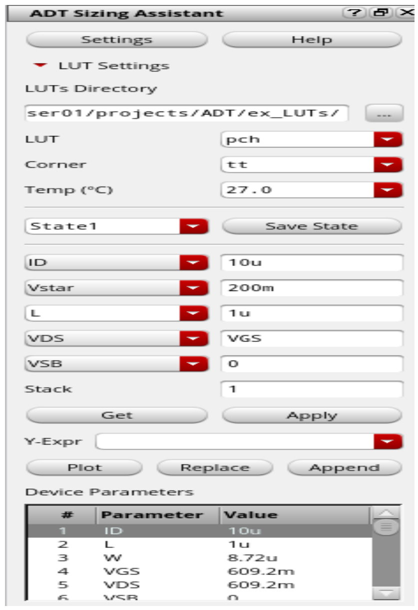
Analog IC Design

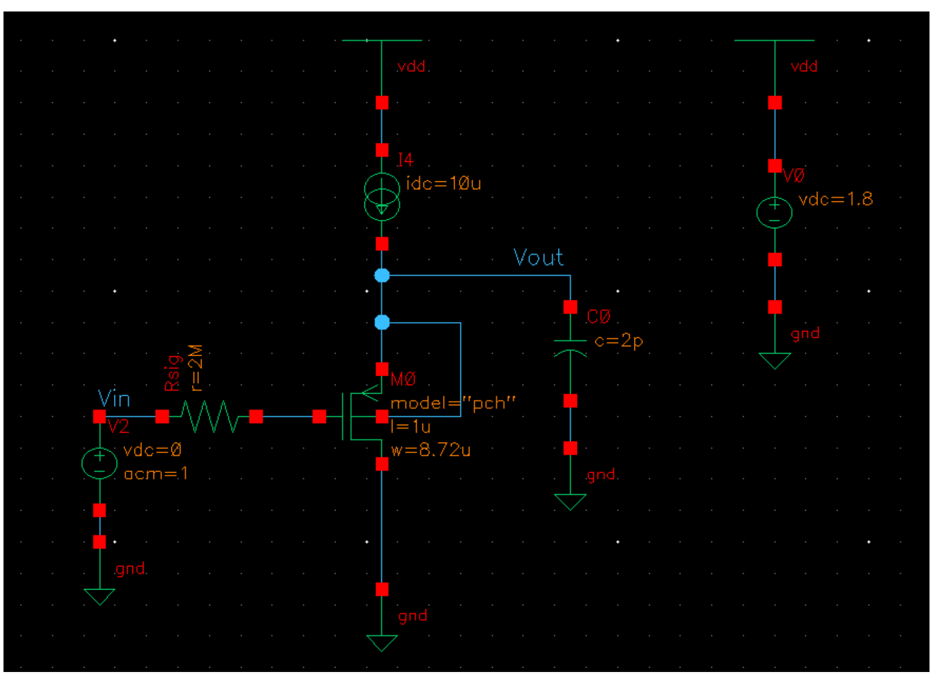
Lab 4

Part 1: Sizing Chart

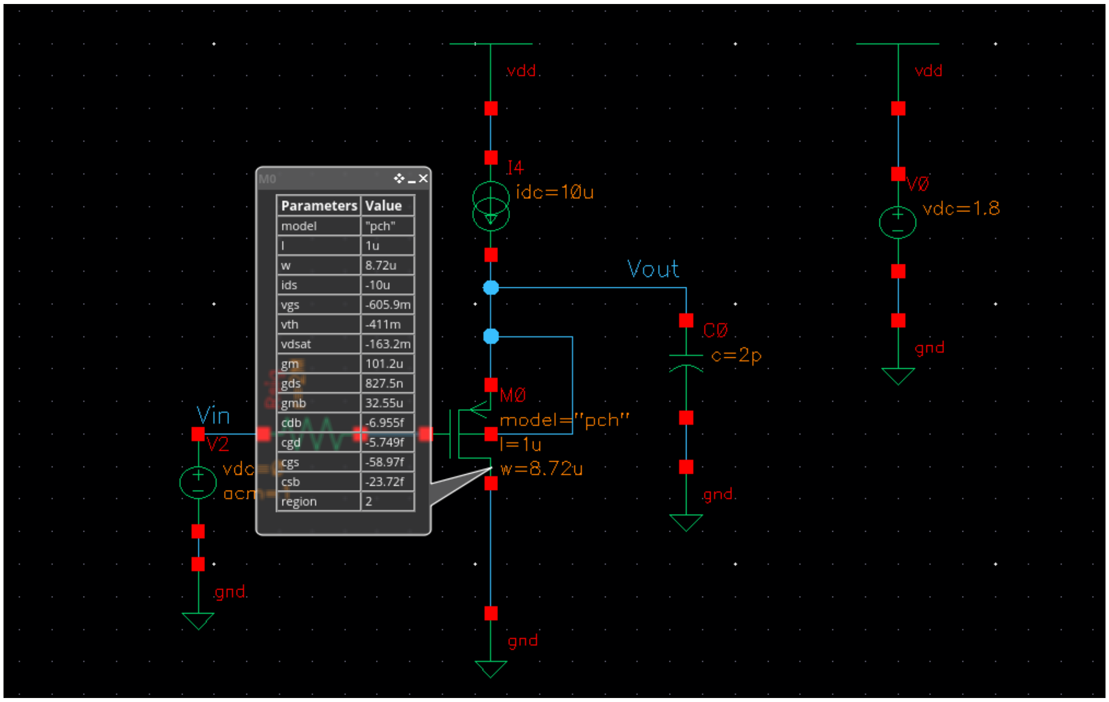


