Comment #41: Effects of the change from Np=13 to Np=200

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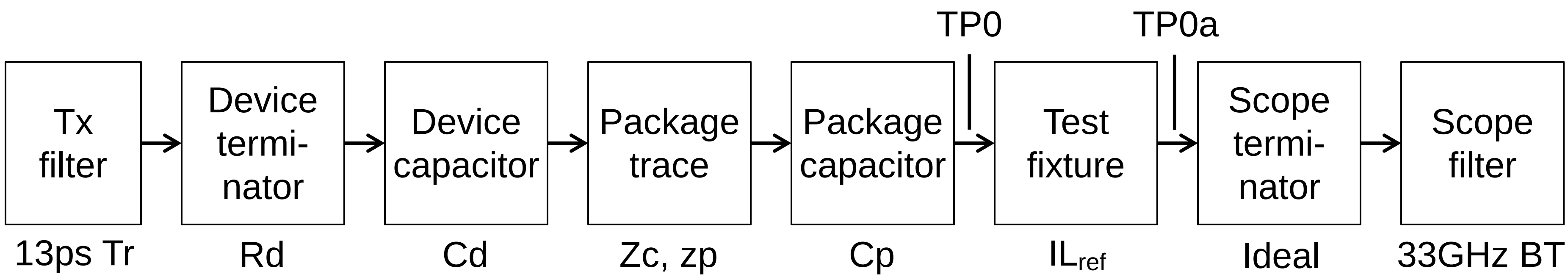
IEEE P802.3bs Task Force
Electrical Ad hoc, October 24, 2016

Background

- Np was changed from 13 to 200 in Draft D2.1.
- A larger Np value increases the steady-state voltage v_f, because a longer fillted pulse will capture more long-term ISI.
  - On the other hand, peak of the fillted pulse does not change.
- As a result, the ratio of the linear fit pulse peak to v_f is reduced.
- In order to keep the requirement for Tx same, we should adjust v_f and the ratio of the linear fit pulse peak to v_f consistently with the change to Np.
- I noticed this problem while I was conducting a different study for P802.3cd project

Simulated Model

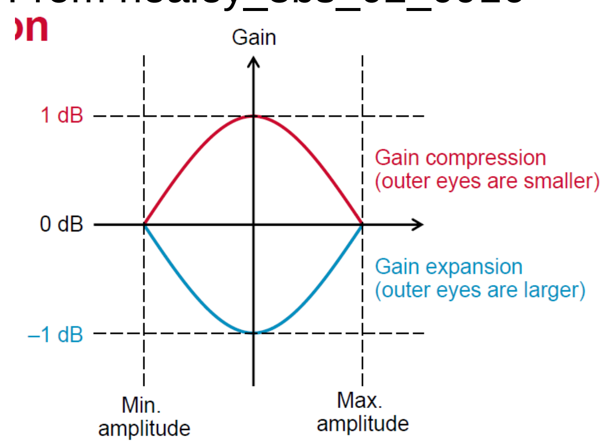


- Tx filter: $S_{21} = (\text{EQ93A}-46 | T_r = 13\text{ps}, \beta = 2)$ (i.e. 13ps 20-80% Tr)
- Device terminator: $S_{21} = 1, S_{22} = \frac{Rd - 50\Omega}{Rd + 50\Omega}$ (i.e. same as Tx in COM)
- Device capacitor: $S = (\text{EQ93A}-8 | C = C_d)$
- Package trace: $S = \left(\text{EQ93A}-13{,}14 \middle| \text{Table93A}-3 \text{ except } Z_c, z_p\right)$
- Package capacitor: $S = \left(\text{EQ93A}-8 \middle| C = C_p\right)$
- Test fixture: $|S_{21}| = 10^{-(\text{EQ93}-1)/20}, \angle S_{21} = \text{minimum phase}(|S_{21}|)$
- Scope terminator: $S_{21} = 1, S_{11} = 0$ (i.e. ideal)
- Scope filter: 4-th order Bessel-Thomson LPF with 33GHz 3dB BW
  - $\omega_0 = 98.2896714244743 5\ \text{G rad/s}$

Simulation Methodology

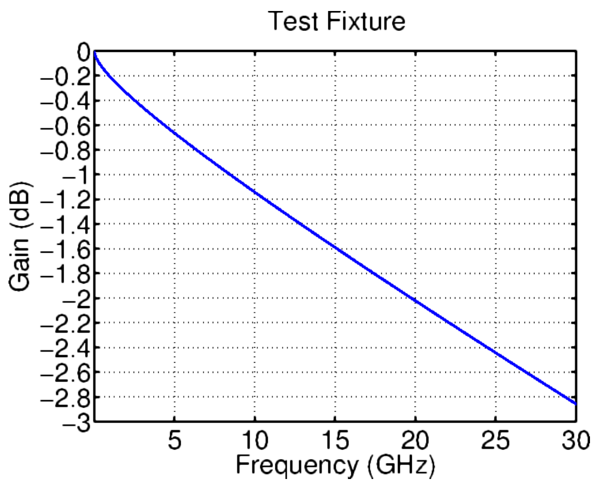
1. Get S_{21} of the entire model from 1MHz to f_{max} with 1MHz step
   - $f_{max} = 26.5625\text{GHz} \times M \div 2$, where $M = 32$
2. Get a single-bit pulse response
3. Get a linear cycle response of PRBS13Q with ideal levels
4. Cancel the DC offset of the linear cycle response of PRBS13Q
5. Get a non-linear cycle response of PRBS13Q by gain expansion / compression (similar to a methodology in healey_3bs_02_0916)
   - Simulated from -1.0dB to +1.0dB with 0.2dB step
6. Get V0, V1, V2, and V3 per 120D.3.1.2.1
7. Get Vmid, ES1, and ES2 per 120D.3.1.2
8. Get ES=(ES1+ES2)/2 per 120D.3.1.3
9. Get linear fit pulse p(k) and error e(k) per 120D.3.1.3, 94.3.12.5.2, 85.8.3.3.5
   - Dp=2 and Np=13 or 200
10. Get steady-state voltage v_f and linear fit pulse peak p_{max} per 120D.3.1.4
11. Get σ_e from e(k), then get SNDR per 120D.3.1.6
    - σ_n is always set to $p_{max} \times 10^{(-50/20)}$ (i.e. -50dB) to have noise floor

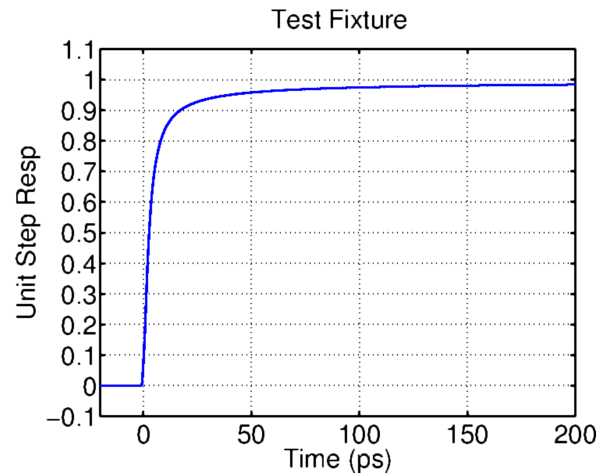
From healey_3bs_02_0916

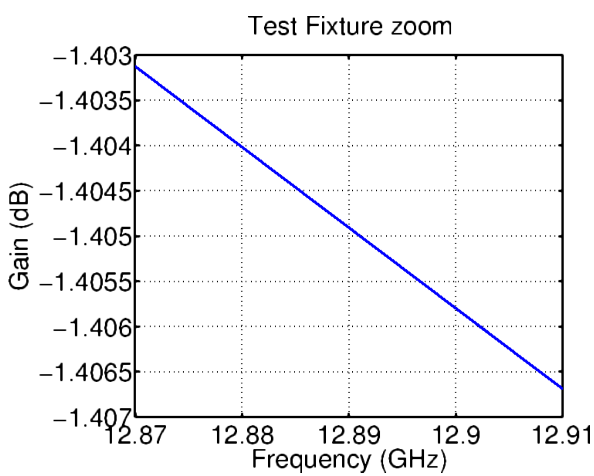


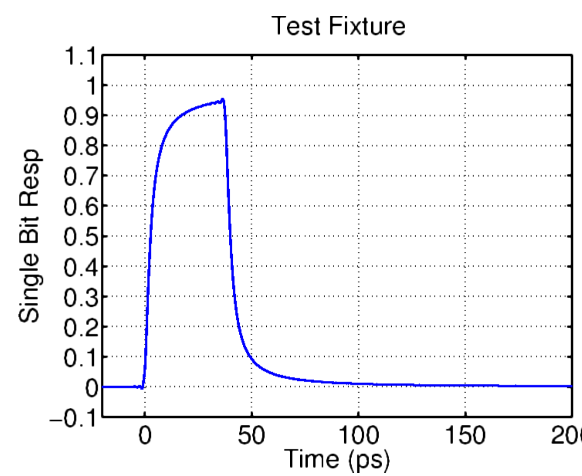
Test Fixture

- The reference insertion loss of the test fixture is defined by
  - $IL_{ref}(f) = -0.0015 + 0.144\sqrt{f} + 0.069f$ (93-1)
    - 1.4049dB at 12.89GHz









Tx Transition Time Filter

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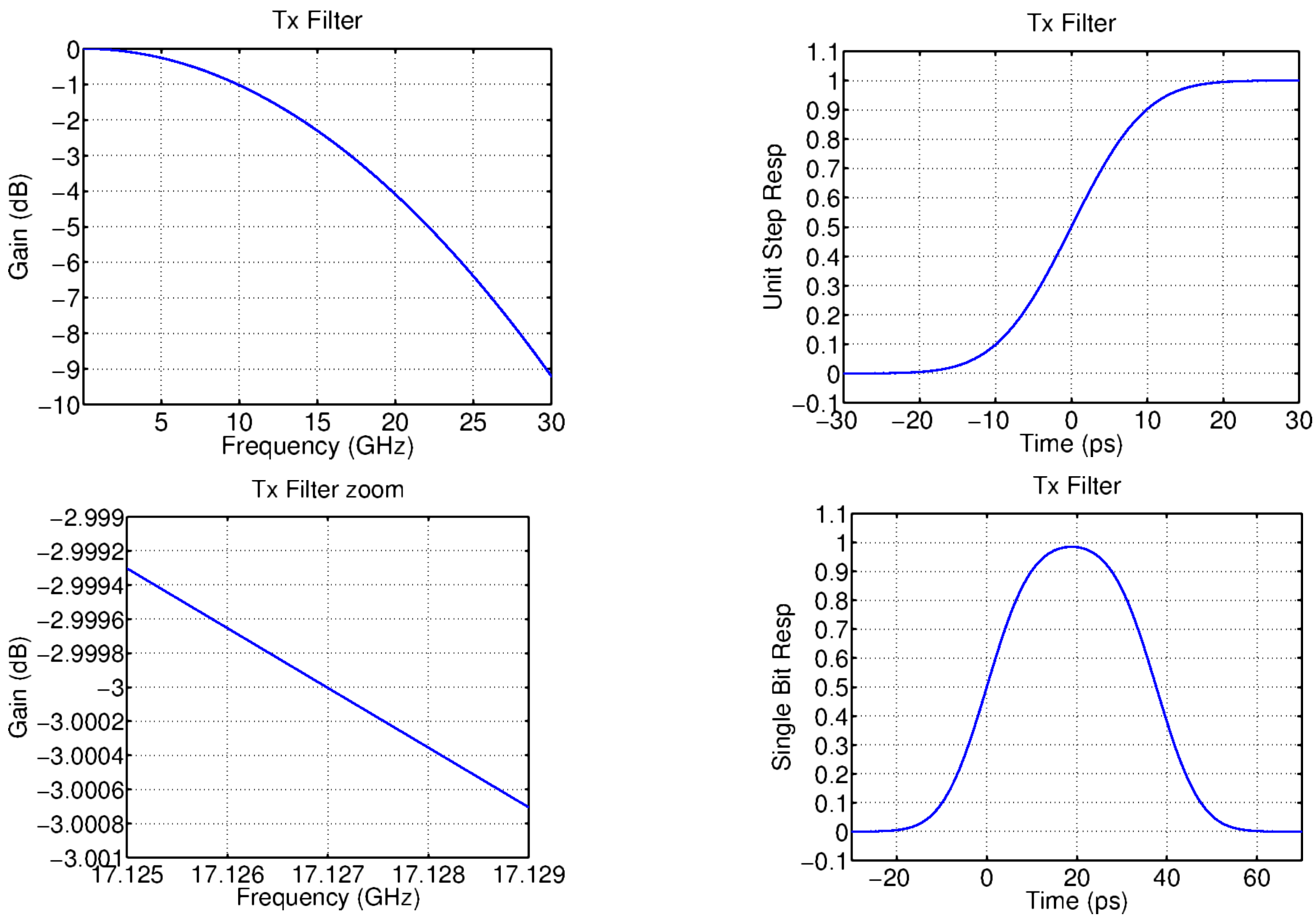
- Tx Transition Time Filter (per 802.3by) is defined by
  - $H_t(f) = \exp(-\beta(\pi f T_r/1.6832)^2)$ (93A-46)
    - with $\beta = 2, T_r = 13ps$



Scope Filter (4th-order Bessel-Thomson LPF)

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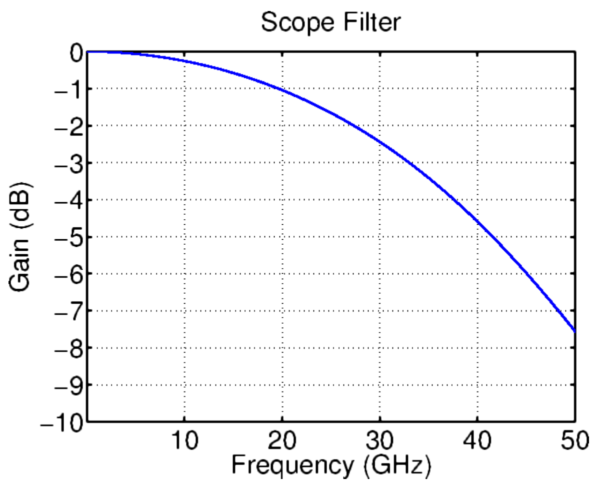
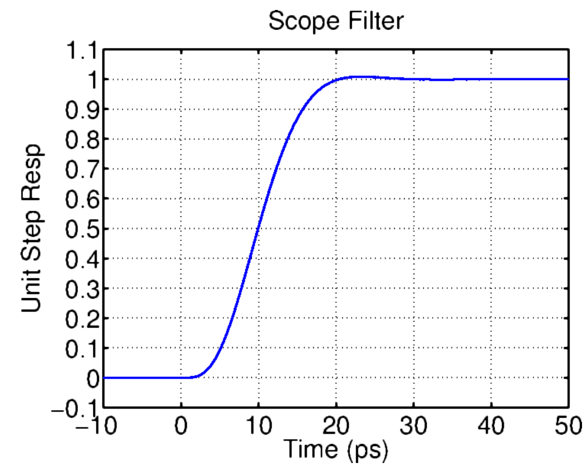
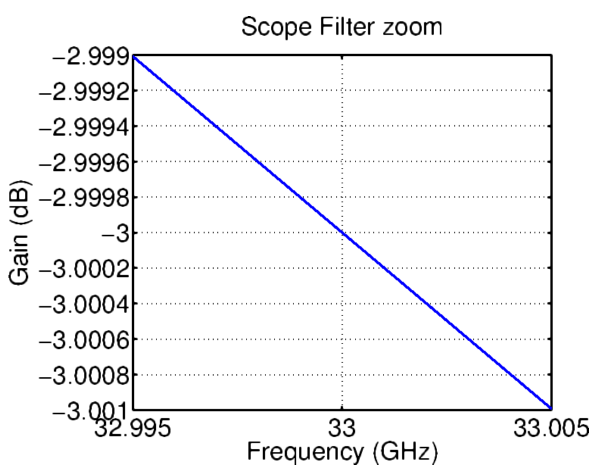
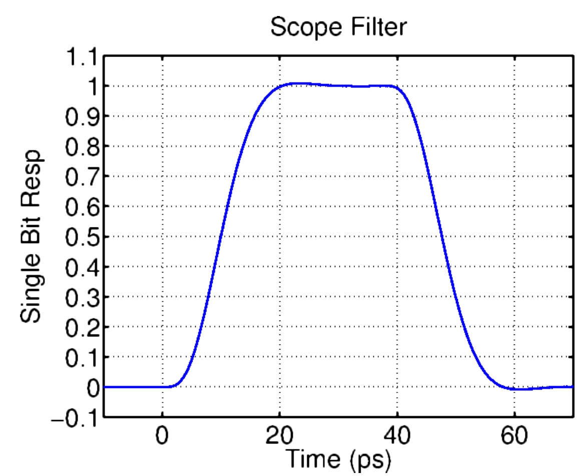
- A 4th-order BT LPF with 33GHz 3dB Bandwidth is defined by
  - $H(s) = \theta_4(0)/\theta_4(s/\omega_0)$ where $\theta_4(s) = s^4 + 10s^3 + 45s^2 + 105s + 105$ and $\omega_0 = 98.2896714244743 5\ \mathrm{G\,rad/s}$









