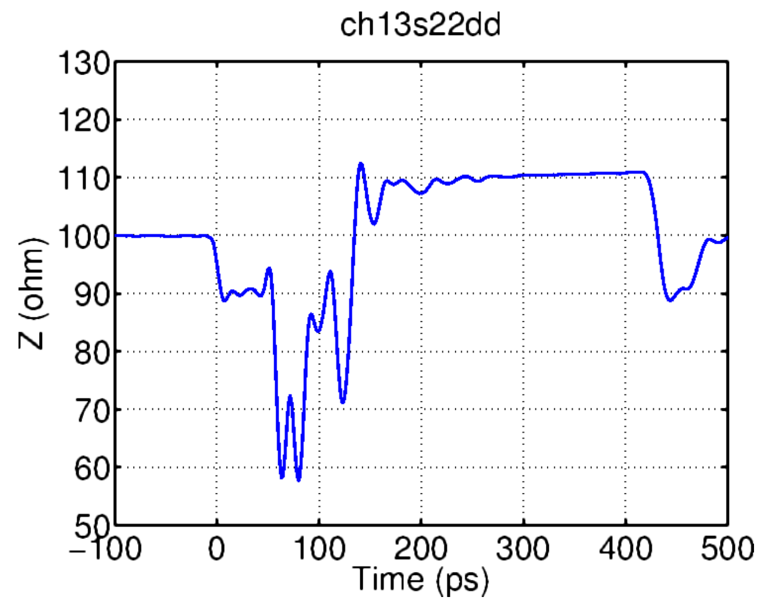
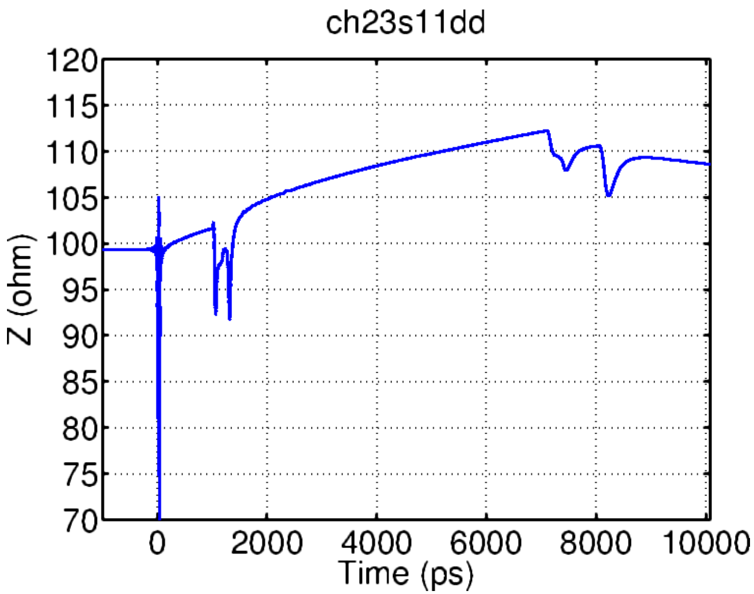


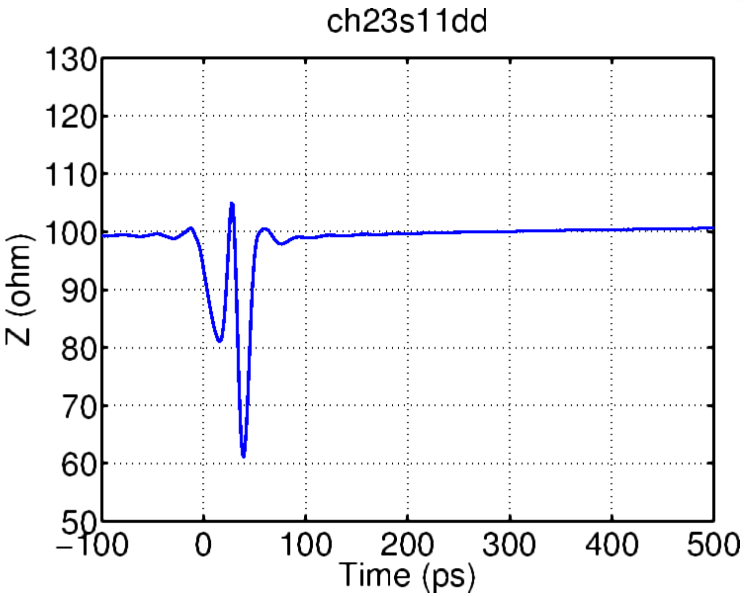


Intel 100Ω 30dB Nom (CH23): Zdiff Profile

FUJITSU

S11dd





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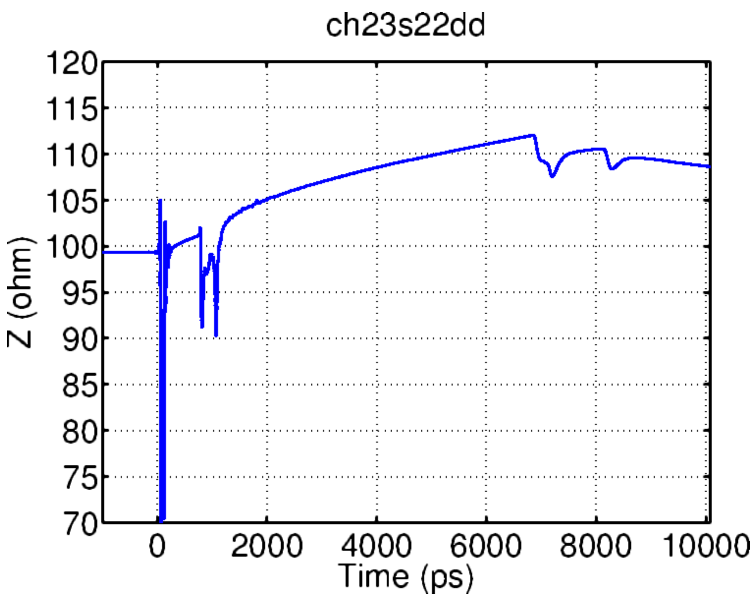
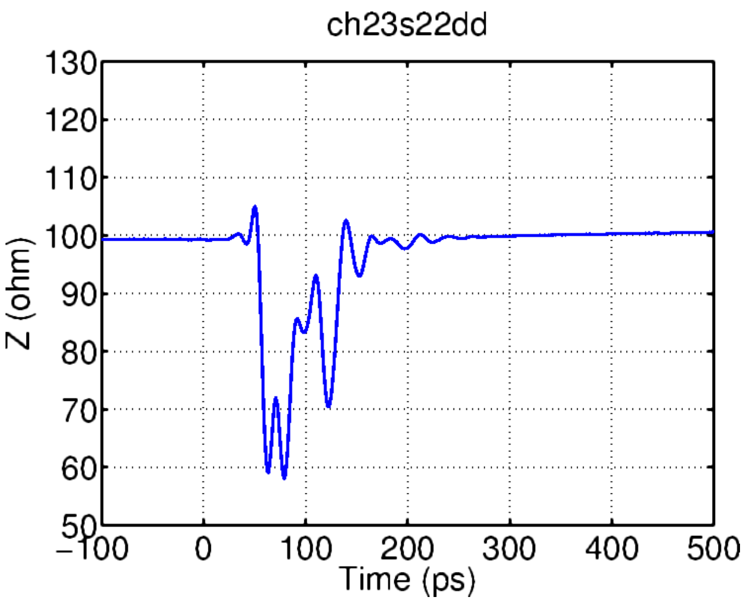
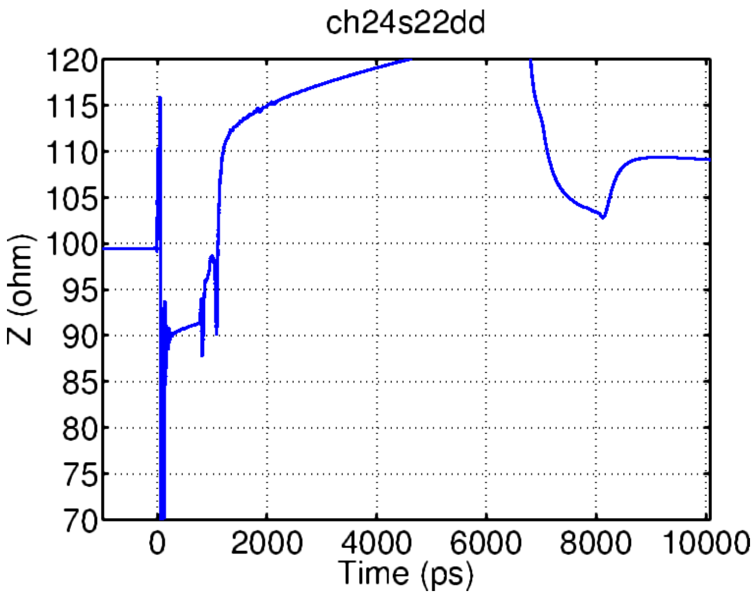