Part 2: CD Amplifier

Schematic



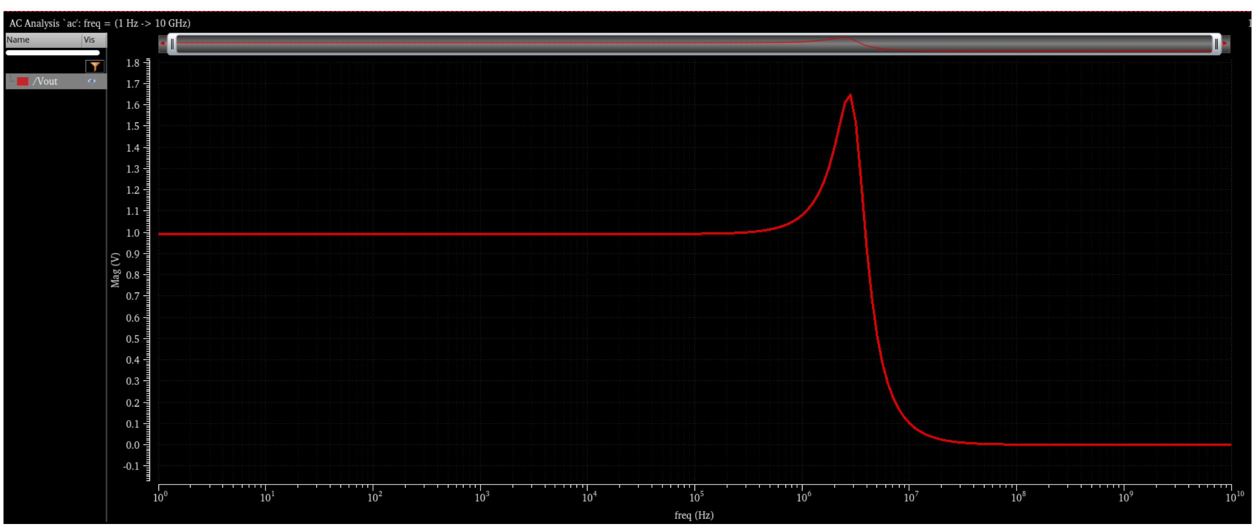
DC OP



Comment: The transistor operates in saturation.