Simulated Package Parameters

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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		

TDR of Entire Path from Scope (zp=12mm)

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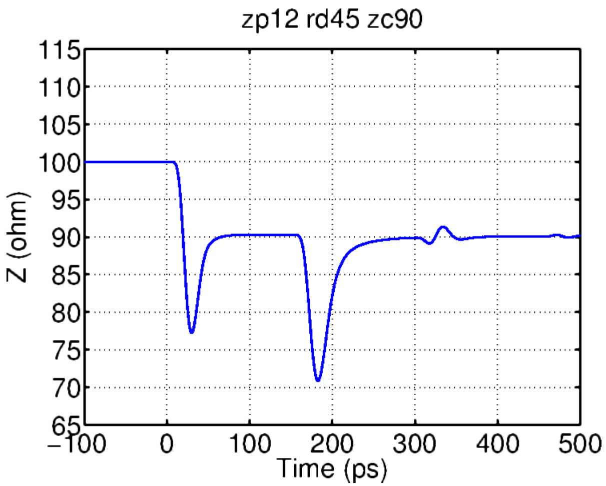
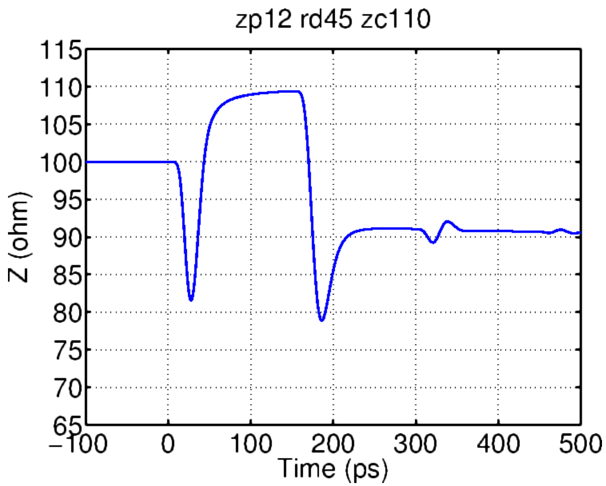
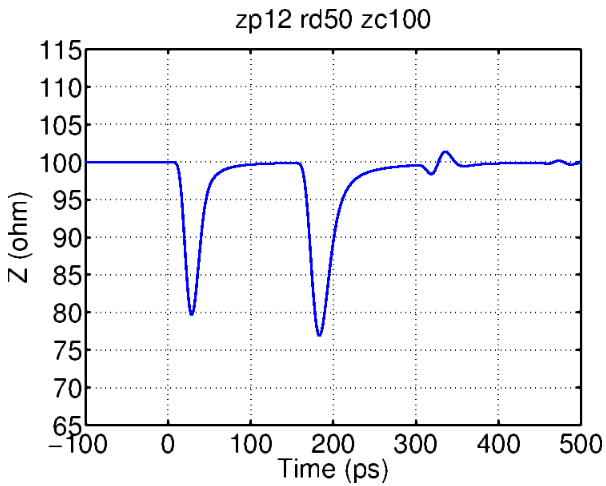
#1: Rd=45, Zc=90



#2: Rd=45, Zc=110



#9: Rd=50, Zc=100



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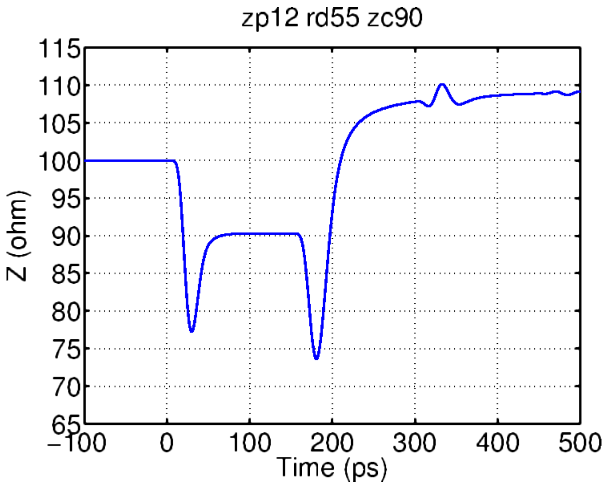
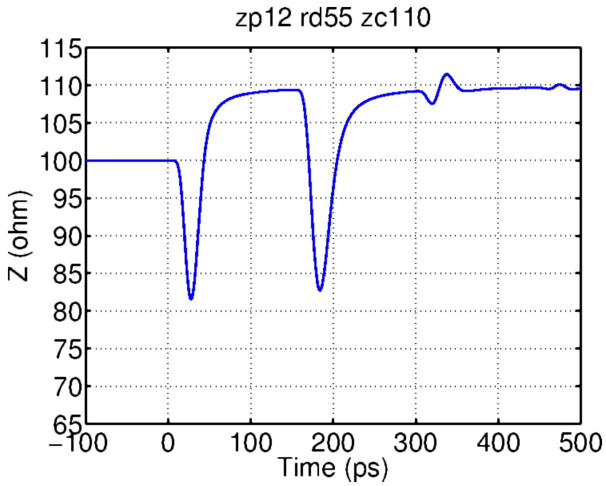


#4: Rd=55, Zc=110



TDR of Entire Path from Scope (zp=30mm)

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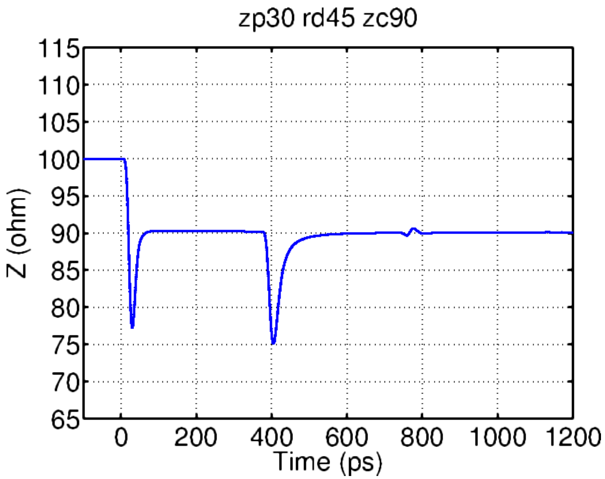
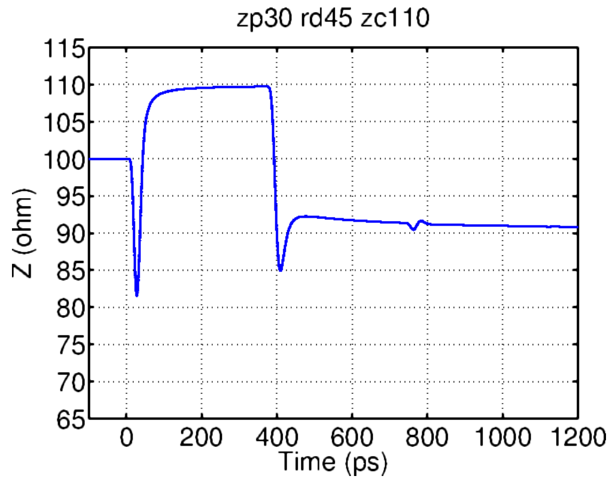
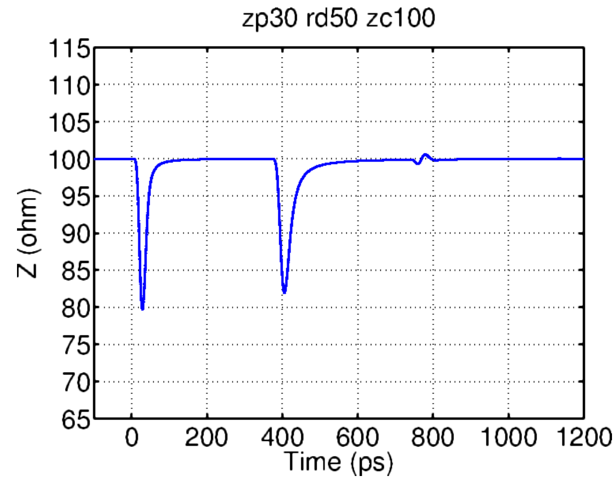
#5: Rd=45, Zc=90



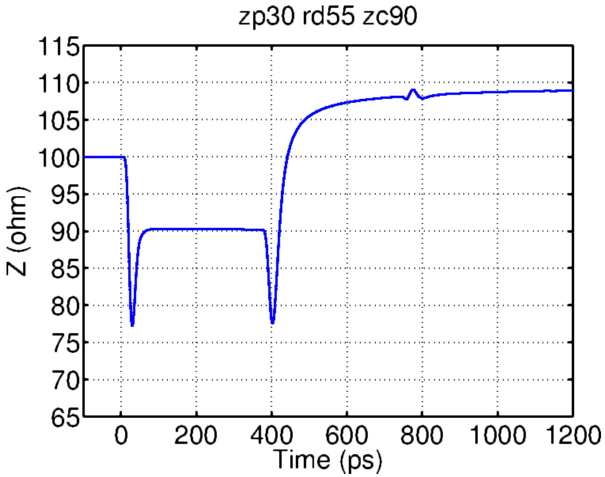
#6: Rd=45, Zc=110



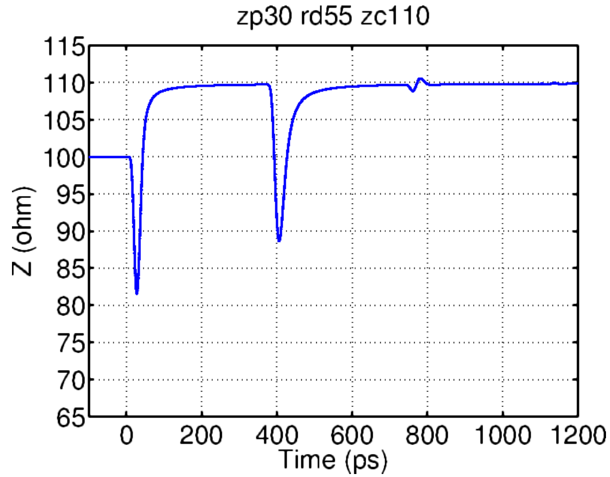
#10: Rd=50, Zc=100



#7: Rd=55, Zc=90



#8: Rd=55, Zc=110



SBR of Entire Path (zp=12mm)

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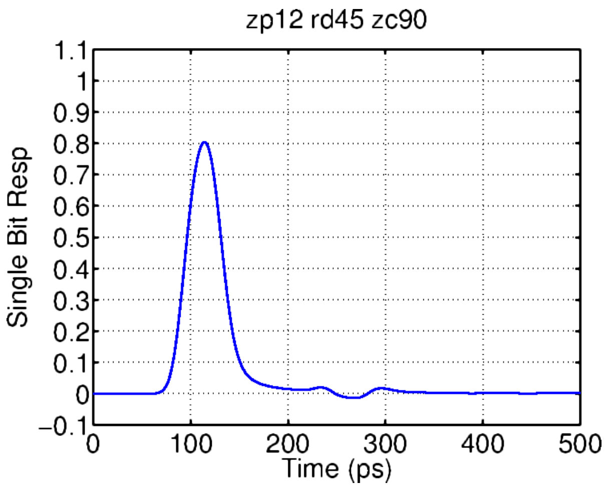
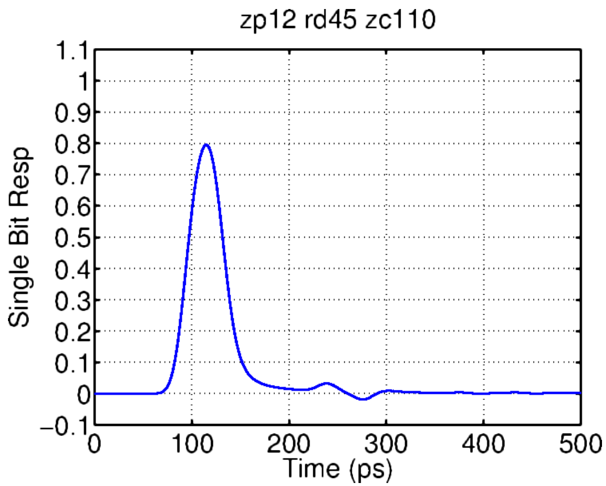
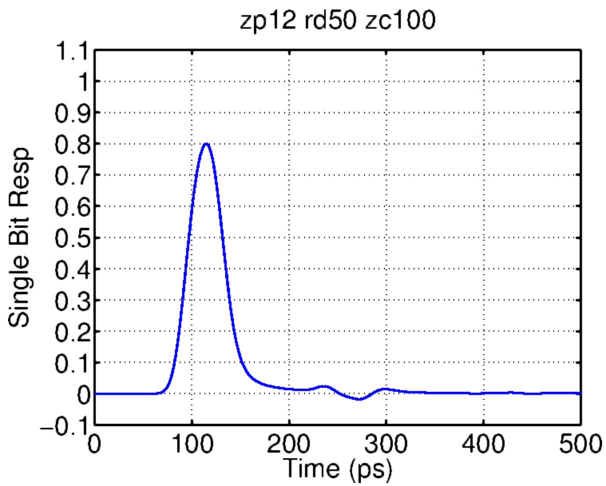
#1: Rd=45, Zc=90



#2: Rd=45, Zc=110



#9: Rd=50, Zc=100



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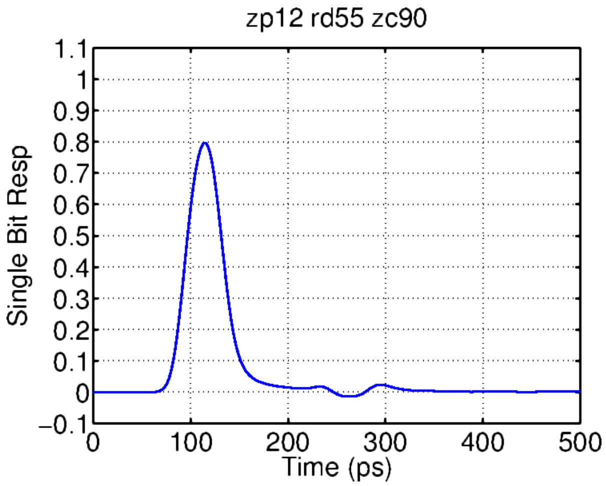
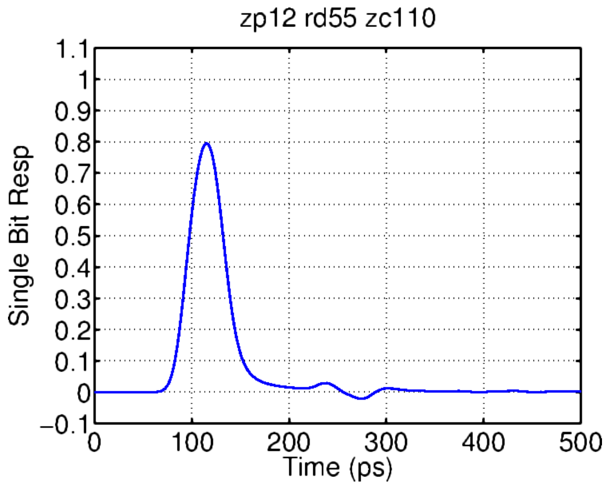


#4: Rd=55, Zc=110



SBR of Entire Path (zp=30mm)

