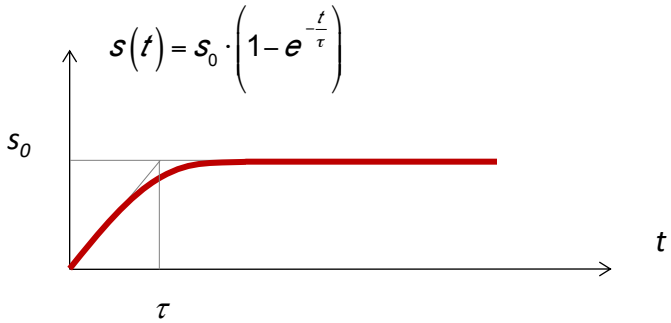
Timing Workshop

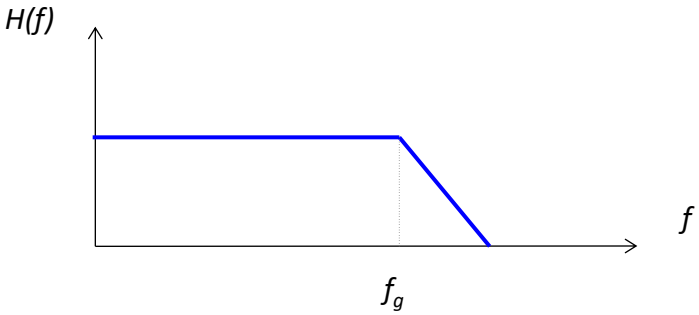
Torino, 16.5.2018

Erich Griesmayer, CIVIDEC Instrumentation

Bandwidth and Time Constant

Boundary condition: Signal s(t) with a first-order frequency spectrum $H(f)$ (PT1).



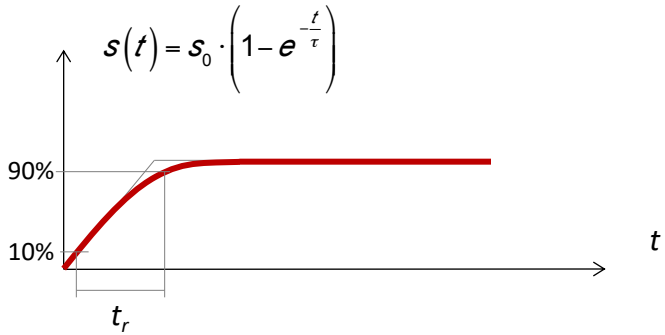


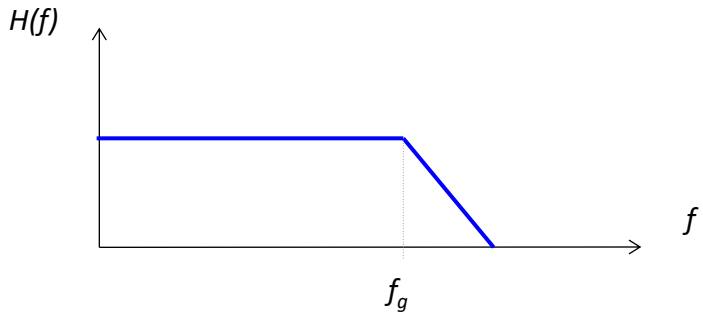
Time constant: $$\tau = \frac{1}{\omega_g} = \frac{1}{2\pi \cdot f_g}$$

Example: f_g = 1 GHz → τ = 159 ps

Bandwidth and Rise Time

Boundary condition: Signal s(t) with a first-order frequency spectrum $H(f)$ (PT1).





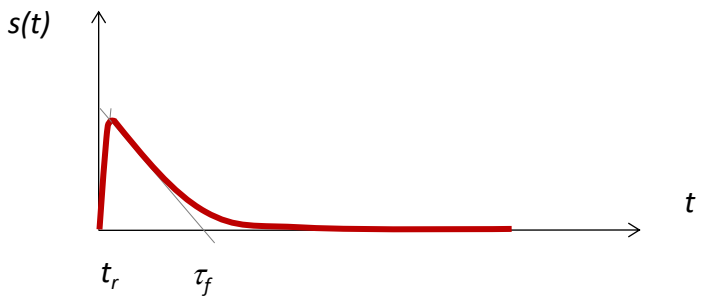
Rie time:

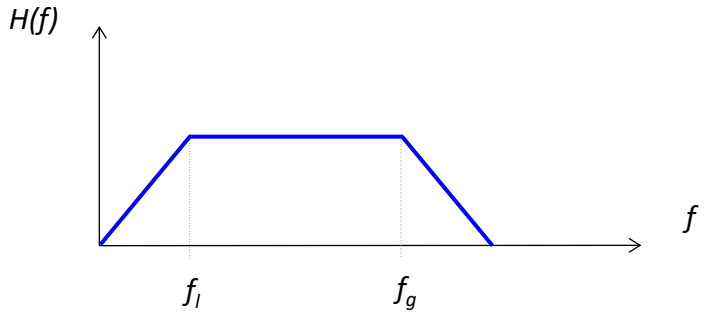
$$t_r = \frac{0.35}{f_g}$$

Example: f_g = 1 GHz → t_r = 350 ps

Broadband Systems

Boundary condition: Signal s(t) with lower and upper cut-off frequencies.





Formula: f_l … lower cut-off frequency, f_g … upper cut-off frequency

t_r … rise time, τ_f … fall time constant

Example: f_g = 1 GHz → t_r = 350 ps

f_l = 1 MHz → τ_f = 160 ns

Detector + Amplifier

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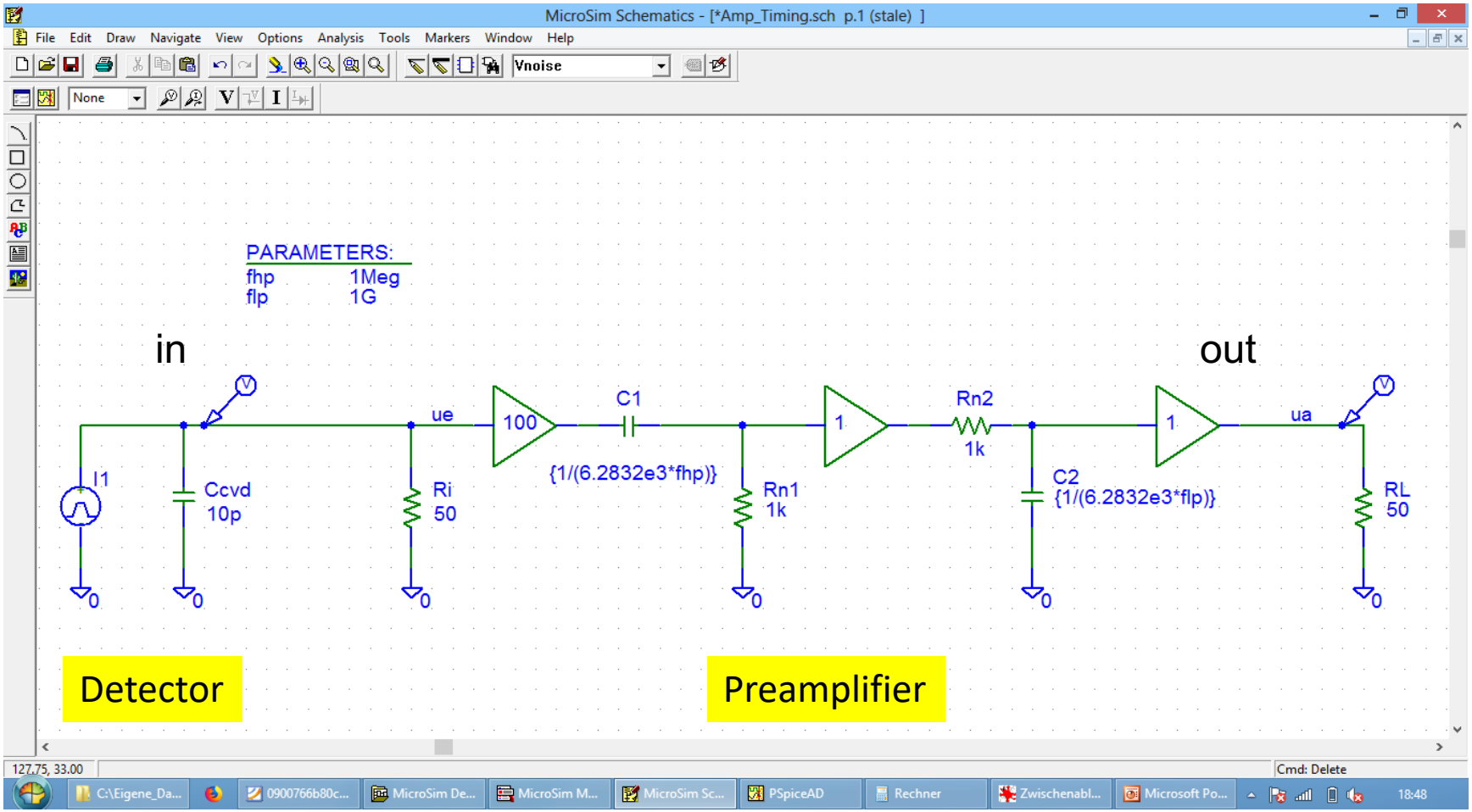
Schematics



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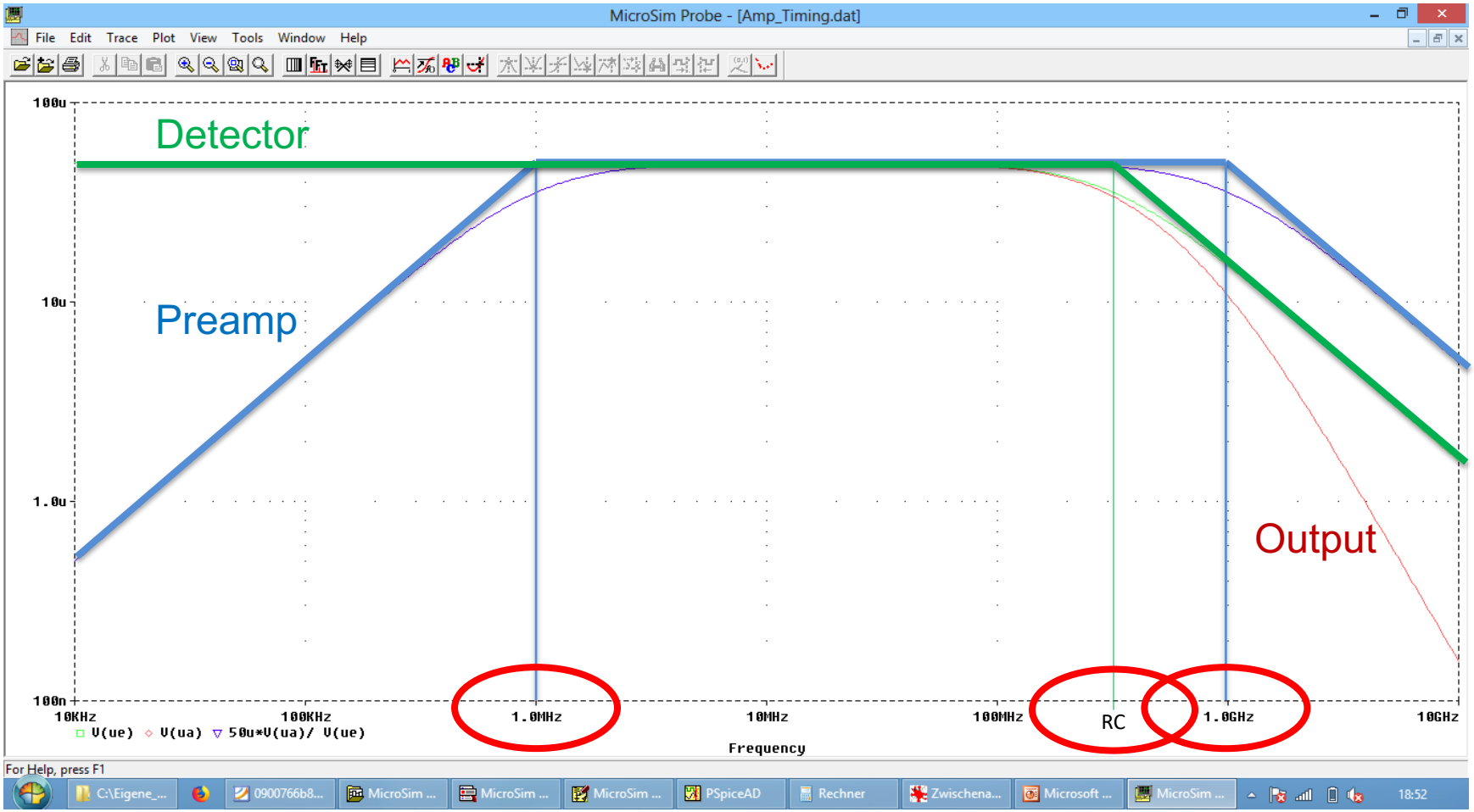
Bode diagram



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Amplifier bandwidth

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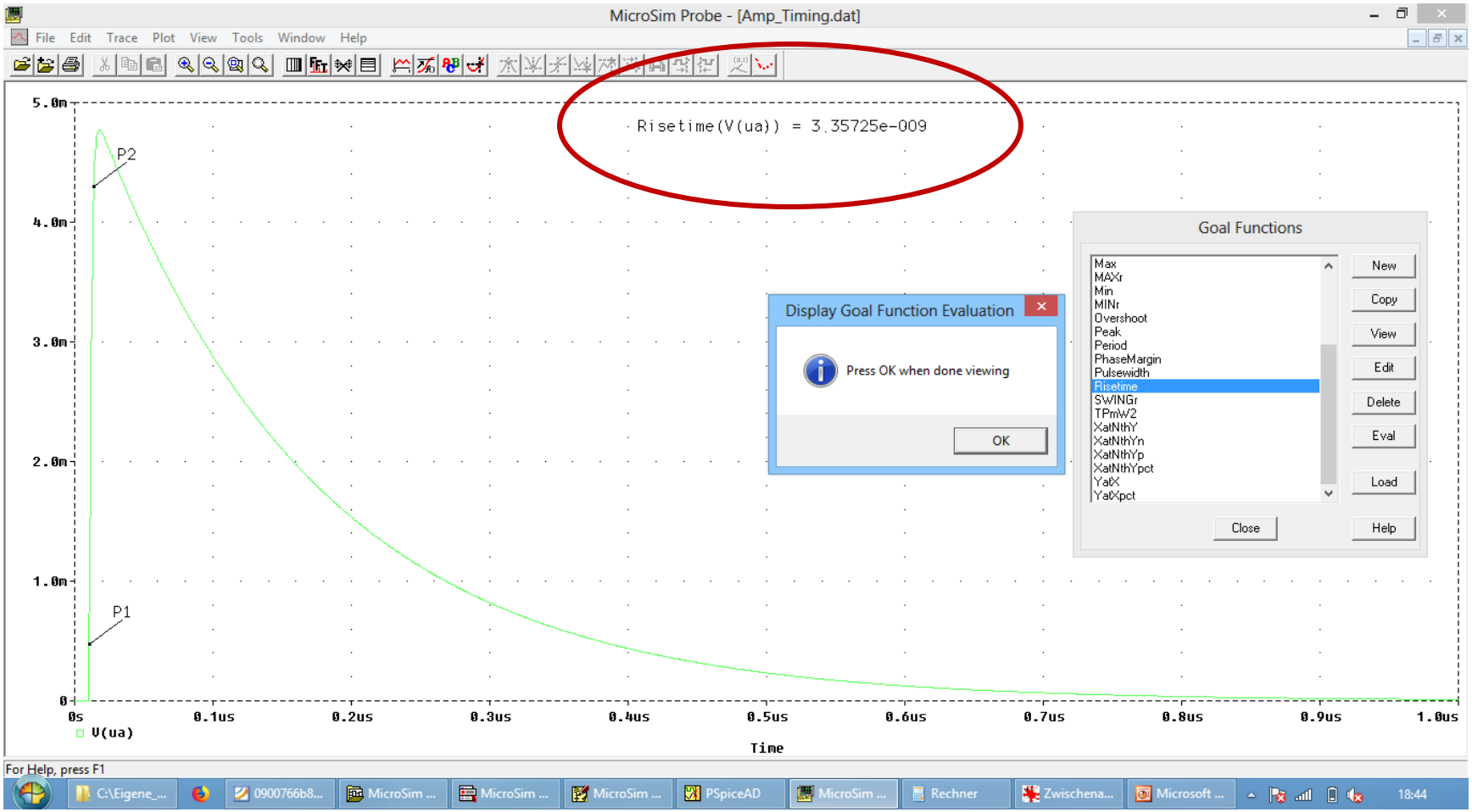
Bandwidth = 100 MHz



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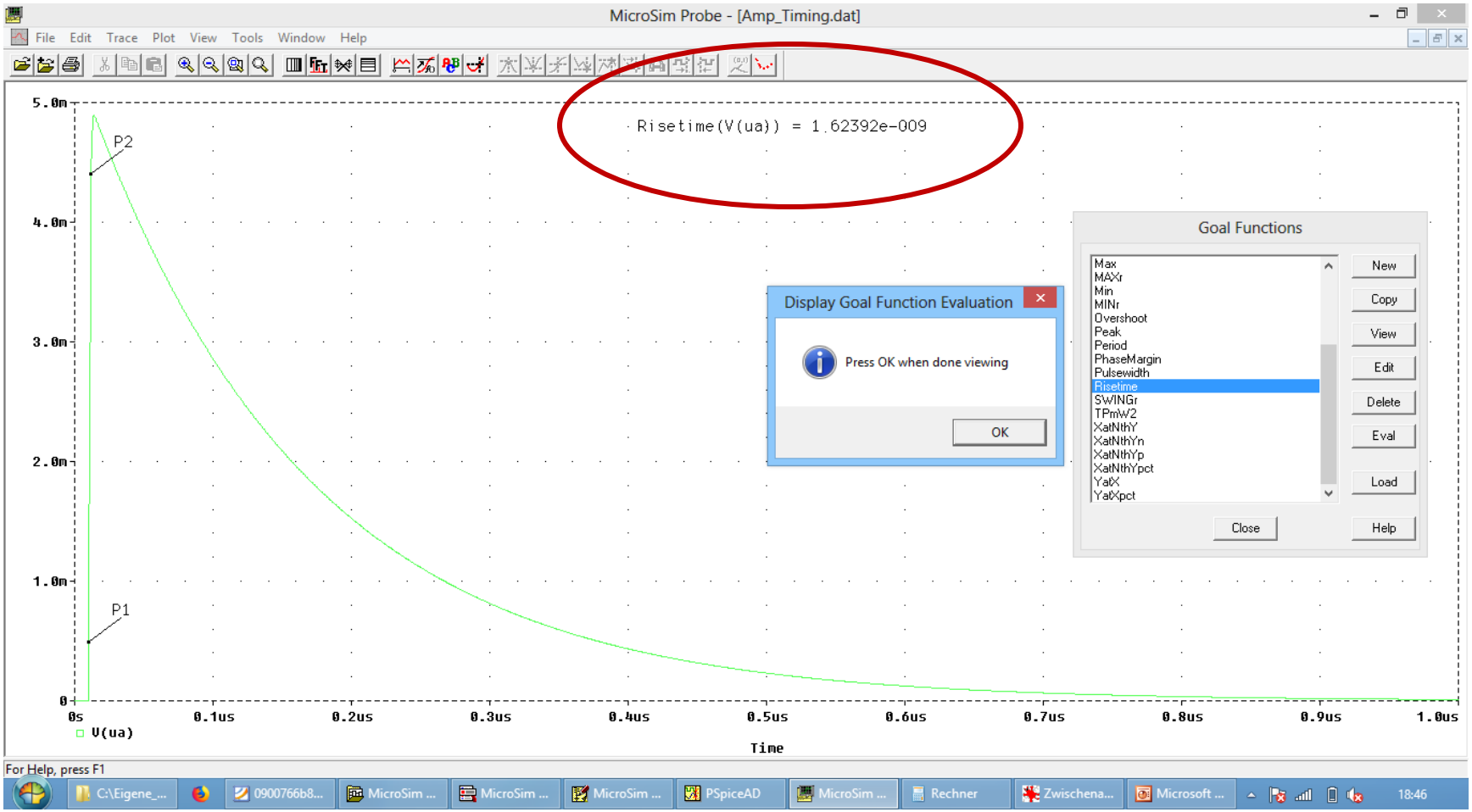
Bandwidth = 300 MHz