AC Analysis

Bode Plot



Type	Details	Value
expr	ymax(dB20(VF("/Vout")))	4.329

Peaking in frequency domain

Quality Factor Analytic Calculation

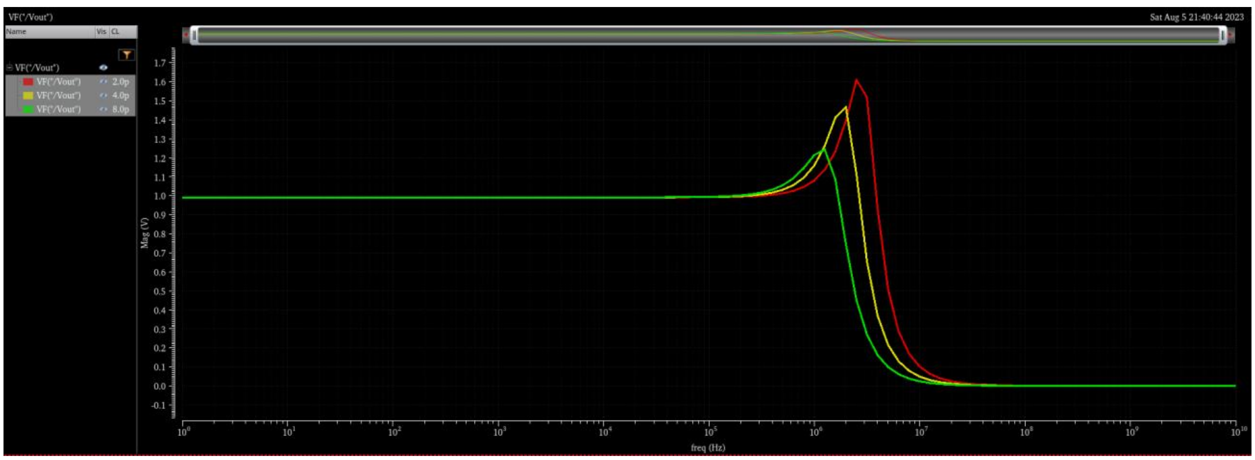
Approximate: Q ≈ $\sqrt{\frac{gm(Cgs+Cgd)Rsig}{C_L}}$ = $\sqrt{\frac{(101.2\mu)(5.75f+59f)(2M)}{2p}}$ = 2.56 → Underdamped system

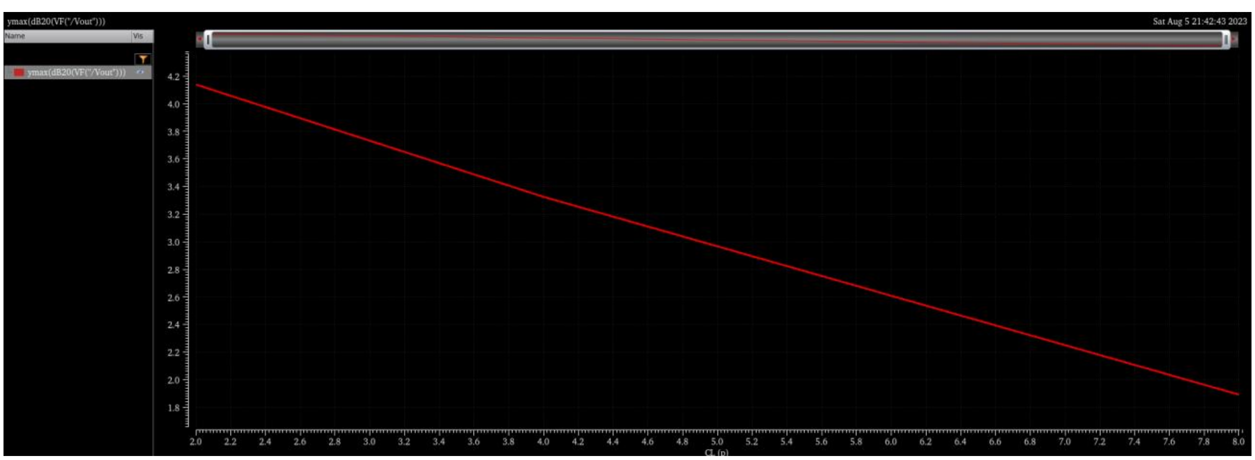
Exact:

$$b_1 = C_{gd}R_{sig} + \frac{C_{gs}+C_L}{g_m}$$
$$b_2 = \left(\frac{(C_{gs}+C_{gd})C_L + C_{gs}C_{gd}}{g_m}\right)R_{sig}$$
$$\omega_z = \frac{g_m}{C_{gs}}, \omega_o = \frac{1}{\sqrt{b_2}}, \boldsymbol{Q = \frac{\sqrt{b_2}}{b_1}}$$