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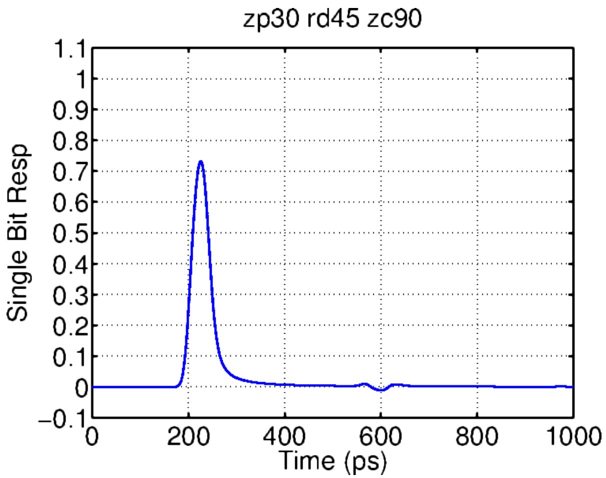
#5: Rd=45, Zc=90



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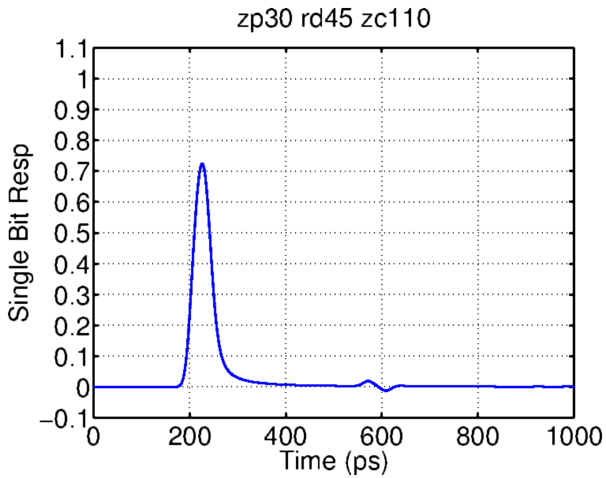
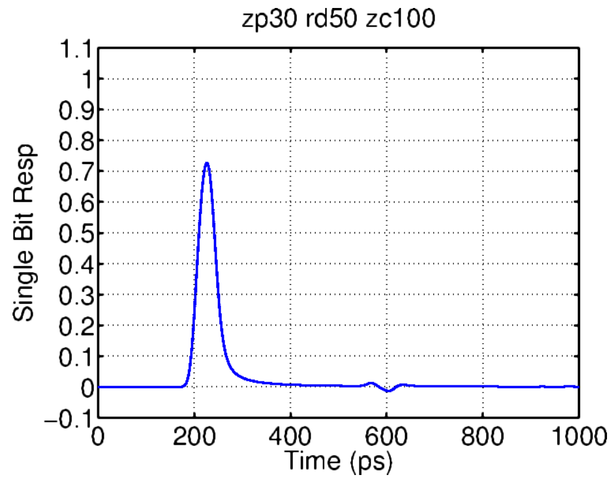
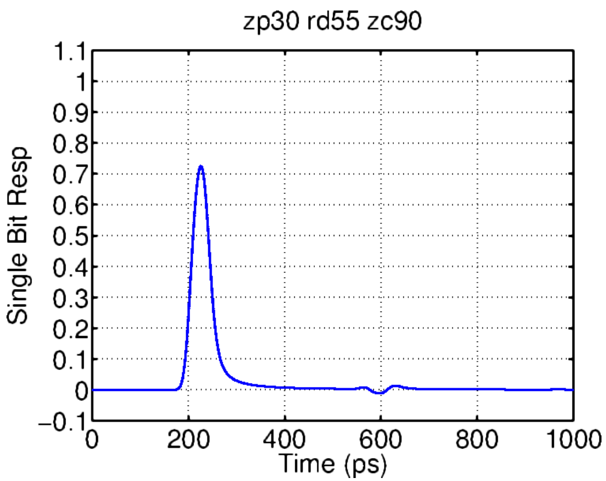


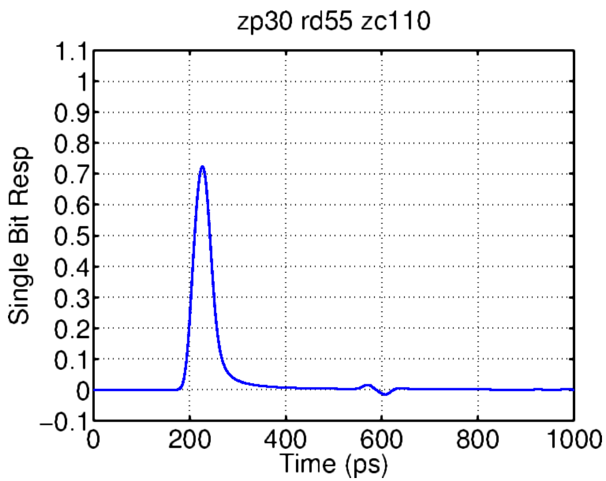
#10: Rd=50, Zc=100



#7: Rd=55, Zc=90



#8: Rd=55, Zc=110



Step Response of Entire Path (zp=12mm)

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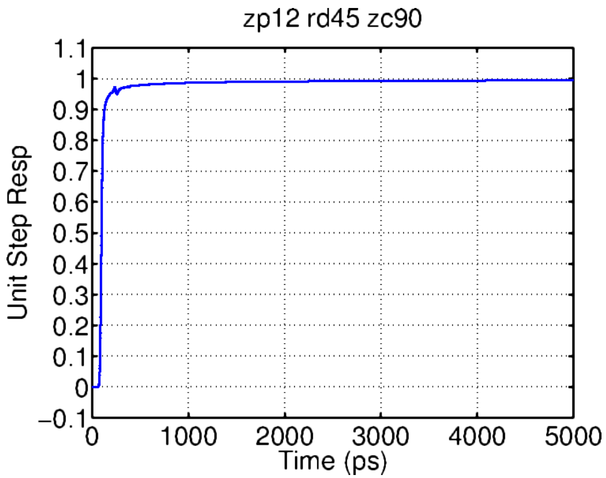
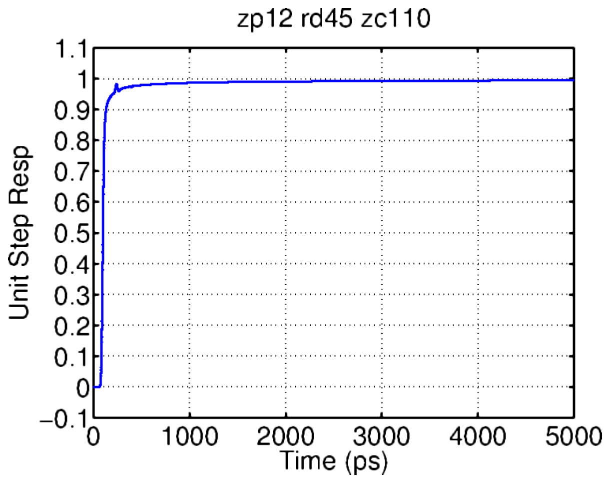
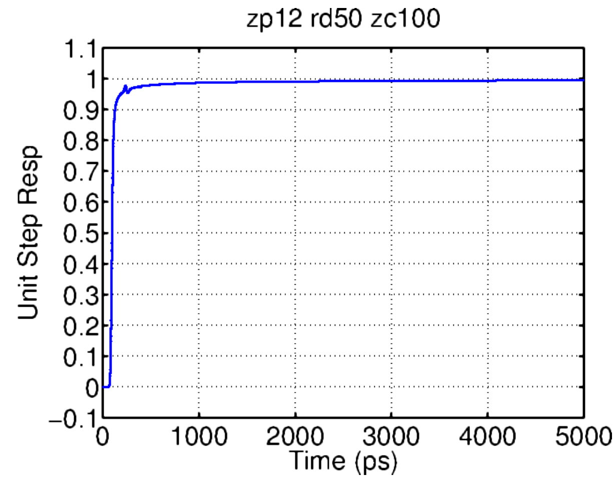
#1: Rd=45, Zc=90



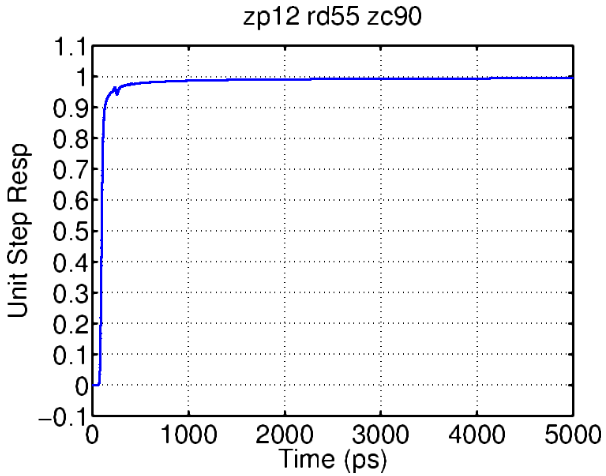
#2: Rd=45, Zc=110



#9: Rd=50, Zc=100



#3: Rd=55, Zc=90



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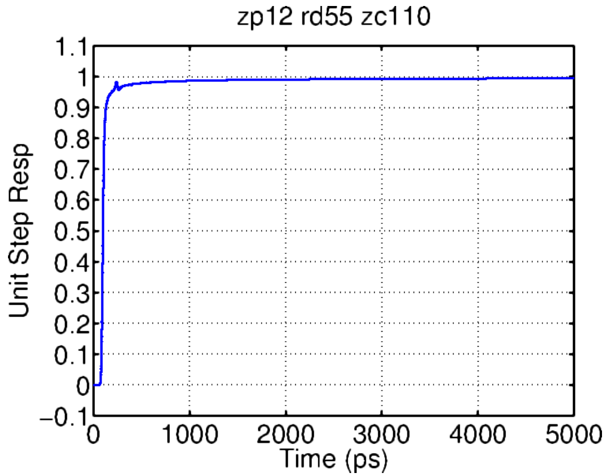

Step Response of Entire Path (zp=30mm)

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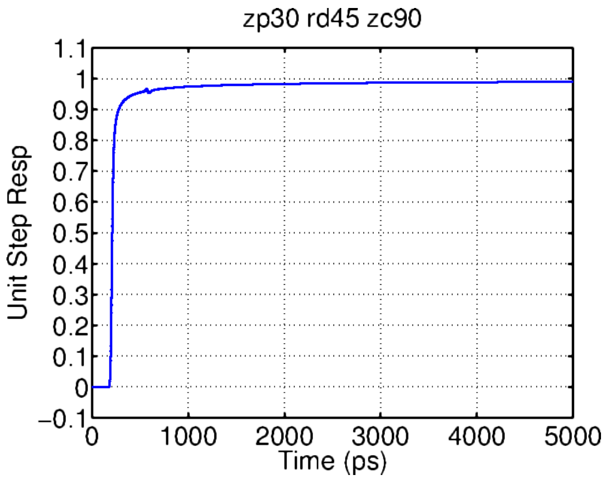
#5: Rd=45, Zc=90



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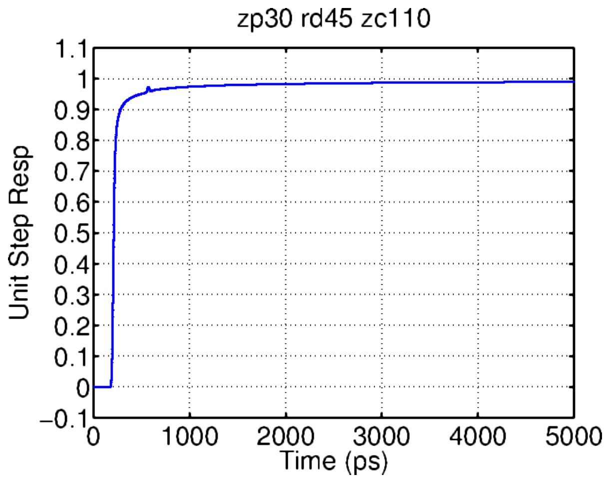

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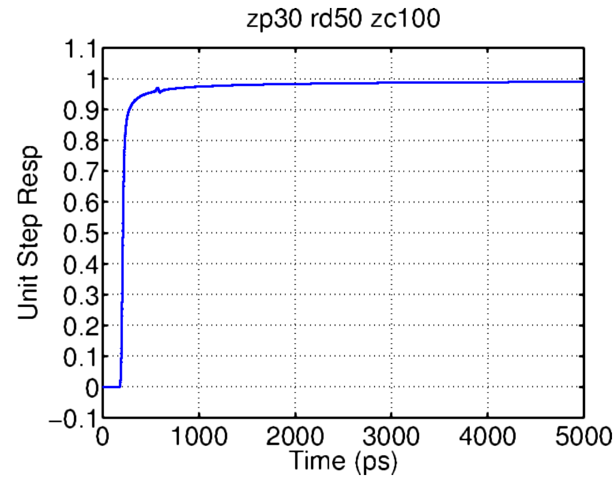

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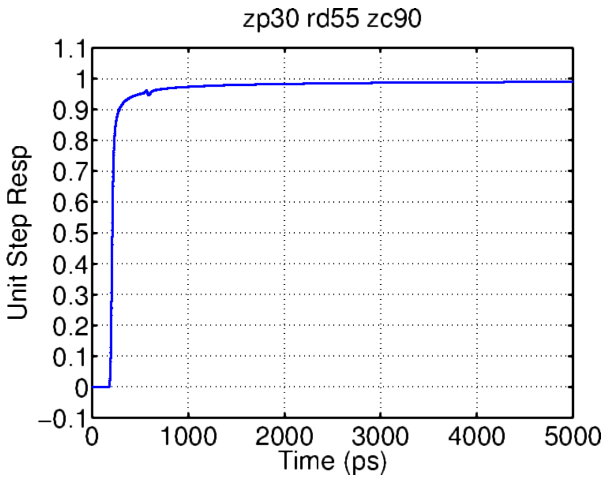
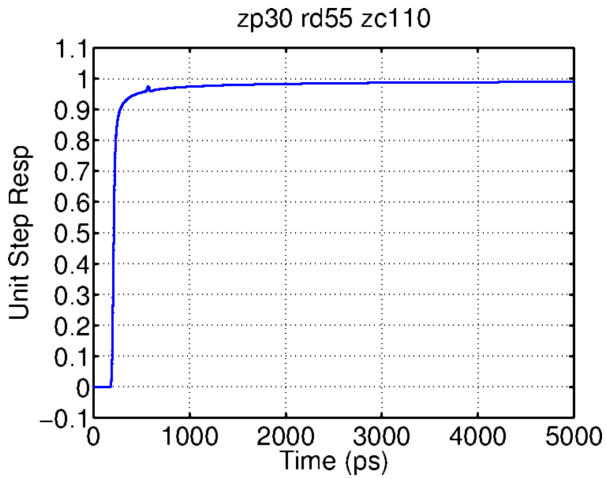