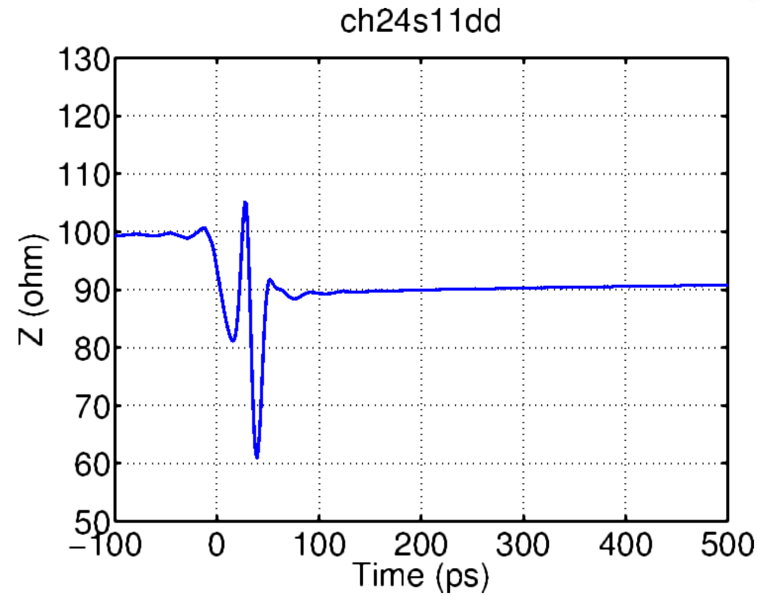


Intel 100Ω 30dB HzLzHz (CH24): Zdiff Profile

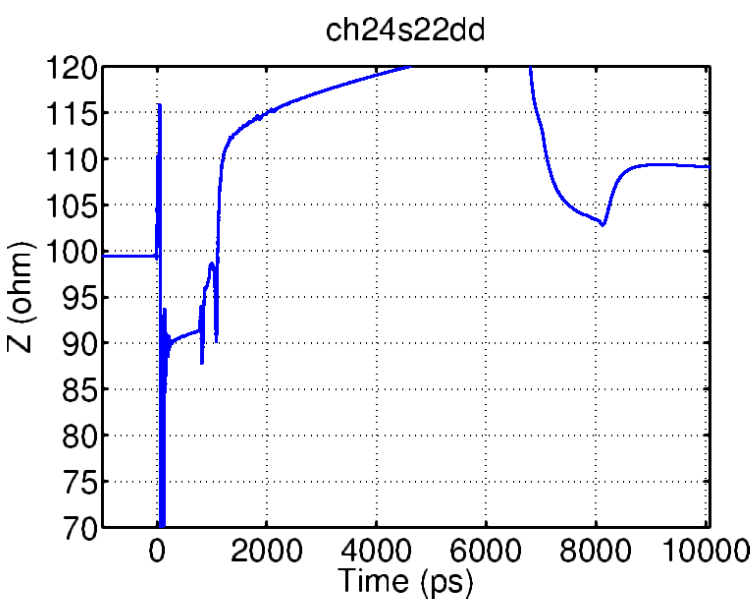
FUJITSU

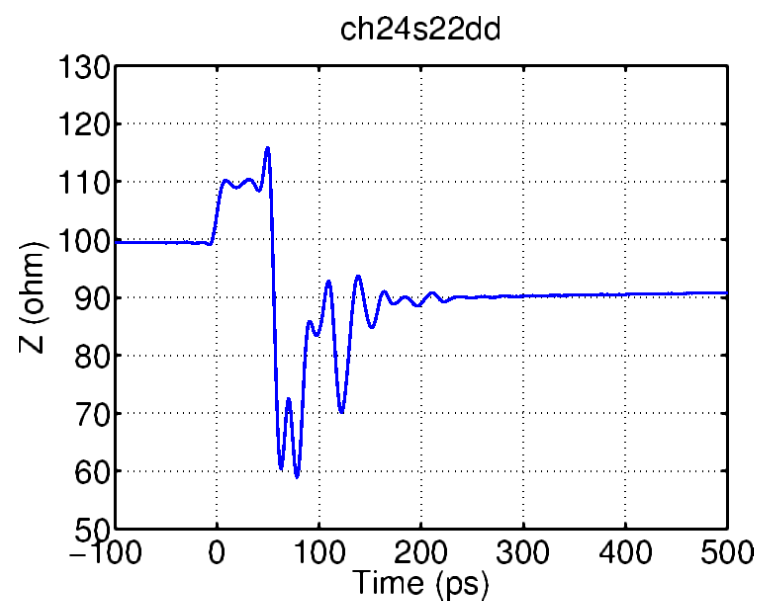
S11dd





S22dd

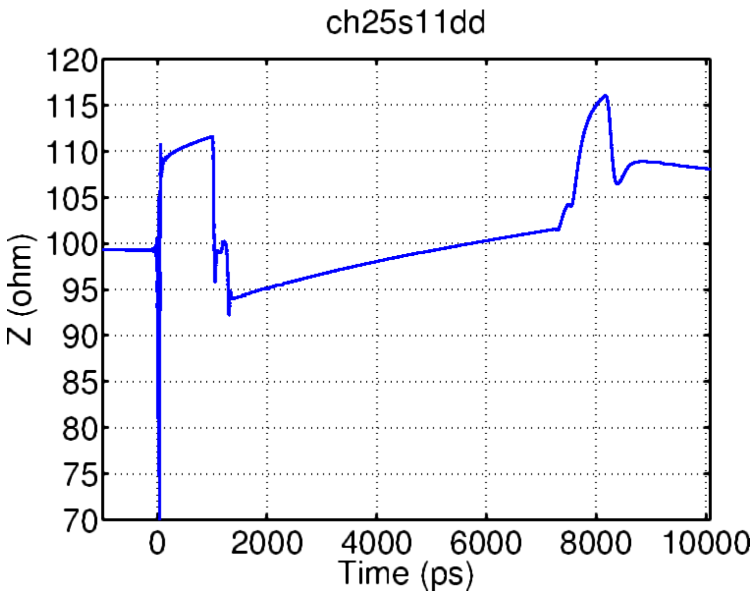


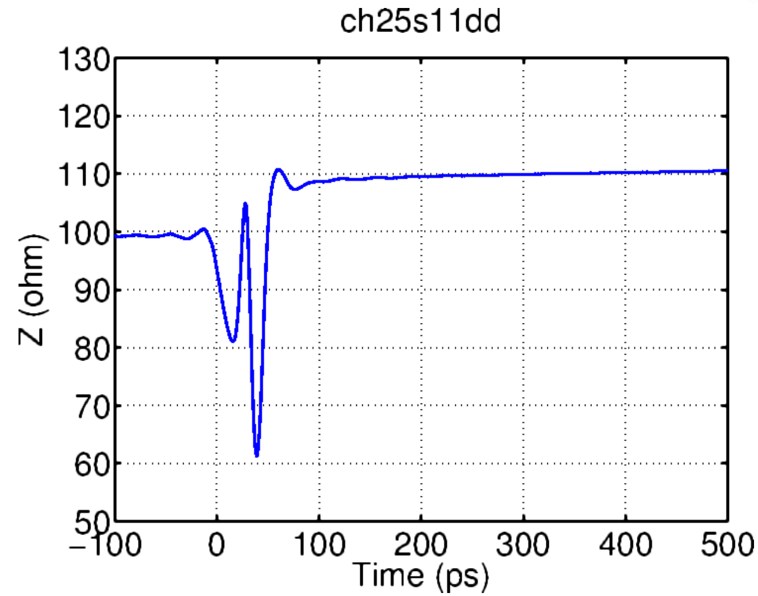


Intel 100Ω 30dB LzHzLz (CH25): Zdiff Profile

FUJITSU

S11dd





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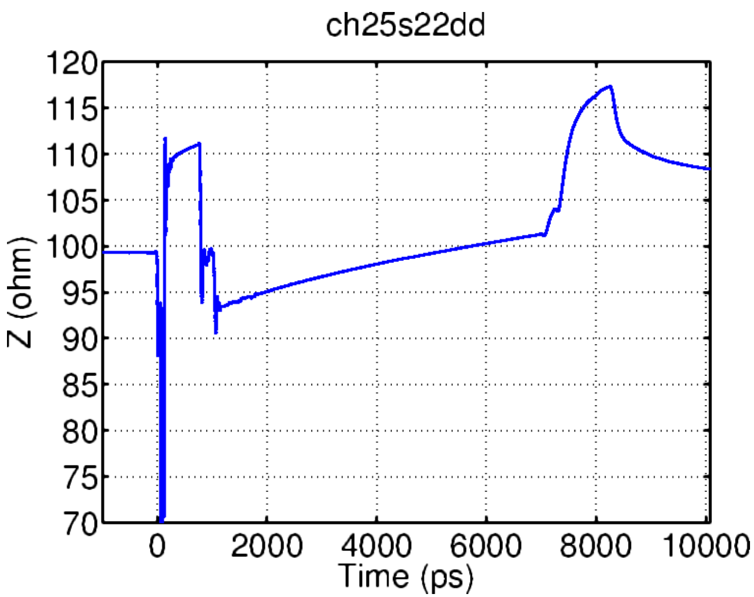
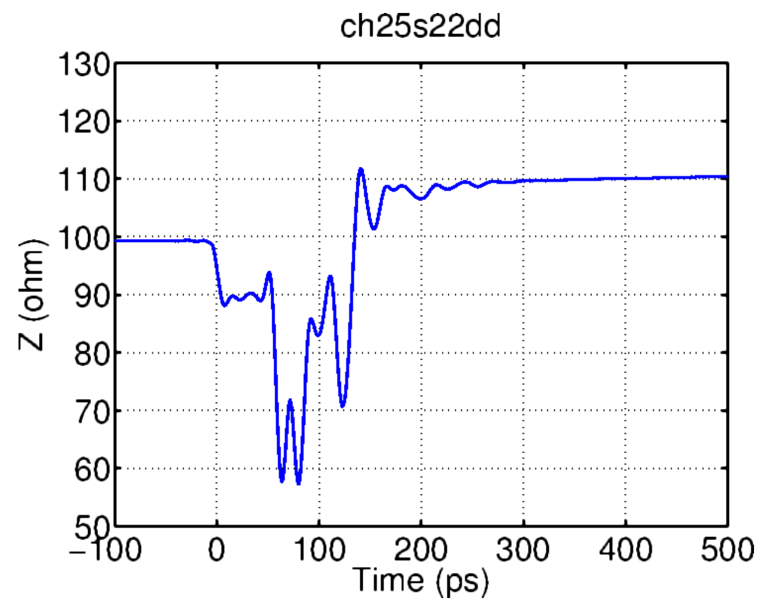




Intel 85Ω Channels (CH26-40)

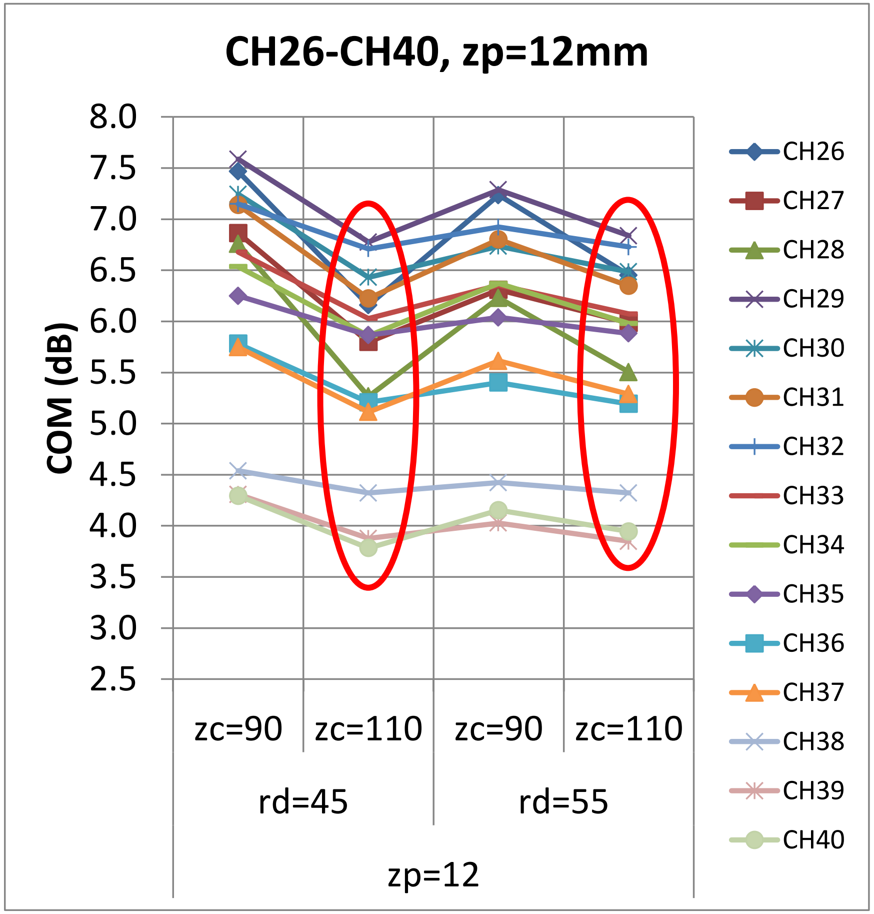
- Data source (in 50G&NGOATH SG Channel Data Area)
  - http://www.ieee802.org/3/50G/public/channel/mellitz_01_021716_??dB_6_channels.zip
- Characteristics
  - http://www.ieee802.org/3/50G/public/adhoc/archive/mellitz_021716_50GE_NGOATH_adhoc.pdf
  - Approximate IL @ Nyquist : 10dB (CH26/27/28) ~ 30dB (CH38/39/40)
  - Crosstalk : 3 FEXT + 4 NEXT