Q = 1.59 → Underdamped system

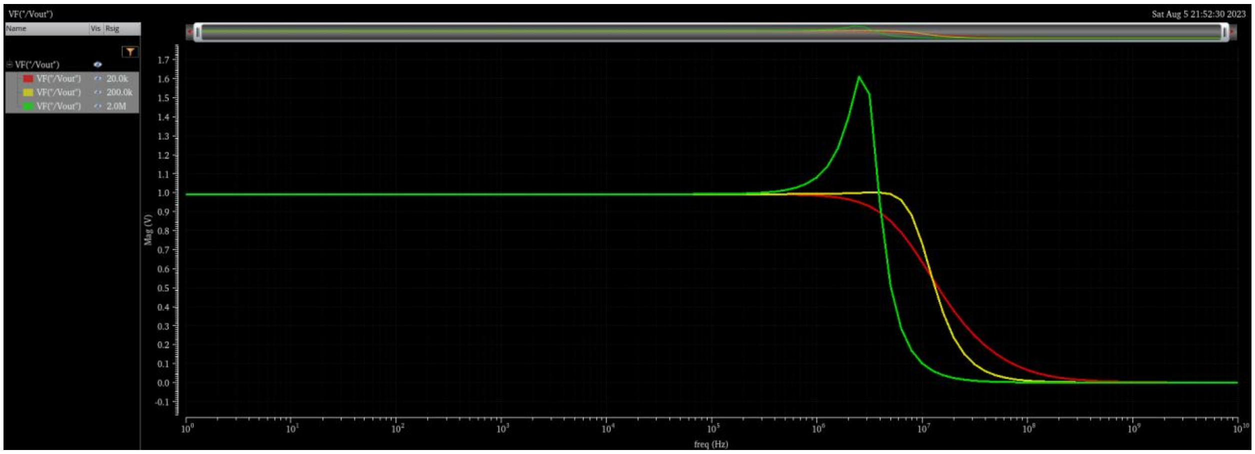
C_L Parametric Sweep

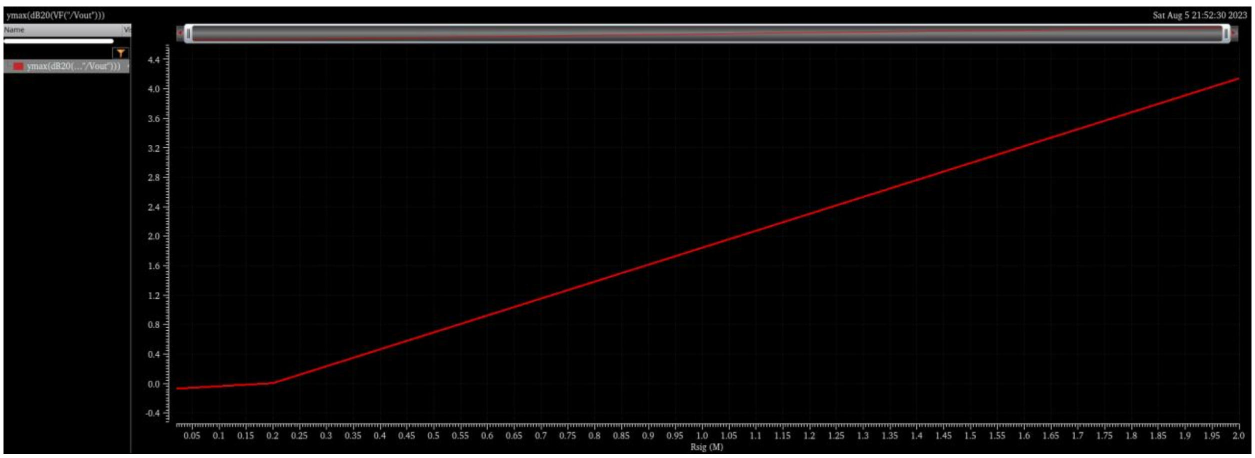




Comment: As CL increases, the peaking in frequency domain decreases. Increasing CL eventually decreases $Q \rightarrow \omega p,out$ becomes dominant.