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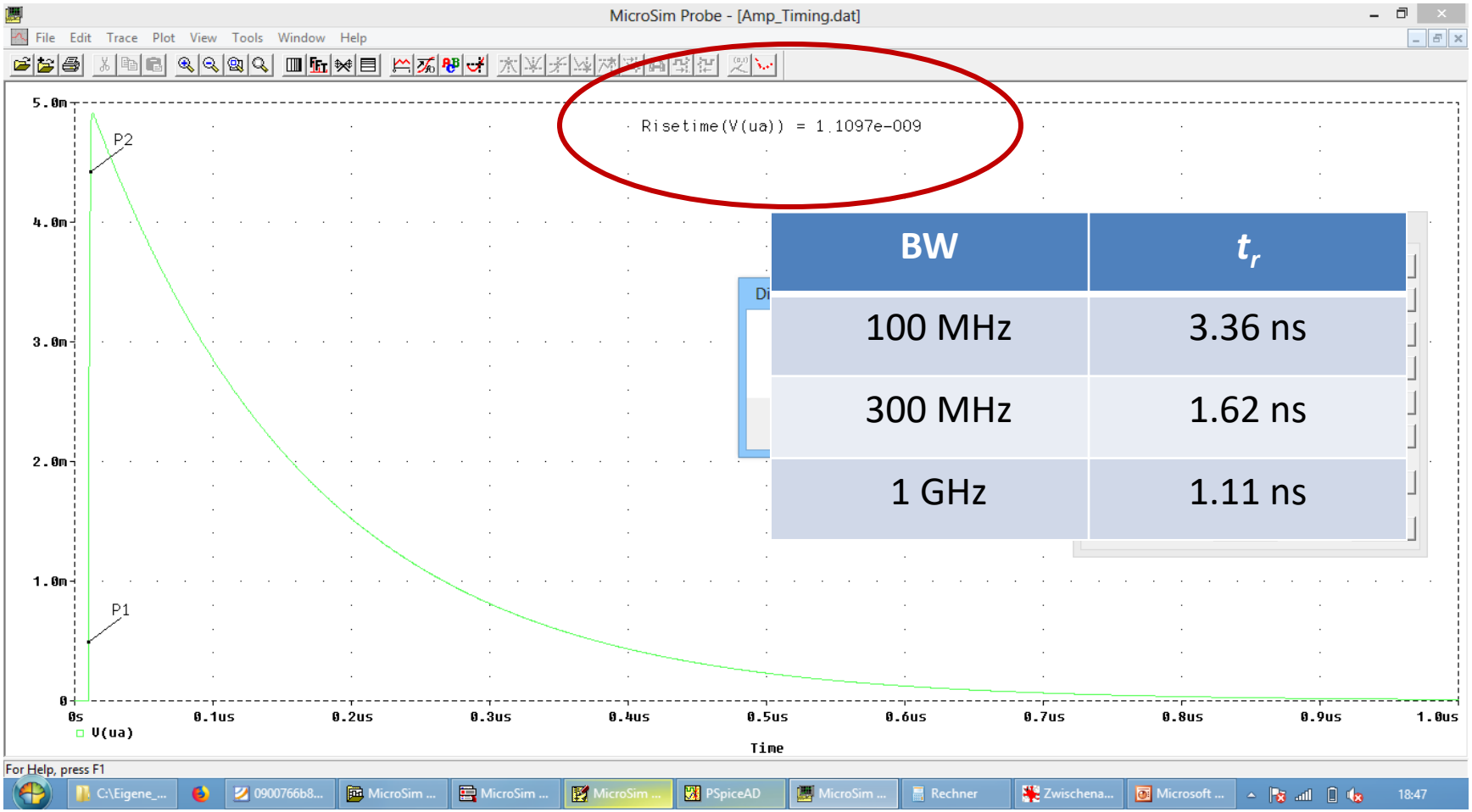
Bandwidth = 1 GHz



BW	t_r
100 MHz	3.36 ns
300 MHz	1.62 ns
1 GHz	1.11 ns

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TCT setup

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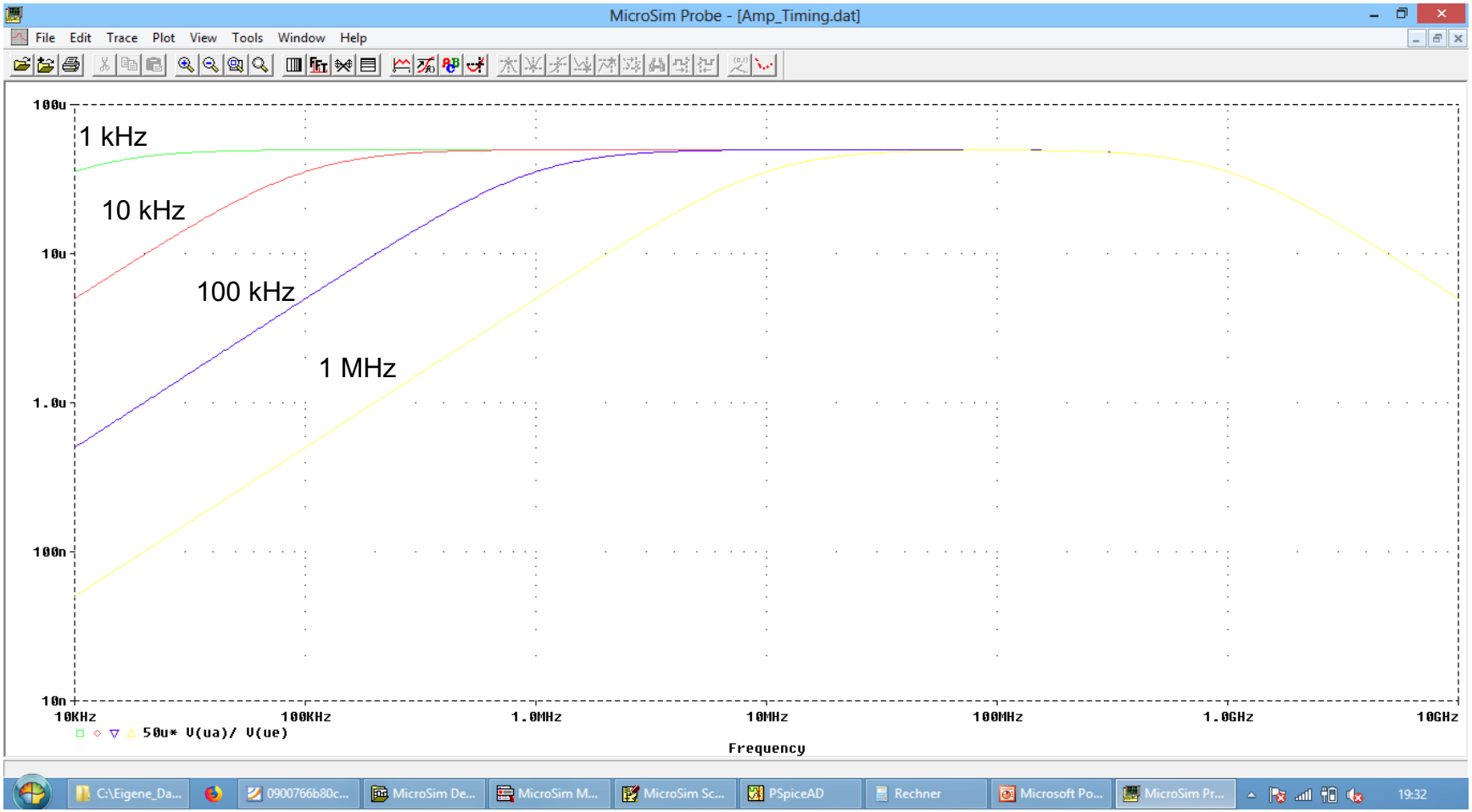
Lower cut-off



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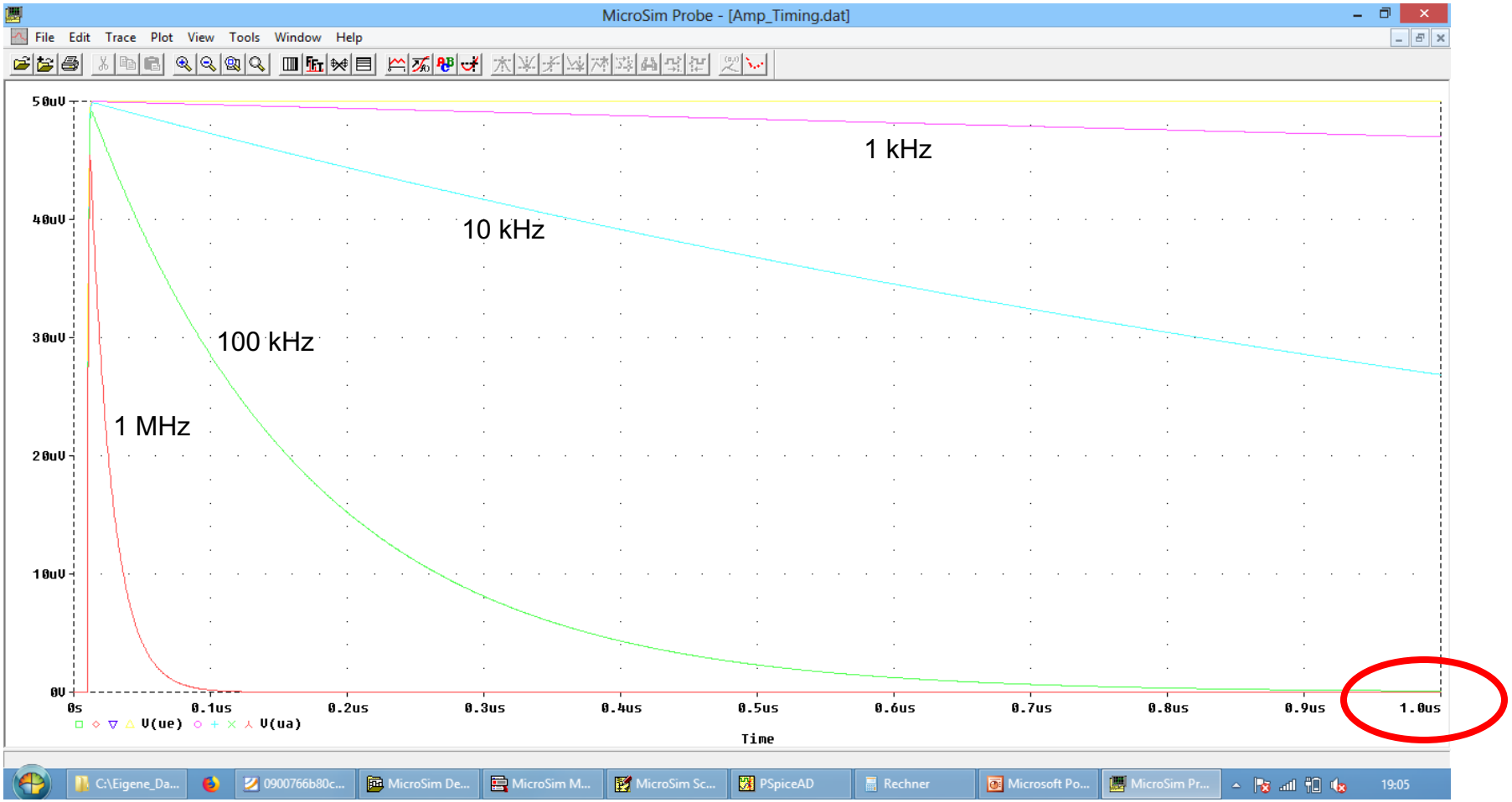
TCT step



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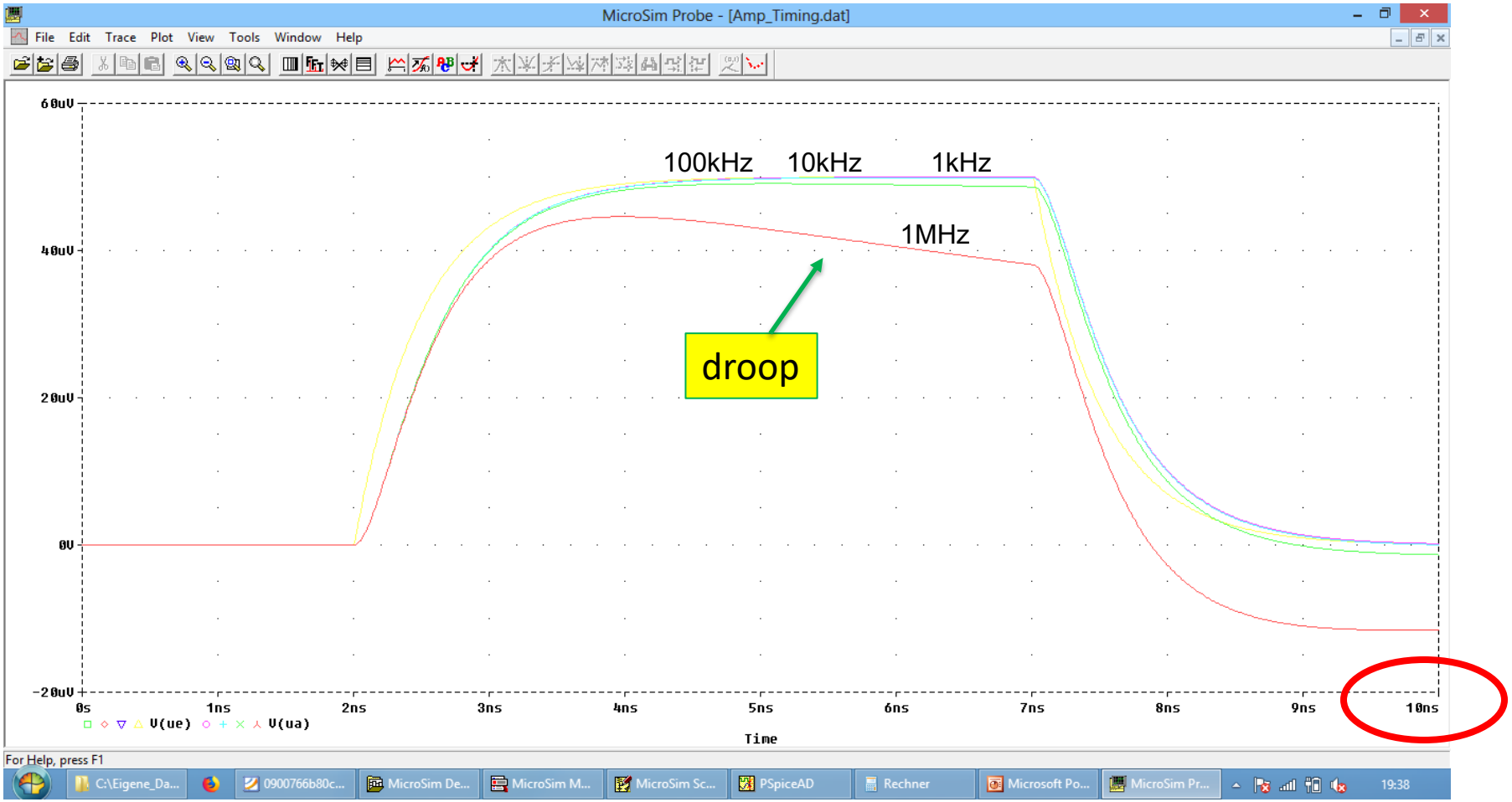
TCT 5 ns pulse



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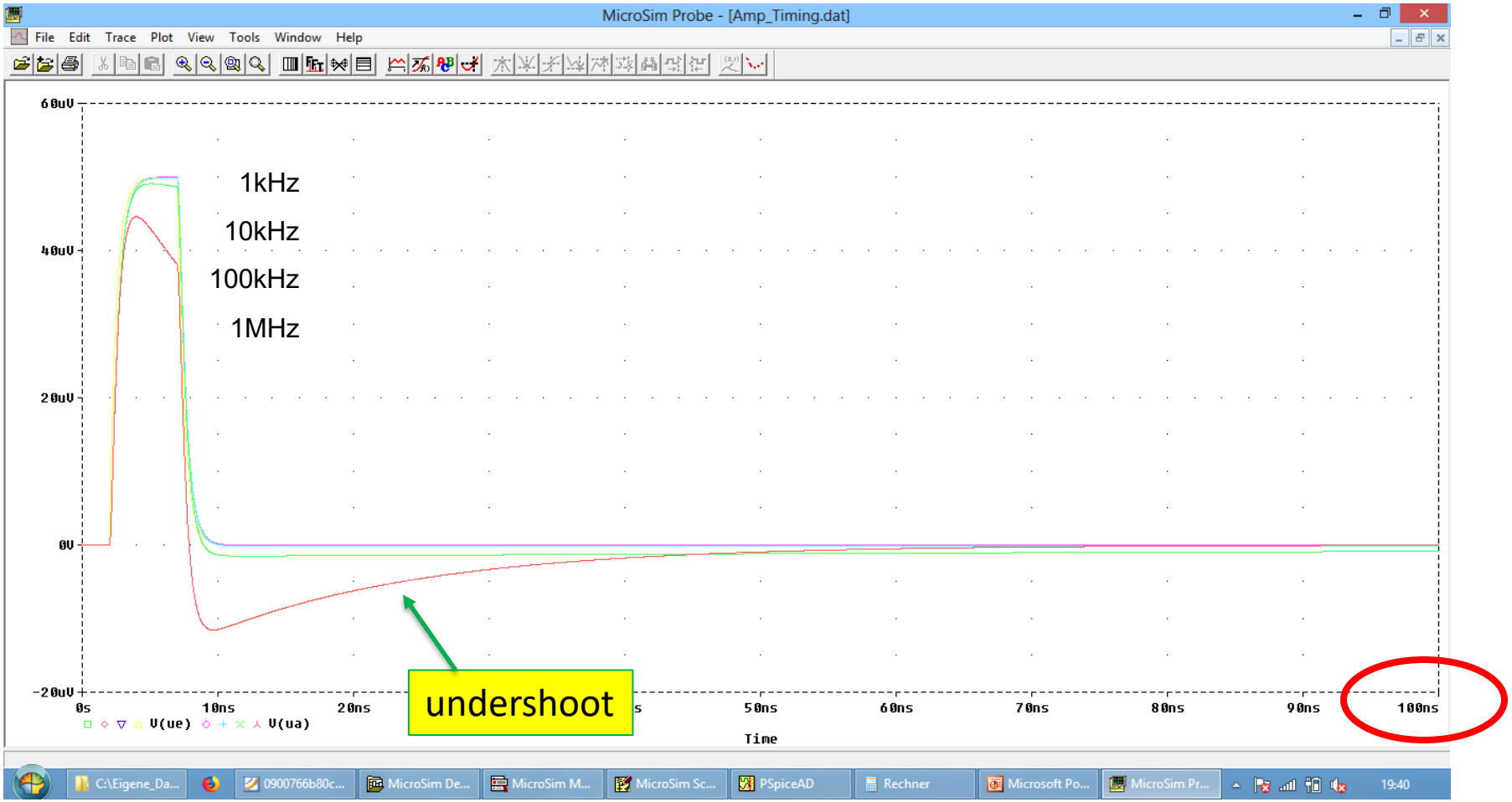
TCT pulse



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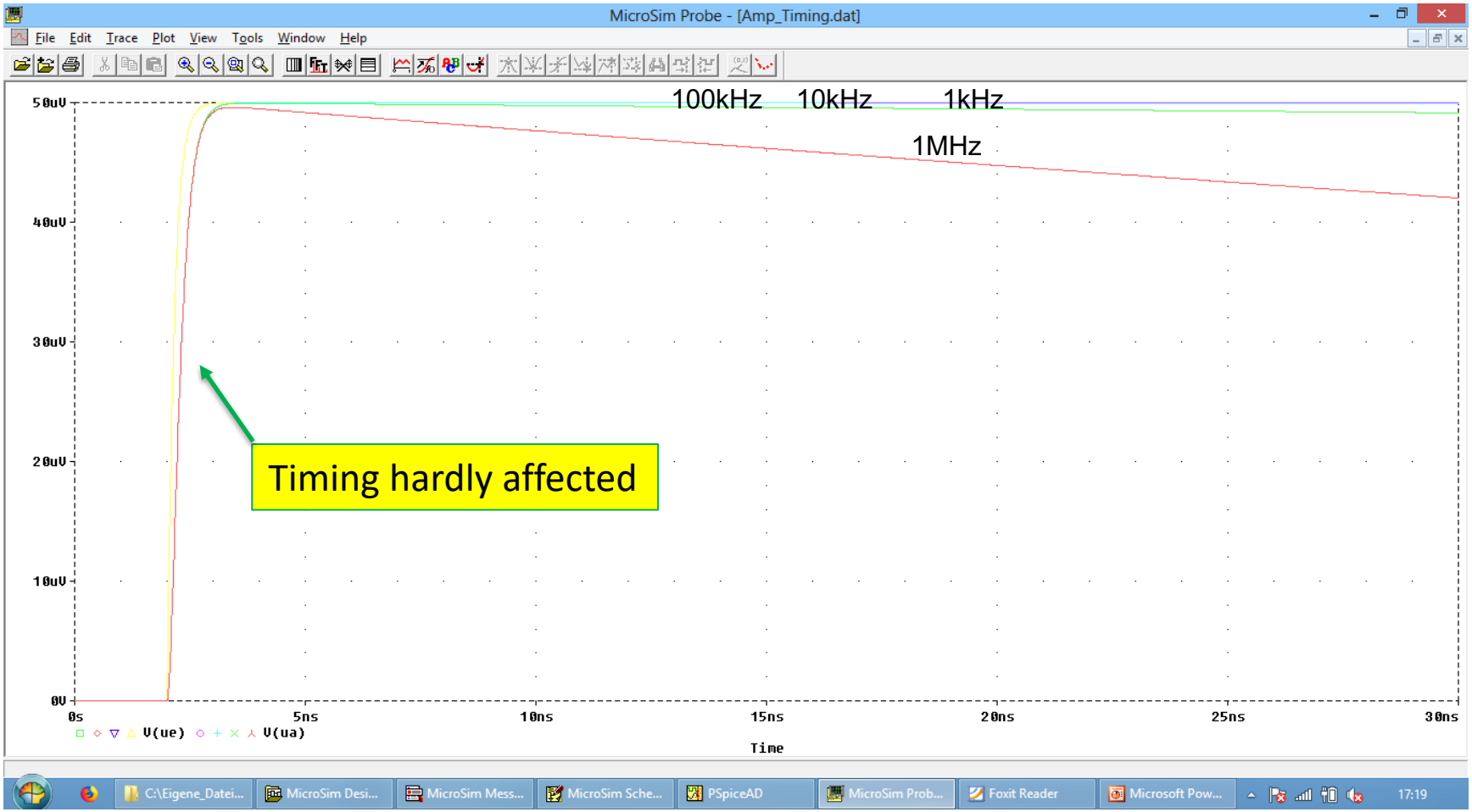
Lower cut-off