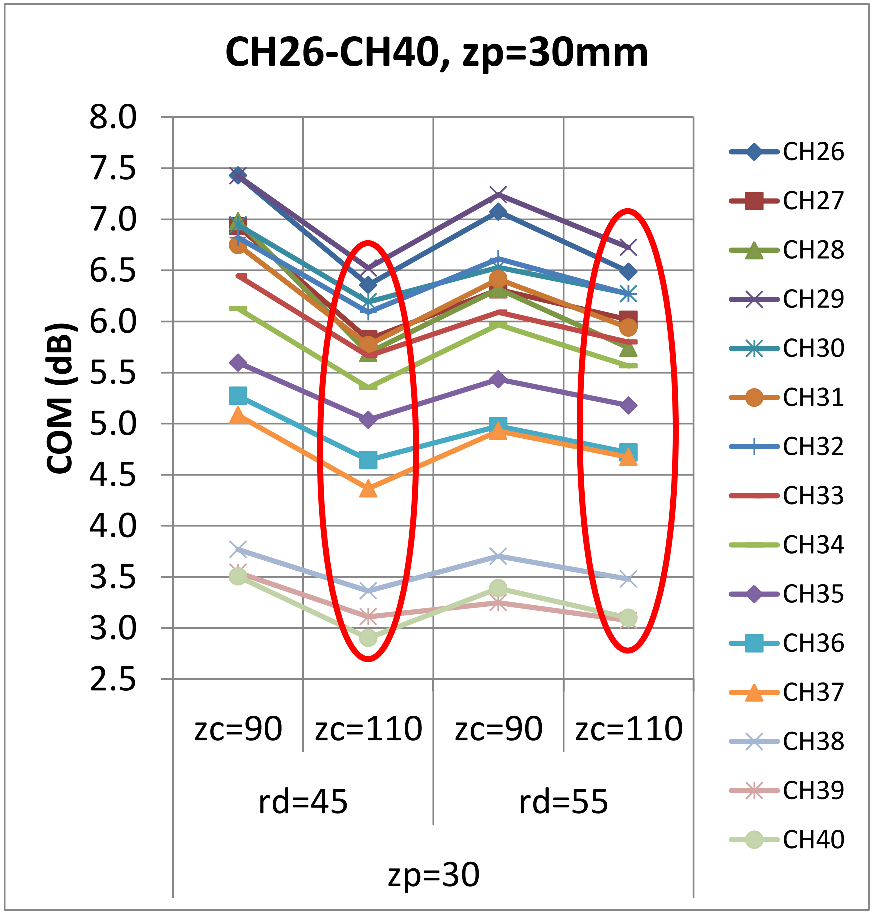
	Corner	IL (dB)	FOM_ILD	ICN(mV)
CH26	Nom	9.7602	0.21802	2.4937
CH27	HzLzHz	9.6093	0.22831	2.4977
CH28	LzHzLz	9.9398	0.23882	2.4522
CH29	Nom	14.6258	0.17817	1.6748
CH30	HzLzHz	15.1722	0.1794	1.6546
CH31	LzHzLz	14.8594	0.20324	1.6914
CH32	Nom	19.7787	0.16126	1.3745
CH33	HzLzHz	19.8607	0.16948	1.3622
CH34	LzHzLz	19.5802	0.1991	1.3502

	Corner	IL (dB)	FOM_ILD	ICN(mV)
CH35	Nom	24.7794	0.16223	1.2236
CH36	HzLzHz	24.9387	0.16377	1.2332
CH37	LzHzLz	24.5843	0.21914	1.2003
CH38	Nom	29.8285	0.17168	1.1554
CH39	HzLzHz	29.9952	0.16709	1.1665
CH40	LzHzLz	29.568	0.27329	1.1305

Intel 85Ω Channels (CH26-40): COM Values

- The worst case is Zc=110Ω & Rd=45Ω or Zc=110Ω & Rd=55Ω
  - Zc=90Ω & Rd=55Ω is better than Zc=110Ω & Rd=45Ω or 55Ω
  - zp=30mm is worse than 12mm except CH26~28 where 12mm is worse





Intel 85Ω 10dB Nom (CH26): Zdiff Profile

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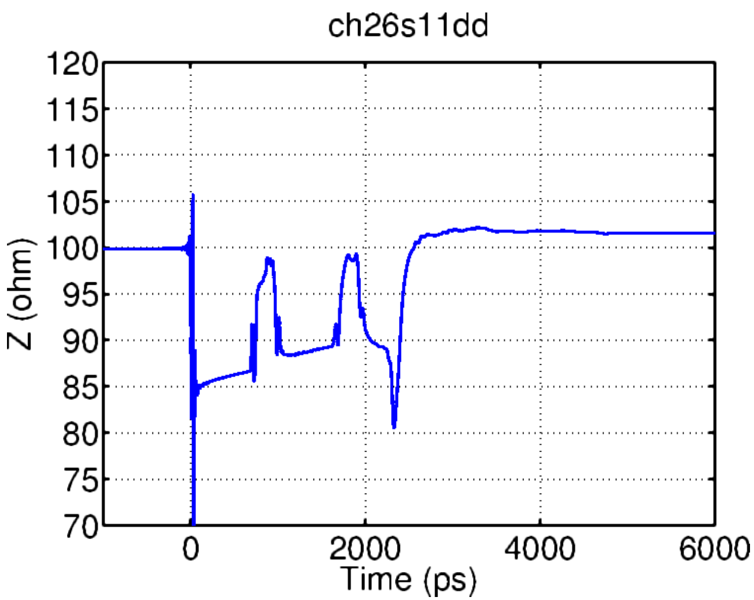
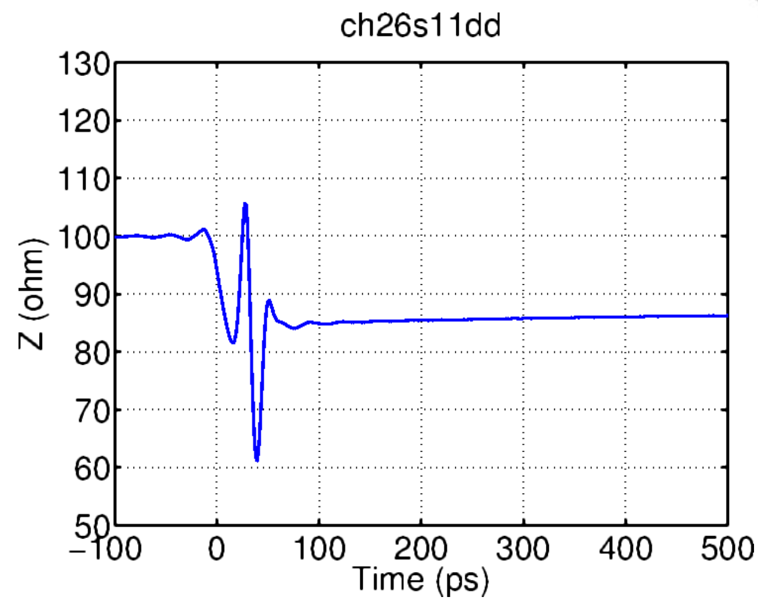
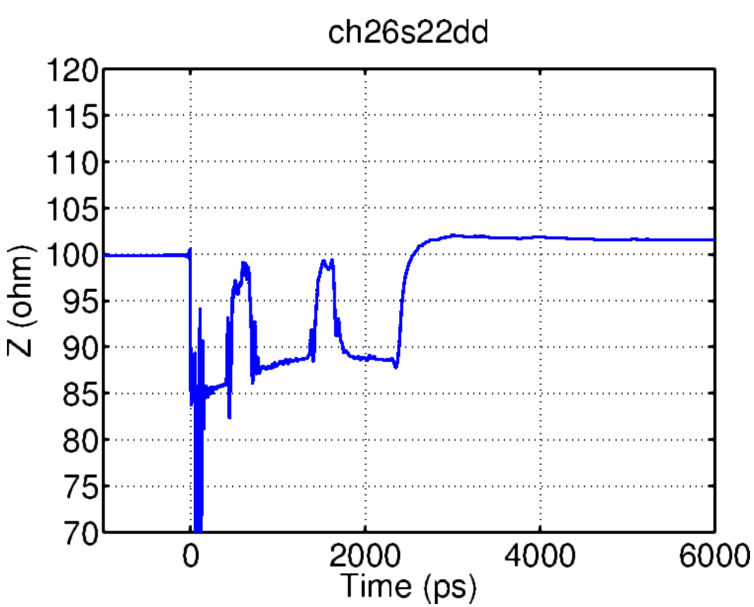
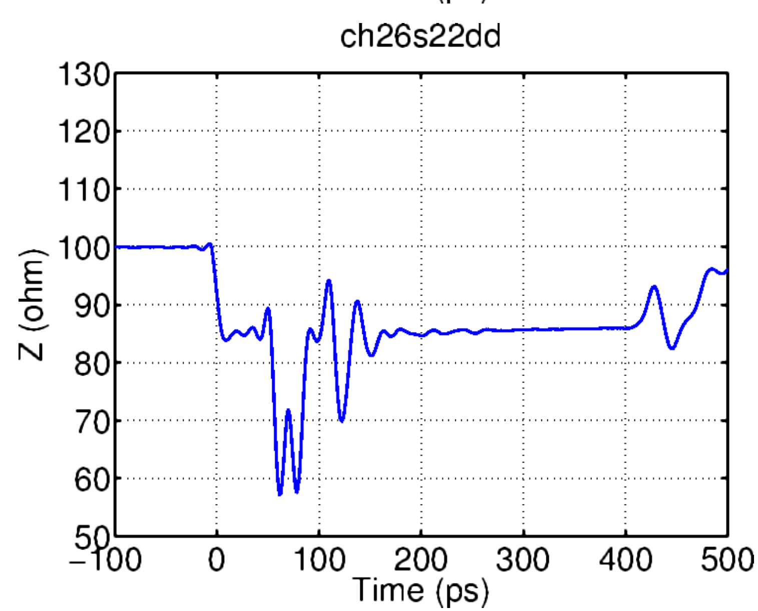
S11dd