R_{sig} Parametric Sweep





Comment: As Rsig increases, the peaking in frequency domain increases and Q increases.

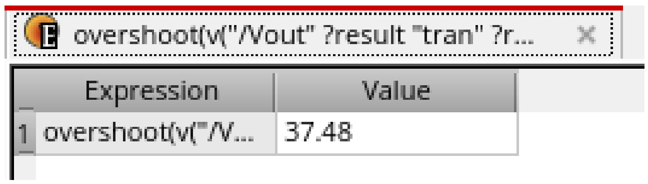
Transient Analysis

- DC shift = VGS = 605.9 mV
- Using NMOS would shift it downwards.

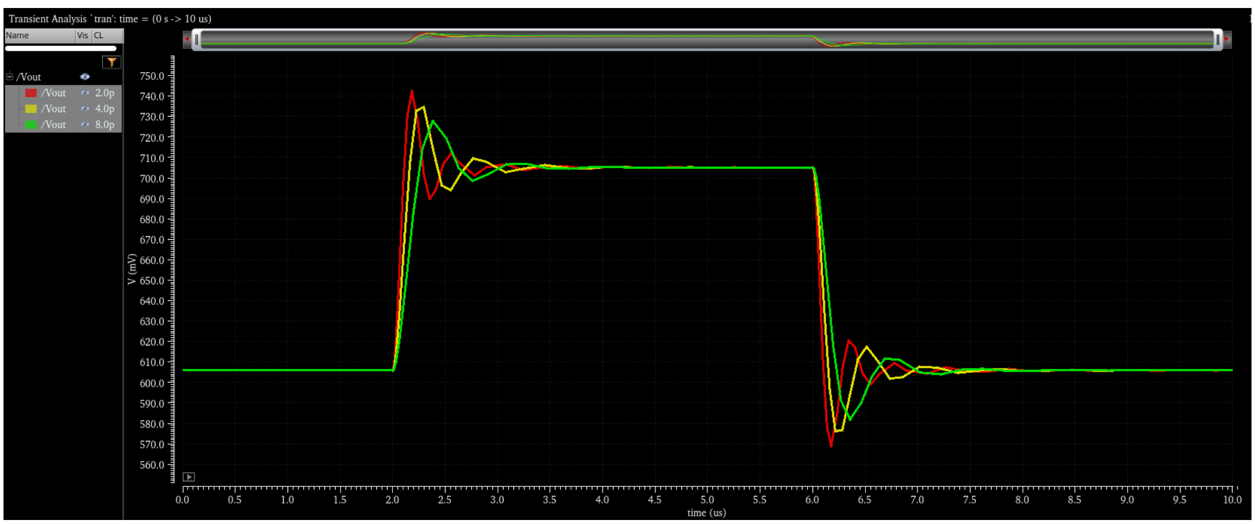
Time Domain Ringing

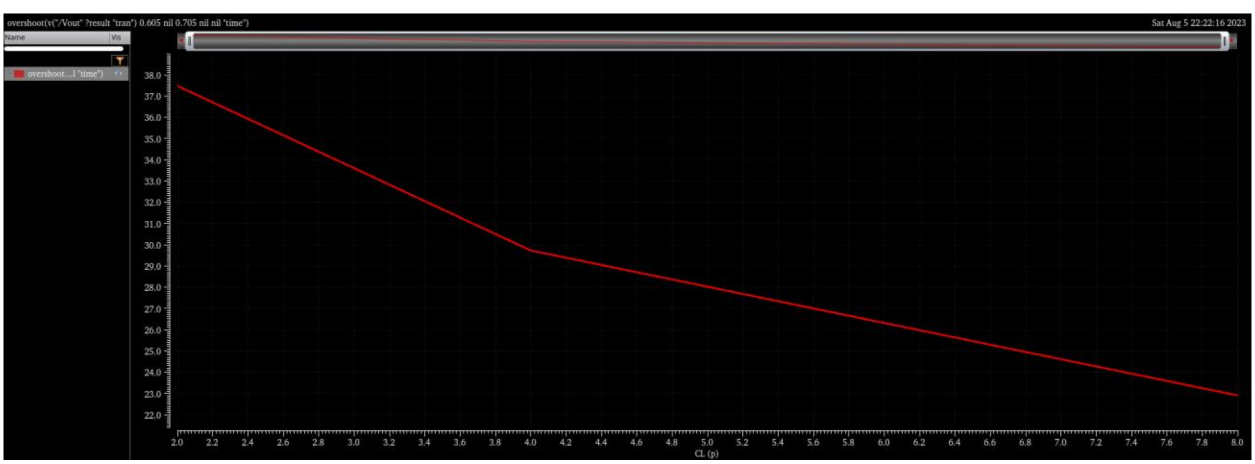
There is ringing in time domain.

```
overshoot(v("/Vout" ?result "tran" ?resultsDir "/home/user01/simulation/Lab4/part1/maestro/results/maestro/ExplorerRun.0/1/Lab4_part1_1/psf") 605m nil 705m nil nil "time" )
```