#8: Rd=55, Zc=110



Level separation mismatch ratio R_{LM}

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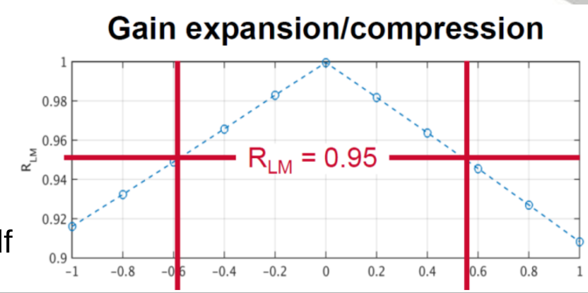
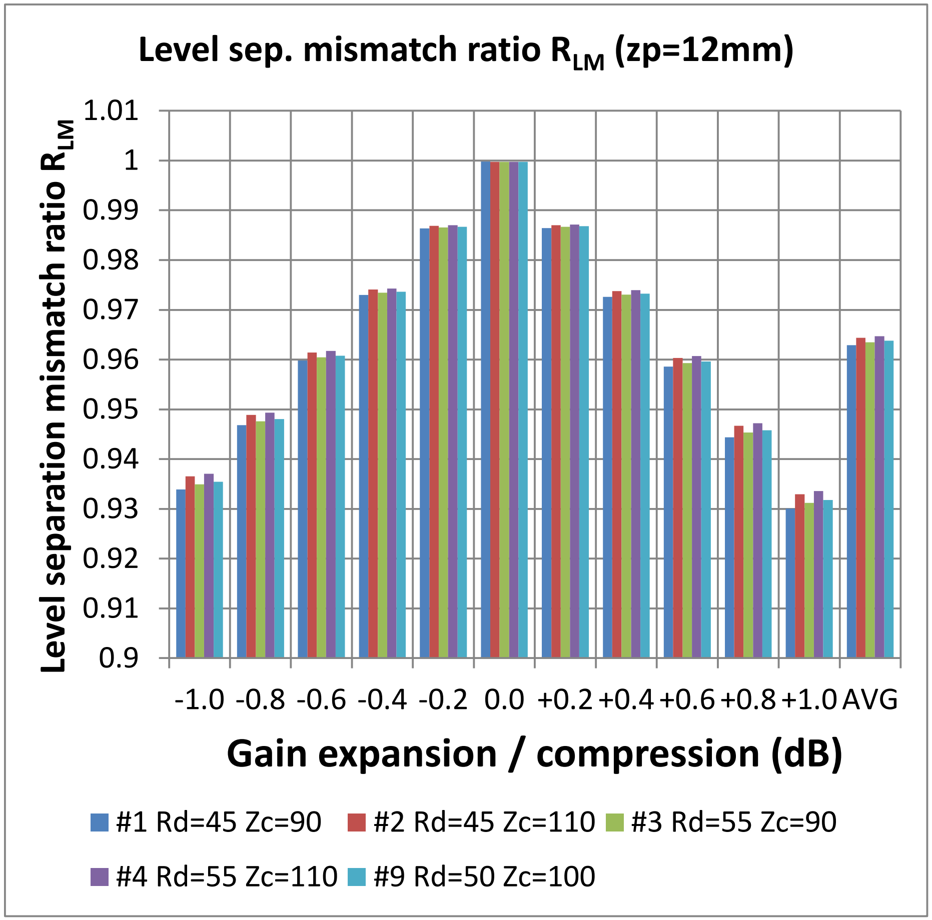
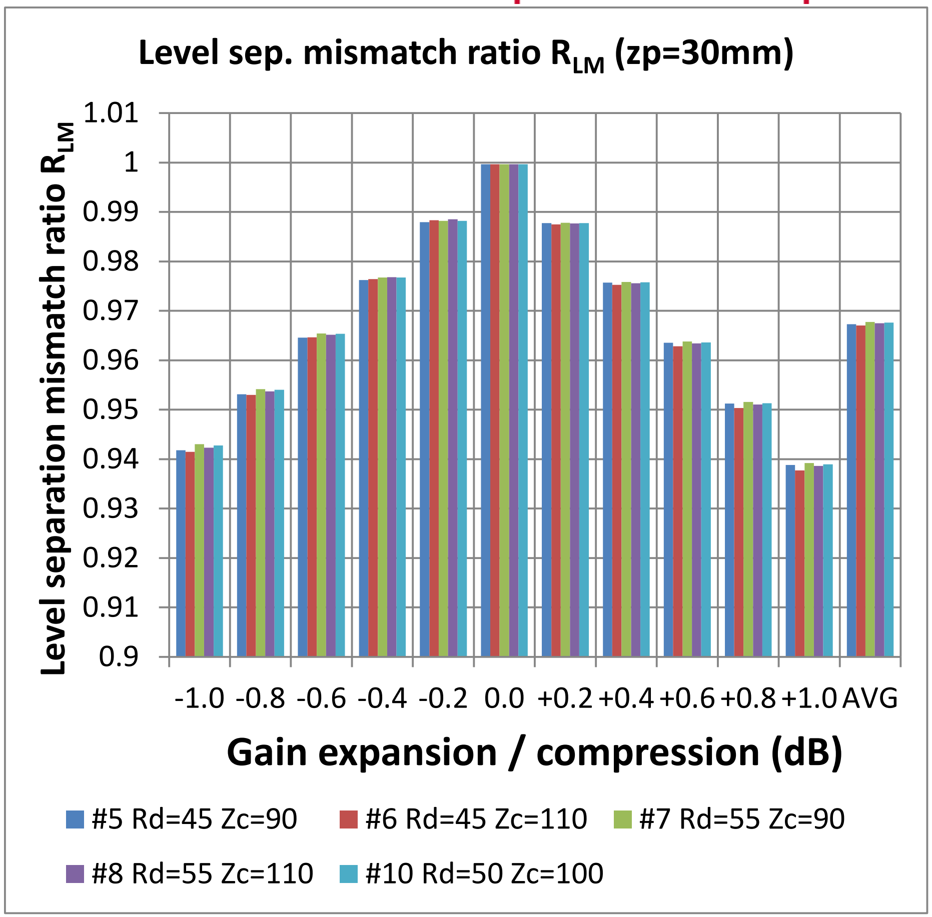
- Better than healey_3bs_02_0916.pdf
  - Maybe some model difference



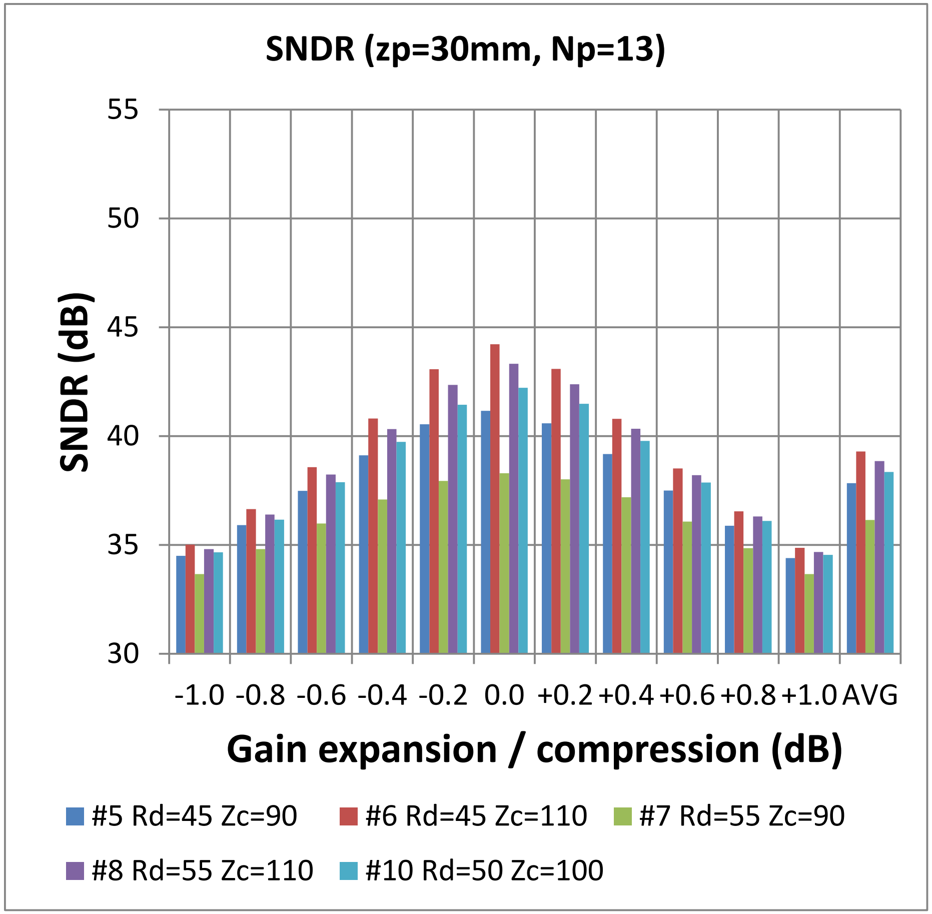
healey_3bs_02_0916.pdf

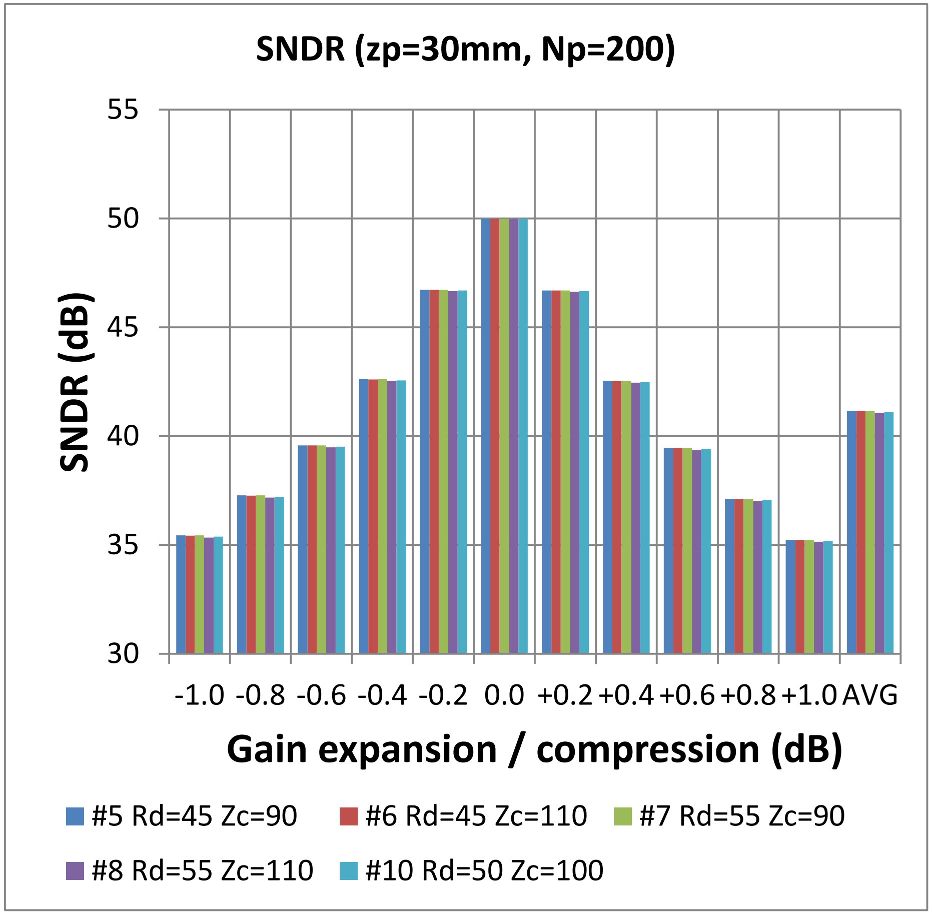




SNDR (zp=30mm)

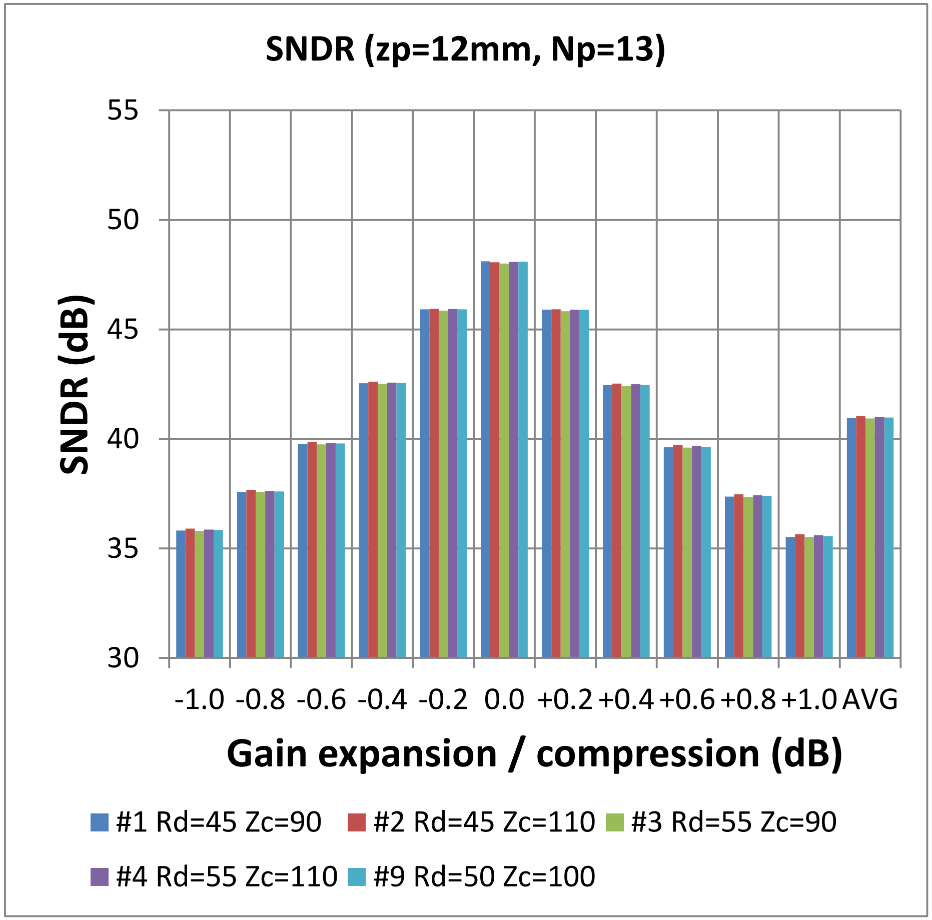
- Less dependent on package parameters as expected
  - For the linear case, we can see the noise floor (50dB in this simulation)

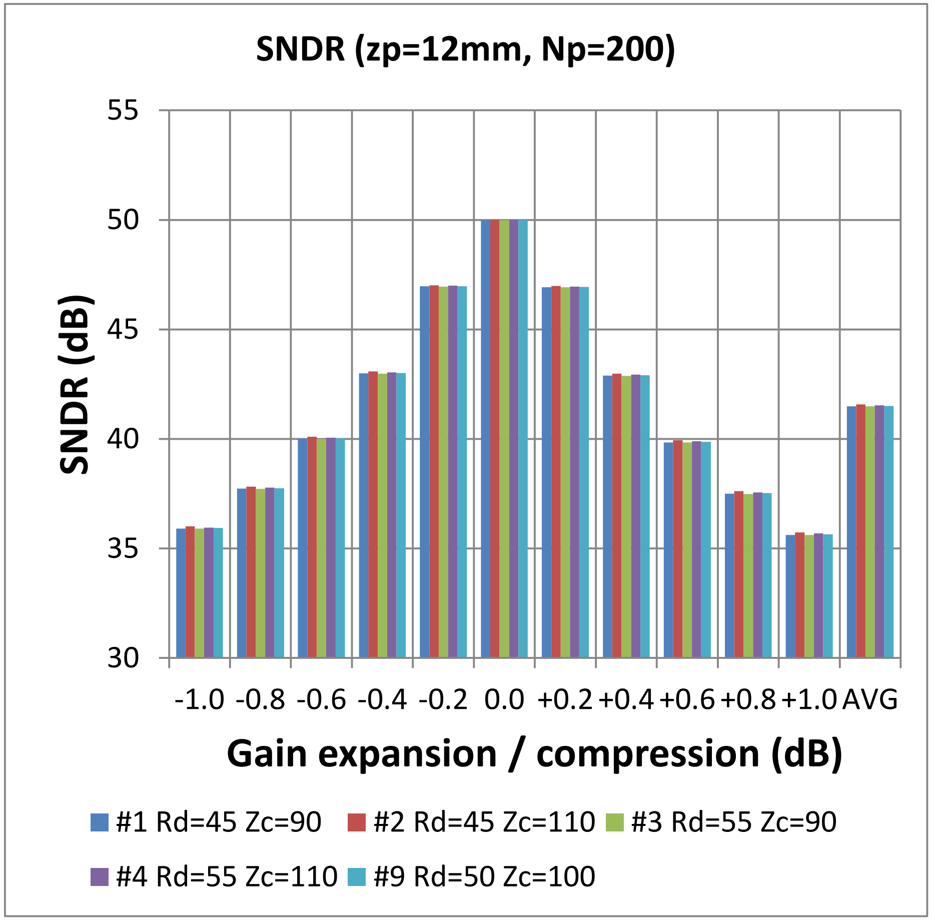




SNDR (zp=12mm)