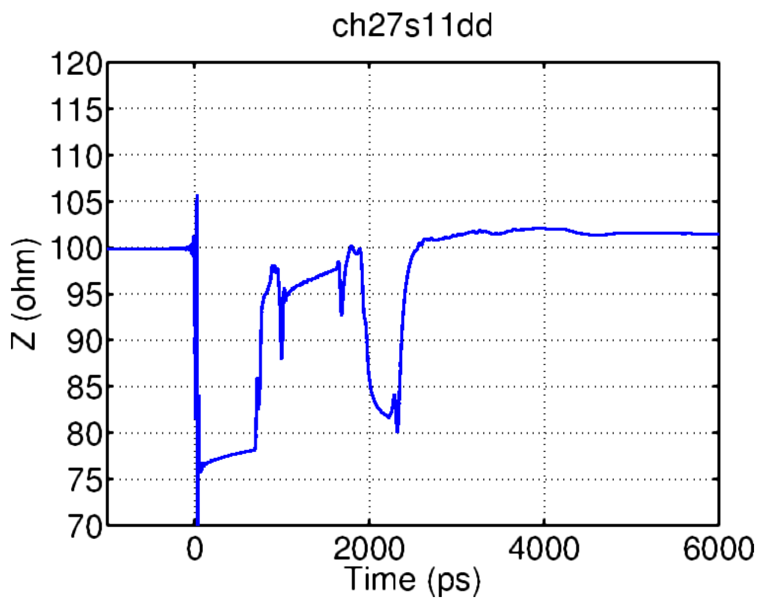
S22dd

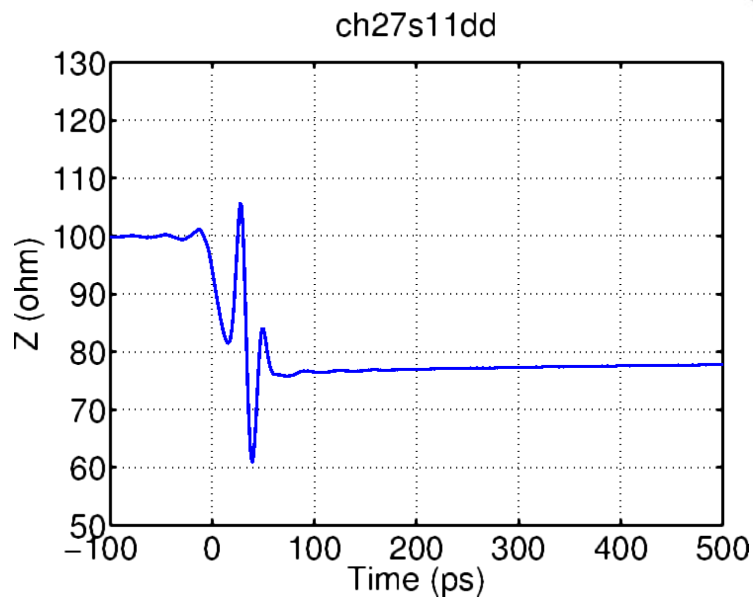




Intel 85Ω 10dB HzLzHz (CH27): Zdiff Profile

S11dd





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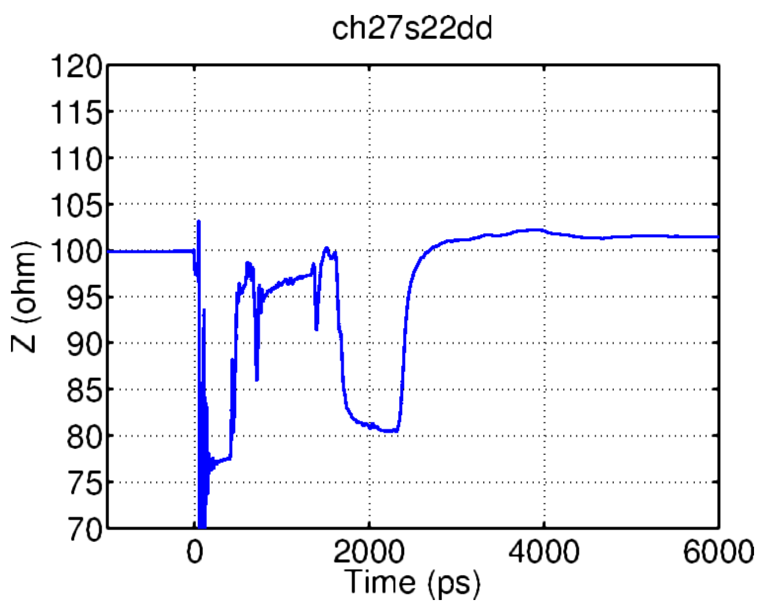
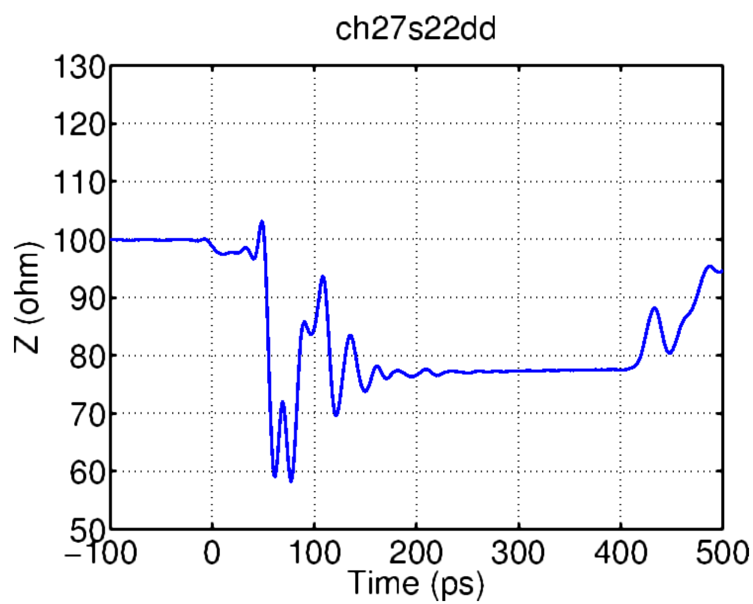
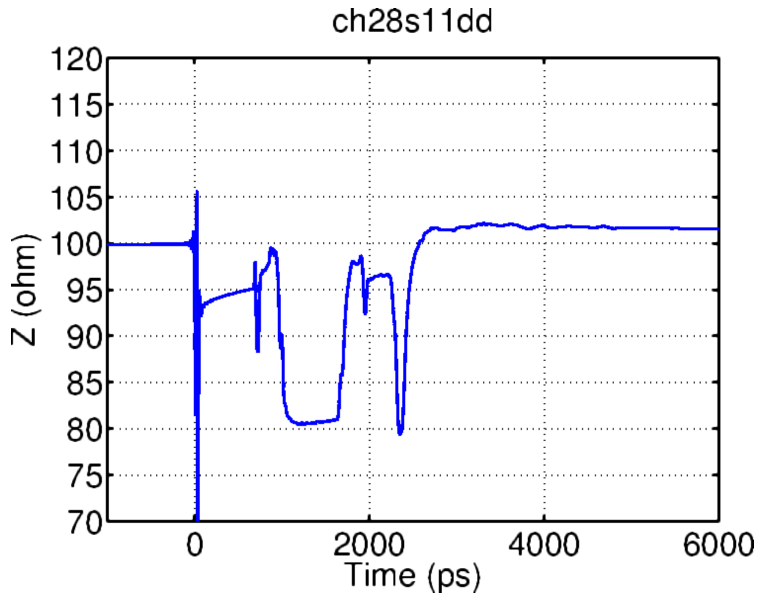