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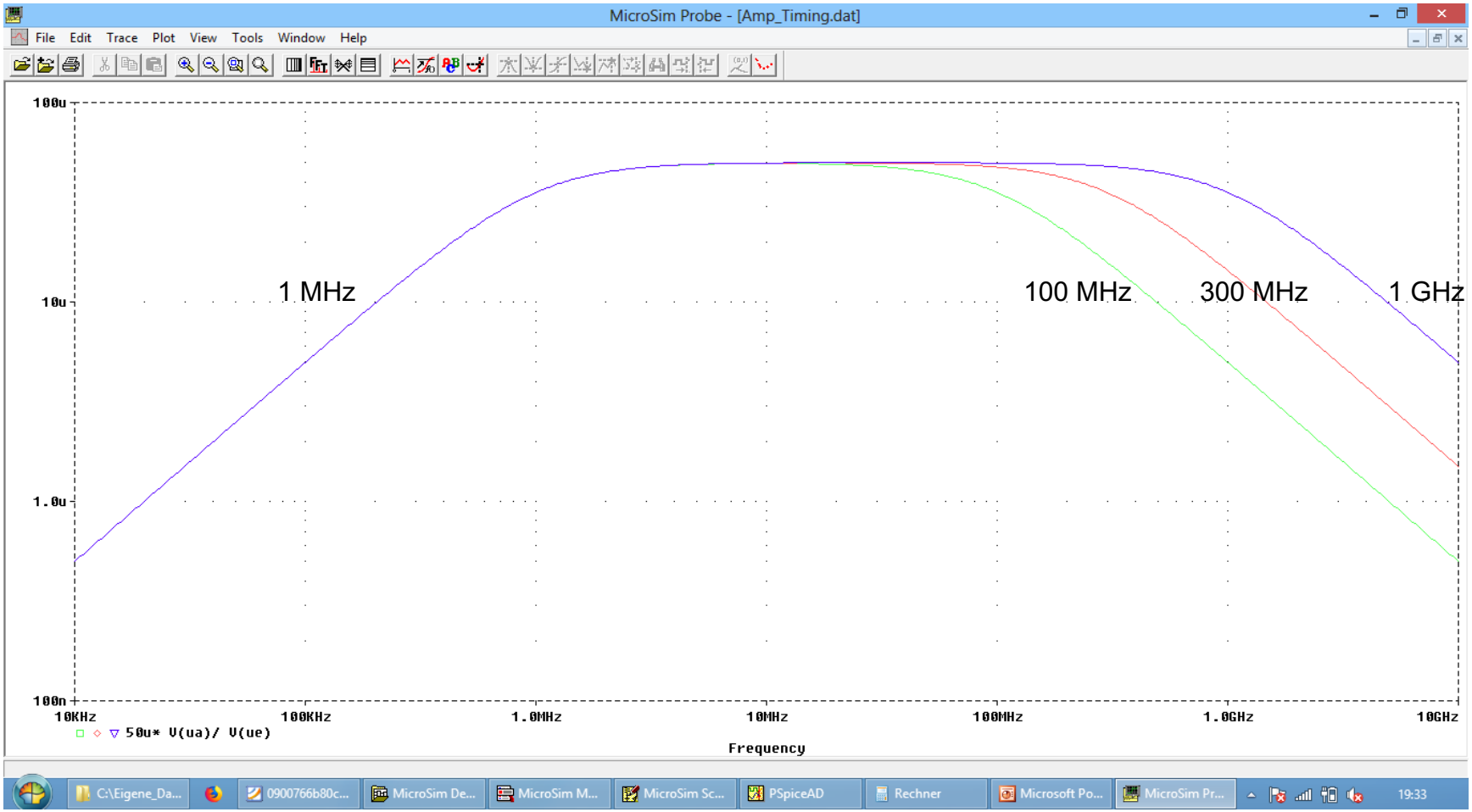
Upper cut-off



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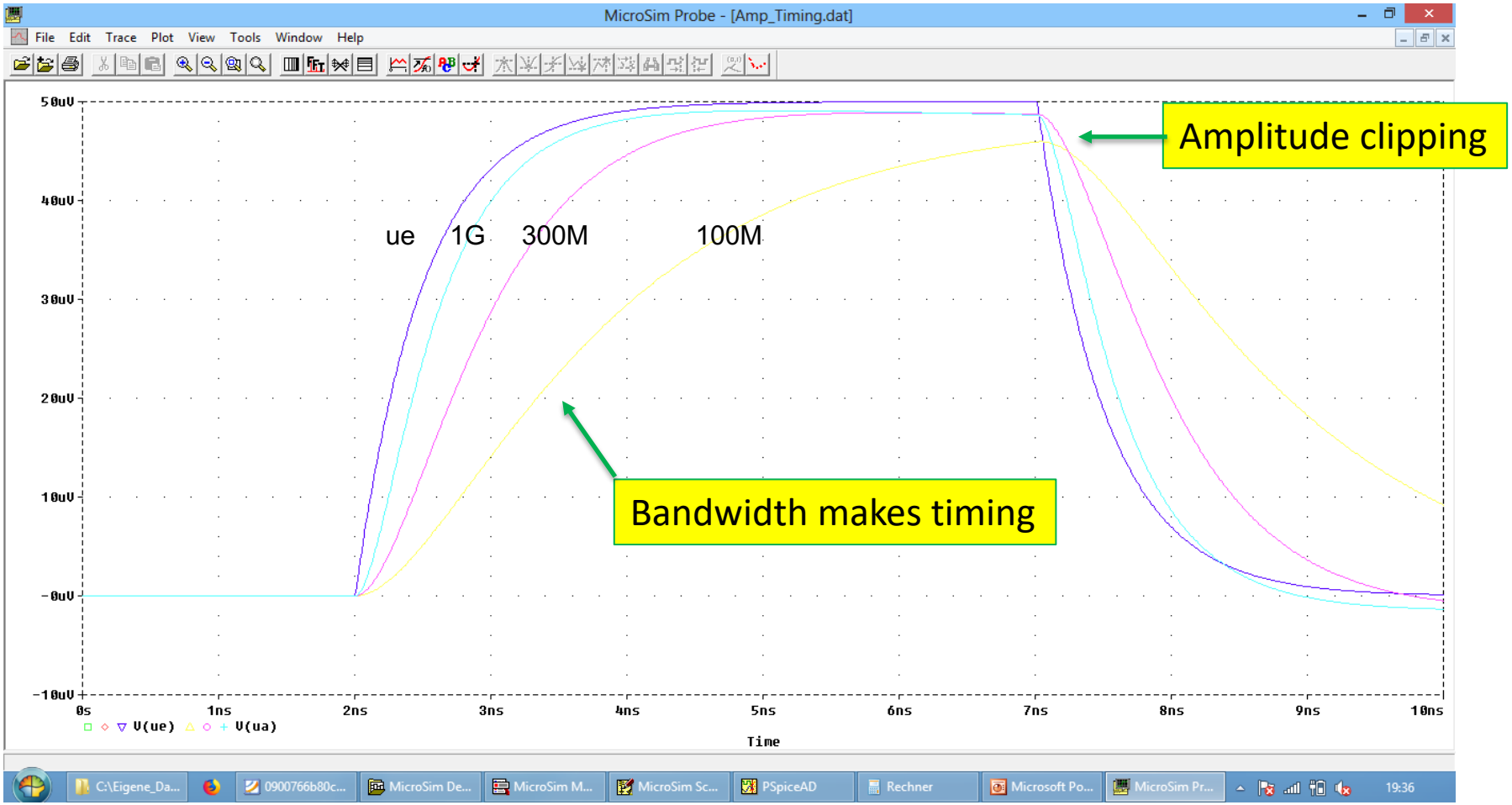
TCT



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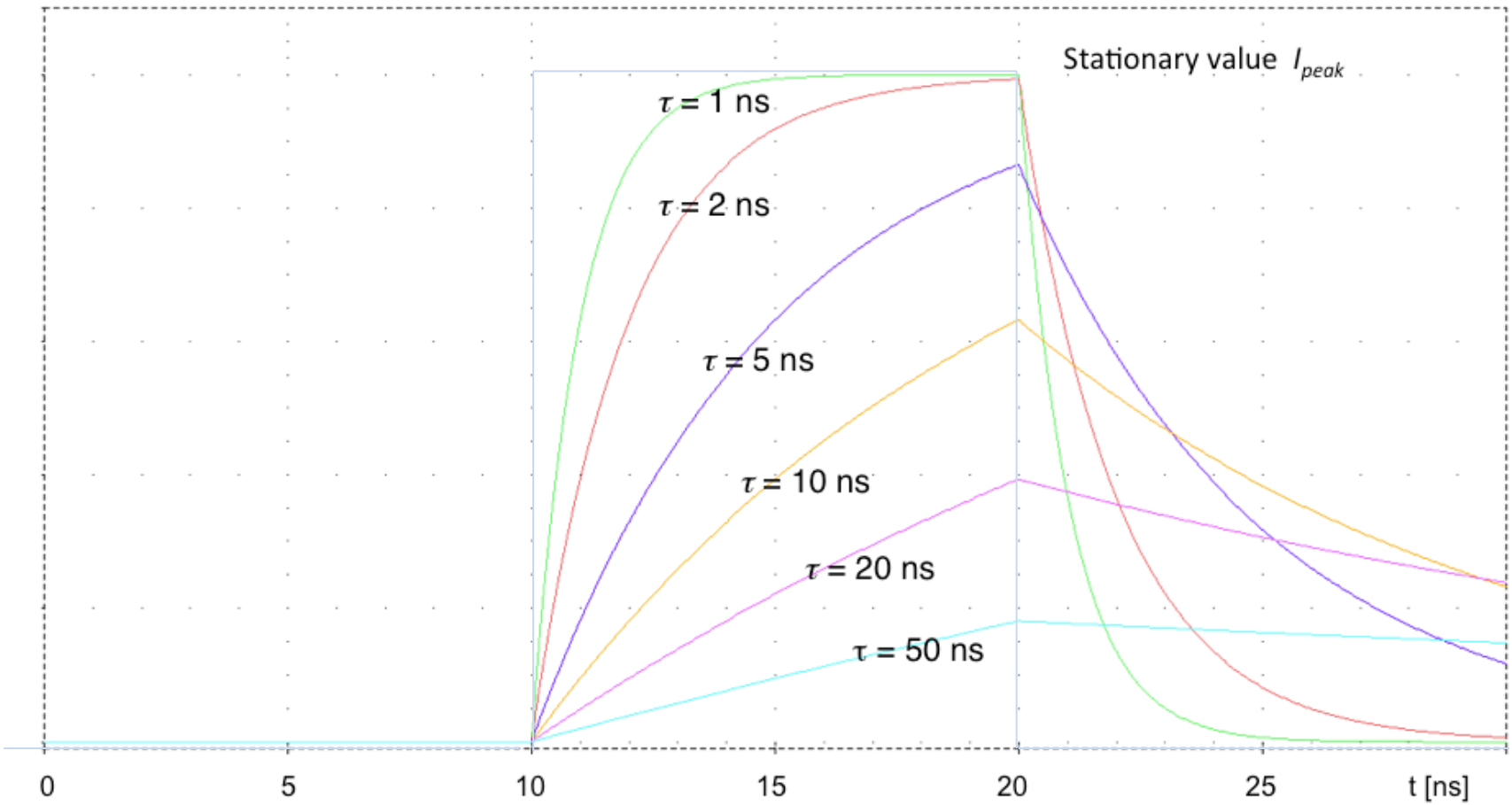
Time constant



Detector capacitance

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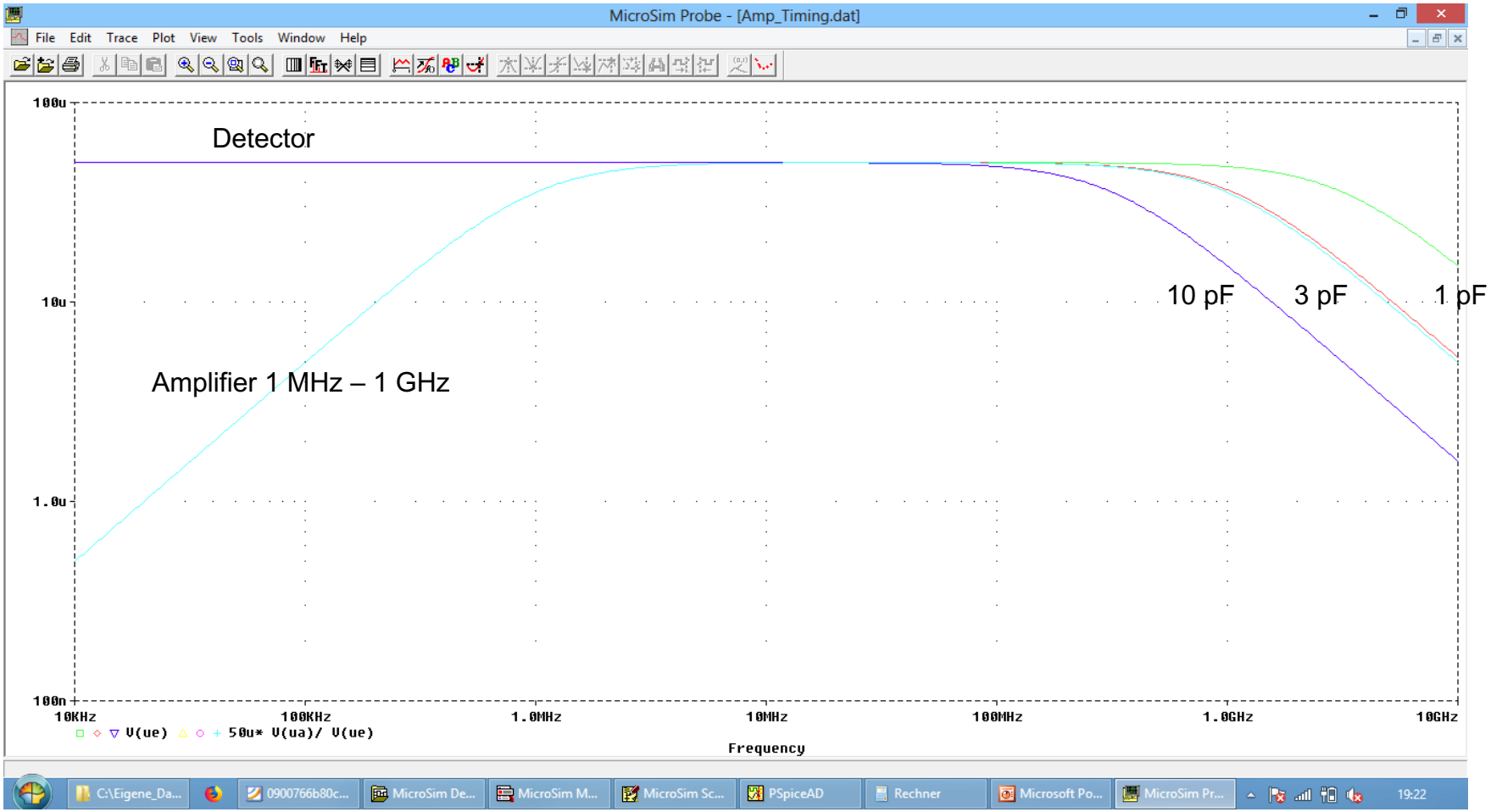
Detector capacitance



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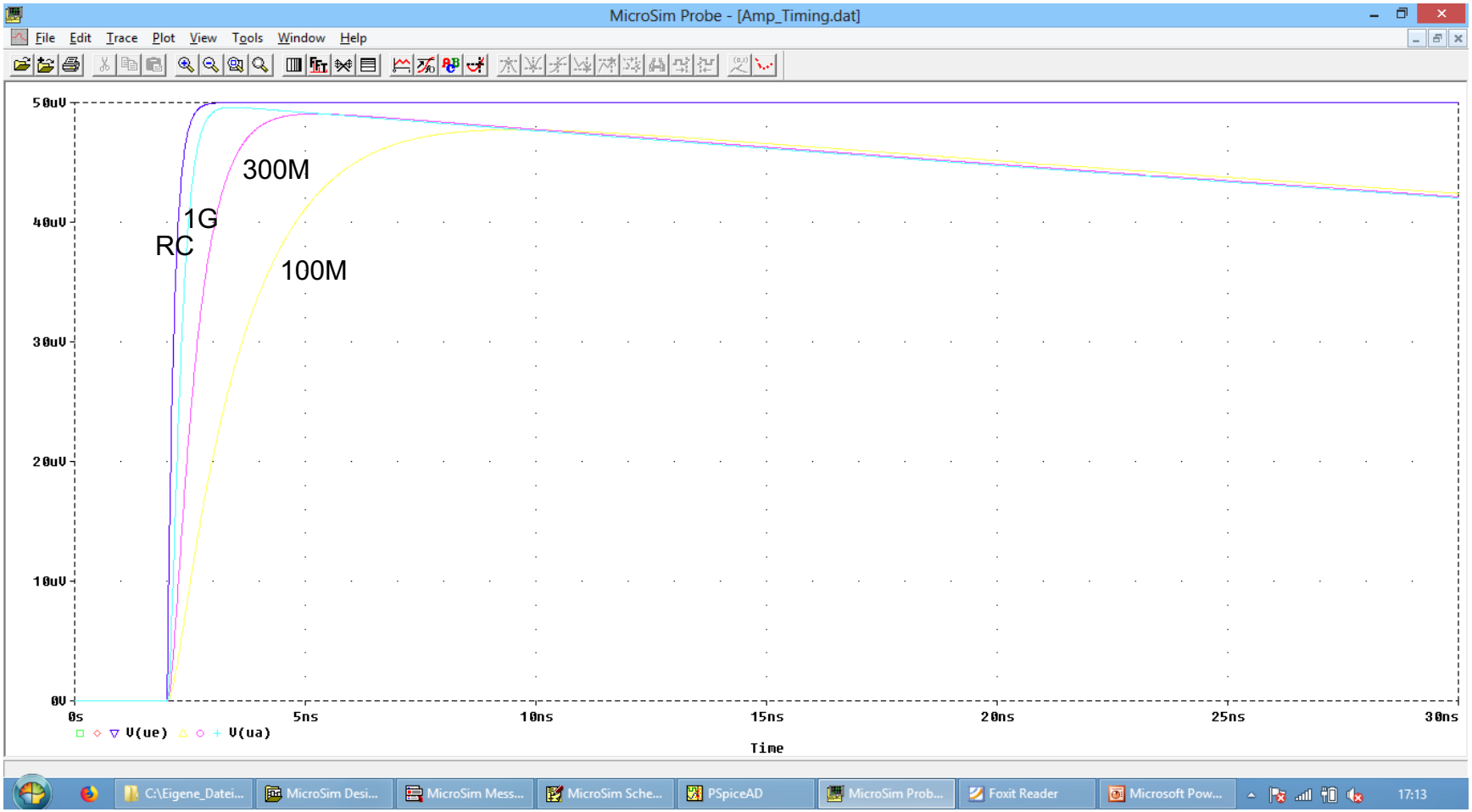
Step response for C_{det}=3 pF



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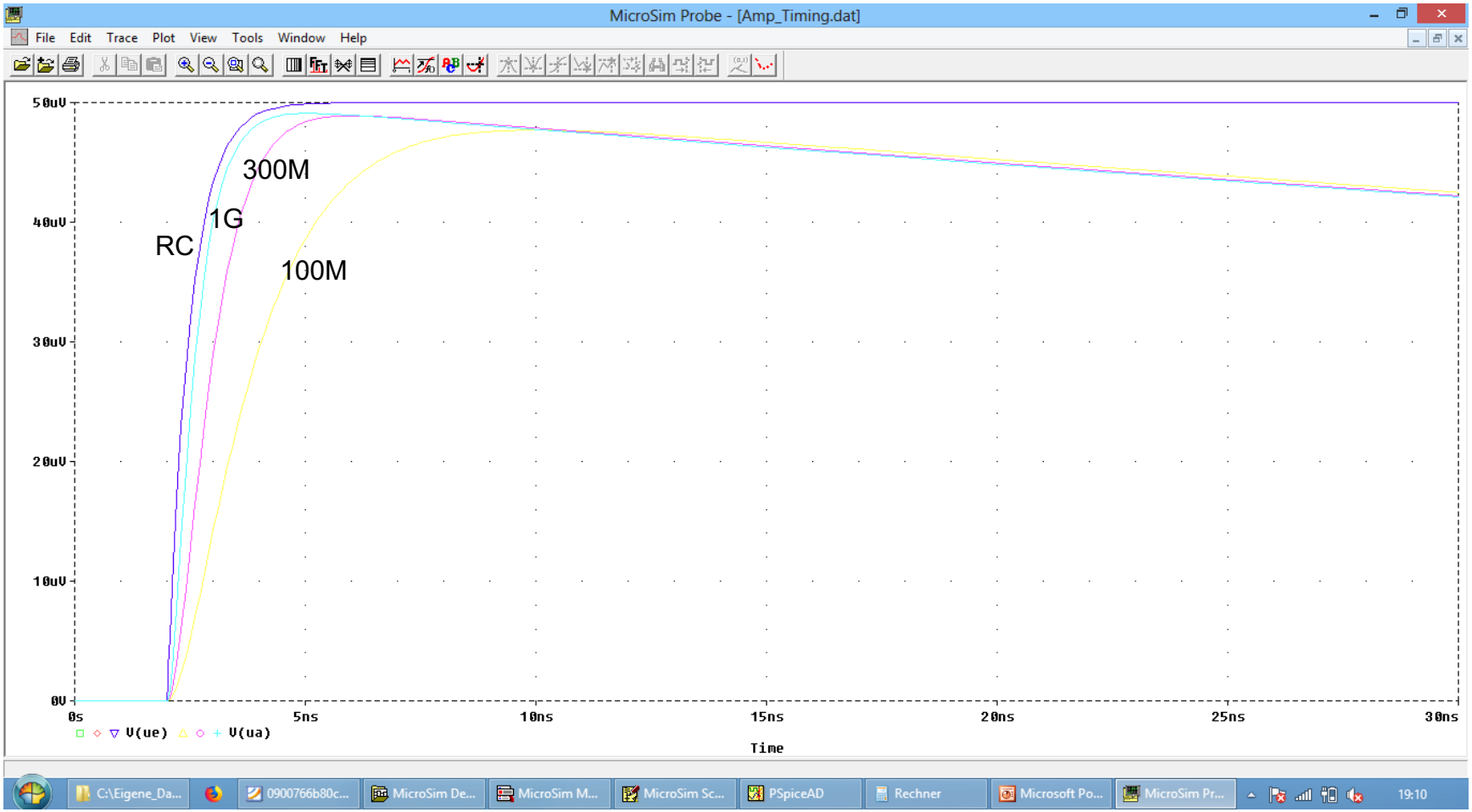
Step response for C_{det}=10 pF