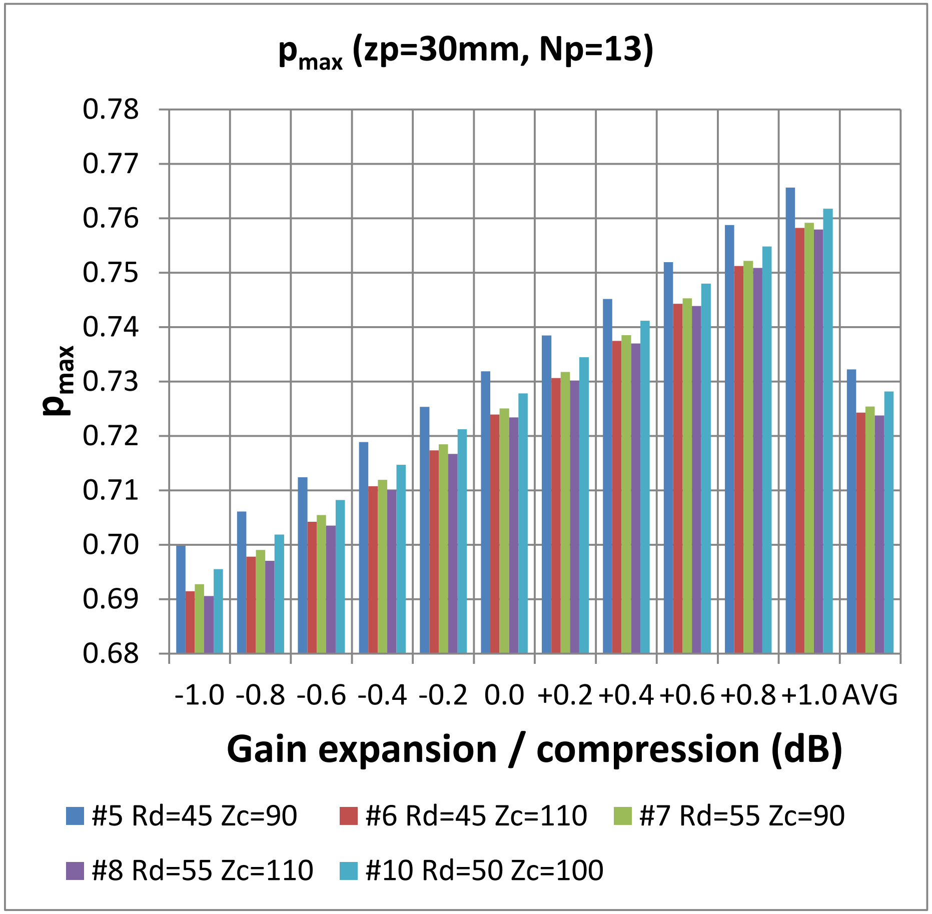
- Improved as expected
  - For the linear case, we can see the noise floor (50dB in this simulation)

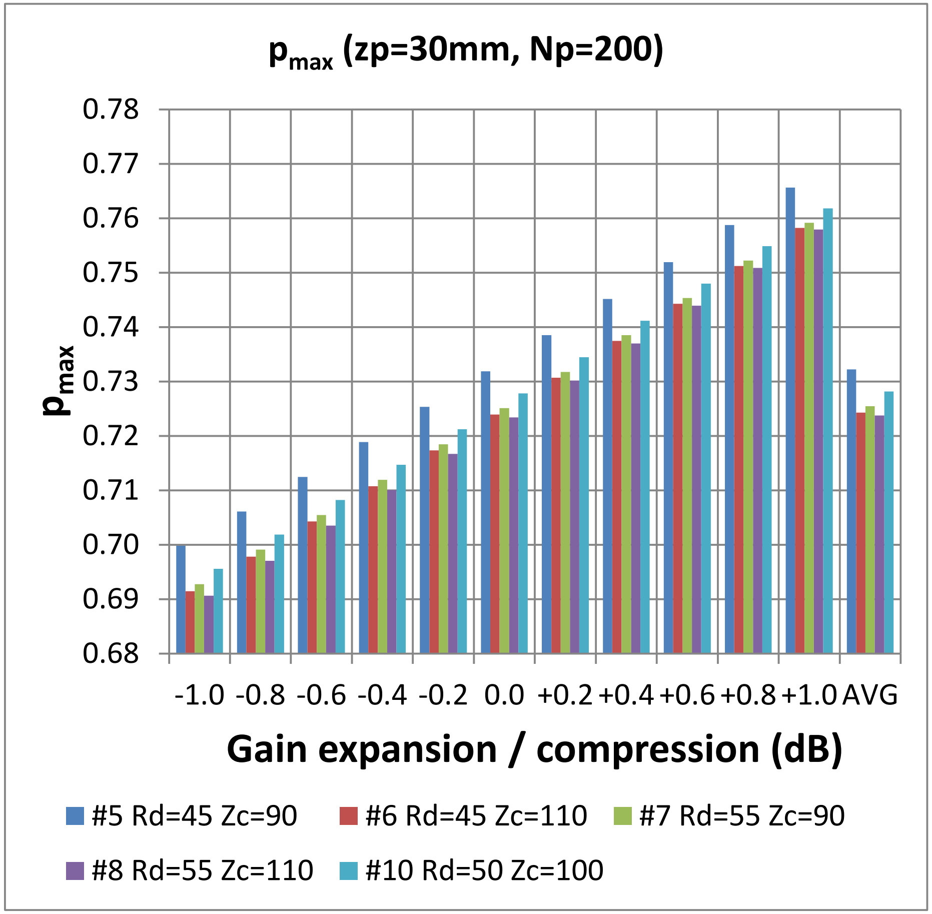




Linear Fit Pulse Peak p_{max} (zp=30mm)

- Almost no effect
  - The average effect was 0.0011%





Linear Fit Pulse Peak p_{max} (zp=12mm)

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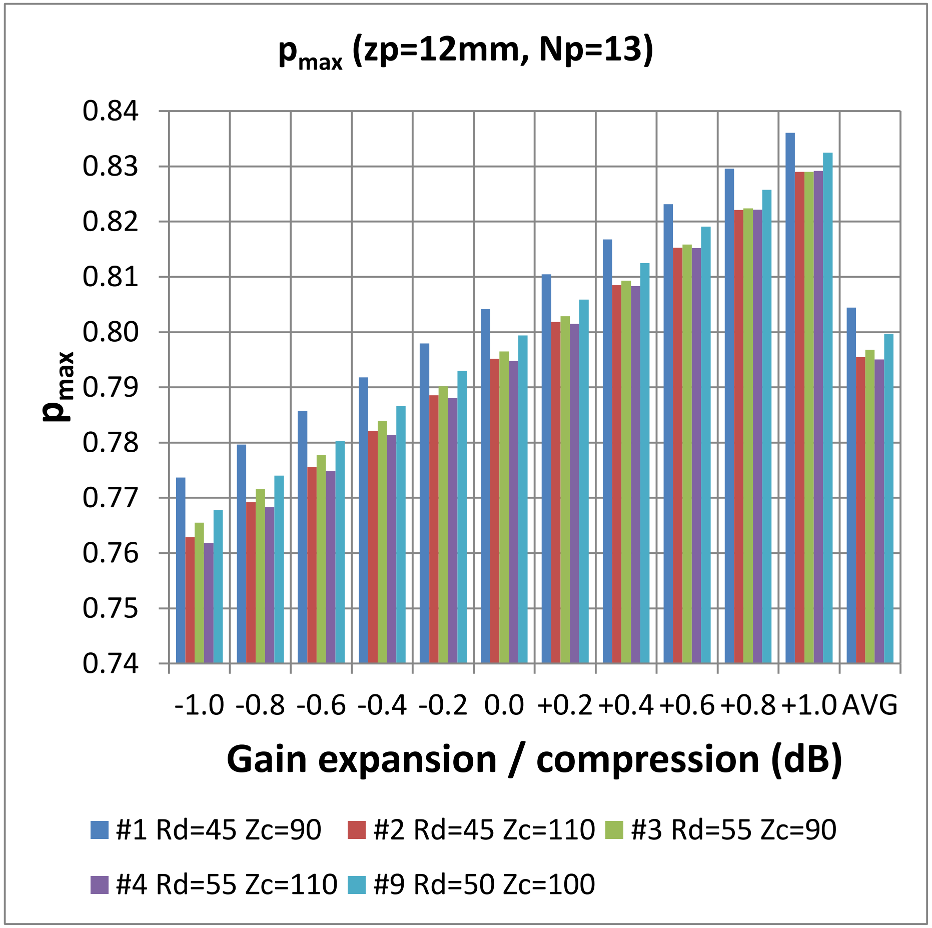
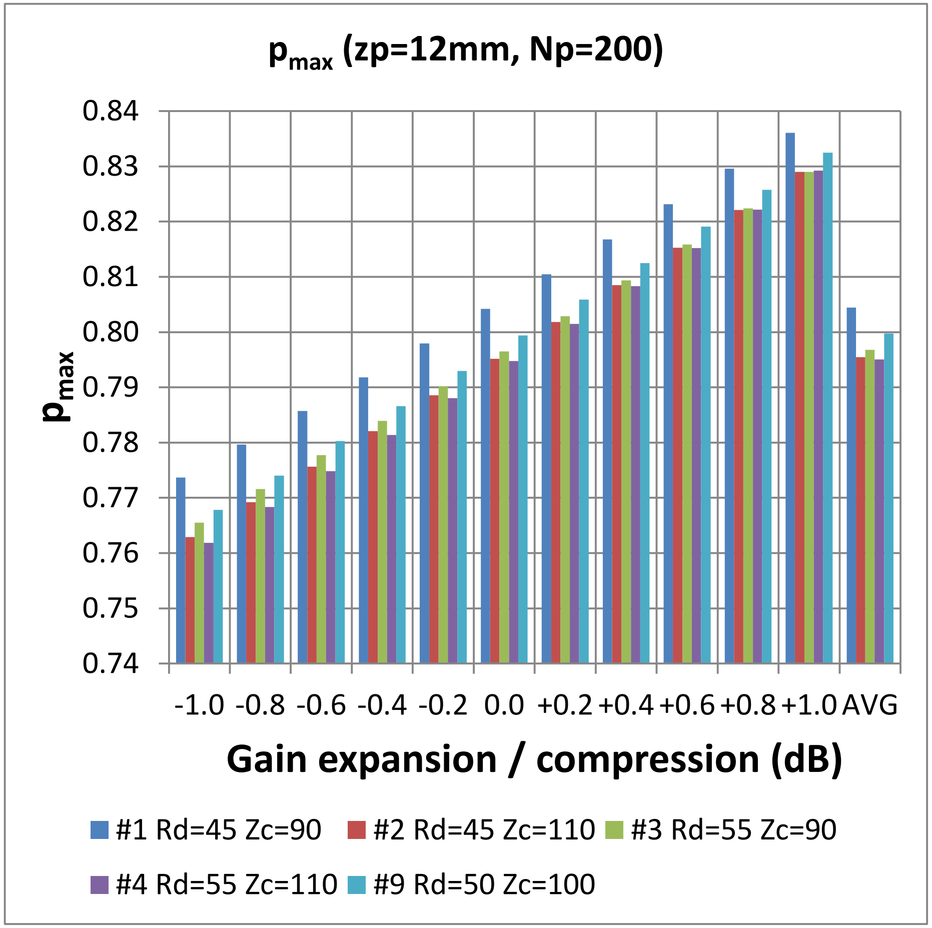
- Almost no effect
  - The average effect was 0.00047%





Steady-State Voltage v_f (zp=30mm)

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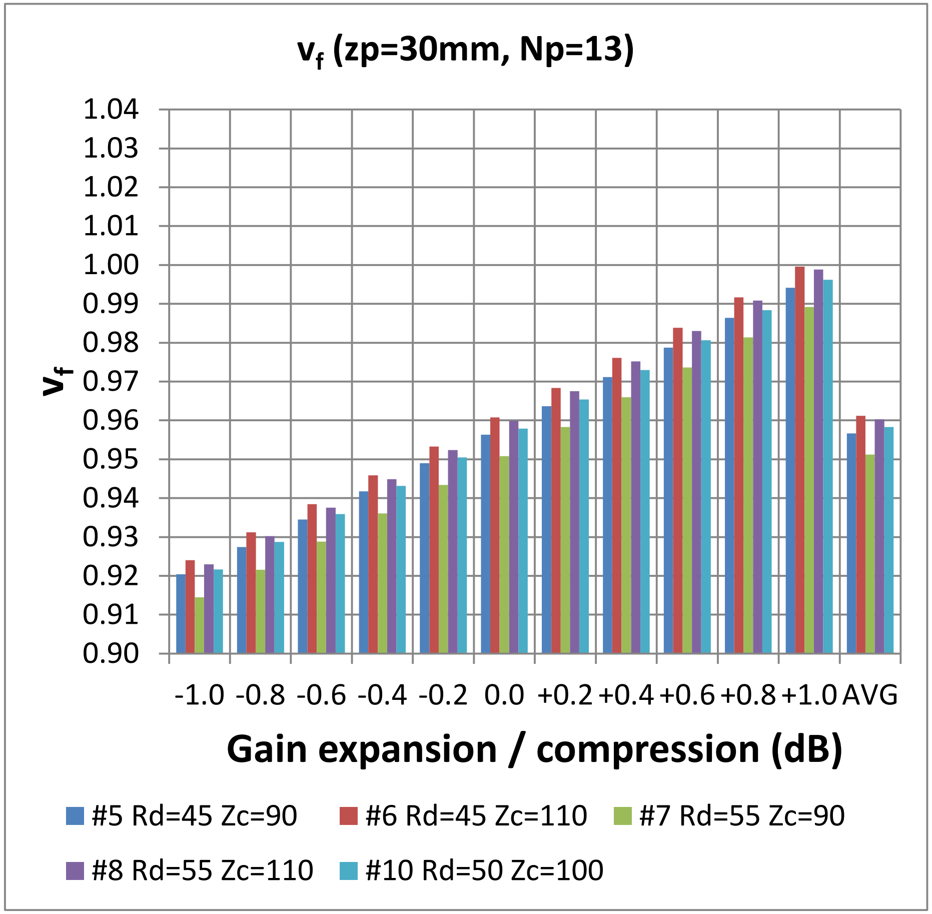
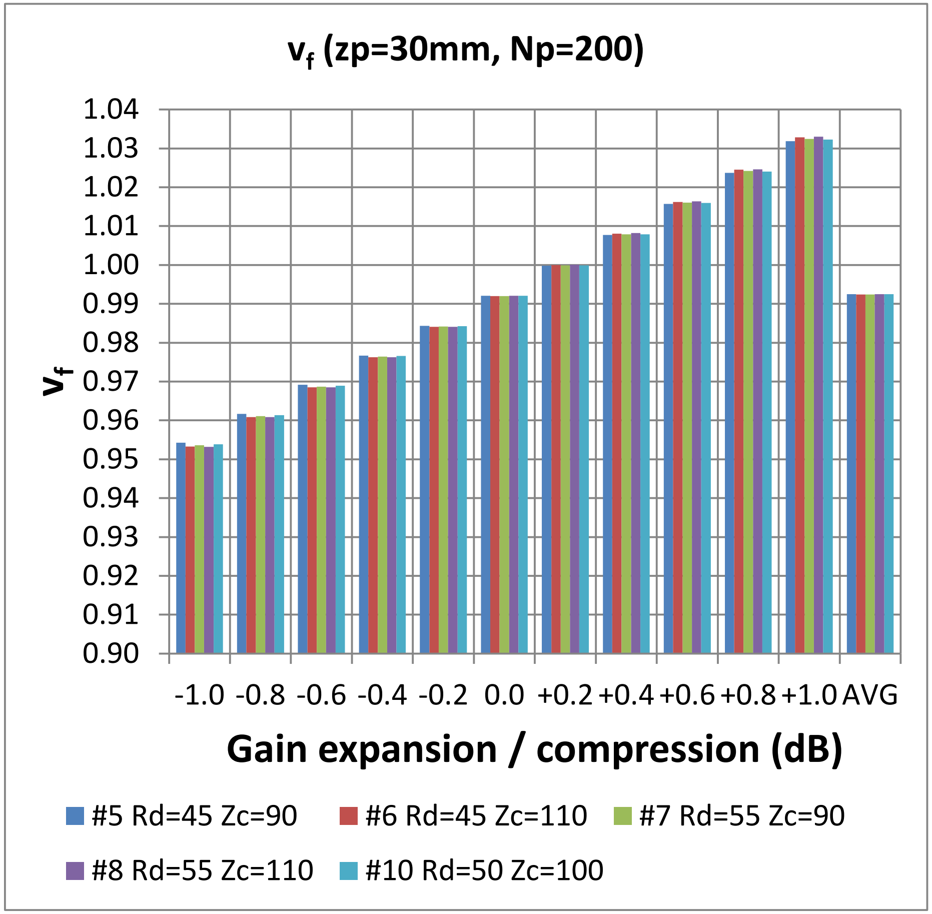
- Non-negligible increase
  - Becaise a longer fitted pulse captures more long-term ISI