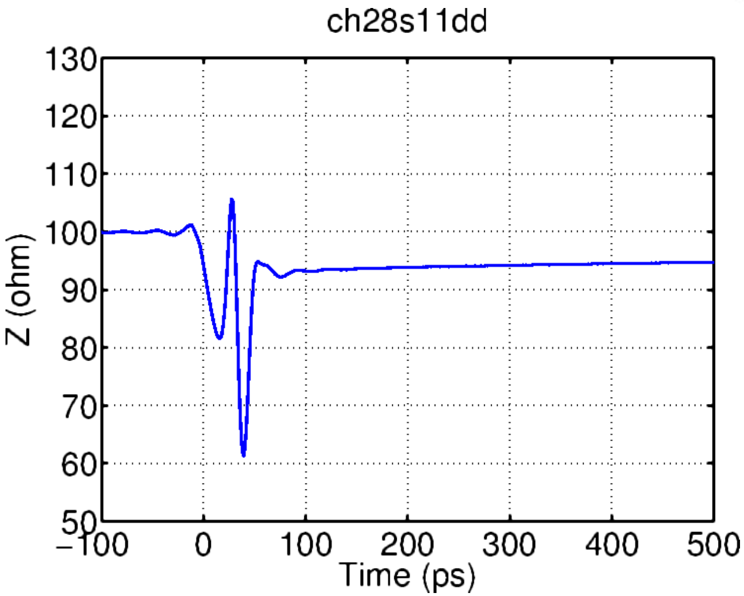


Intel 85Ω 10dB LzHzLz (CH28): Zdiff Profile

FUJITSU

S11dd





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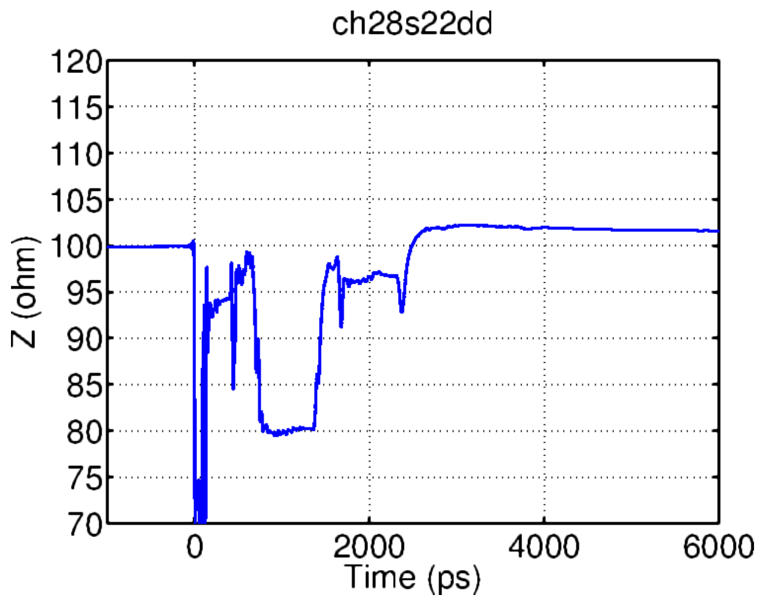
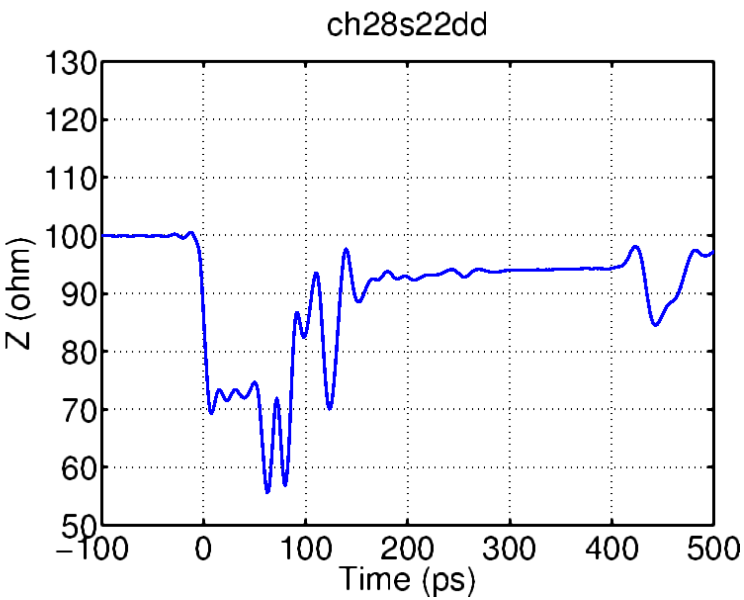
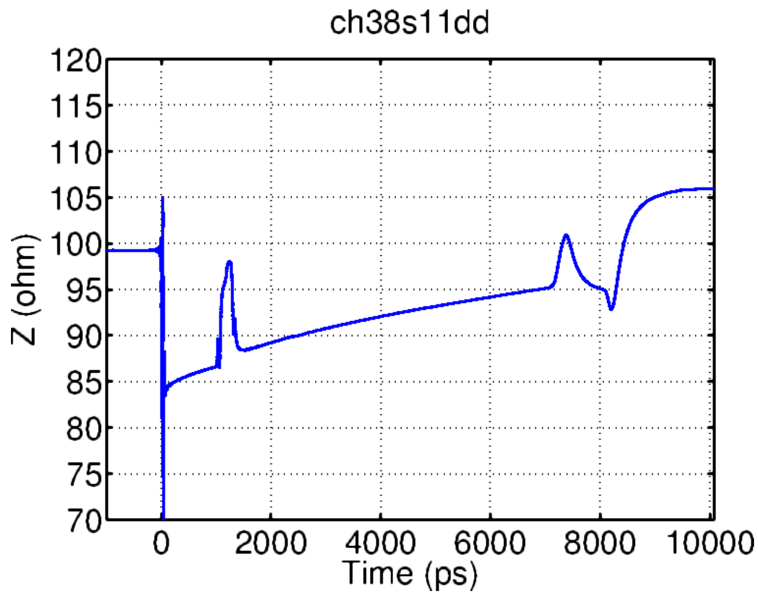