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Time resolution

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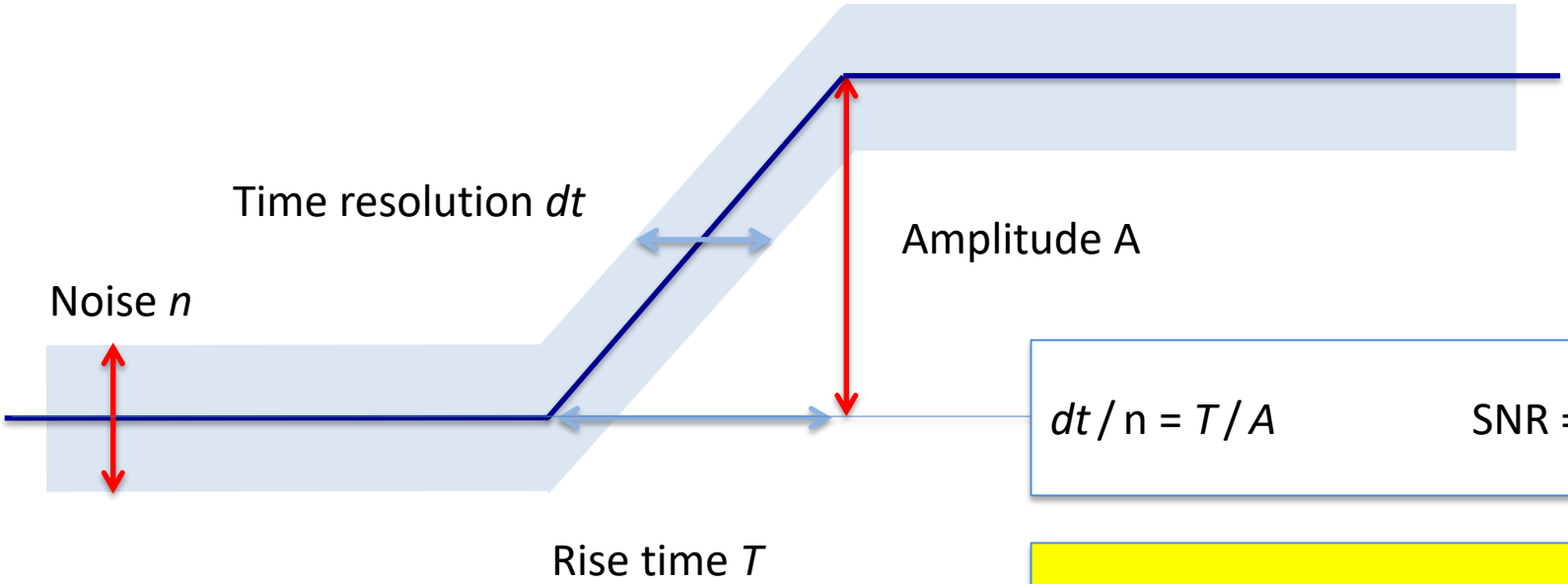
Time resolution



$dt / n = T / A$ SNR = A / n

Time resolution: $dt = \frac{T}{\mathrm{SNR}}$

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Noise considerations

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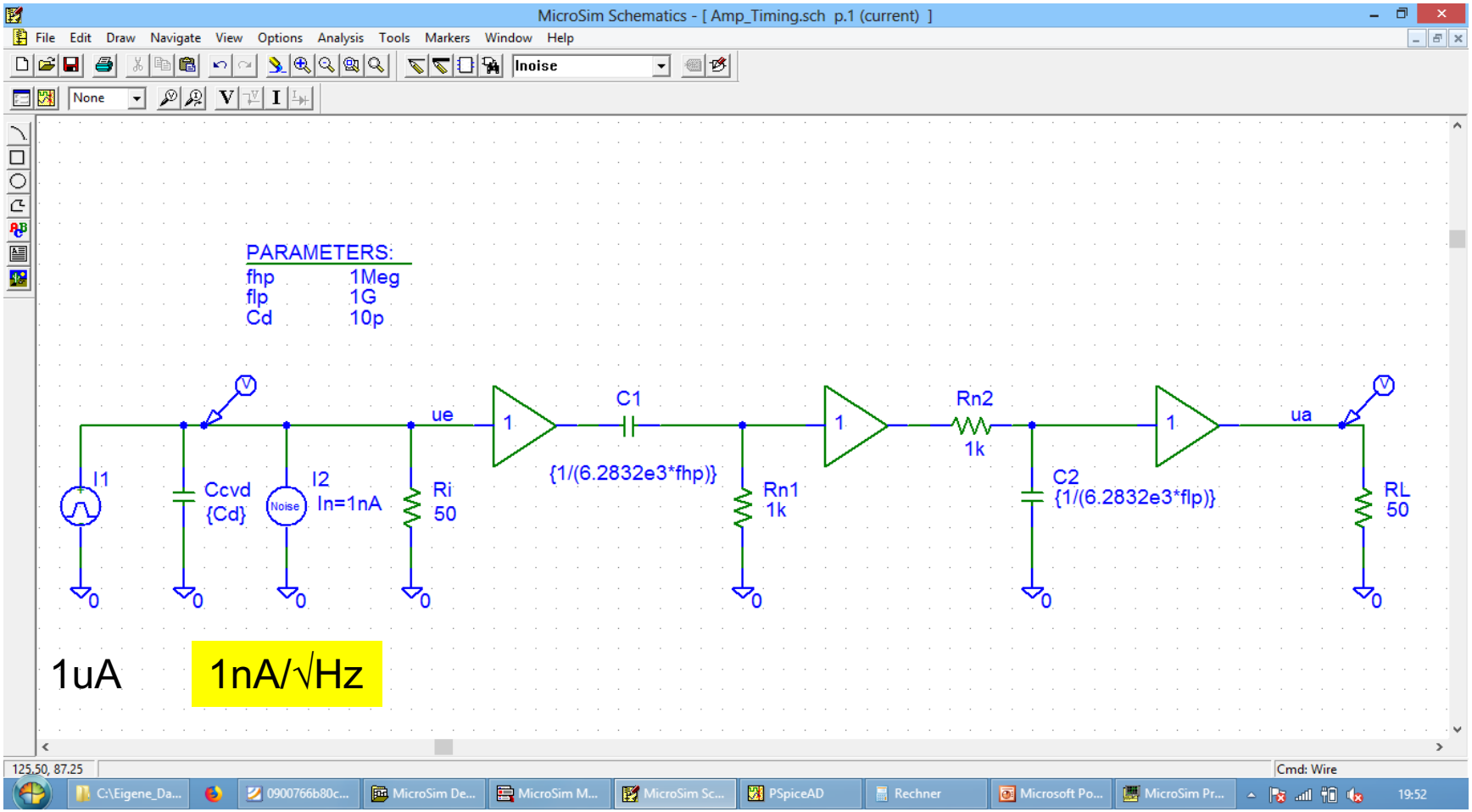
Noise considerations



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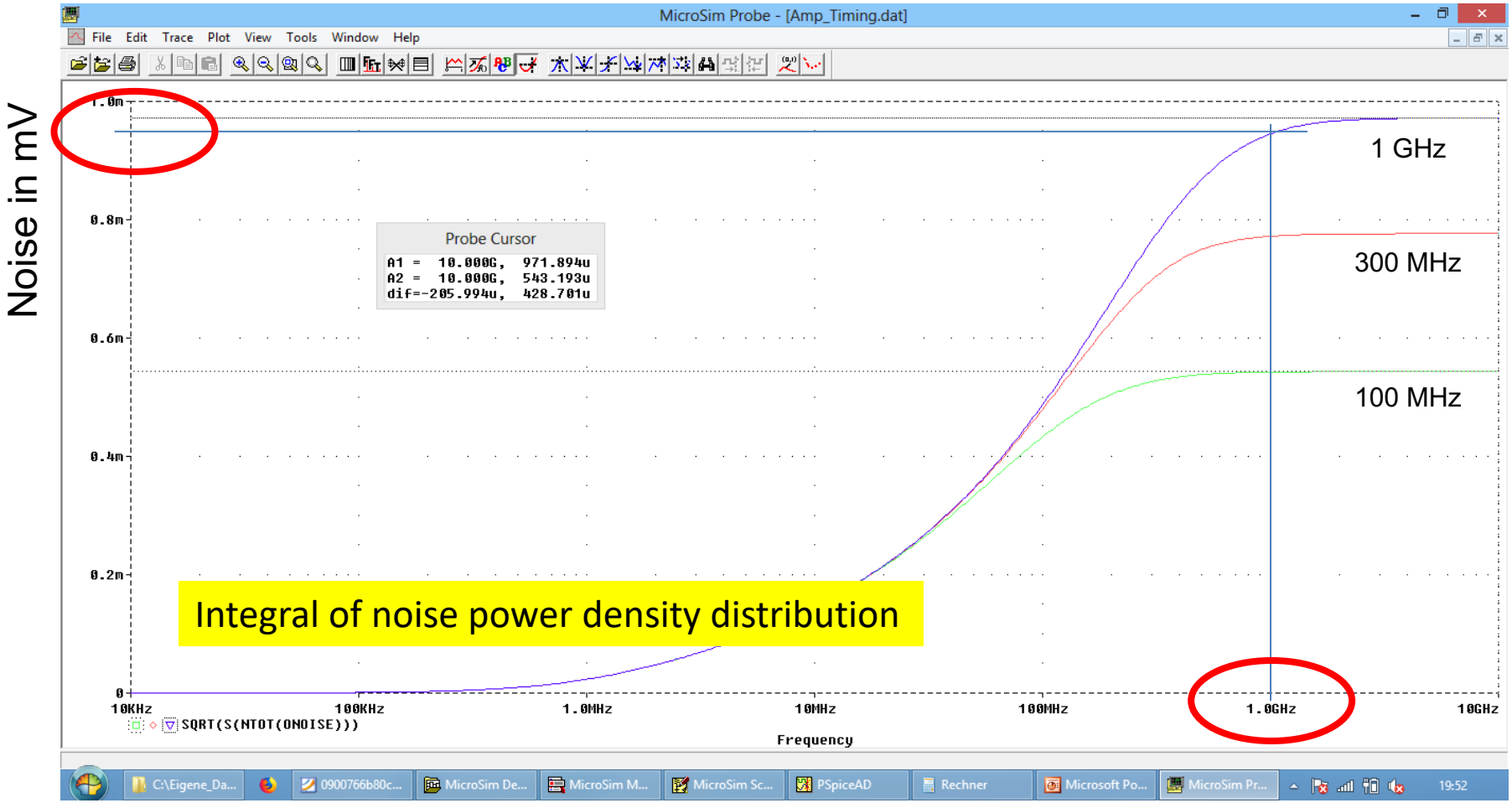
Noise spectrum



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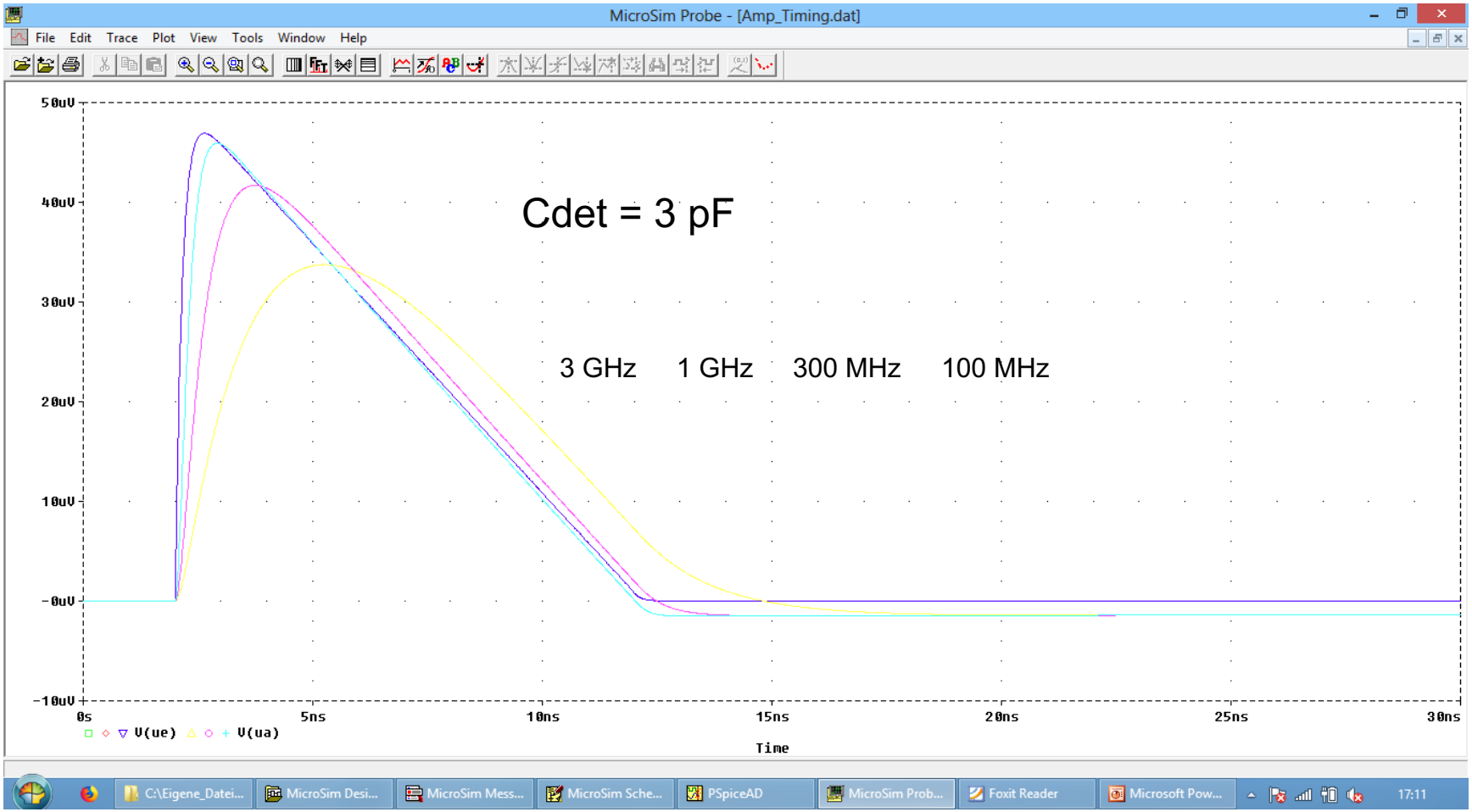
Detector signal



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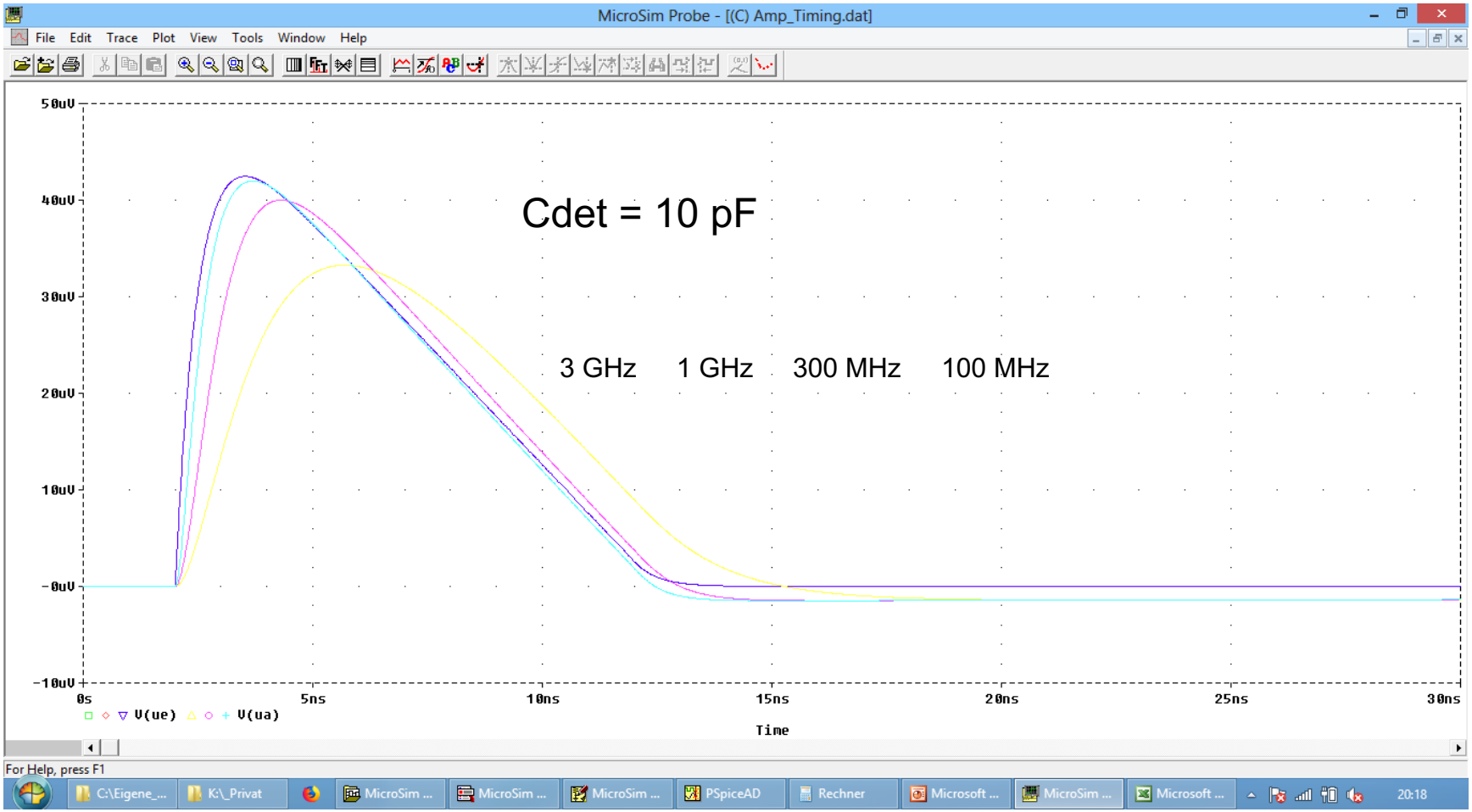
Detector signal



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Timing

Cd=10pF	fg	318 MHz			
fg	Noise	tr	Signal	SNR	tr/SNR
MHz	µVrms	ns			
100	540	3,36	28,3	5,2	641
300	776	1,62	36,2	4,7	347
1.000	972	1,11	38,9	4,0	277
3.000	1060	0,70	39,2	3,7	188
Cd=3pF	fg	1.061 MHz			
fg	Noise	tr	Signal	SNR	tr/SNR
MHz	µVrms	ns			
100	596	1,49	29,0	4,9	306
300	956	0,80	38,6	4,0	199
1.000	1420	0,43	44,1	3,1	137
3.000	1750	0,30	45,5	2,6	114

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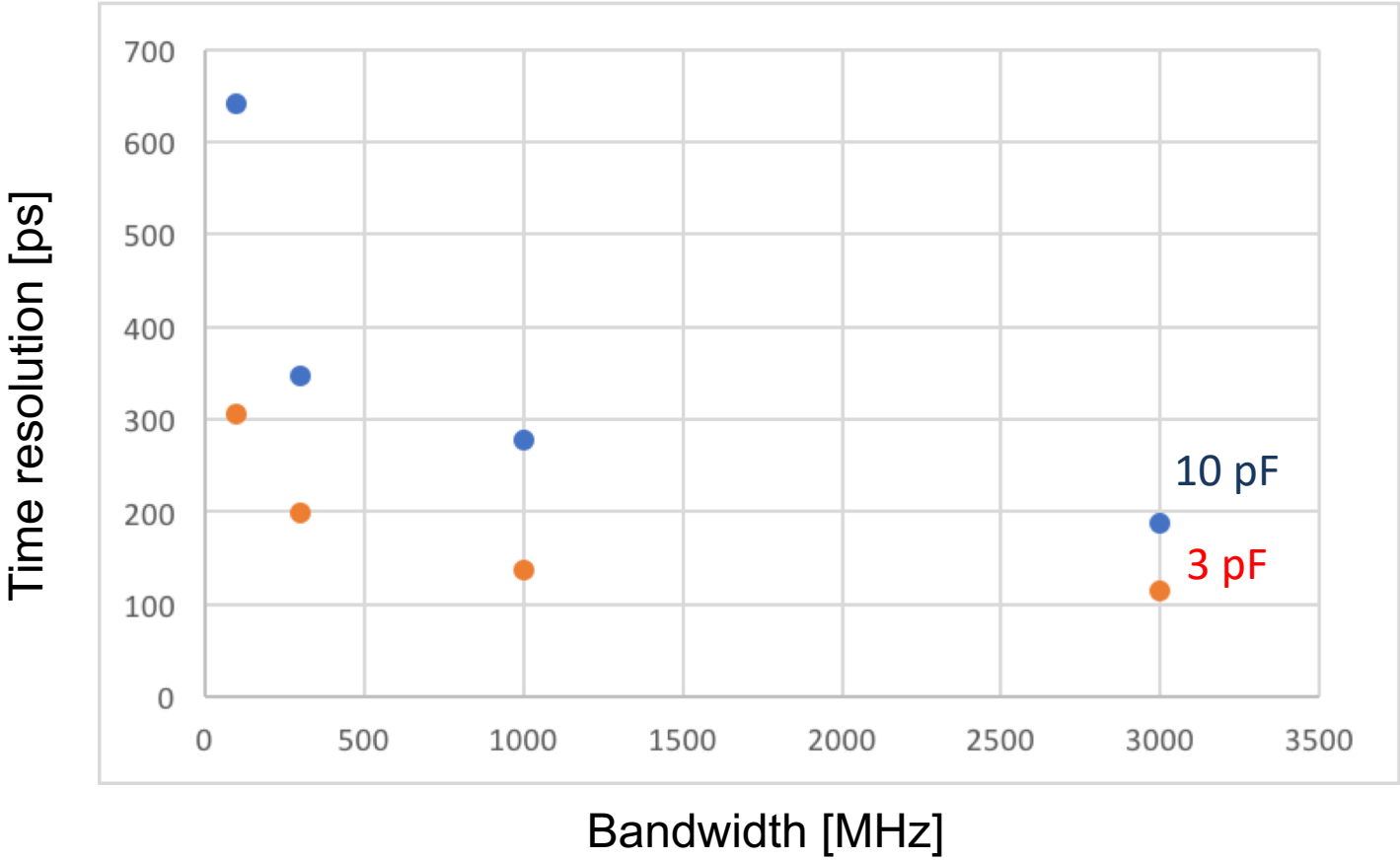
Time resolution