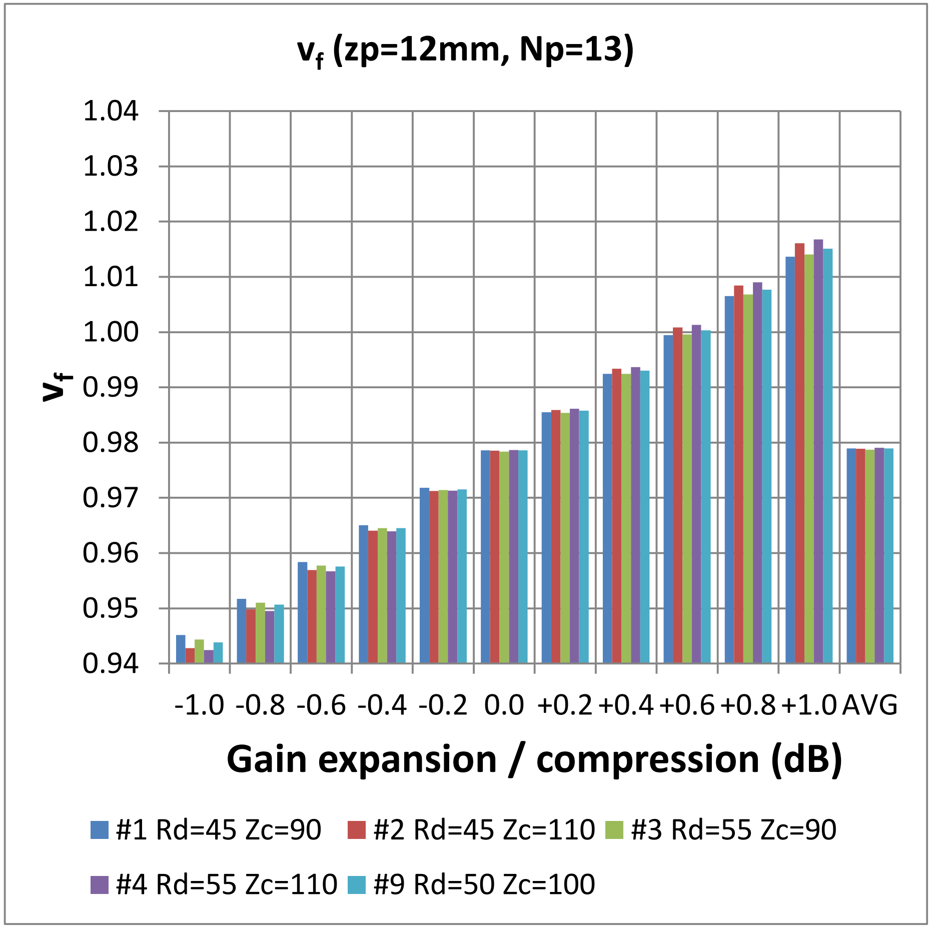


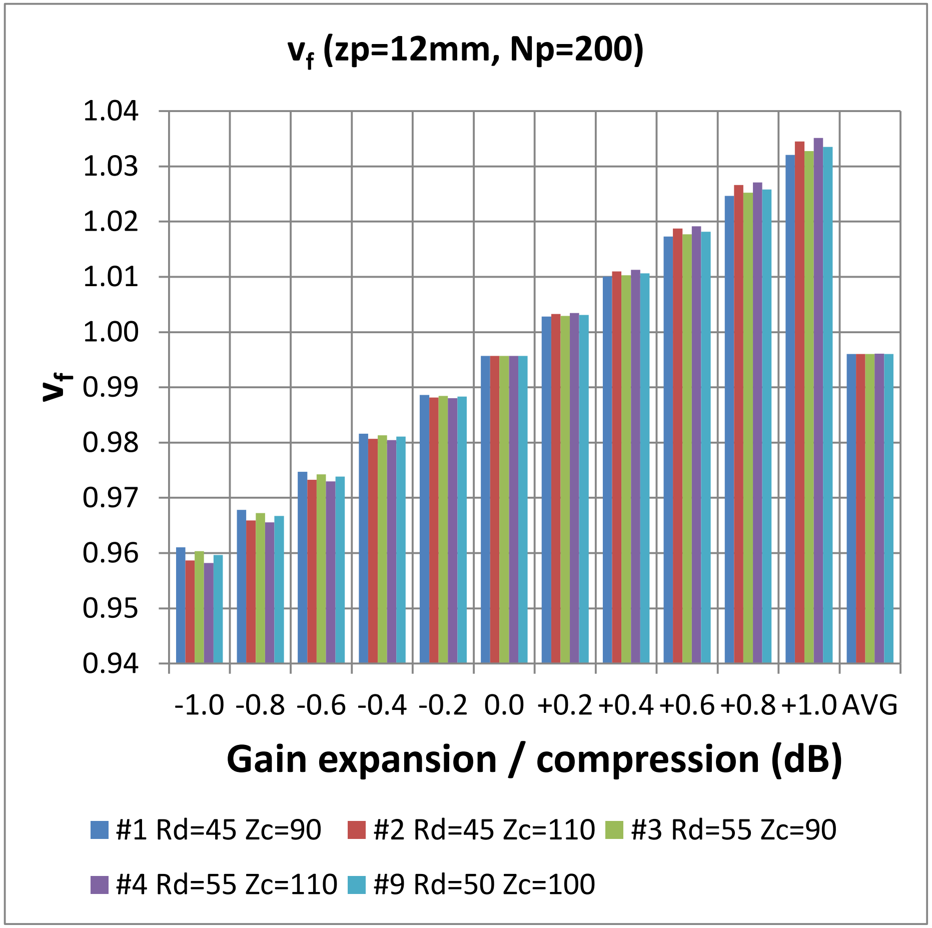


Steady-State Voltage v_f (zp=12mm)

FUJITSU

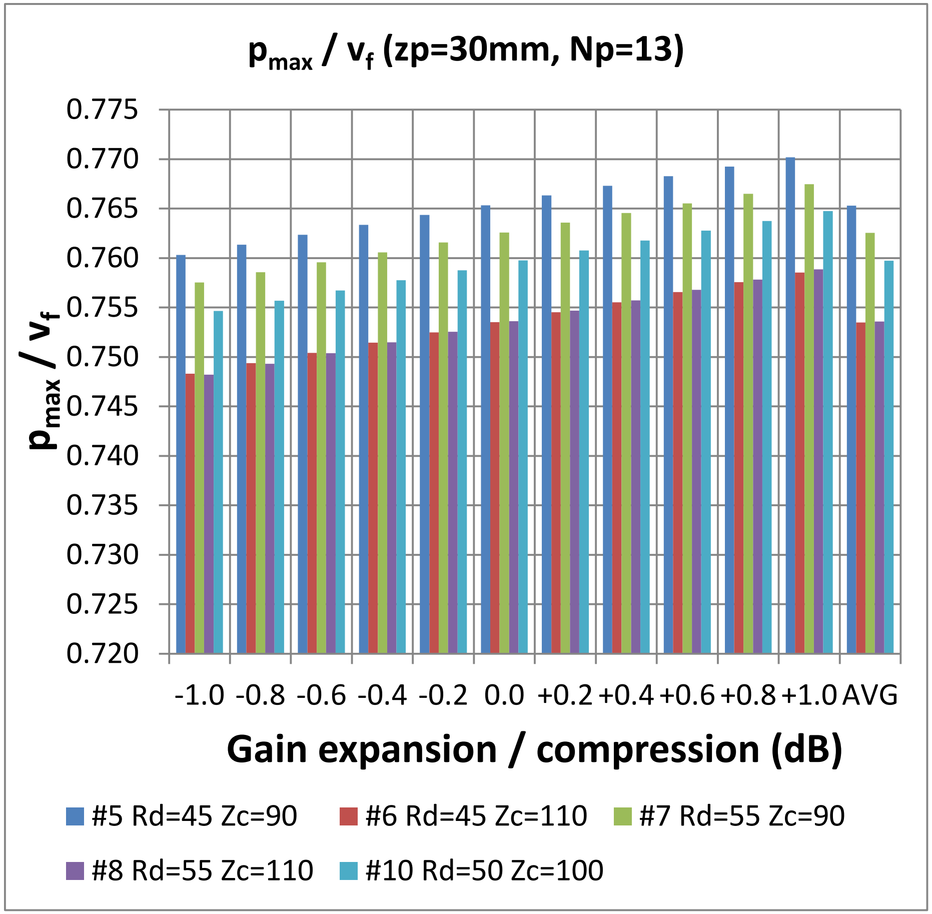
- Non-negligible increase
  - Becaise a longer fitted pulse captures more long-term ISI

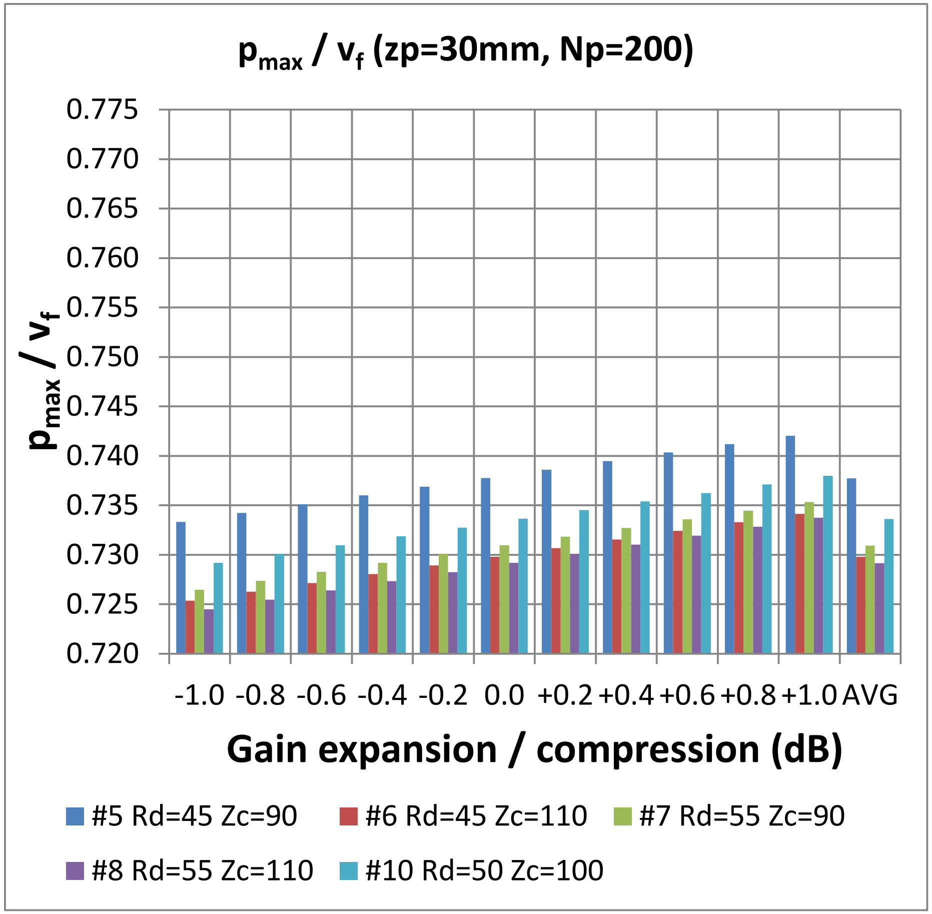




Ratio of p_{max} to v_f (zp=30mm)

- Reduced
  - Because v_f increases while p_{max} does not change





Ratio of p_{max} to v_f (zp=12mm)

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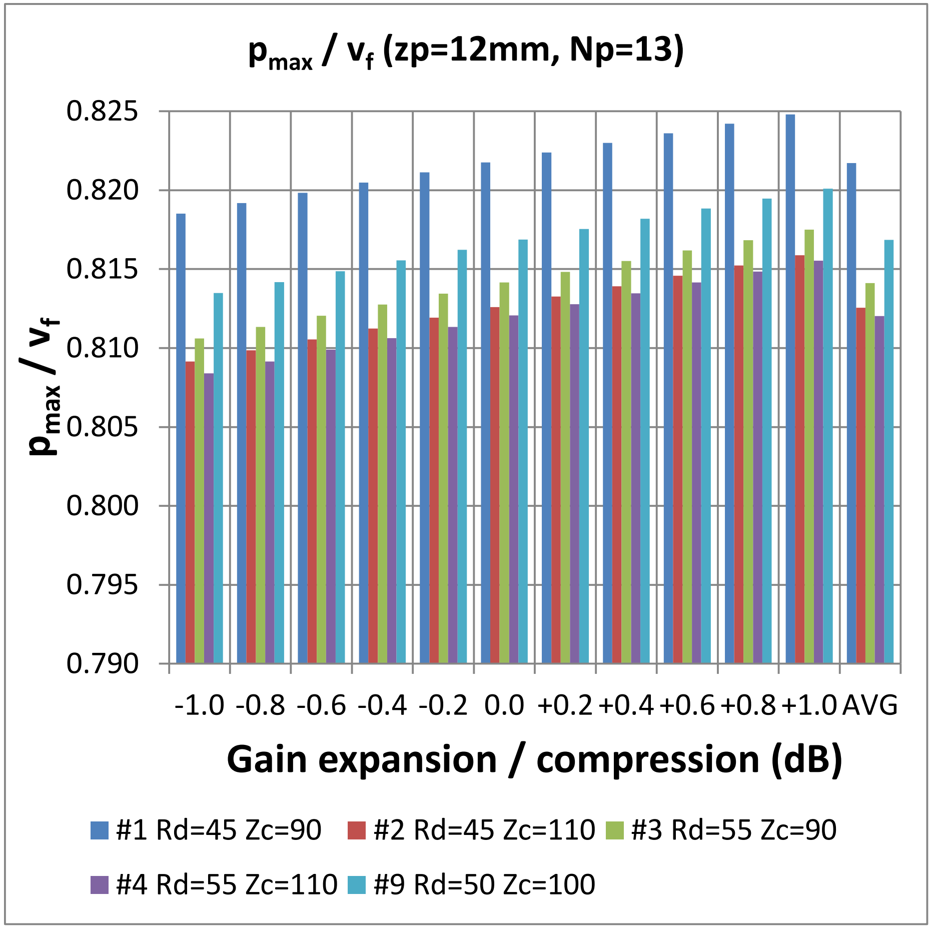
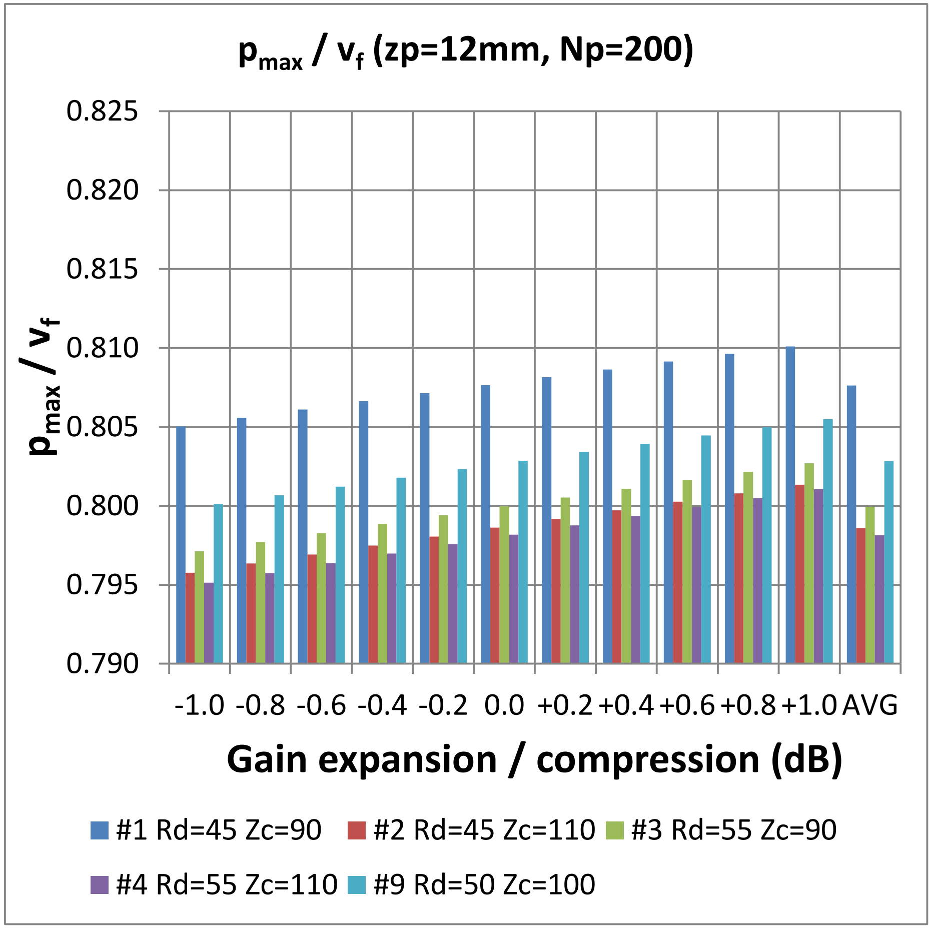
- Reduced
  - Because v_f increases while p_{max} does not change