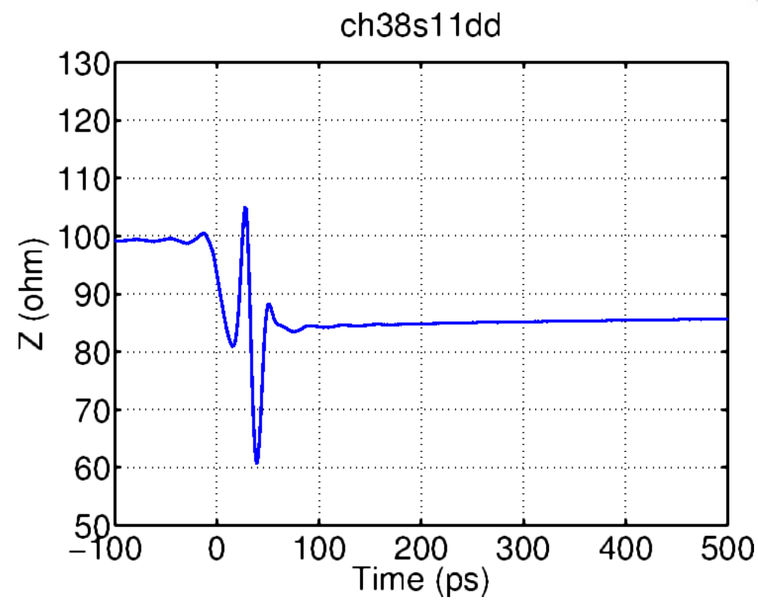


Intel 85Ω 30dB Nom (CH38): Zdiff Profile

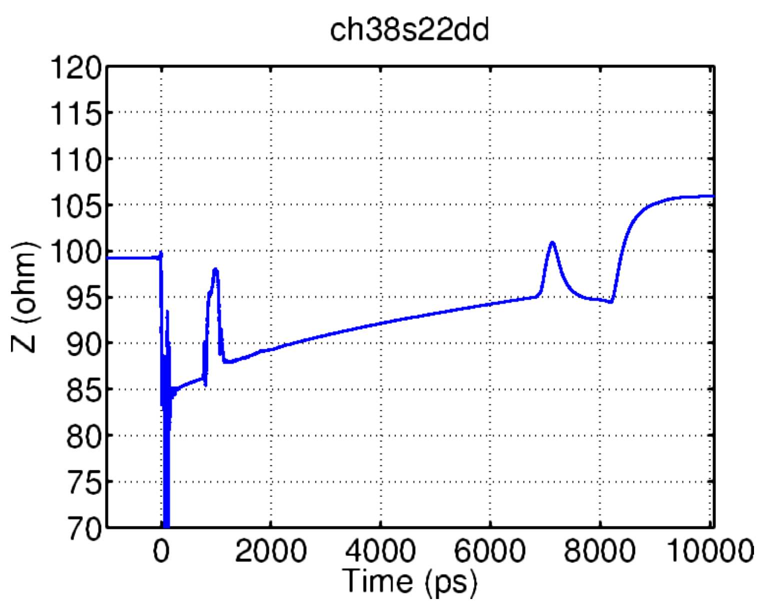
FUJITSU

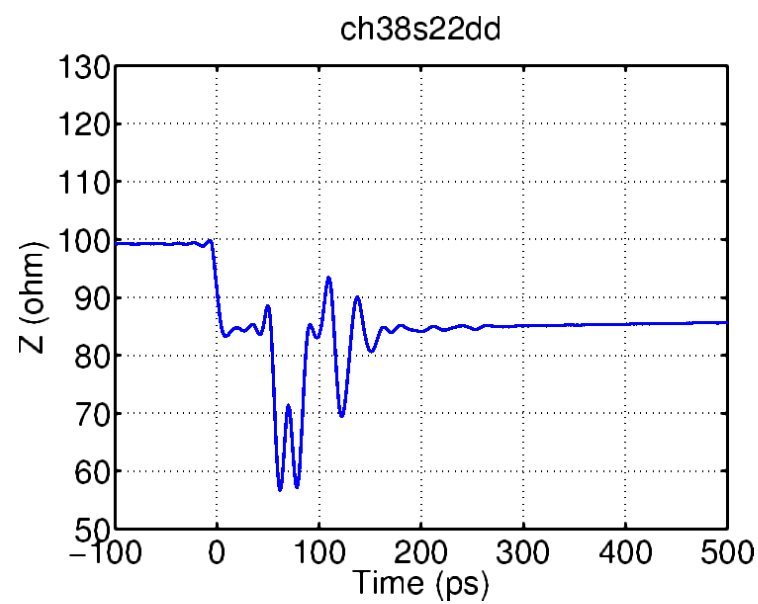
S11dd





S22dd

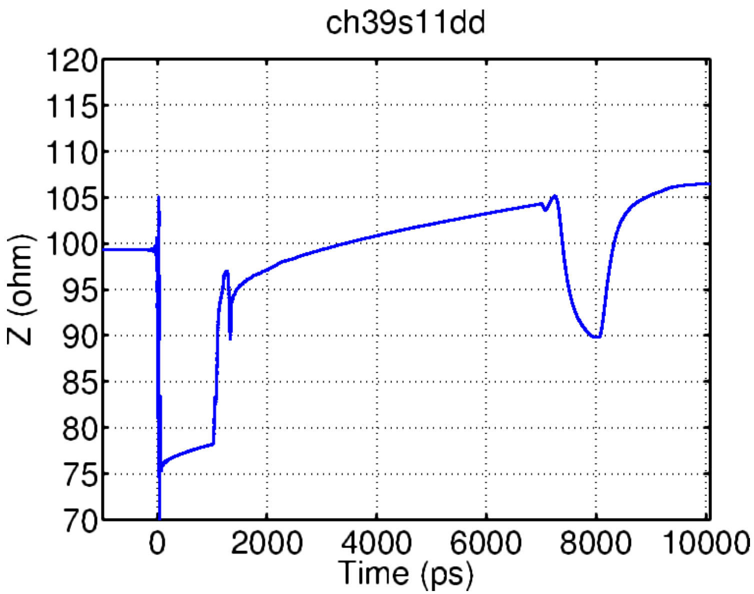


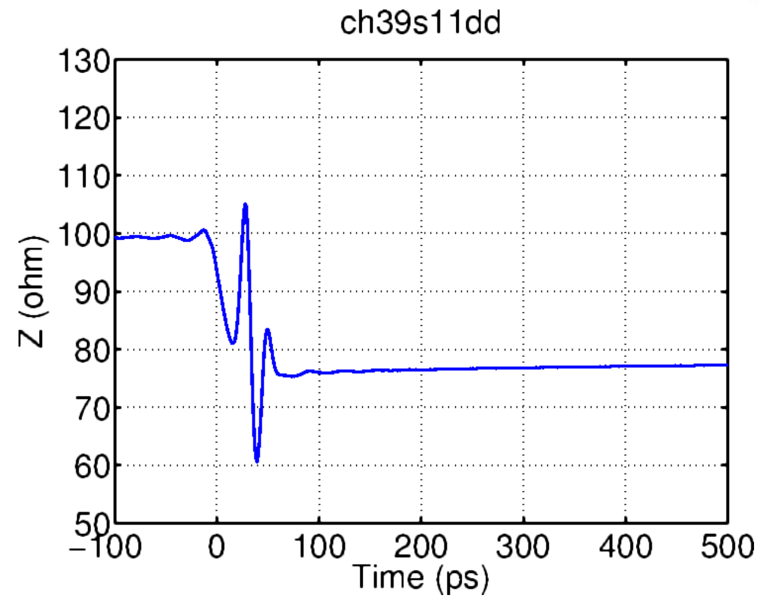


Intel 85Ω 30dB HzLzHz (CH39): Zdiff Profile

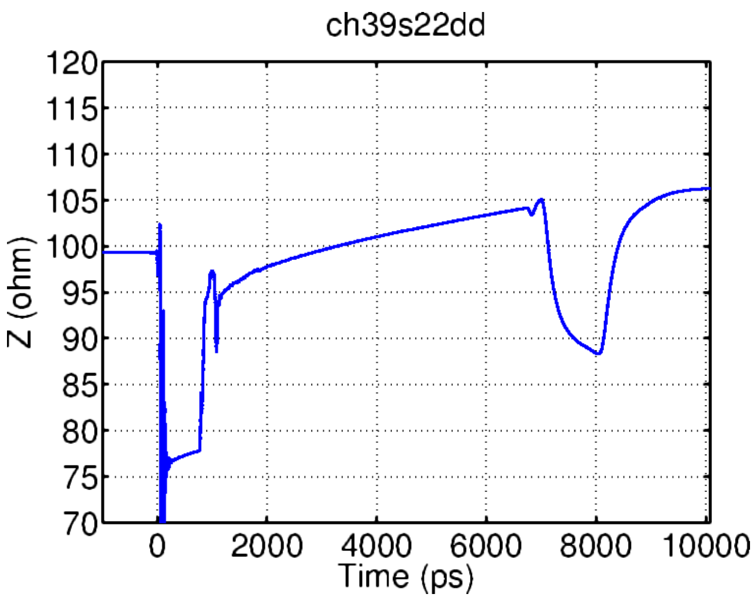
FUJITSU

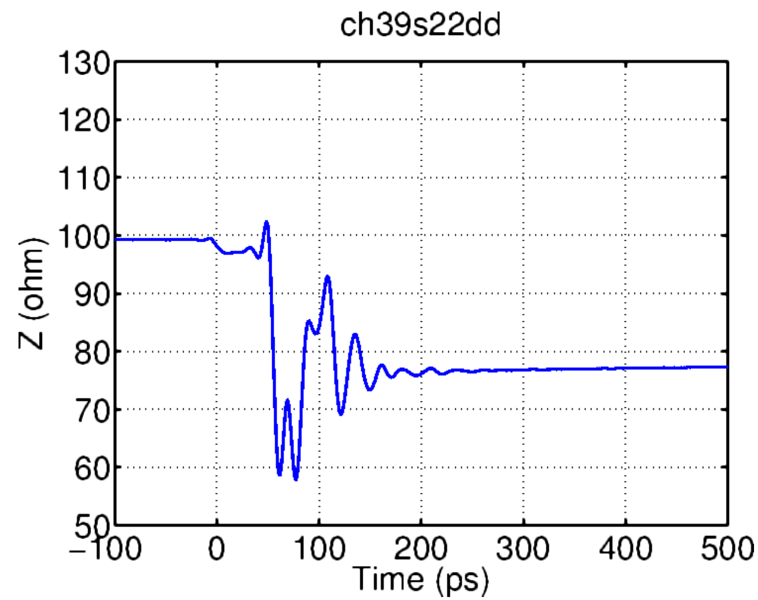
S11dd





S22dd

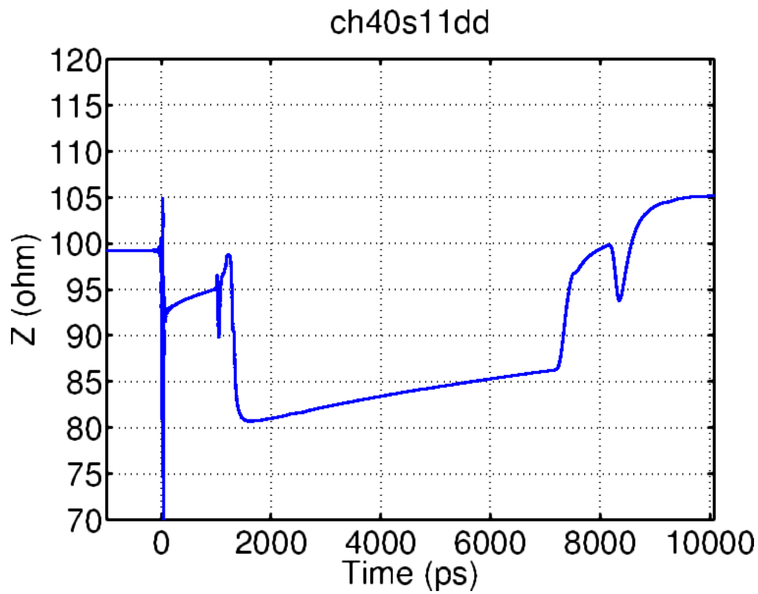


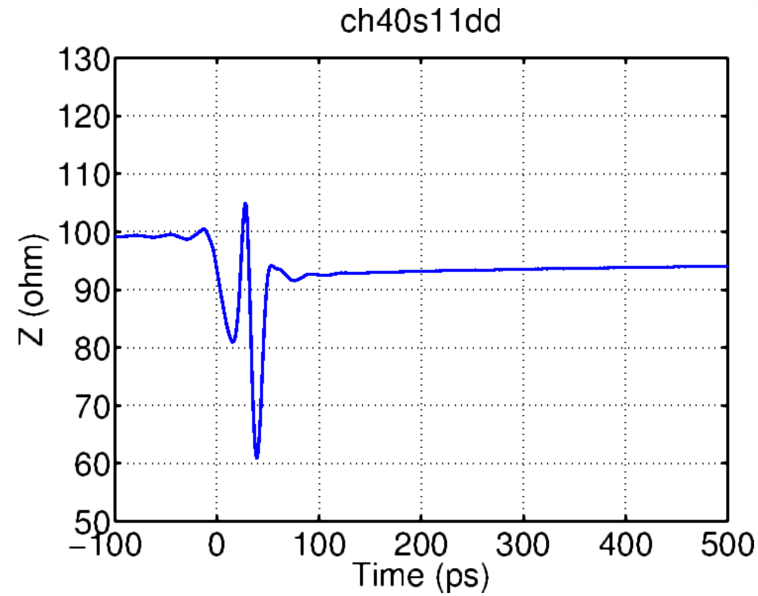


Intel 85Ω 30dB LzHzLz (CH40): Zdiff Profile

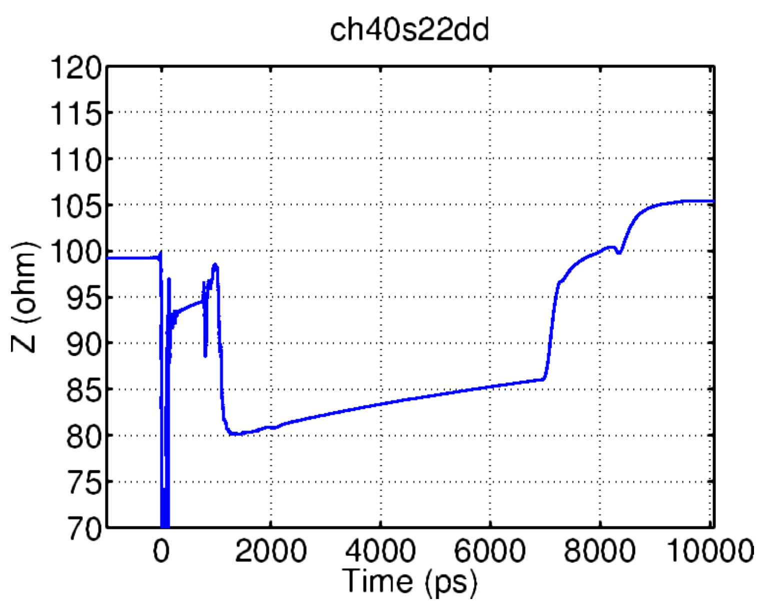
FUJITSU

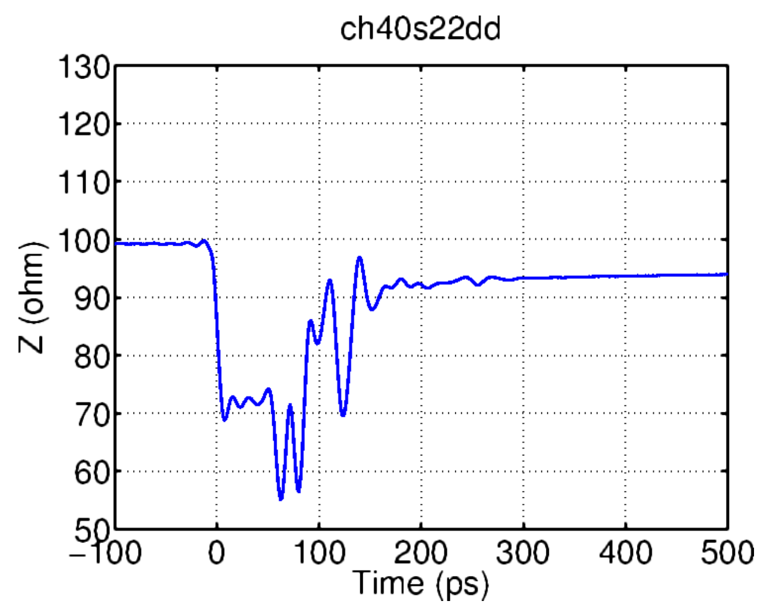
S11dd





S22dd





TE Measured Backplane Channels (CH41-43)