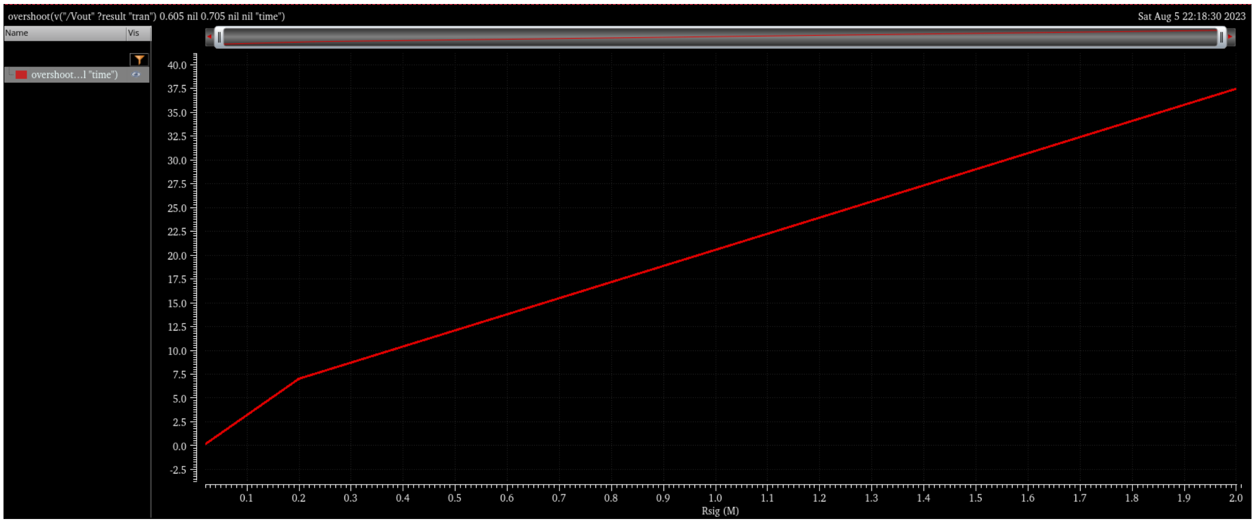
C_L Parametric Sweep





Comment: As CL increases, the ringing (overshoot) in time domain decreases.