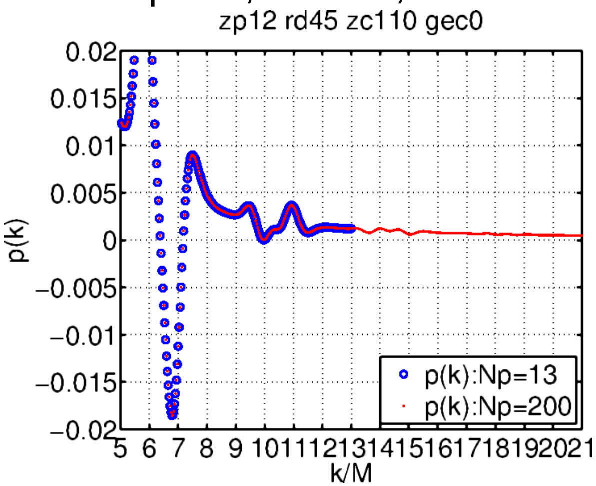




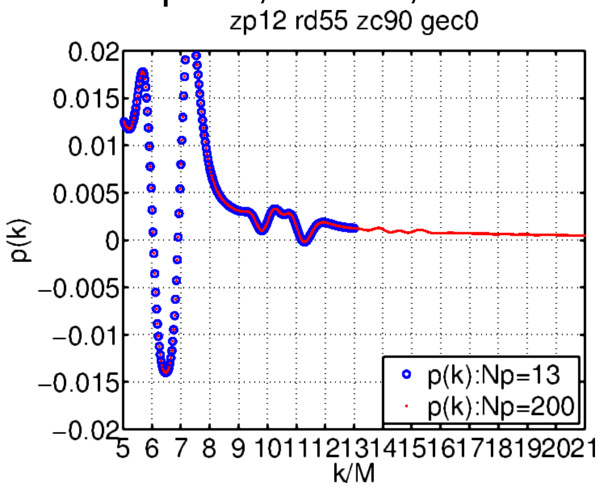
Linear Fit Pulse p(k)

- p(k) does not change for k ≤13*M between Np=13 and Np=200

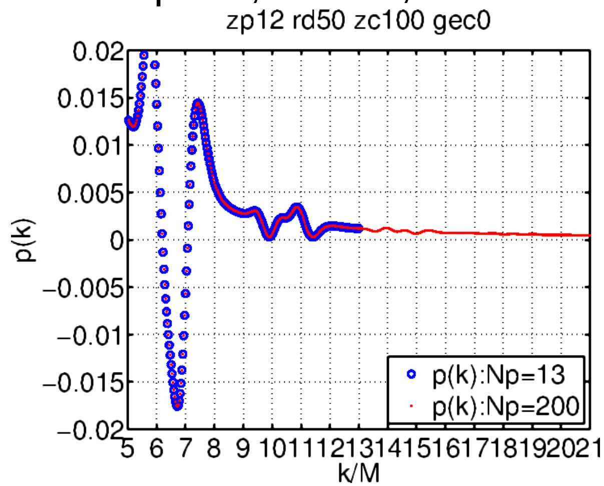
#2: Zp=12, Rd=45, Zc=110



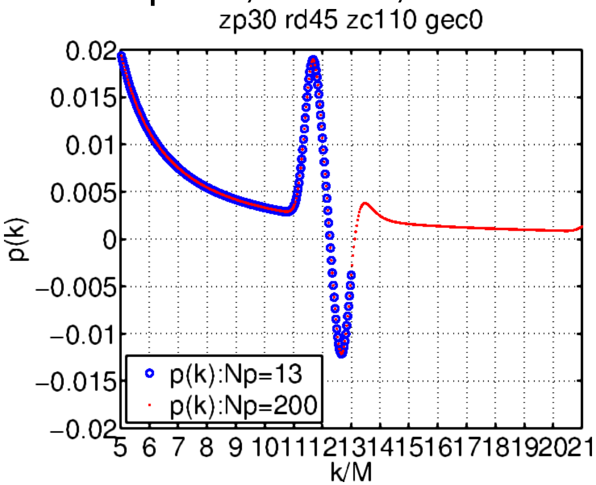
#3: Zp=12, Rd=55, Zc=90



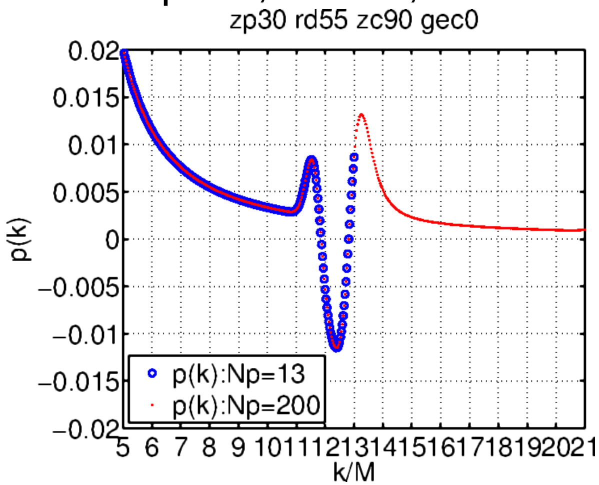
#9: Zp=12, Rd=50, Zc=100



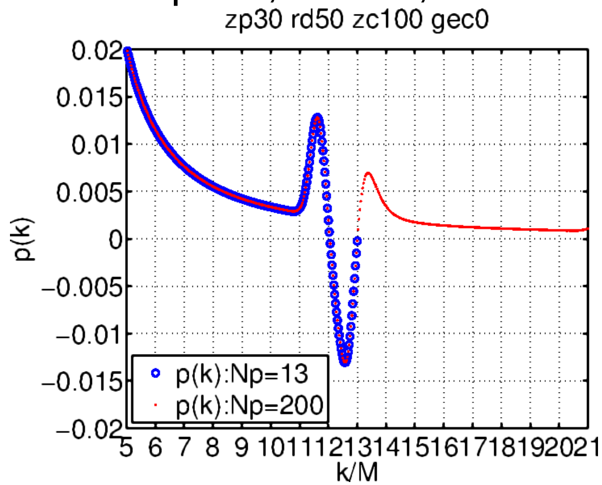
#6: Zp=30, Rd=45, Zc=110



#7: Zp=30, Rd=55, Zc=90



#10: Zp=30, Rd=50, Zc=100



Change of Steady-State Voltage v_f

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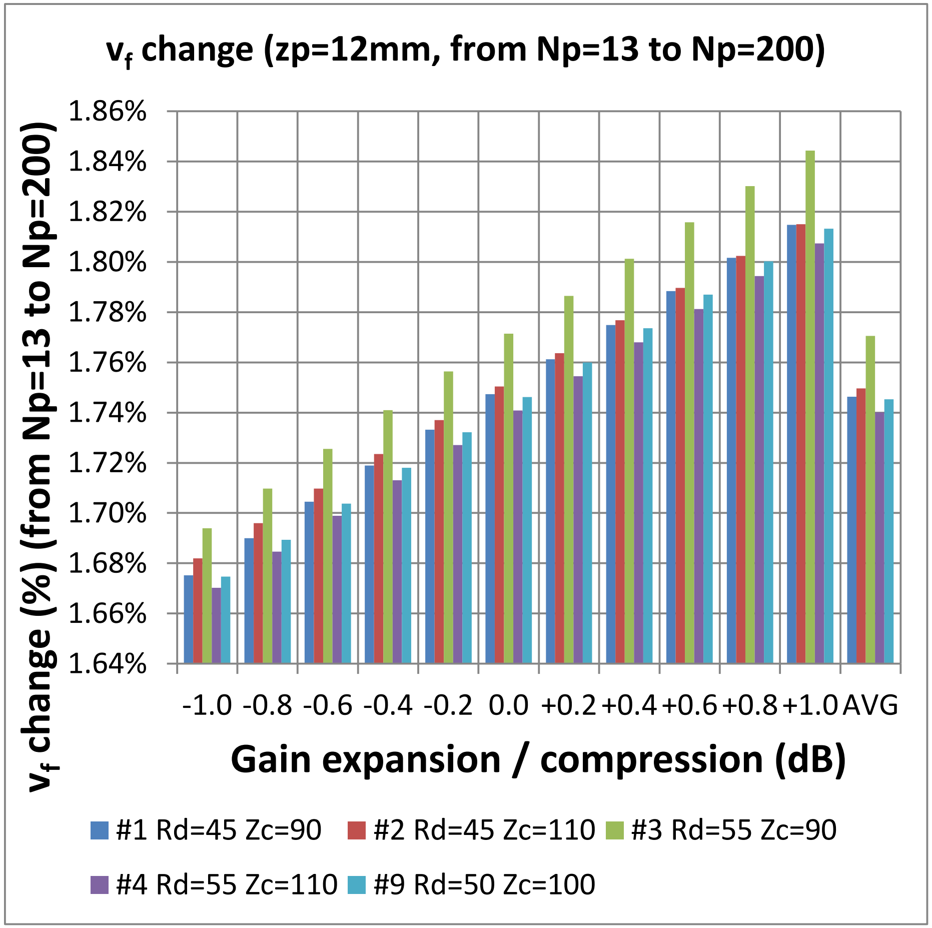
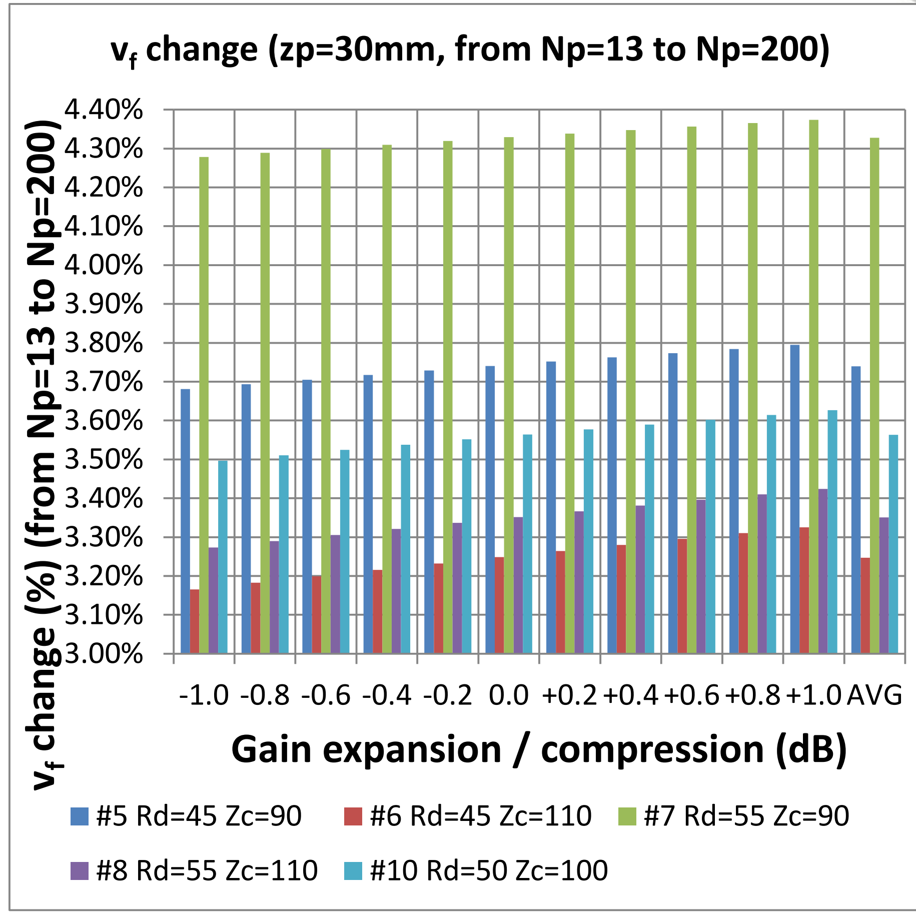
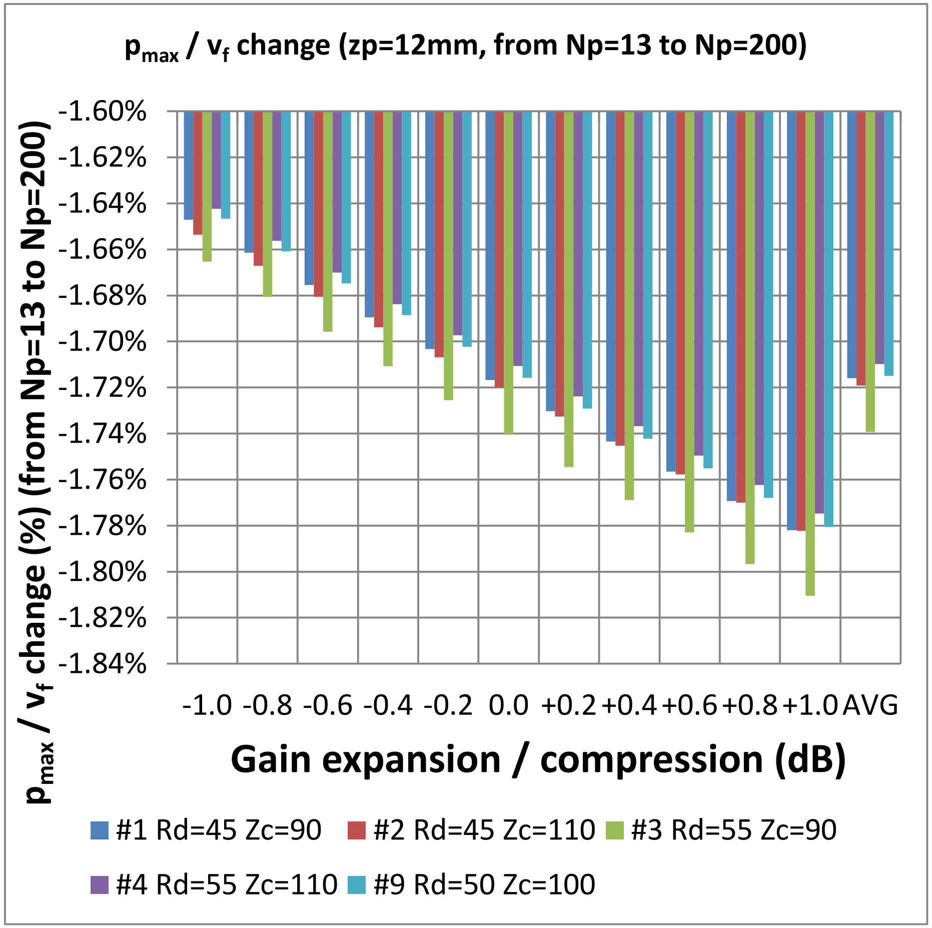