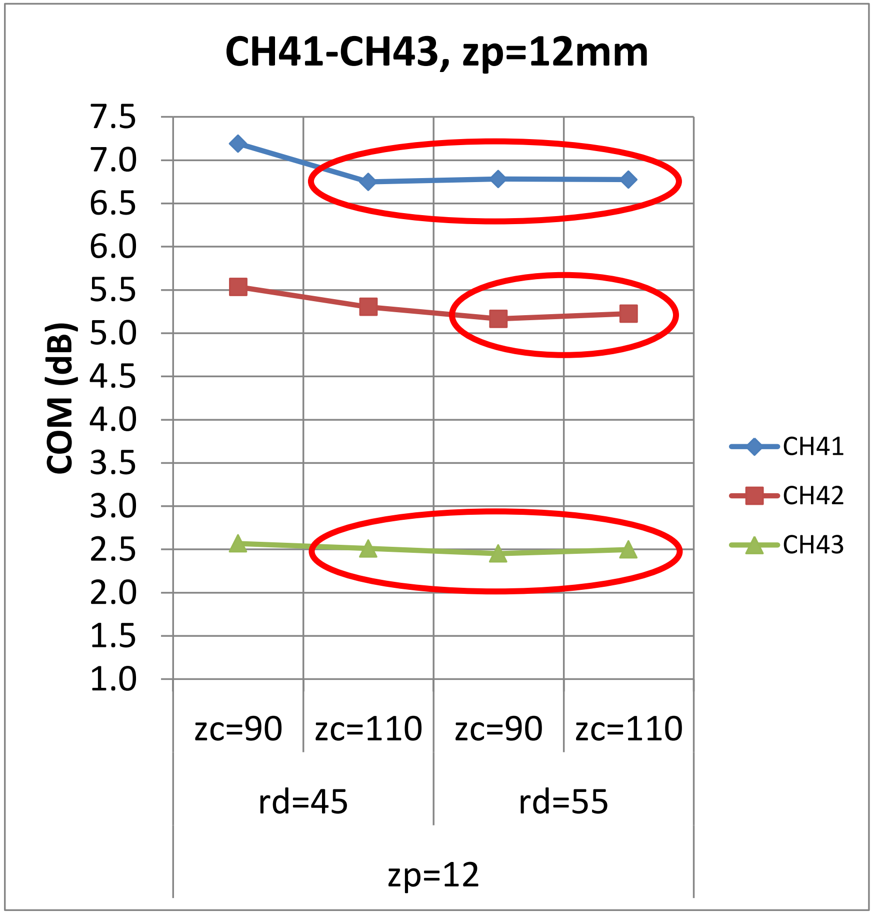
FUJITSU

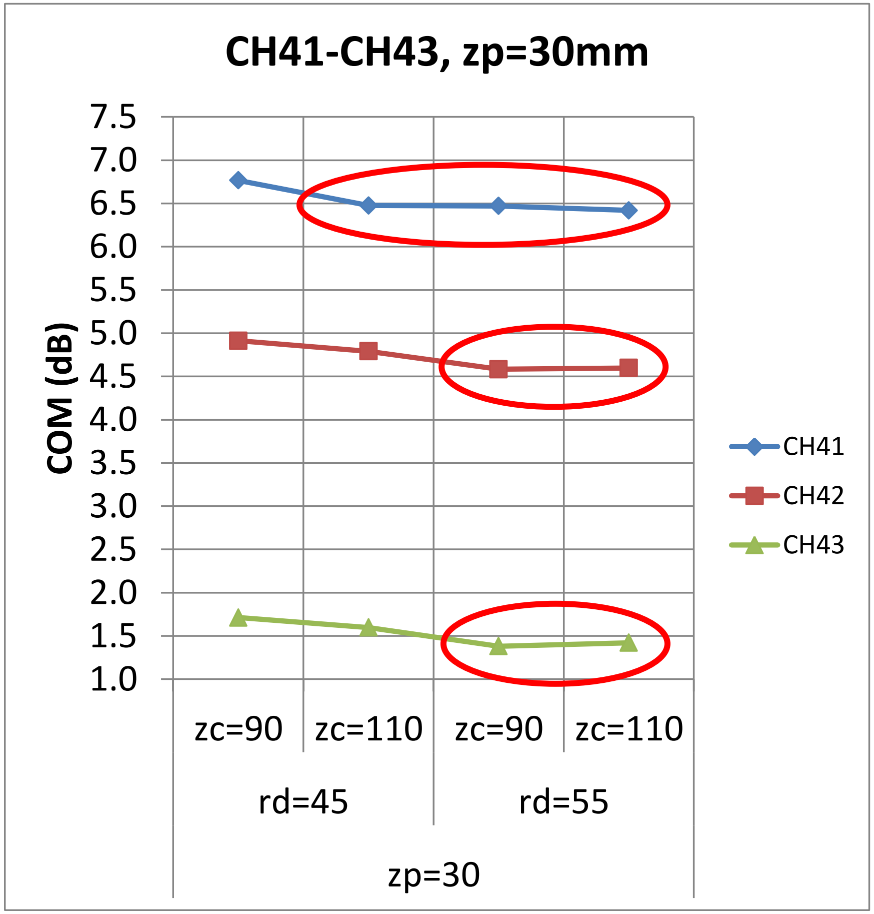
- Data source (in P802.3cd TF Channel Data Area)
  - http://www.ieee802.org/3/cd/public/channel/TEC_STRADAWhisper*.zip
- Characteristics
  - http://…/Reference_document_for_TE_Connectivity_Backplane_S-Parameter_Channels_07_28_16.pdf
  - Insertion Loss @ Nyquist : 10.4567dB (CH41) ~ 31.9644dB (CH43)
  - Crosstalk : 4 FEXT + 4 NEXT
    - FEXT : F11F12, F17F18, H11H12, H17H18
    - NEXT : F14F15, G11G12, G17G18, H14H15

	Length	IL (dB)	FOM_ILD	ICN (mV)
CH41	11.75in	10.4567	0.1476	1.6848
CH42	27in	21.835	0.17028	1.1781
CH43	40in	31.9644	0.256	1.1277

TE Channels (CH41-43): COM Values

- The worst case is Zc=90Ω & Rd=55Ω or Zc=110Ω & Rd=55Ω
  - zp=30mm is worse than 12mm
  - For zp=12mm, the worst is Zc=110Ω & Rd=45Ω or Zc=90Ω & Rd=55Ω





TE 10dB (11.75in) Channel (CH41): Zdiff Profile

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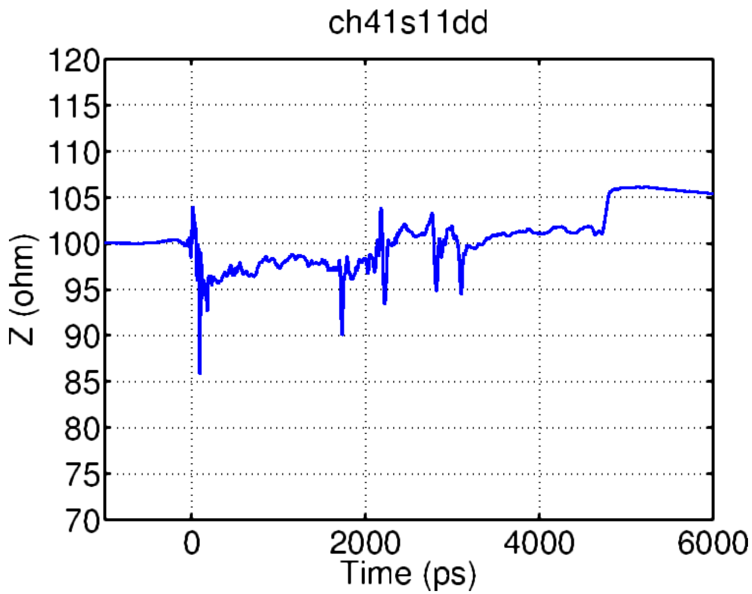
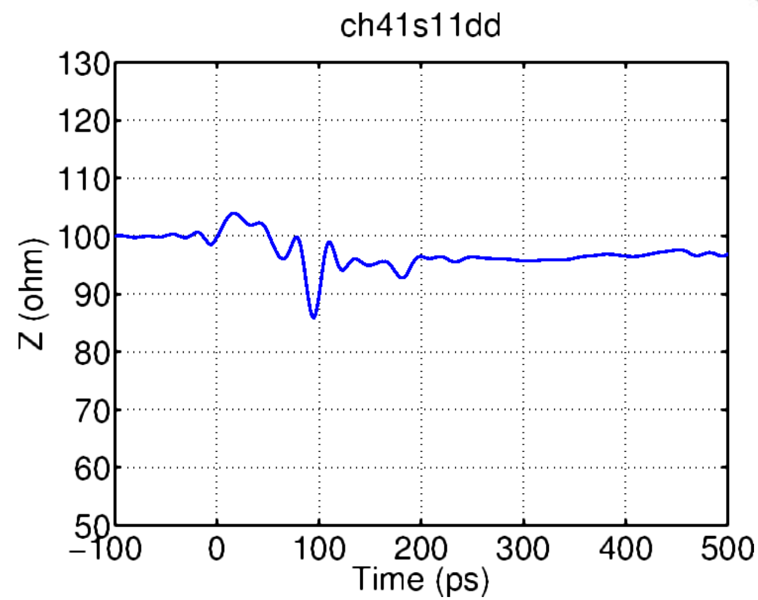
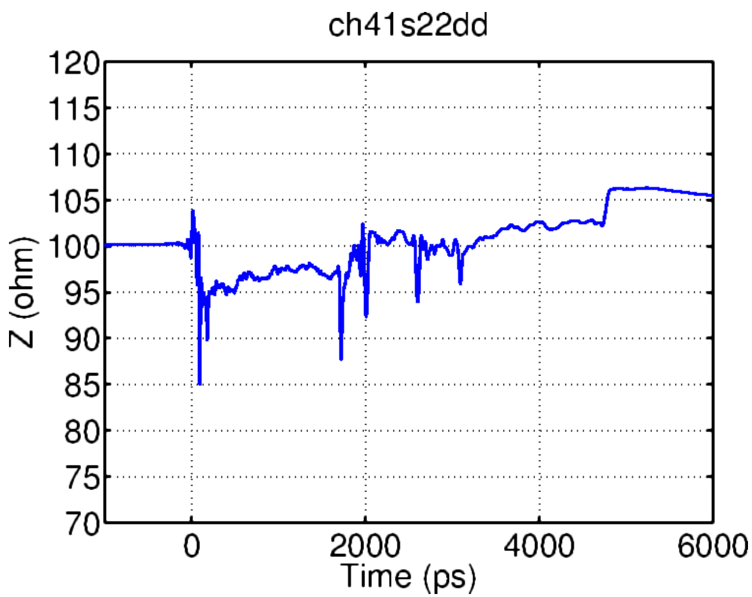
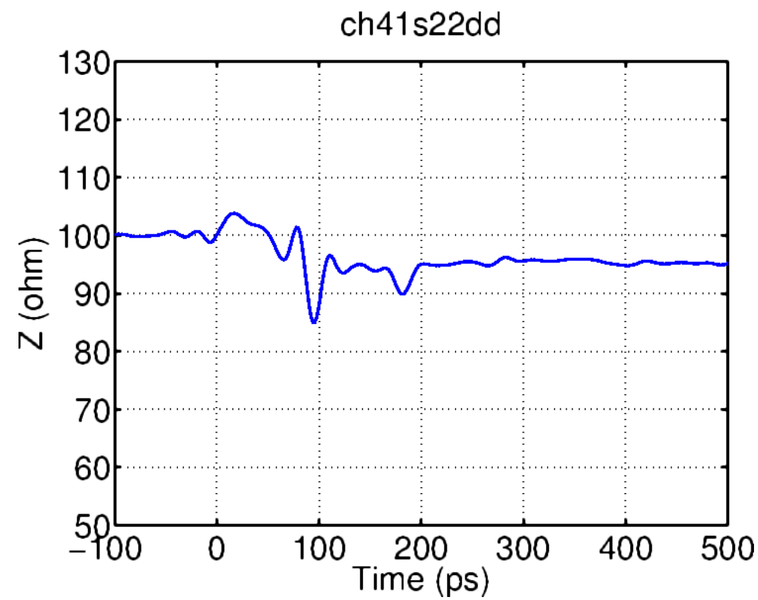
S11dd