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Parasitic effects

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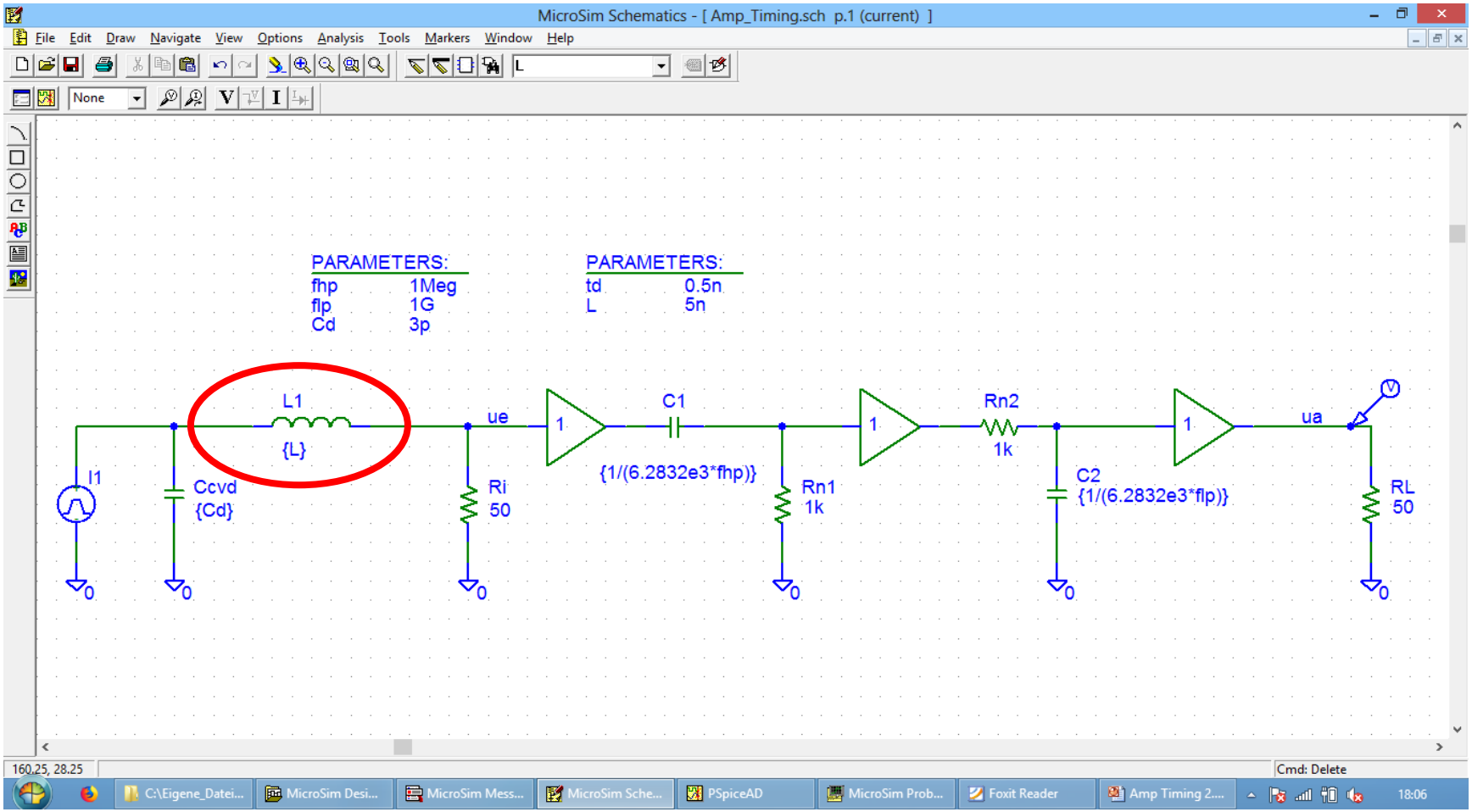
Inductance



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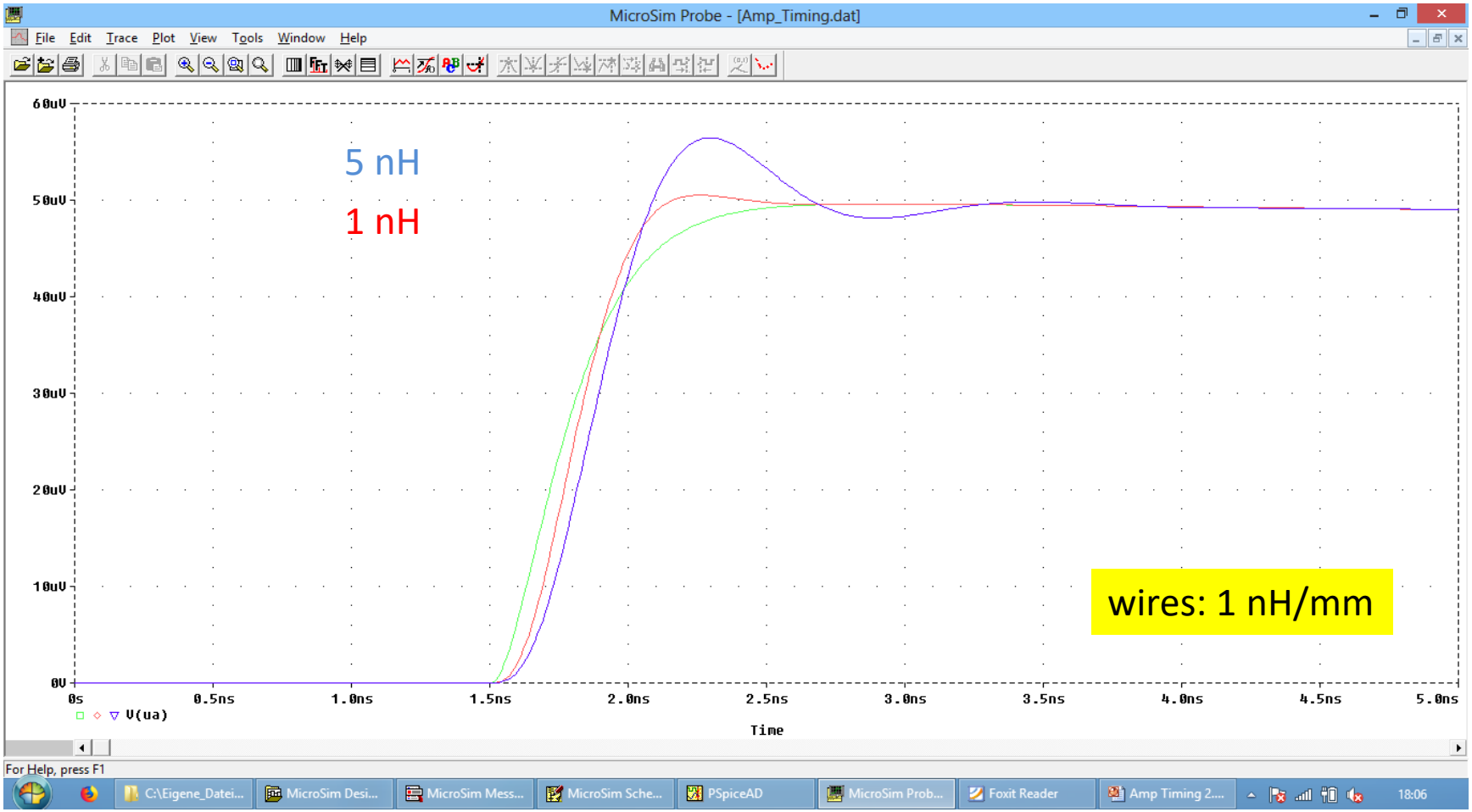
Inductance



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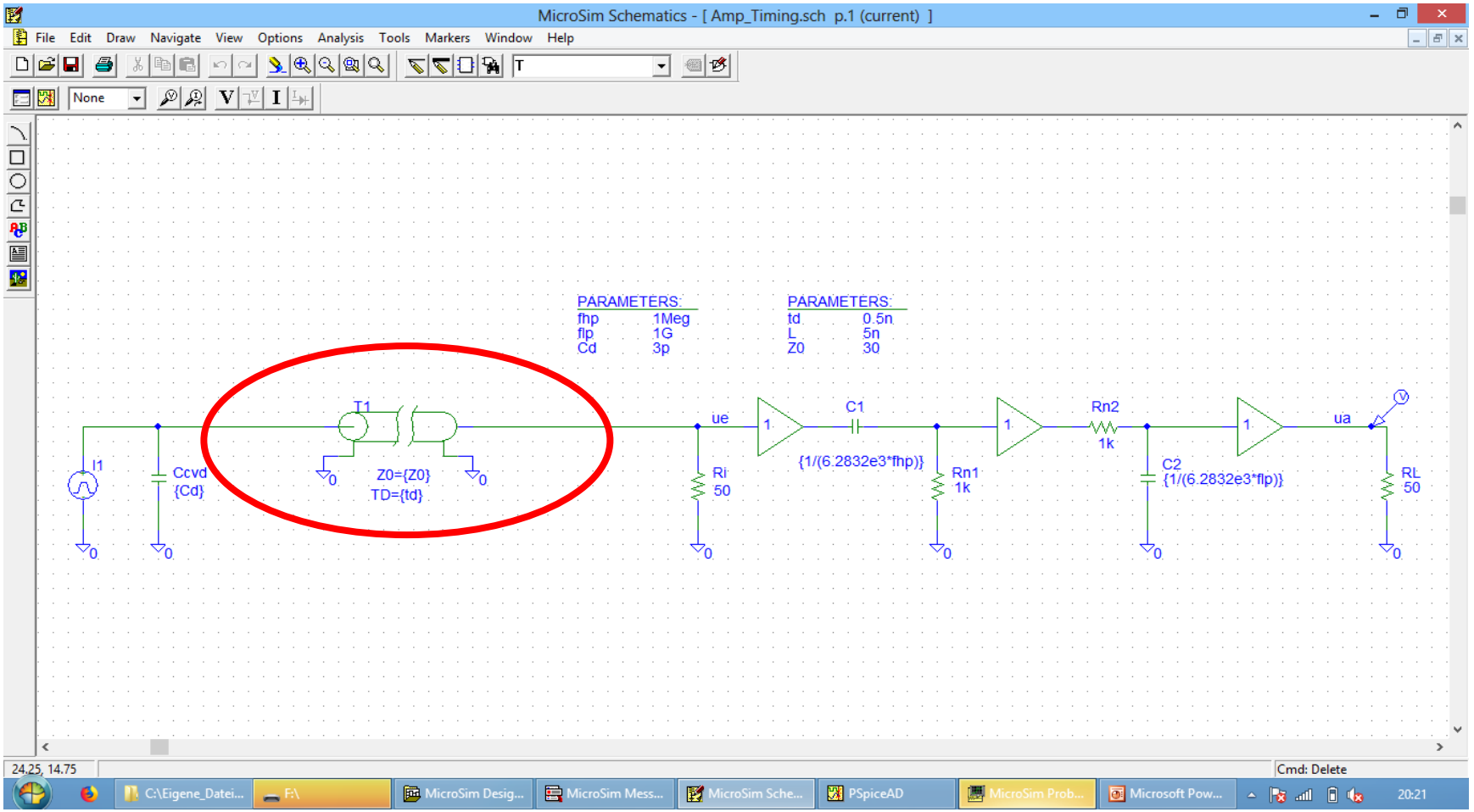
Impedance mismatch



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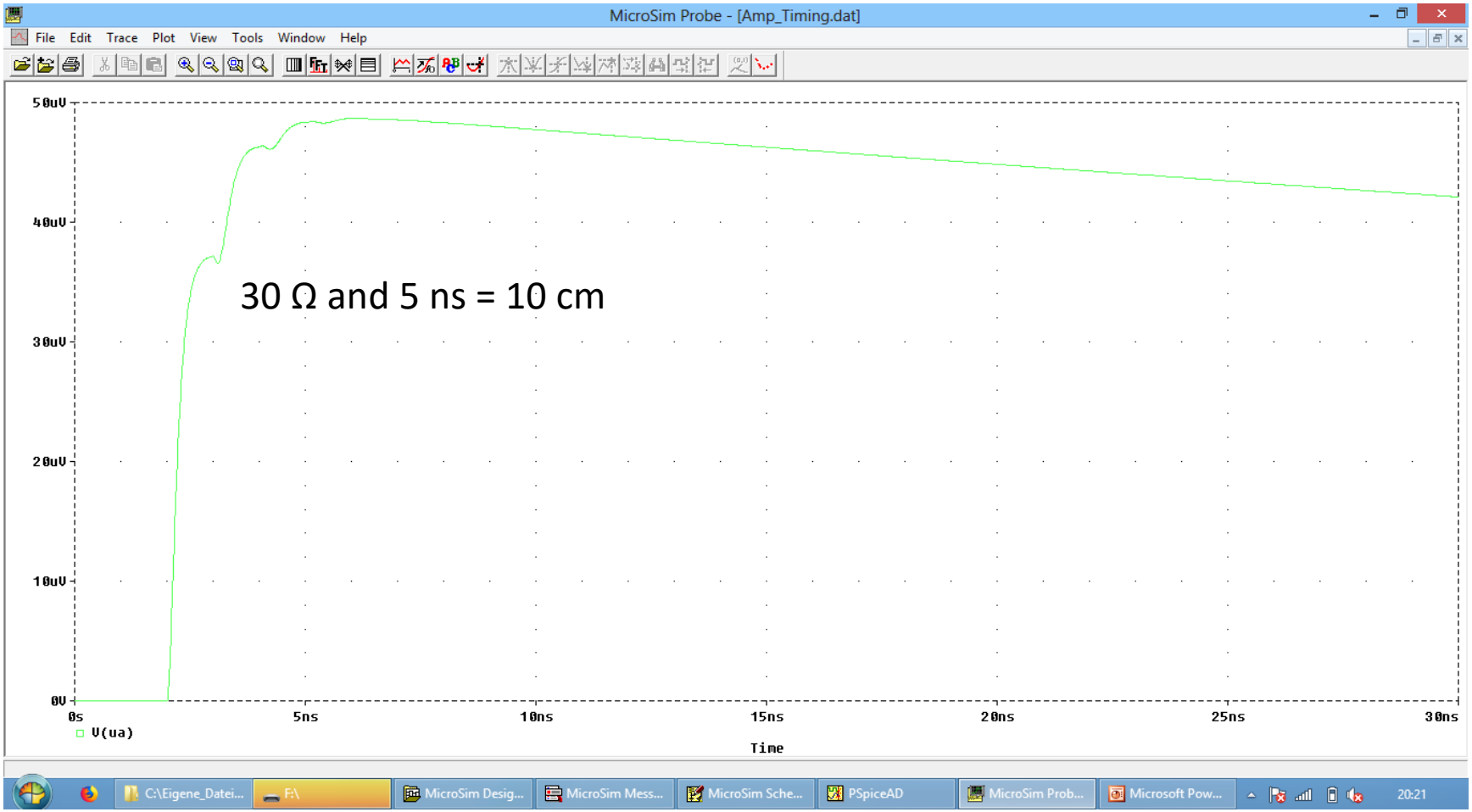
Impedance mismatch



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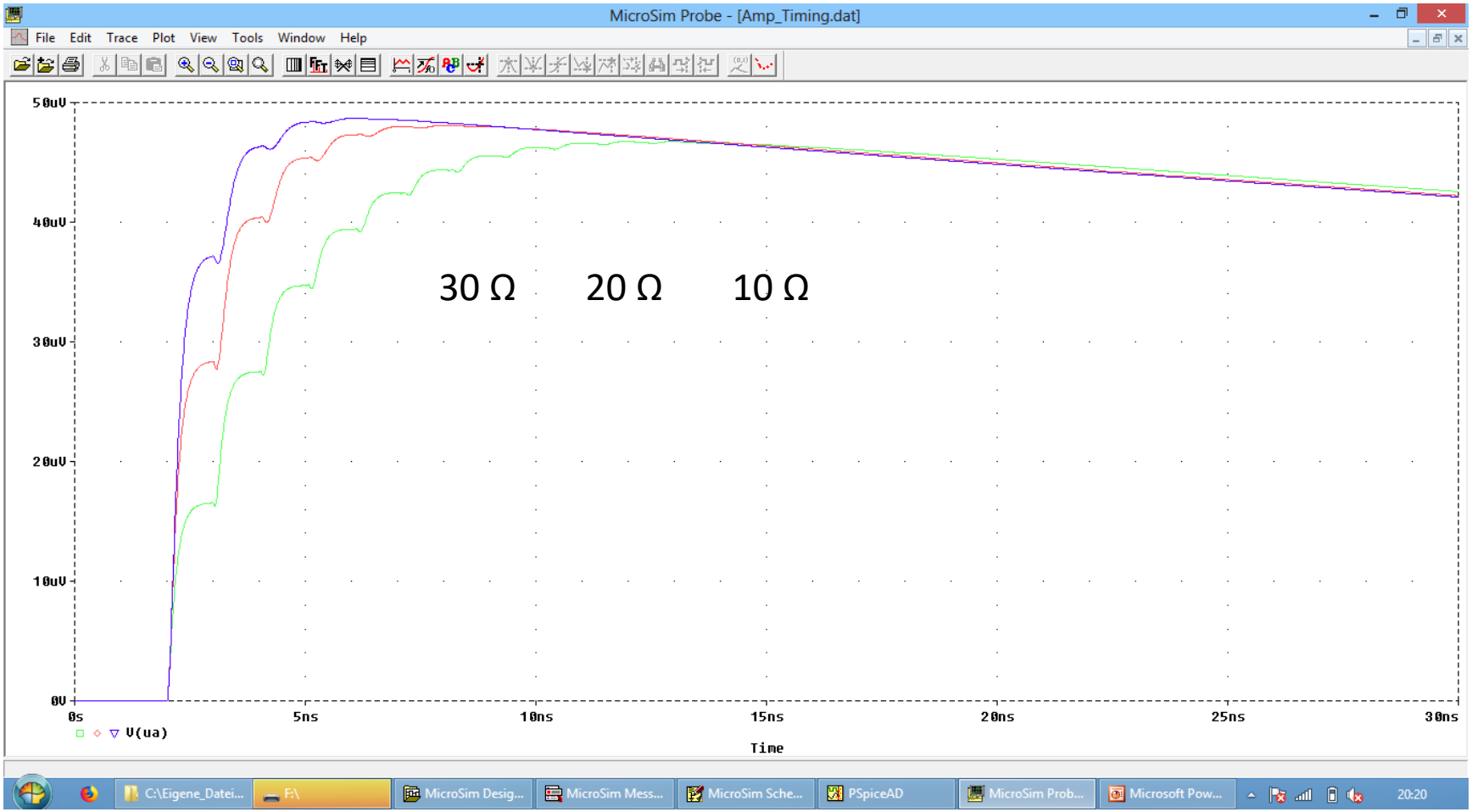
Impedance mismatch