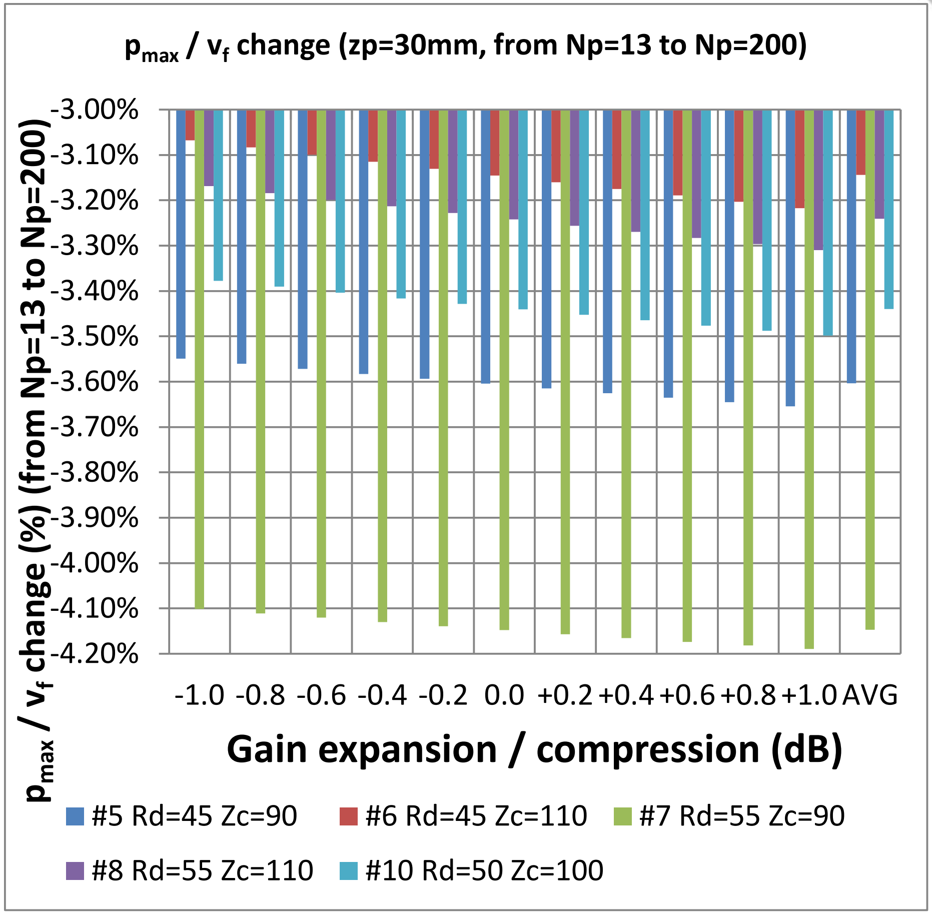


Condition	#3 (Rd=55, Zc=90)	AVG (#1,2,3,4,9)
Change	+1.7706%	+1.7504%
0.6V (max) in D2.1	0.61062	0.61050

Condition	#7 (Rd=55, Zc=90)	AVG (#5,6,7,8,10)
Change	+4.3279%	+3.6456%
0.4V (max) in D2.1	0.41731	0.41458

Change of Ratio of p_{max} to v_f





Condition	#3 (Rd=55, Zc=90)	AVG (#1,2,3,4,9)
Change	–1.7393%	–1.7198%

Condition	#7 (Rd=55, Zc=90)	AVG (#5,6,7,8,10)
Change	–4.1471%	–3.5151%
0.736 (min) in D2.1	0.705477	0.710129

Conclusion

- Recommended changes based on the results for #3 and #7
  - Change the Steady state voltage v_f (max)
    - from 0.6 V to 0.611 V
  - Change the Steady state voltage v_f (min)
    - from 0.4 V to 0.417 V
  - Change the Linear fit pulse peak (min)
    - from 0.736 x v_f to 0.705 x v_f

- Or, recommended changes based on the average results
  - Change the Steady state voltage v_f (max)
    - from 0.6 V to 0.611 V
  - Change the Steady state voltage v_f (min)
    - from 0.4 V to 0.415 V
  - Change the Linear fit pulse peak (min)
    - from 0.736 x v_f to 0.710 x v_f

Back up Slides

- Linear Fit Pulse & Error (Linear)
- Linear Fit Pulse & Error (Non-linear)

Linear Fit Pulse & Error (Linear)

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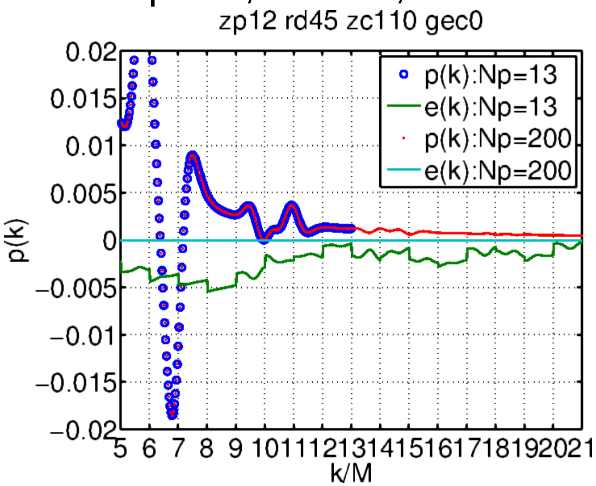
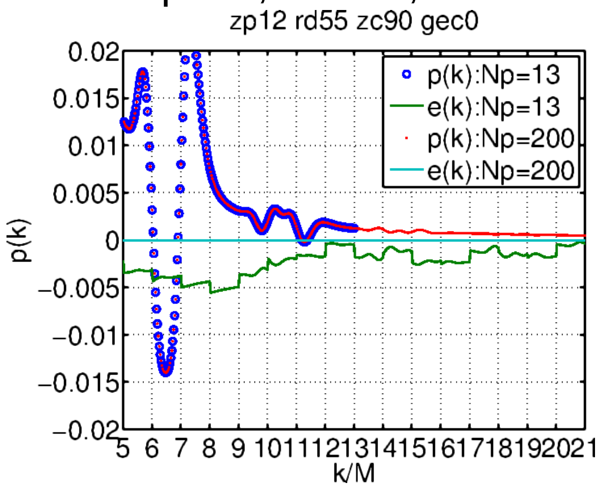
- p(k) after Np (i.e. k/M > Np) is trunslated to e(k)

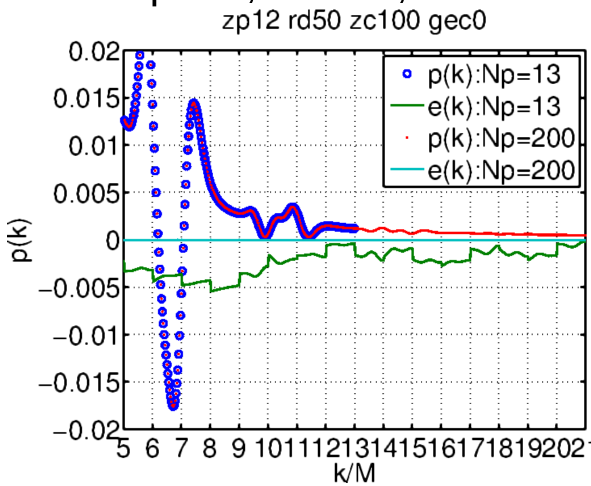
#2: Zp=12, Rd=45, Zc=110



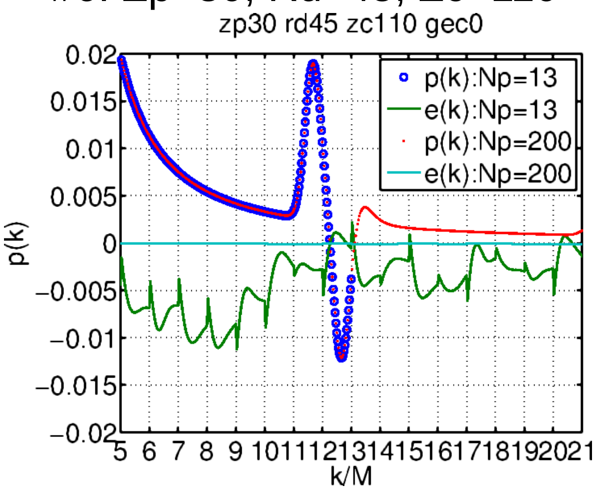
#3: Zp=12, Rd=55, Zc=90



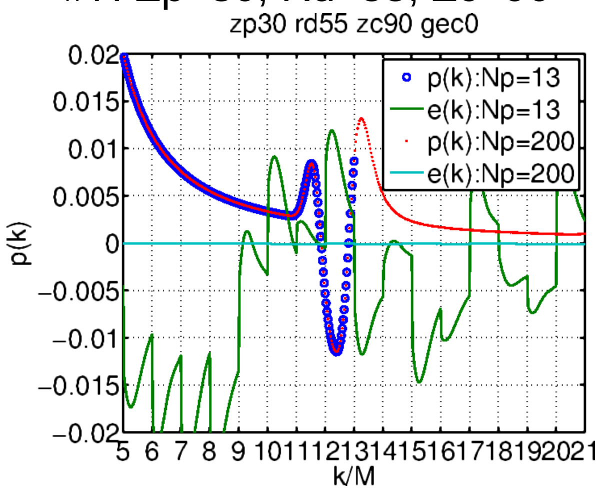
#9: Zp=12, Rd=50, Zc=100



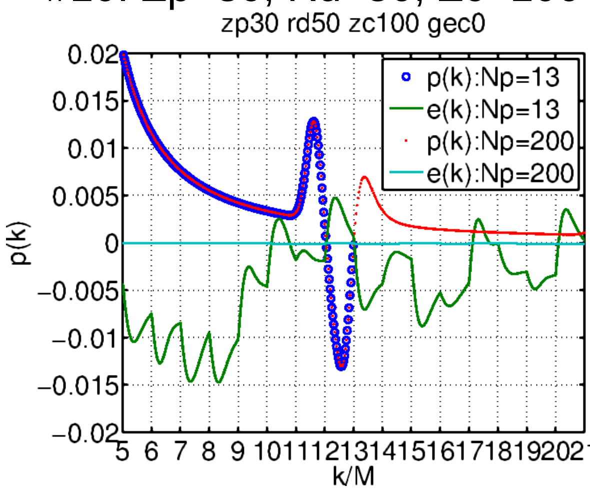
#6: Zp=30, Rd=45, Zc=110



#7: Zp=30, Rd=55, Zc=90



#10: Zp=30, Rd=50, Zc=100



Linear Fit Pulse & Error (Non-Linear)

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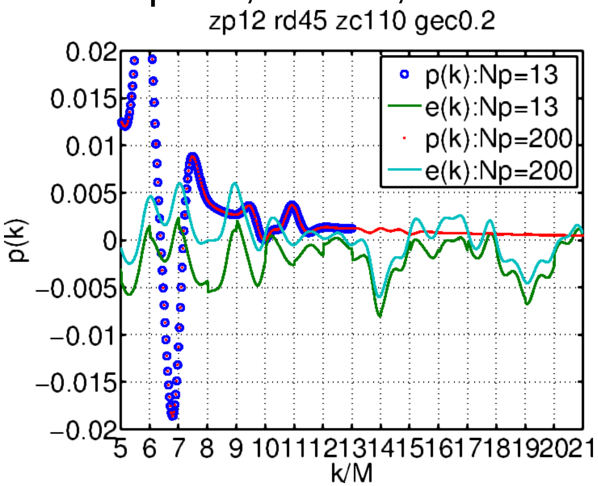
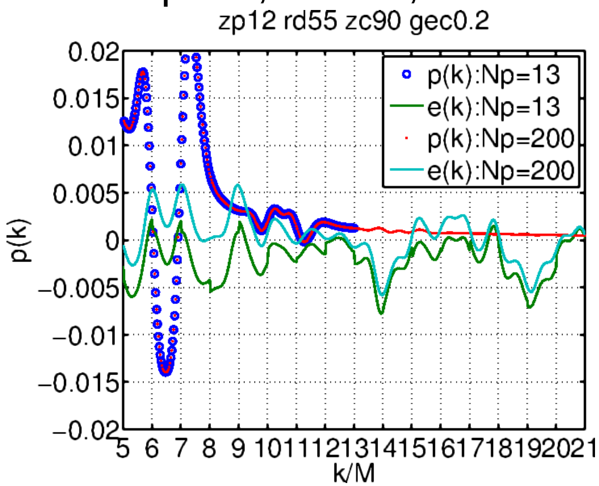
- e(k) represents non-linearity plus p(k) after Np

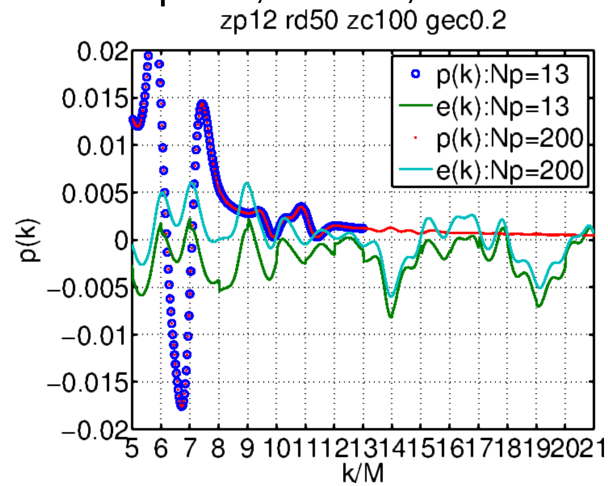
#2: Zp=12, Rd=45, Zc=110



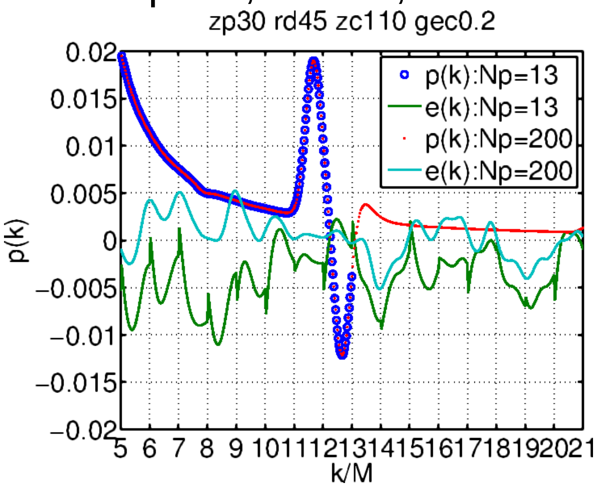
#3: Zp=12, Rd=55, Zc=90



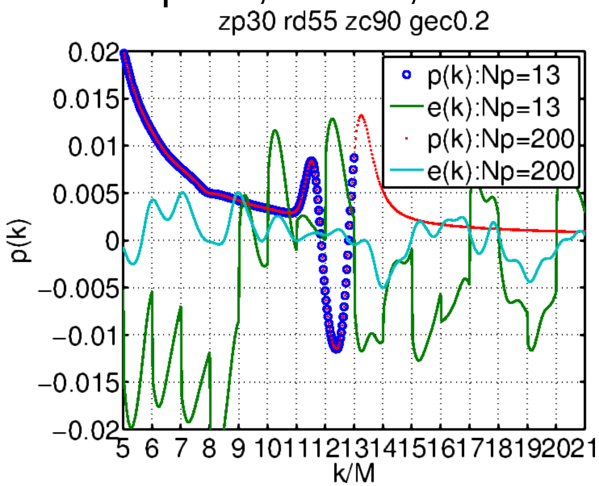
#9: Zp=12, Rd=50, Zc=100



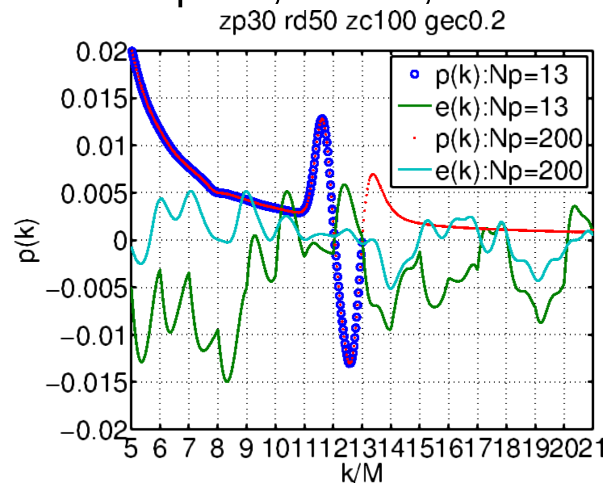
#6: Zp=30, Rd=45, Zc=110



#7: Zp=30, Rd=55, Zc=90



#10: Zp=30, Rd=50, Zc=100



Thank you