S22dd

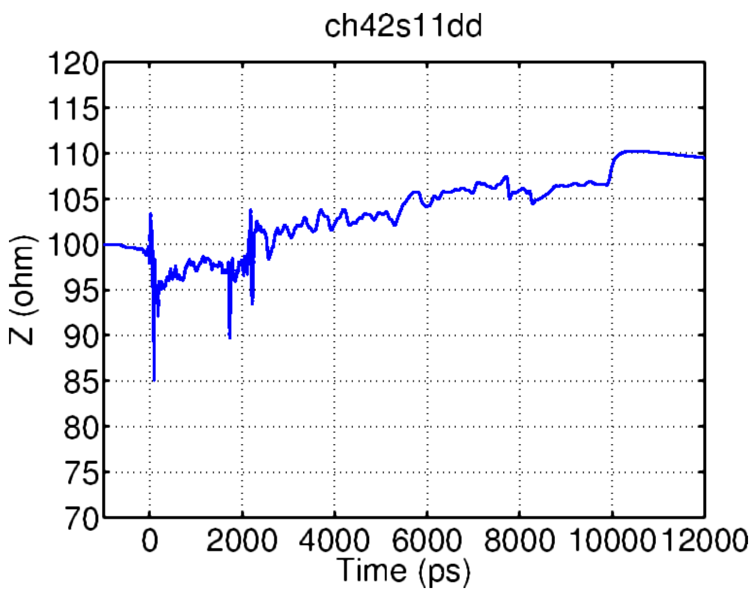


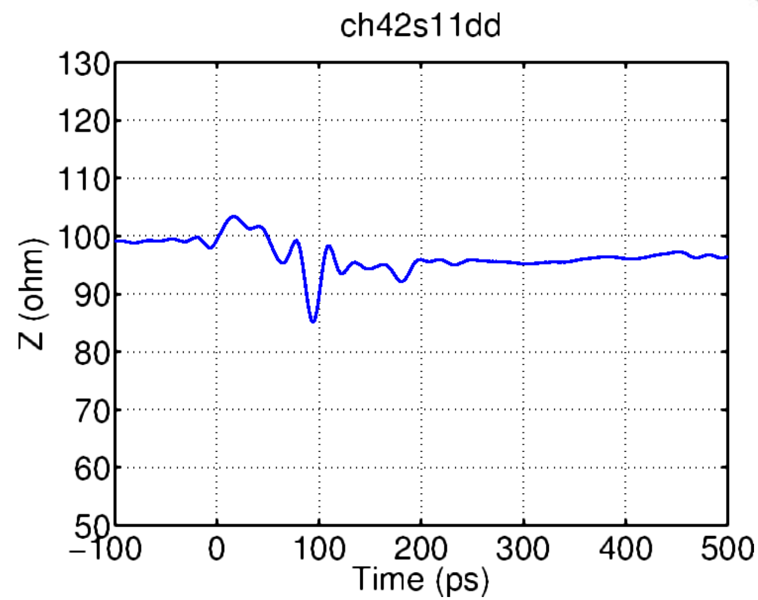


TE 22dB (27in) Channel (CH42): Zdiff Profile

FUJITSU

S11dd





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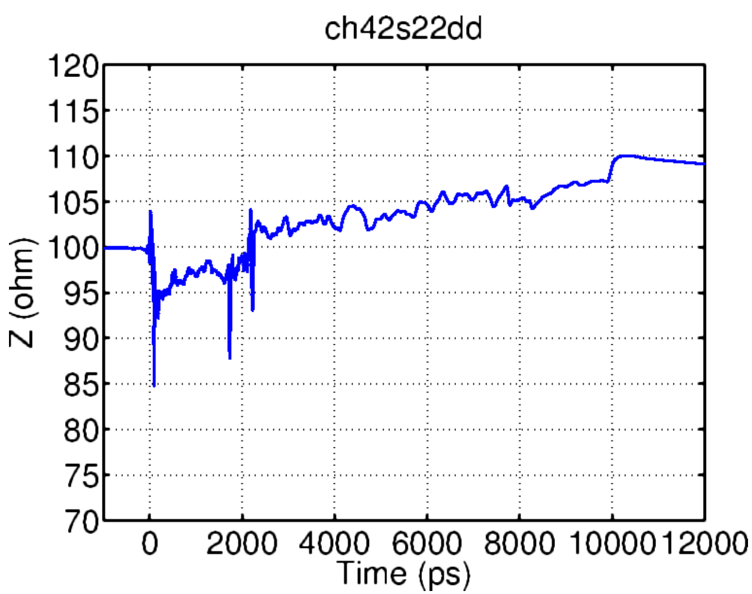
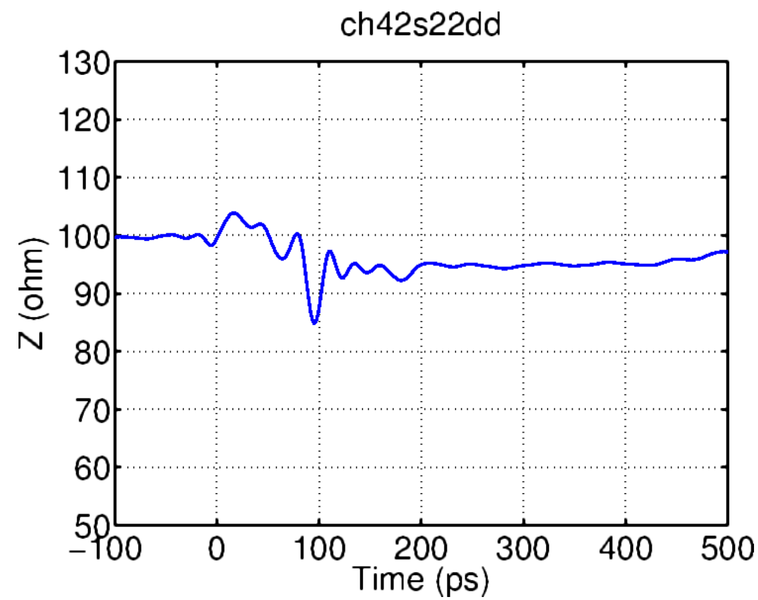
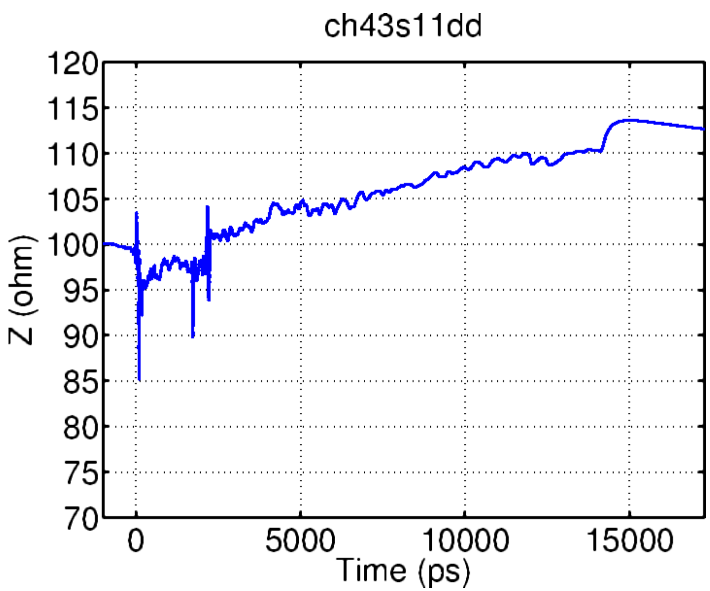


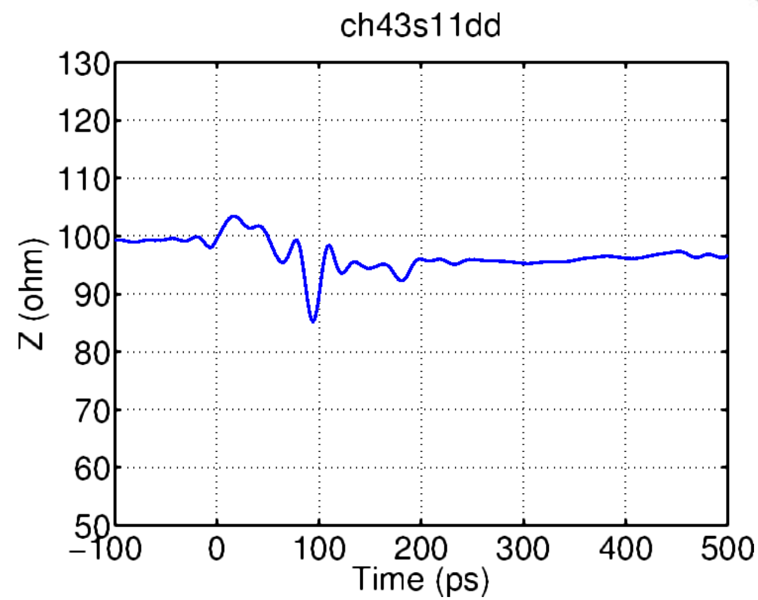


TE 32dB (40in) Channel (CH43): Zdiff Profile

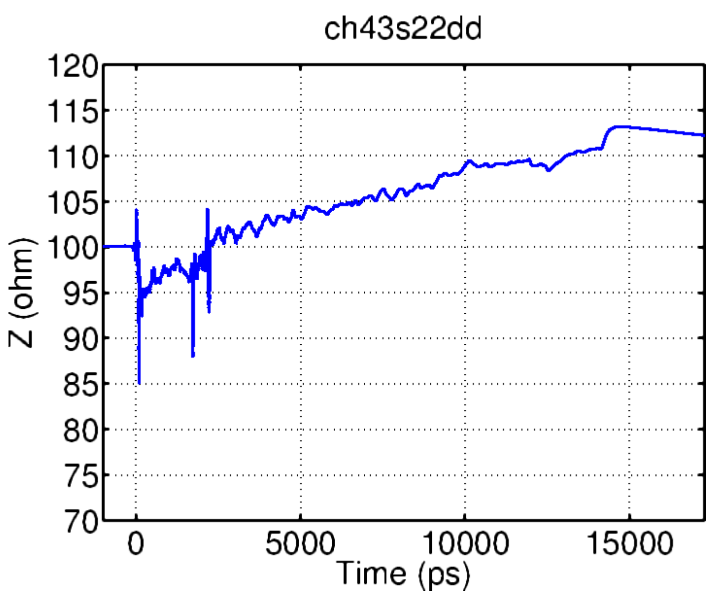
FUJITSU

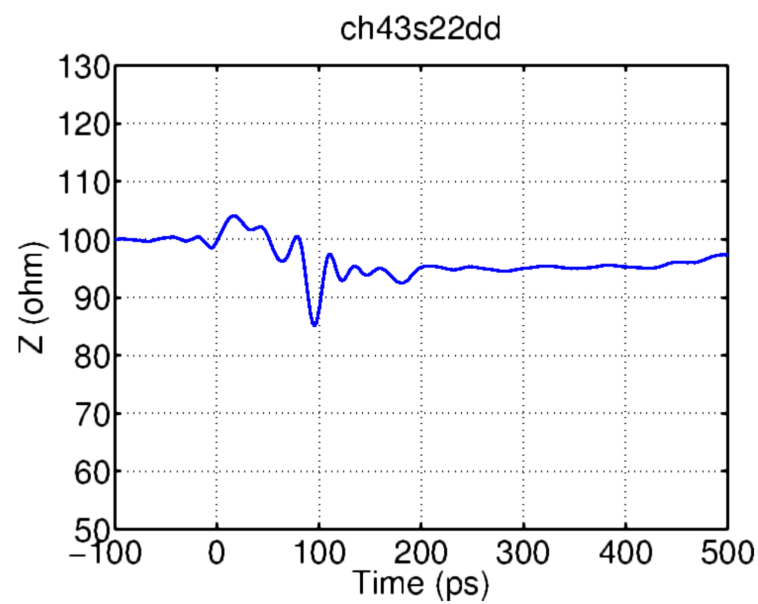
S11dd





S22dd





Thank you