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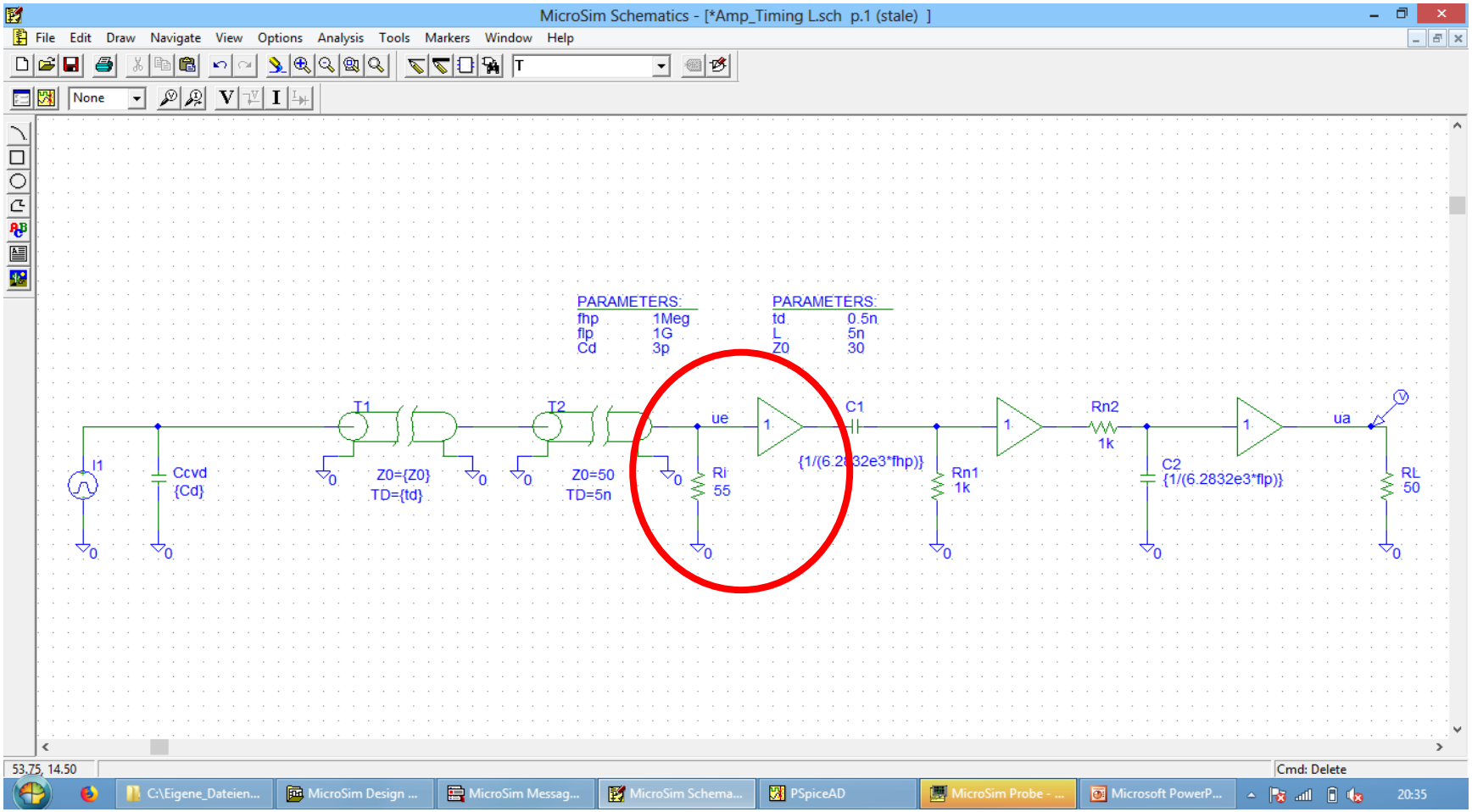
Amplifier impedance



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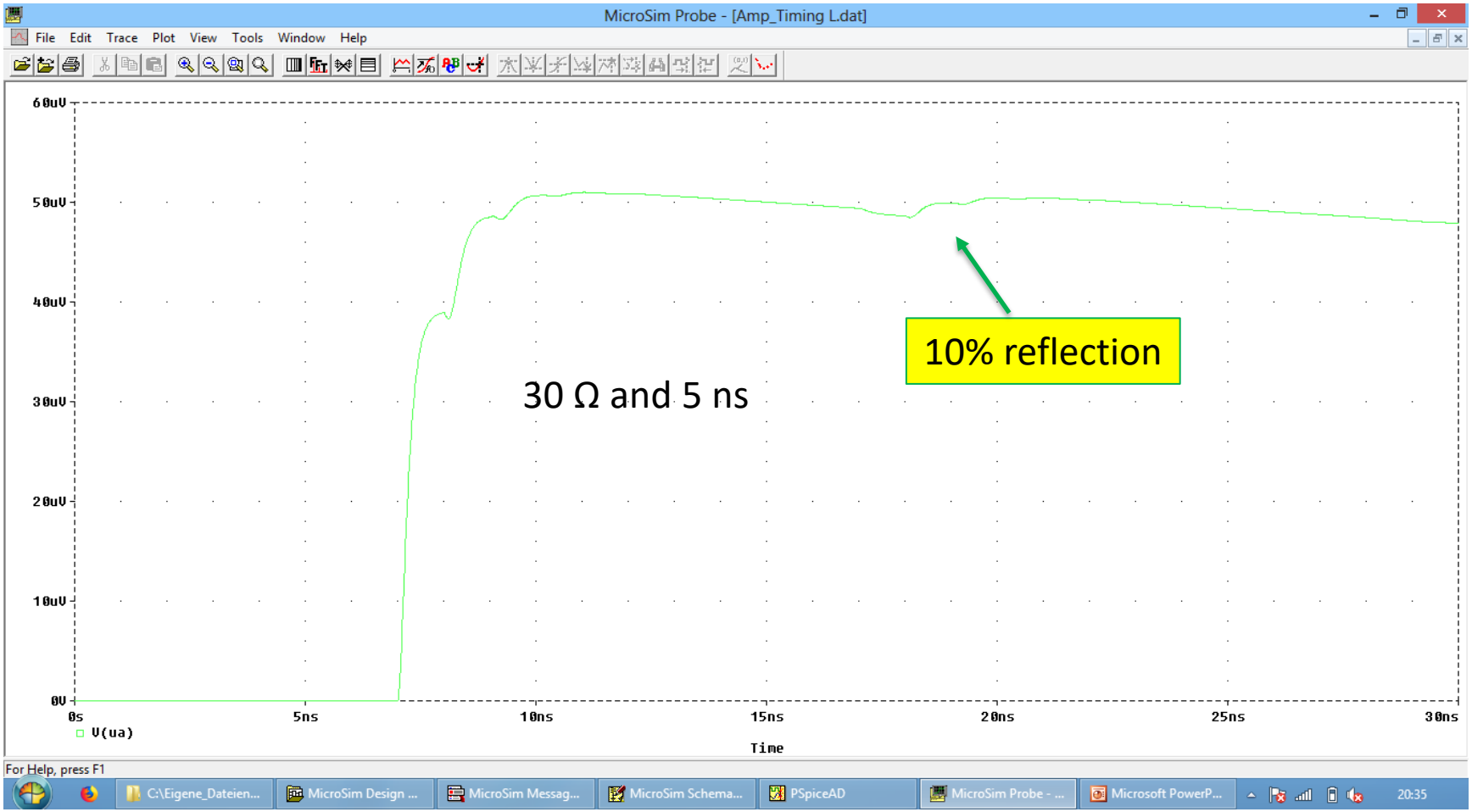
$Z_0 = 30\ \Omega + 55\ \Omega$



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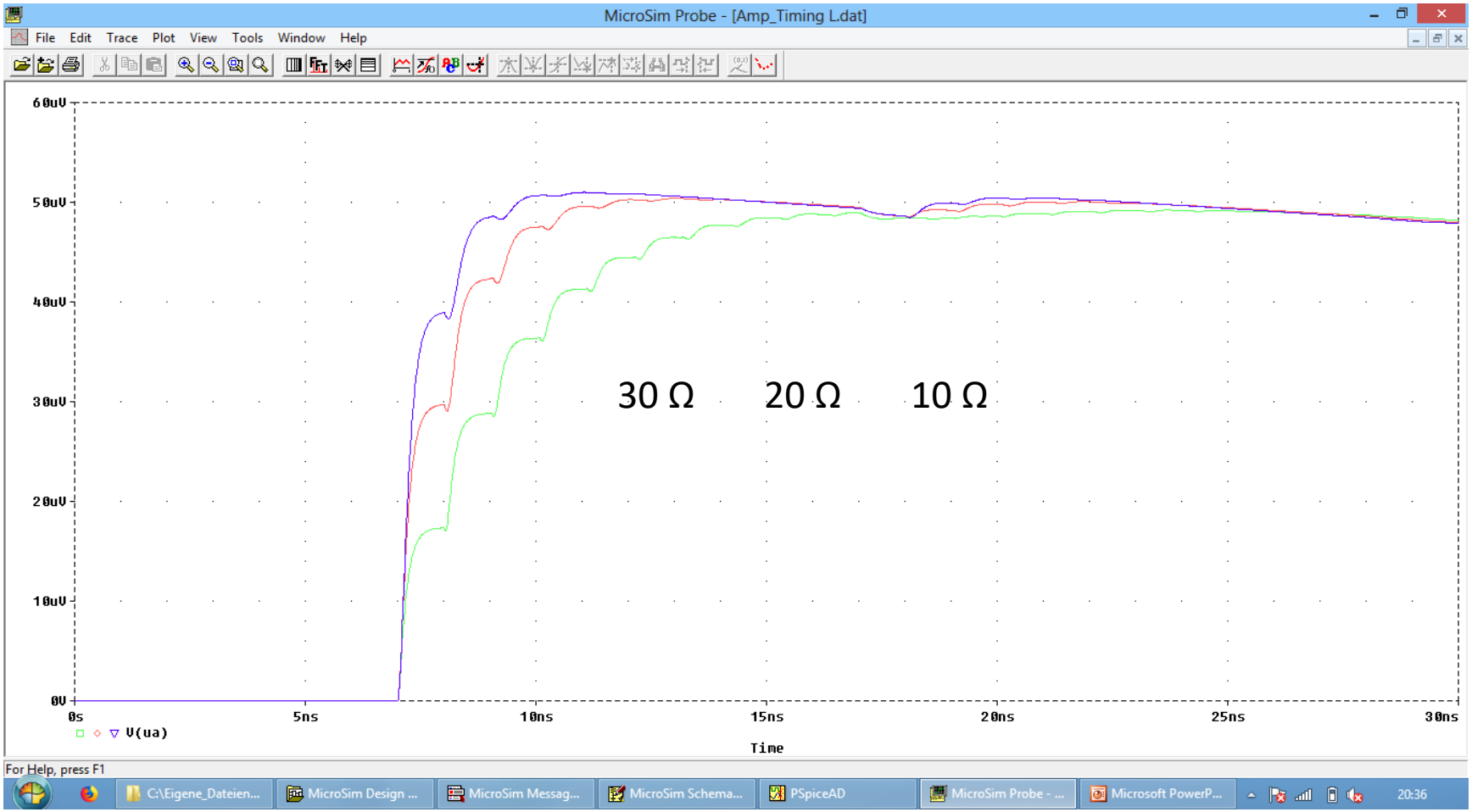
Z_0 = 10,20,30 Ω + 55 Ω



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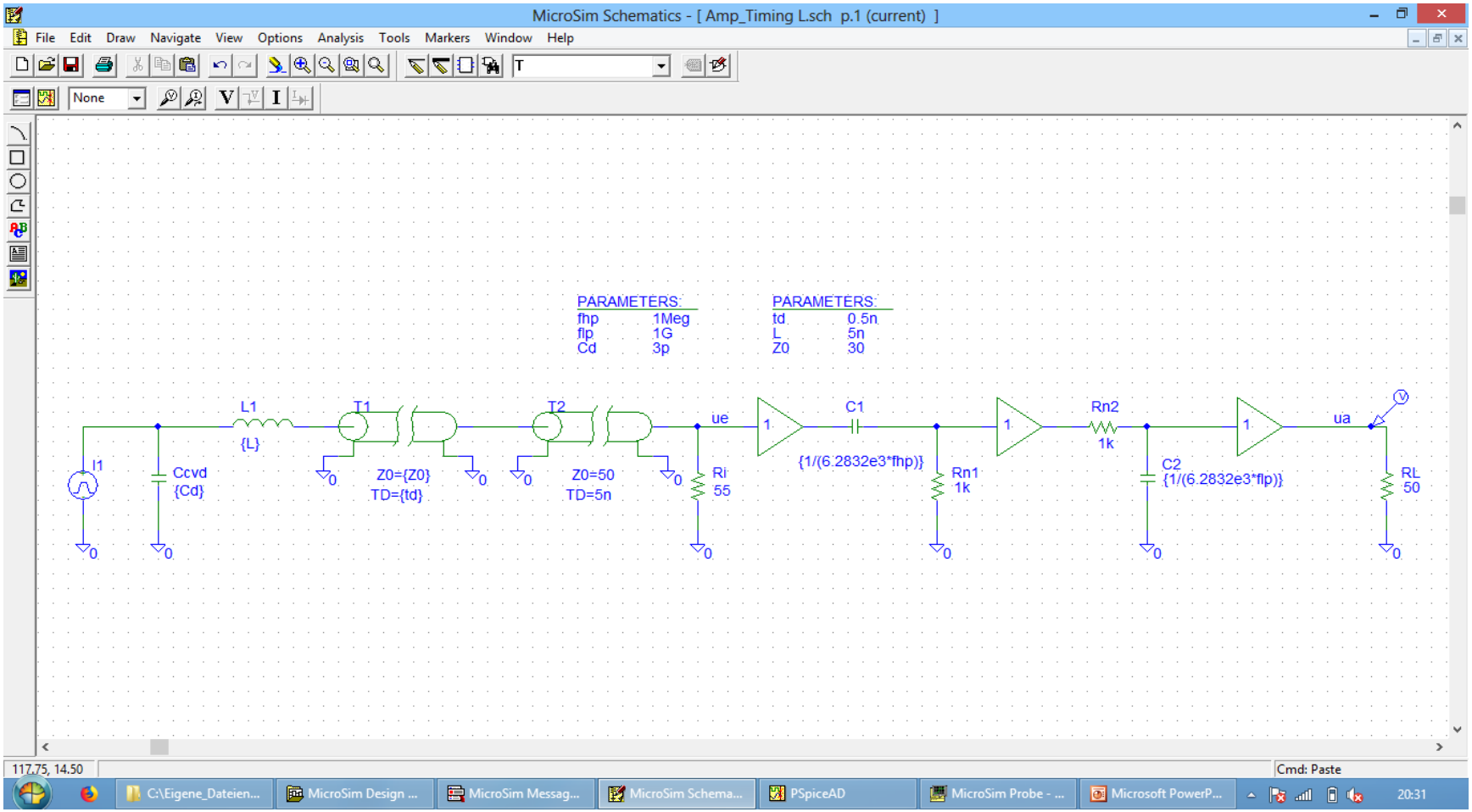
Combined effects



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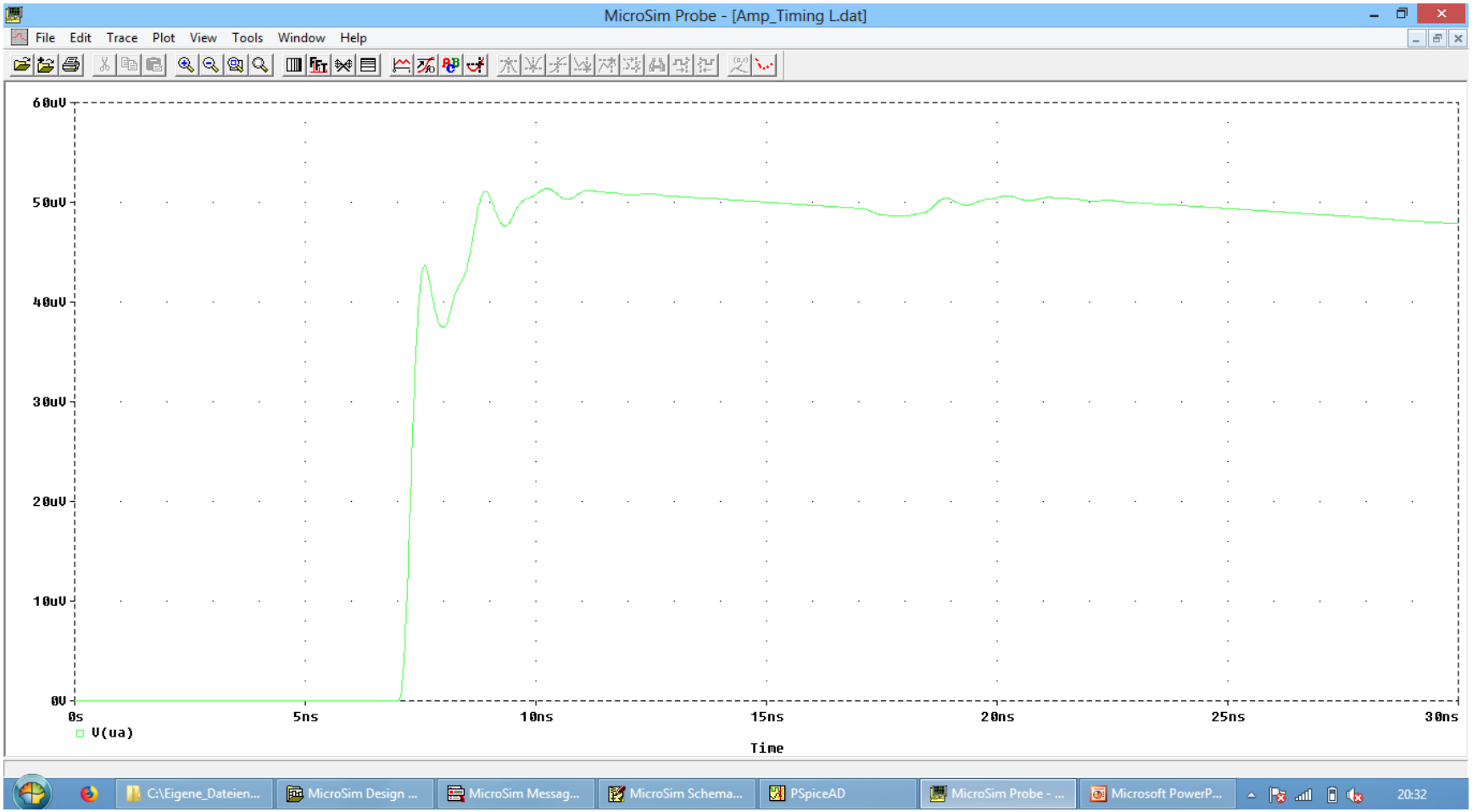
$Z_0 = 30\ \Omega + 5\ \text{nH} + 55\ \Omega$



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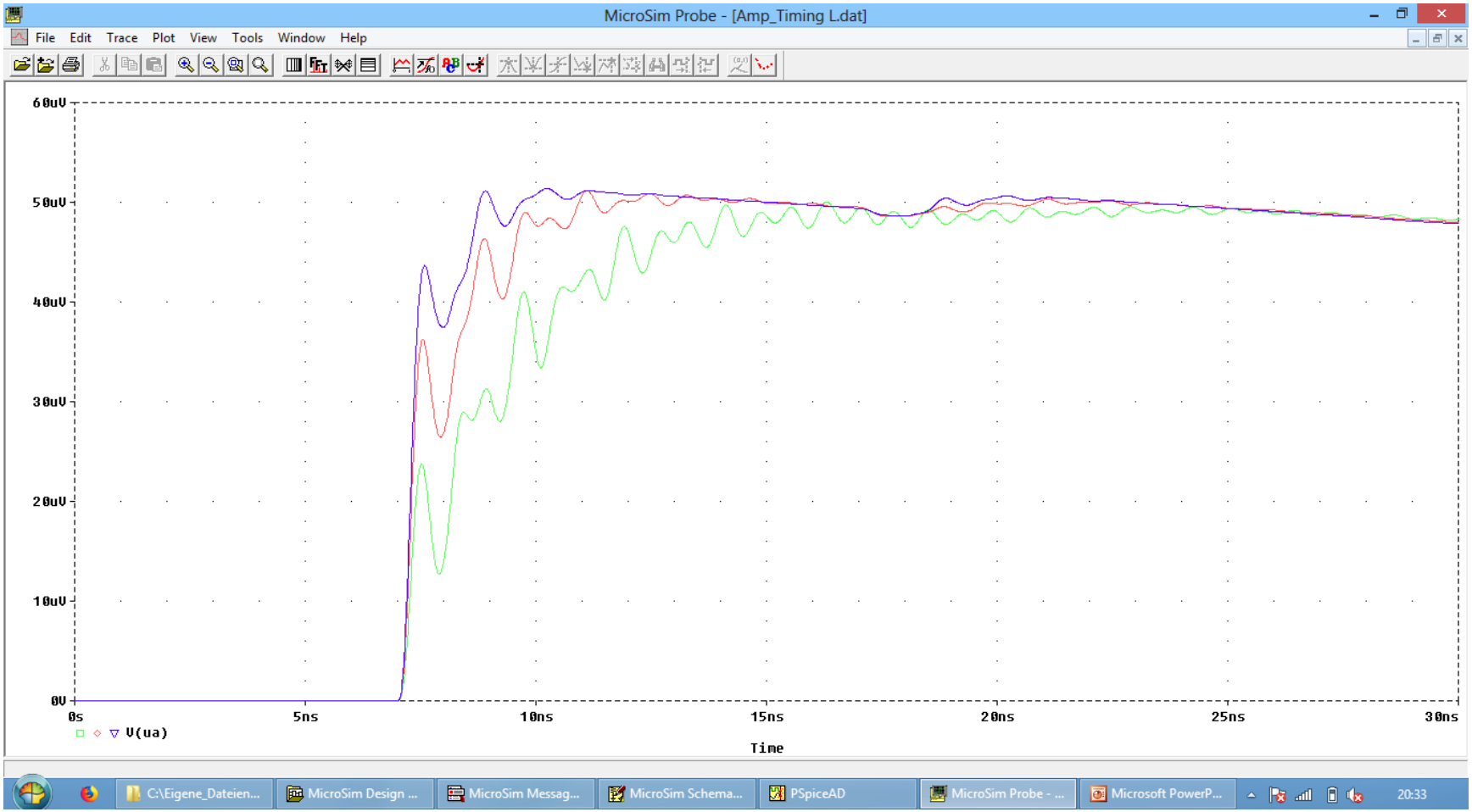
Z_0 = 30,20,10 Ω + 5 nH + 55 Ω



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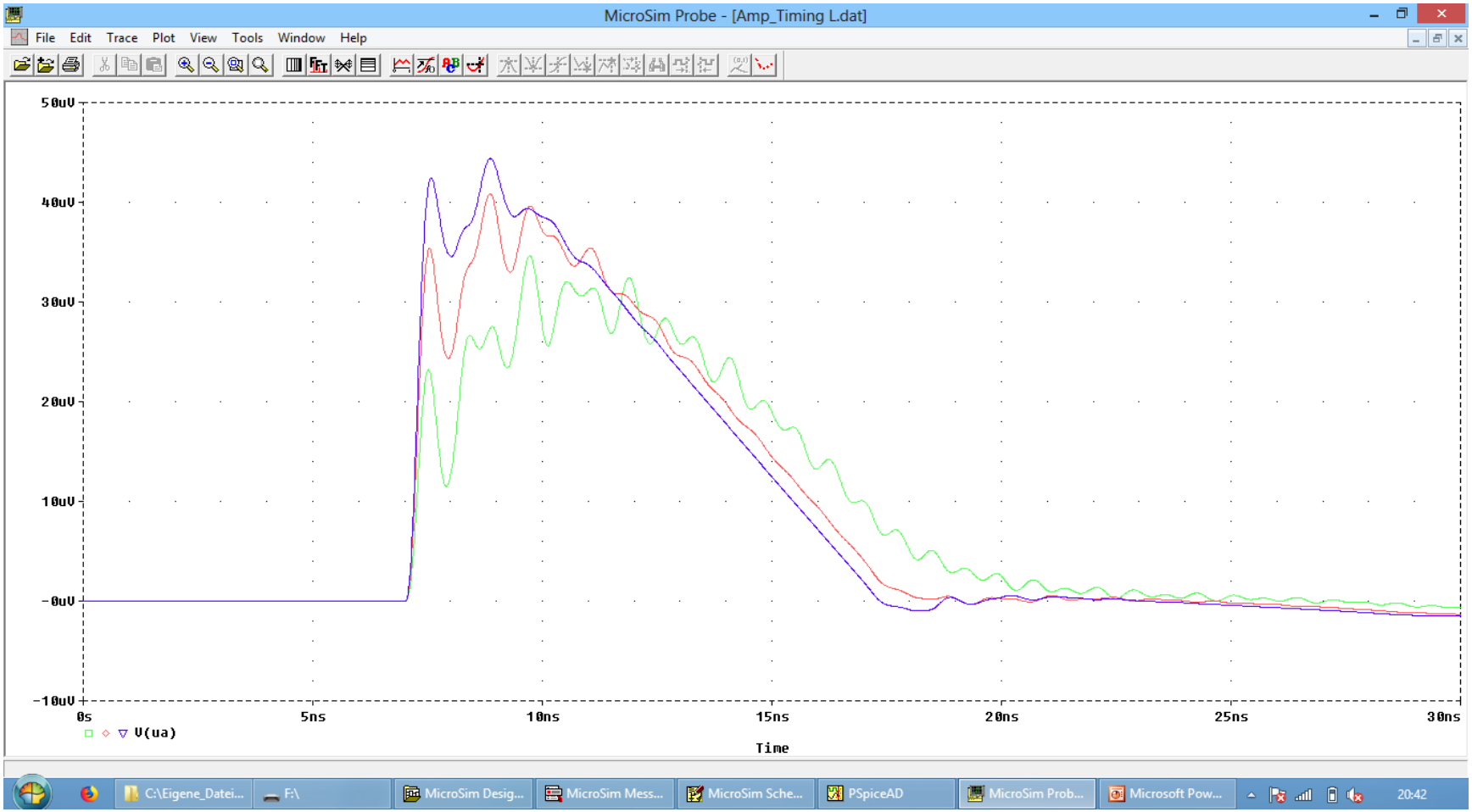
Detector signal



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Measurements

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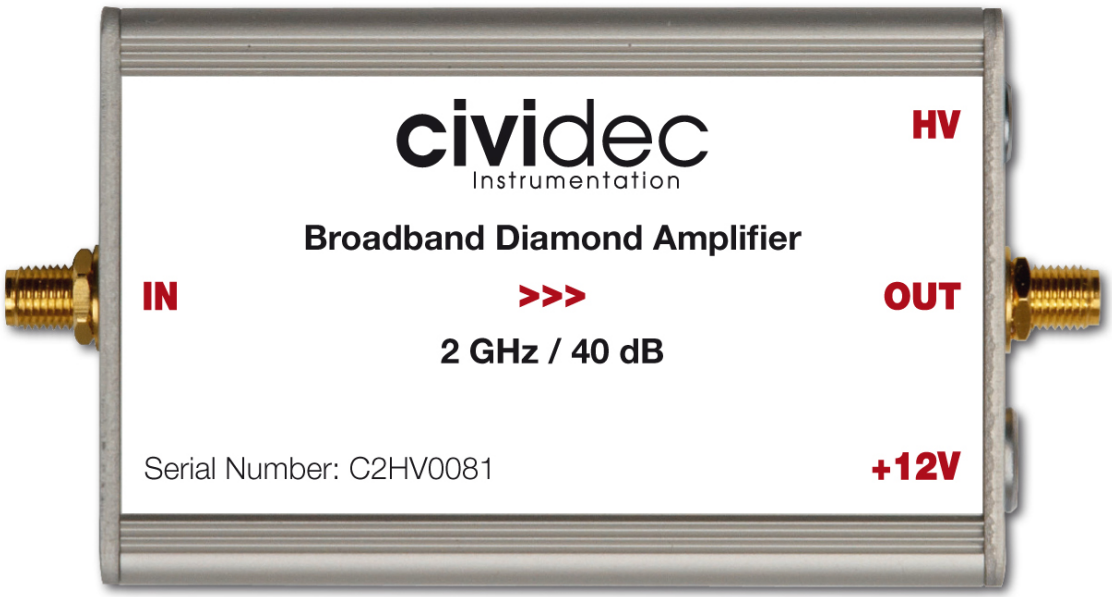
C2 Amplifier



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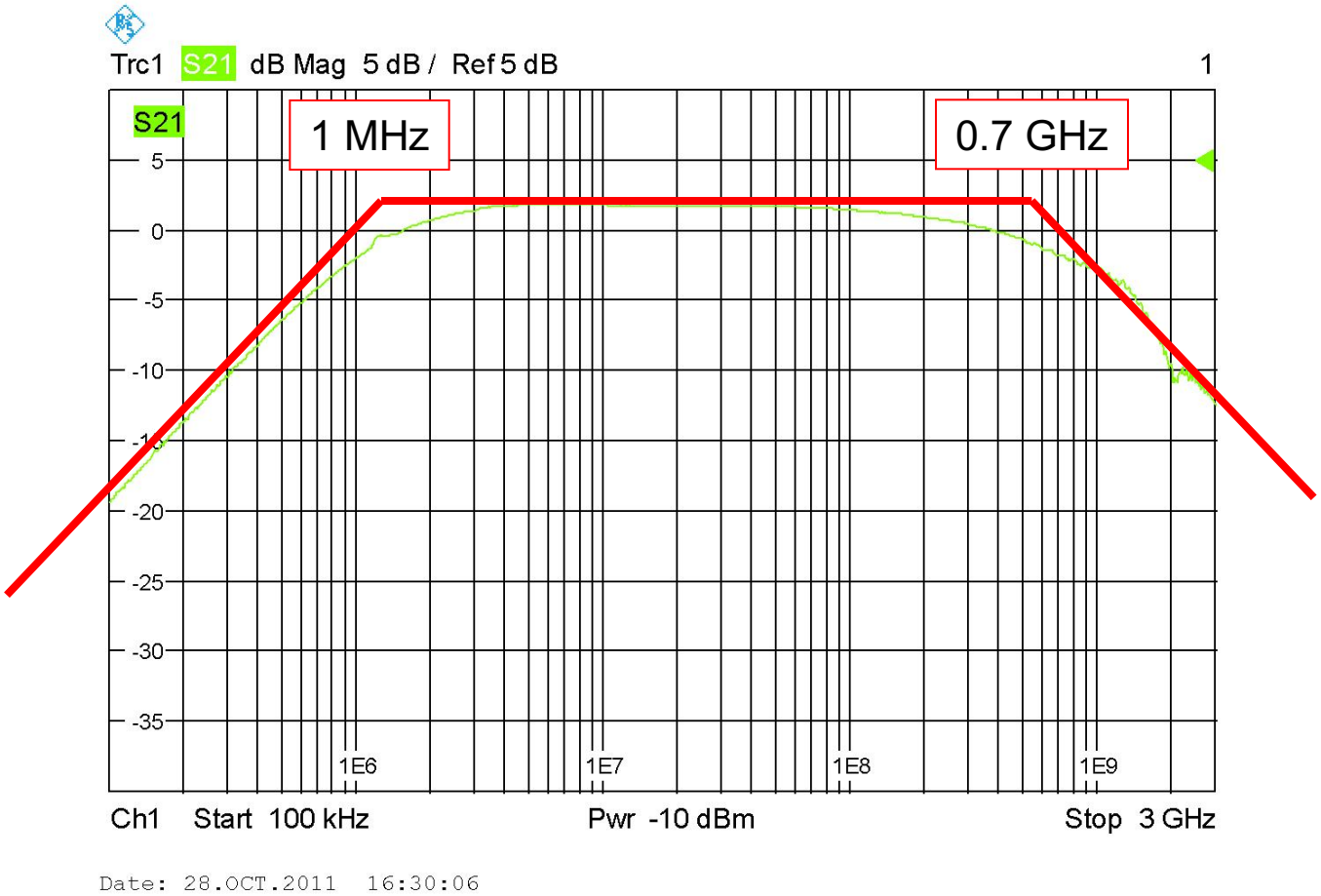
C2 (1M – 2G)



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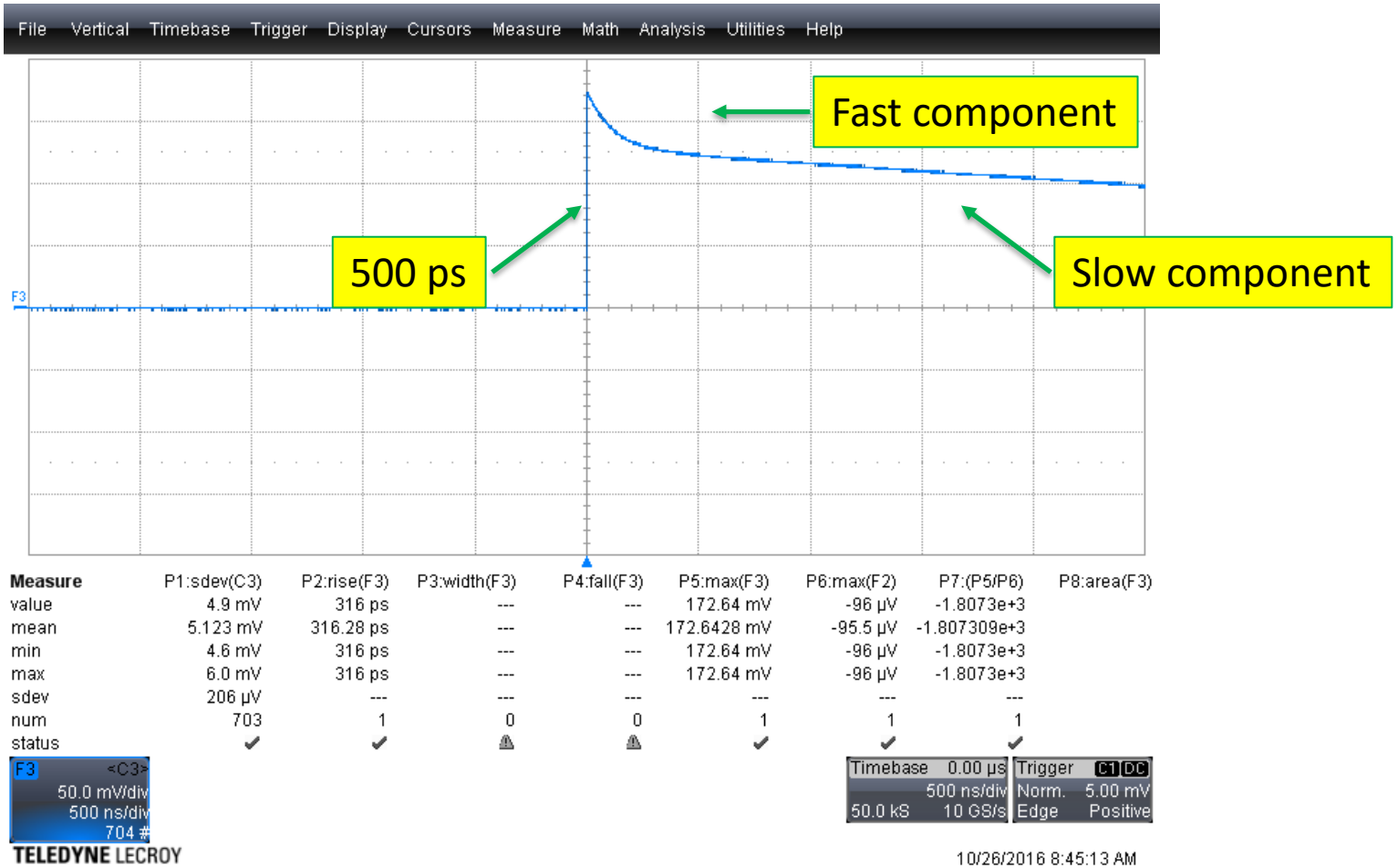
LHC Beam Loss



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C2-TCT Amplifier

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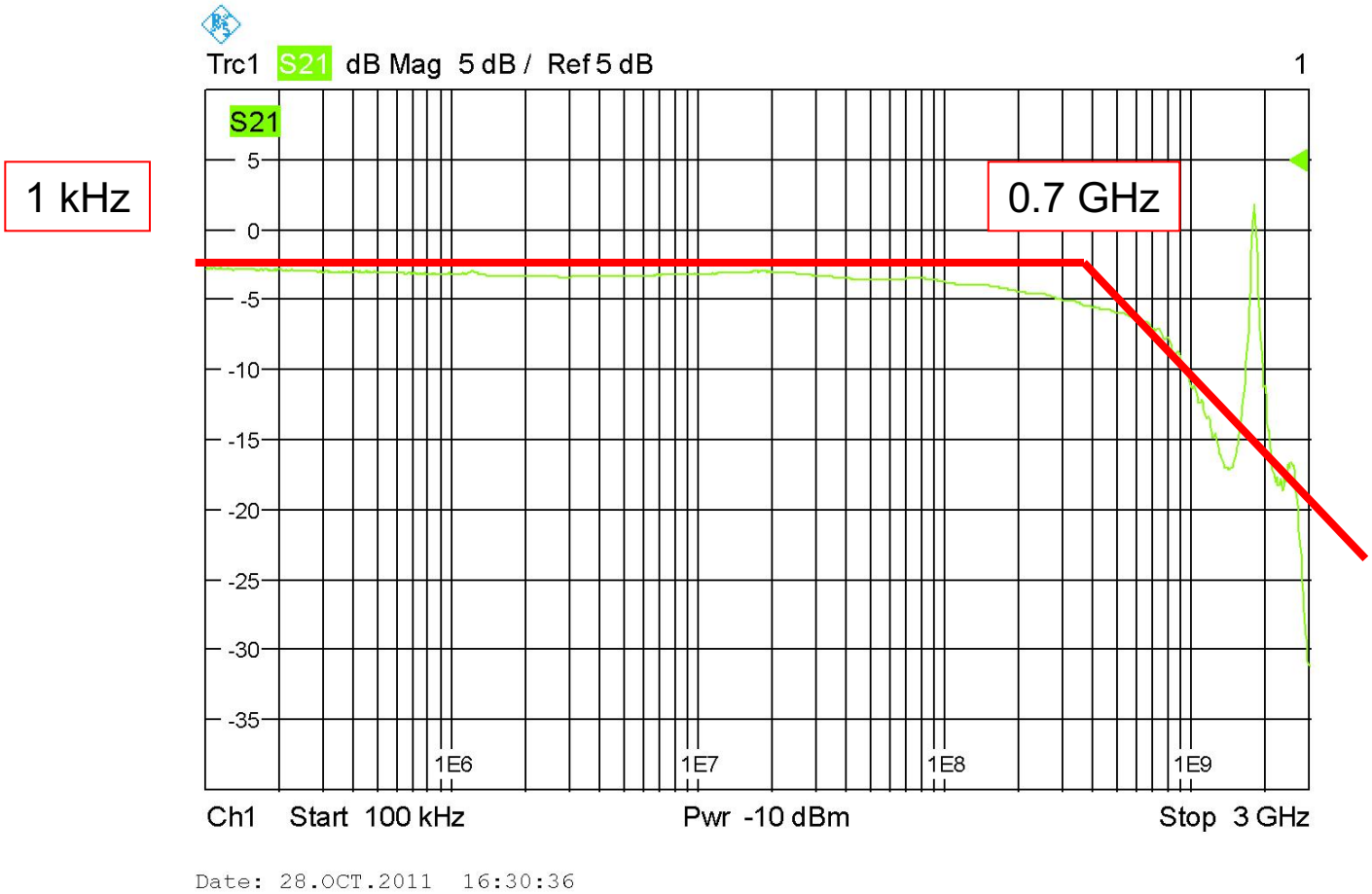
C2 TCT (1k – 2G)



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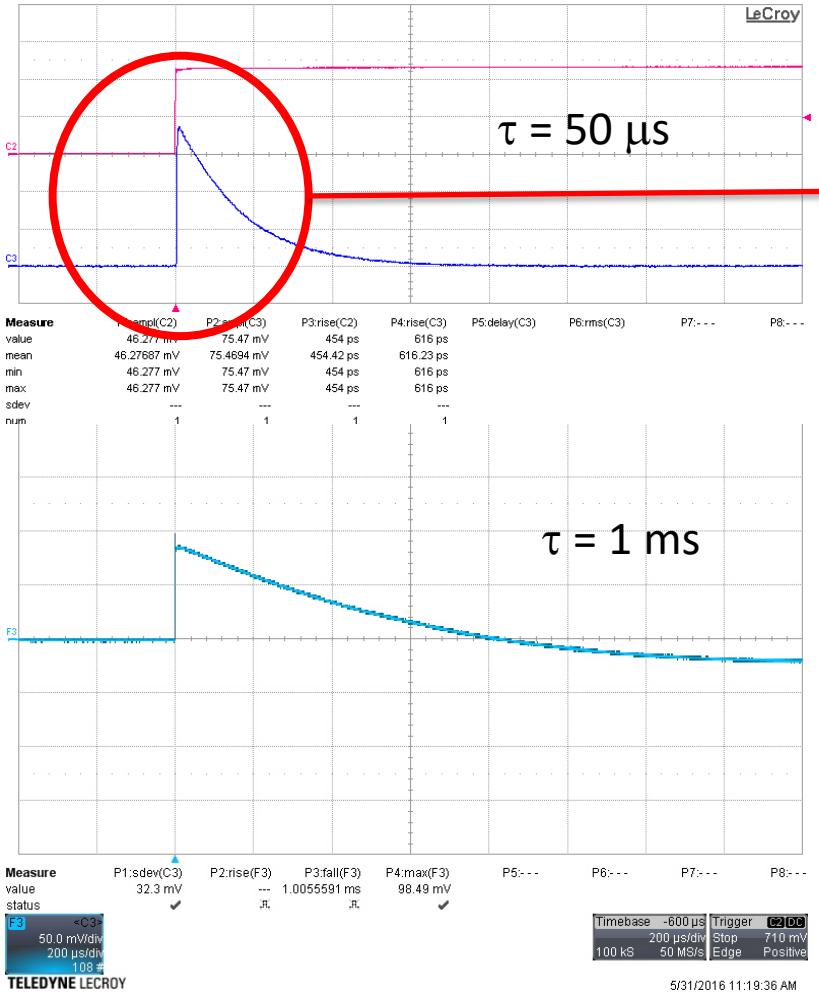
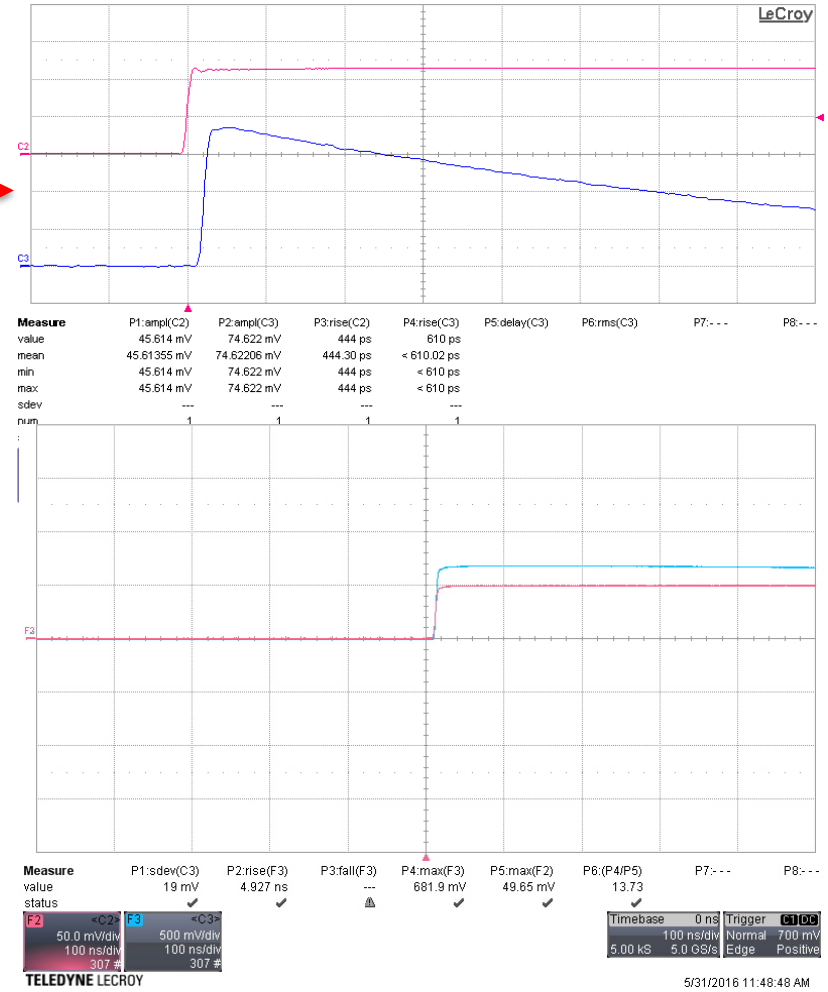
TCT measurements





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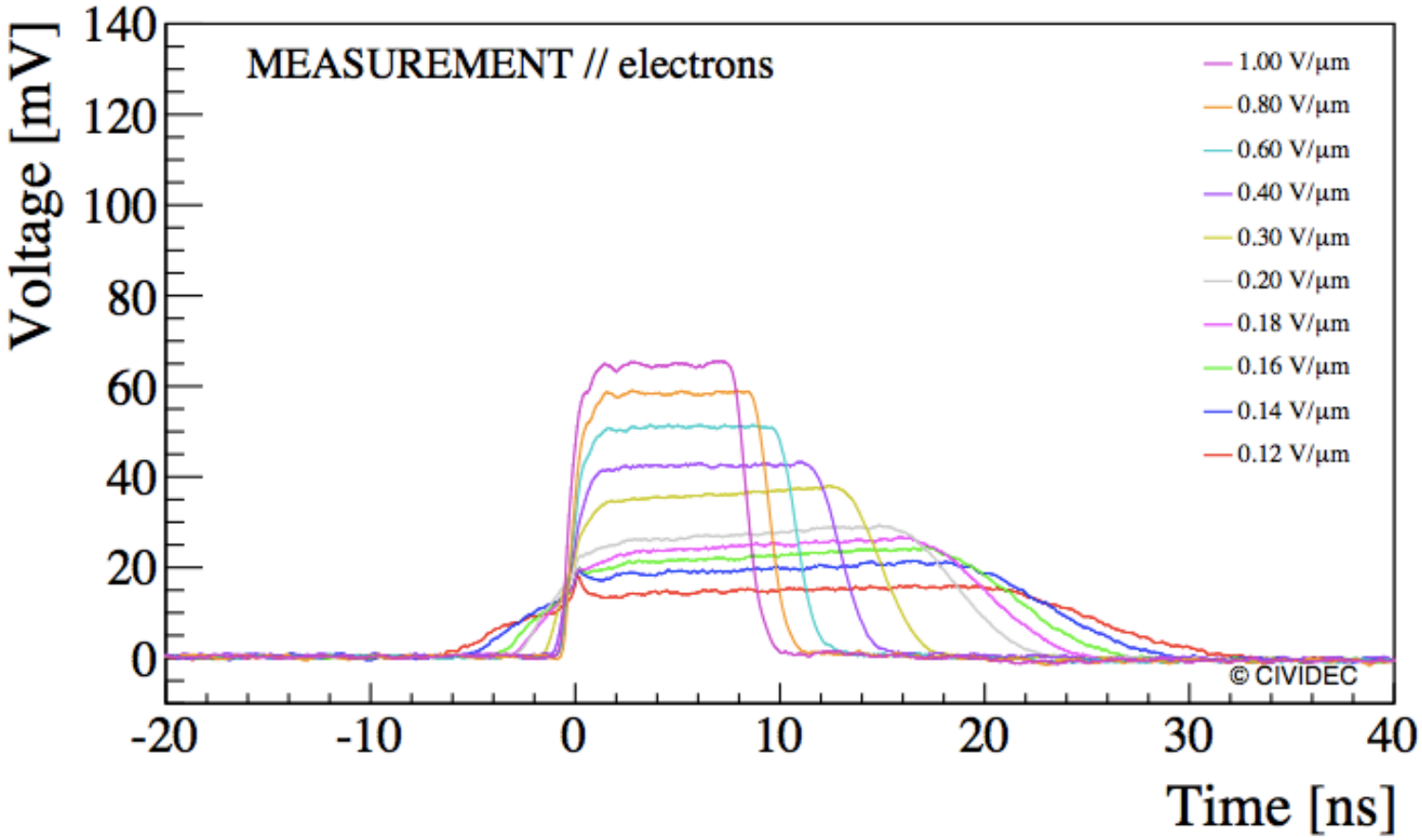
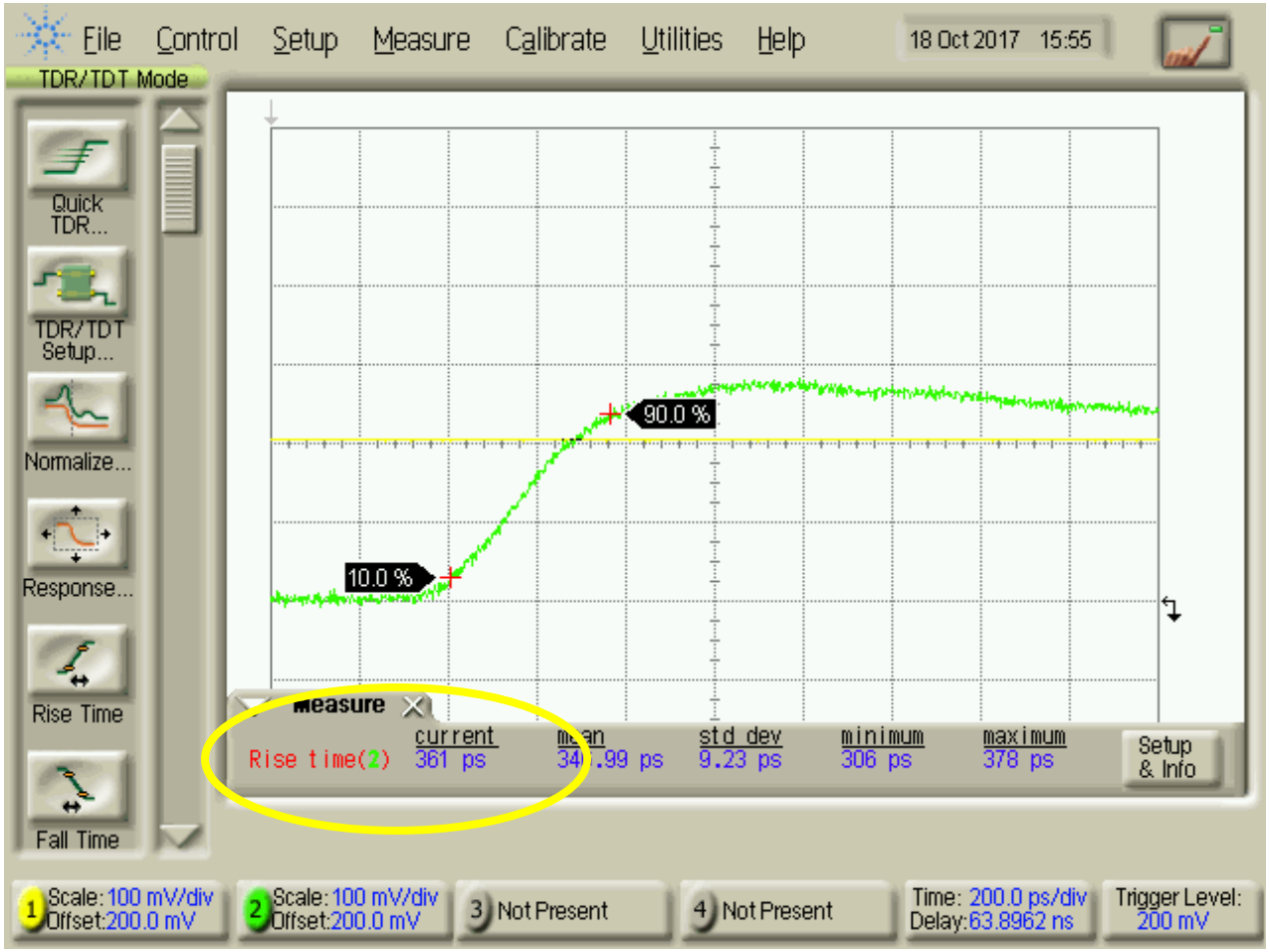
Electron Pulses



361 ps



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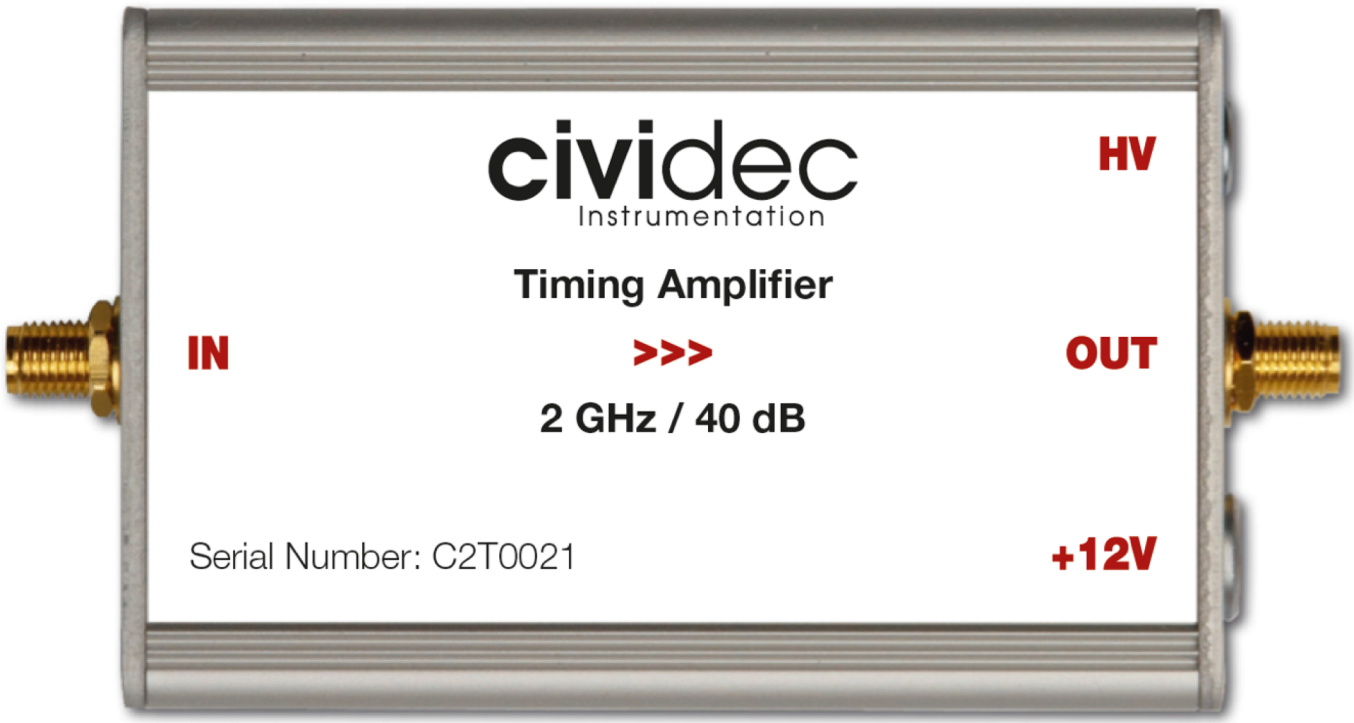
Timing Amplifier



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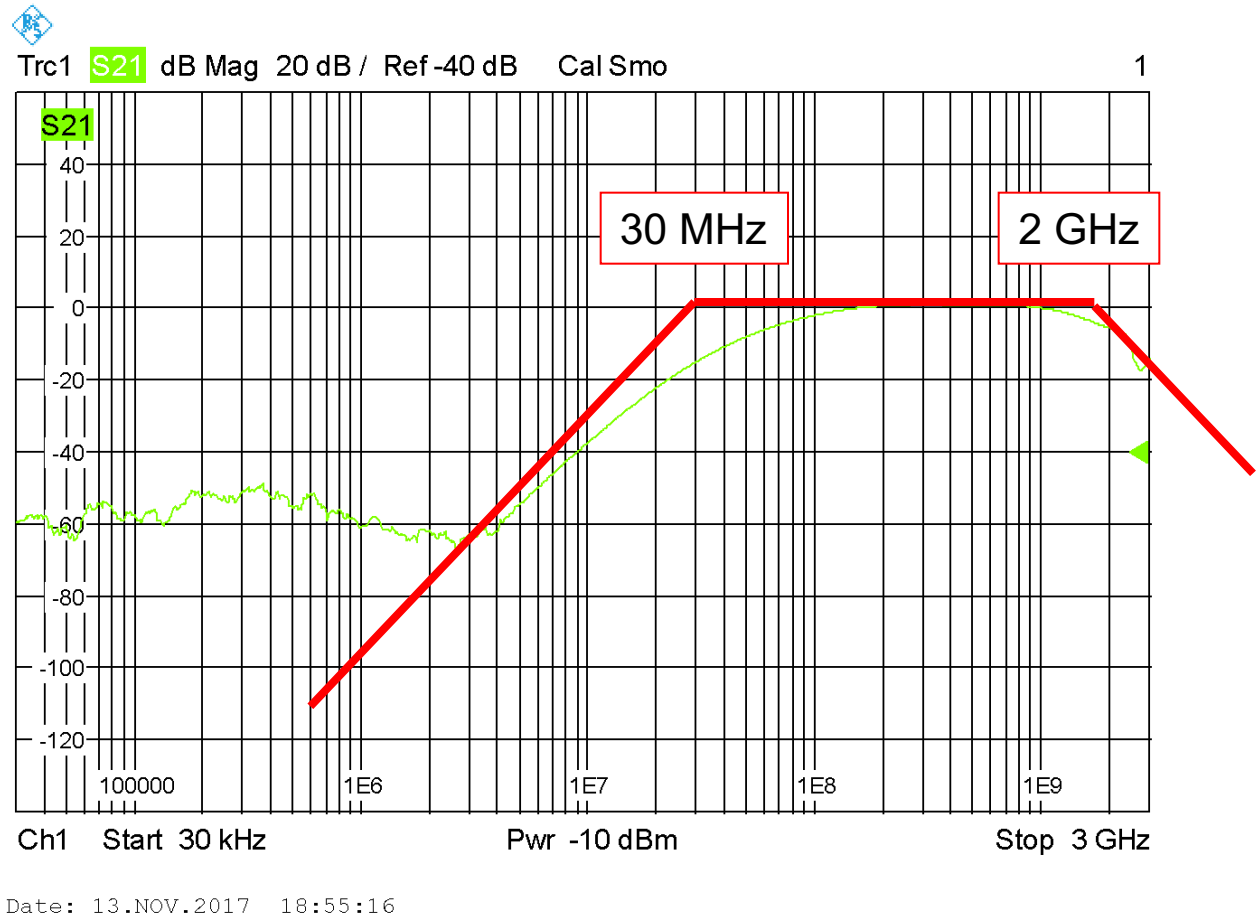
C2 Timing (30M– 2G)



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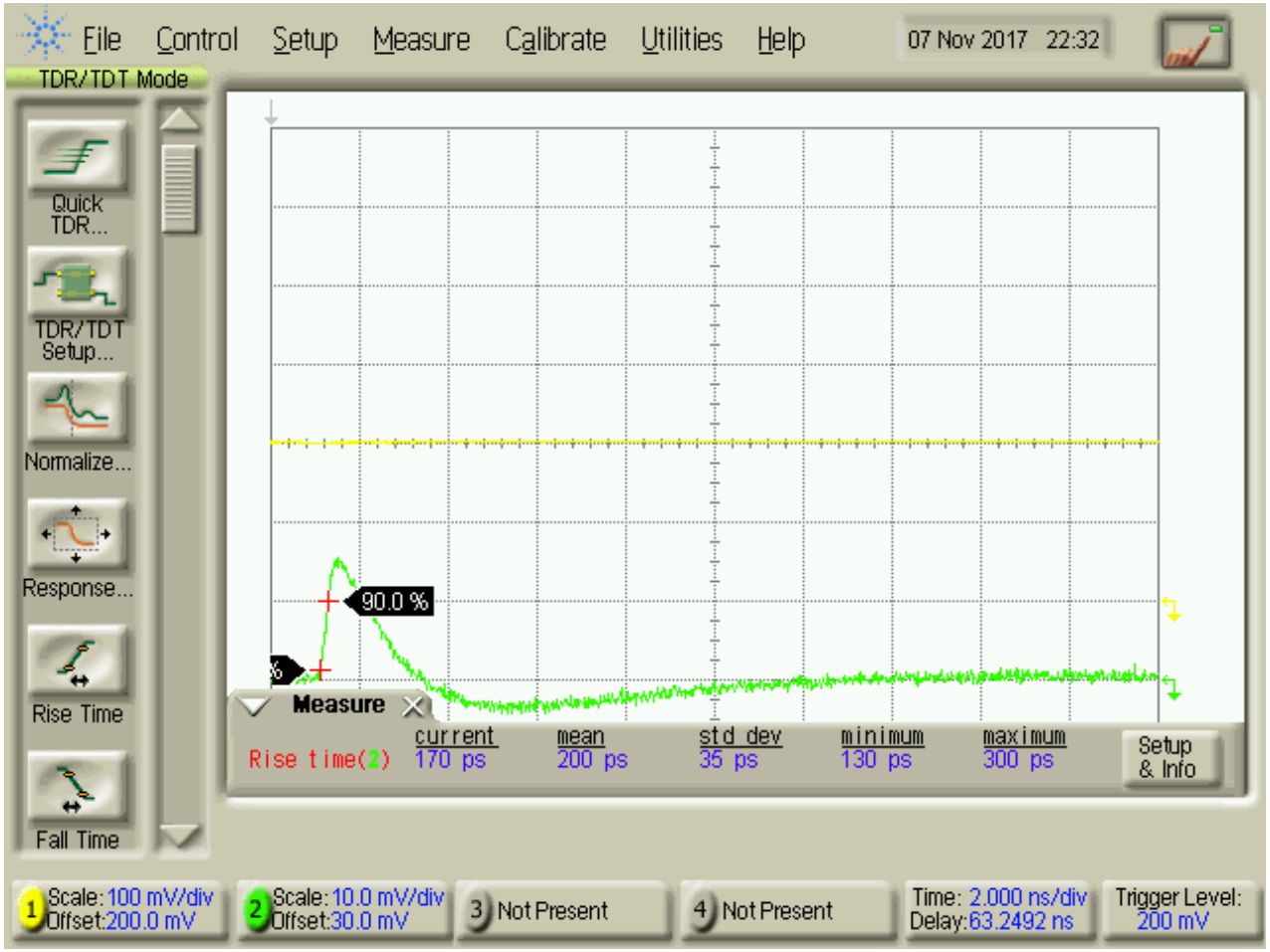
C2 timing



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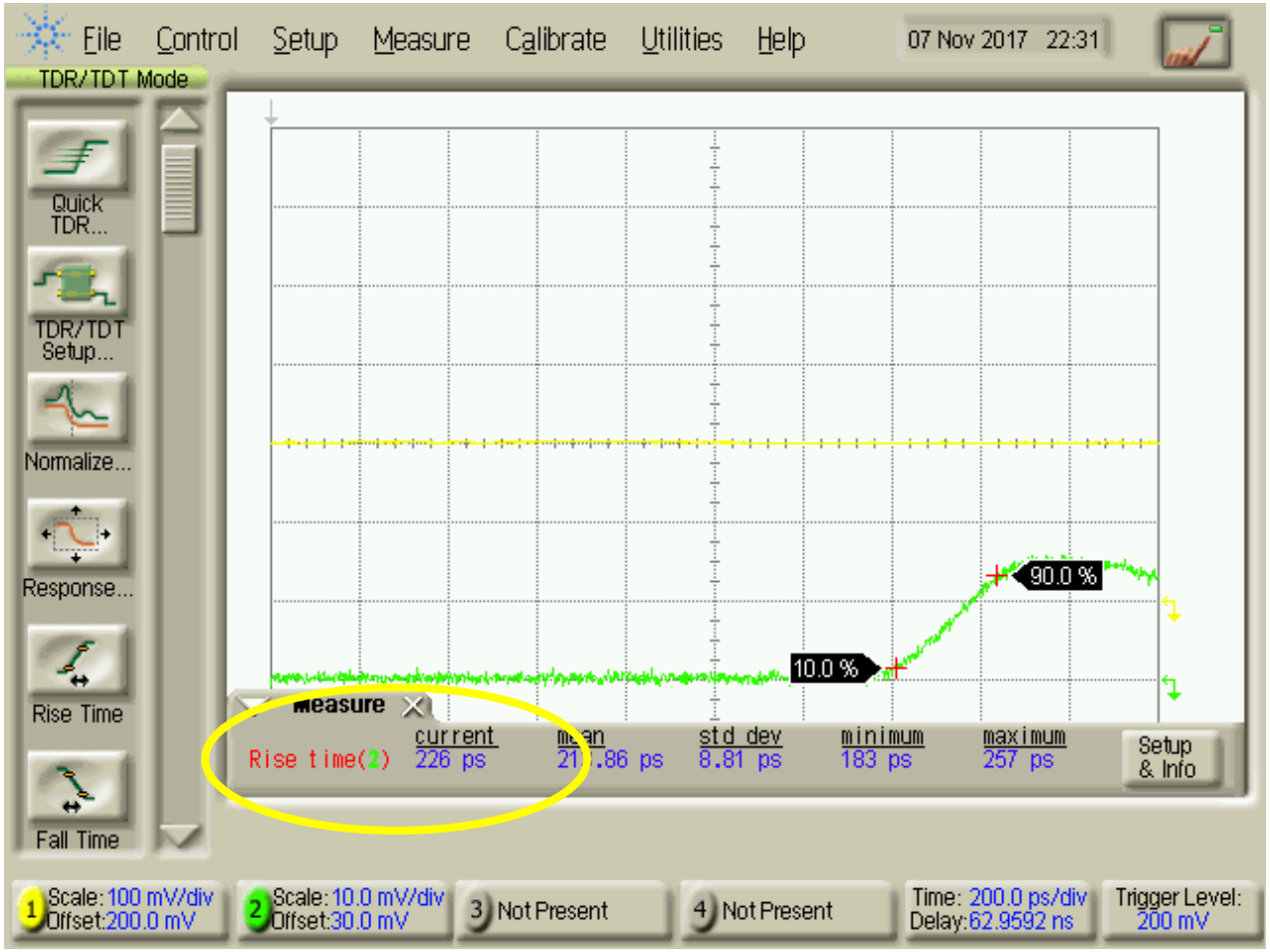
Zoom in



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Summary

- Timing needs dedicated amplifier designs
- Needs matching to detector
- Needs careful detector design

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Thank you for the attention!

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