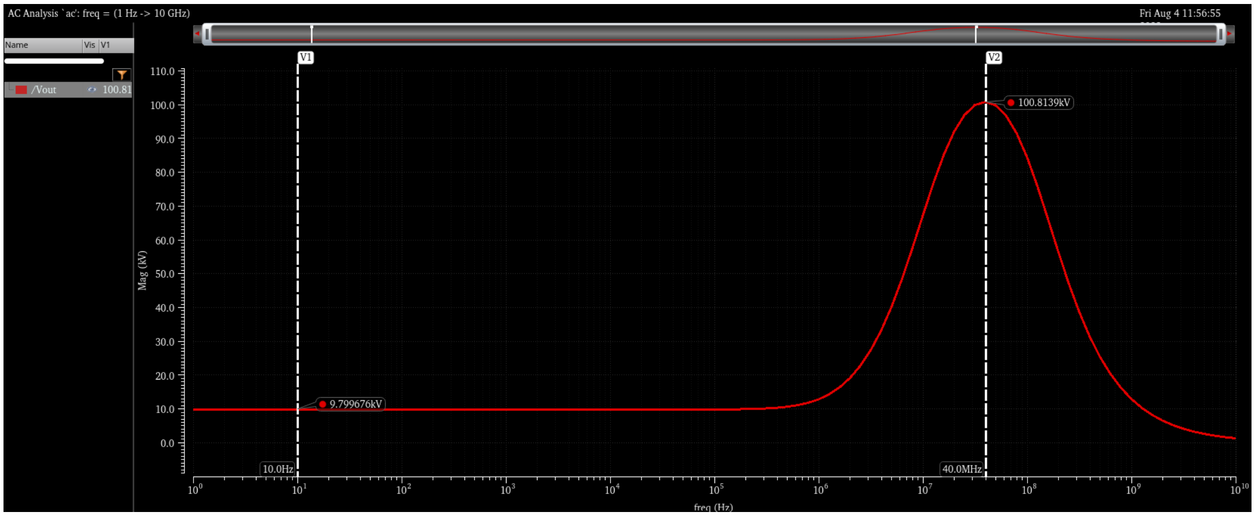
R_{sig} Parametric Sweep



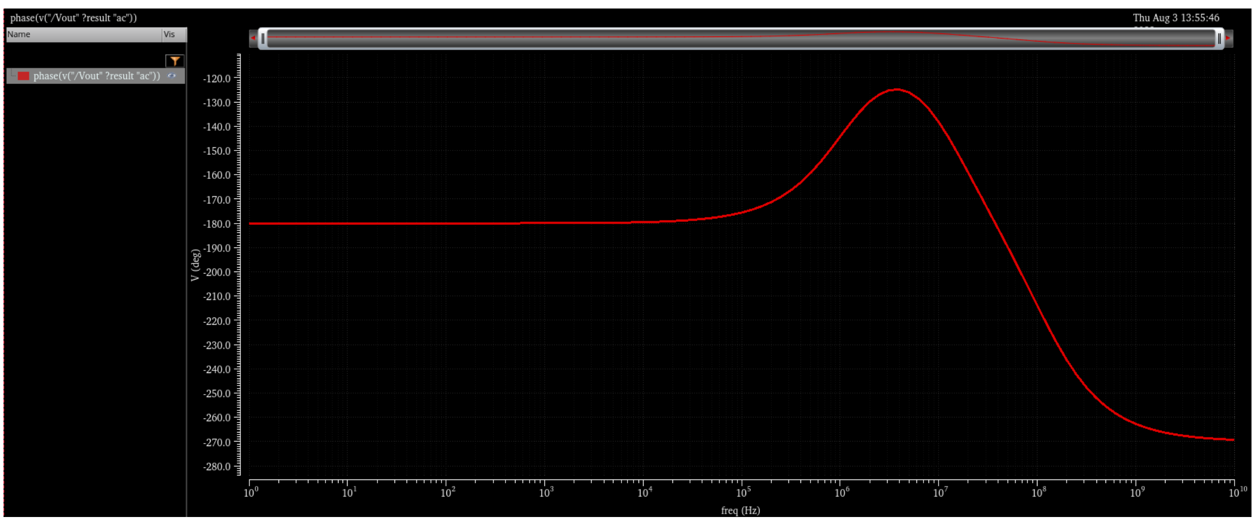
Comment: As Rsig increases, the ringing (overshoot) in time domain increases.

Z_{out} (Inductive Rise)

Magnitude



Phase



Comments

- $\omega_z = \frac{1}{Rsig\ Cgs}$ & $\omega_p = \frac{gm}{Cgs}$
- There is an inductive rise because Rsig (2M) > 1/gm (9.88k), so $\omega_z < \omega_p$. This zero causes this inductive rise.

- At high frequency, Cgd shunts Rsig ($\frac{Rsig}{1+s.Rsig.Cgd}$). This causes a new pole at this frequency, so we notice that Zout falls.

Analytical Calculations

/poles /zeros

	qfactor	/poles (Hz)	qfactor	/zeros (Hz)
1	500.0E-3	13.48E6	500.0E-3	1.174E6
2	500.0E-3	115.9E6		

Poles & Zeros

- $f_z = \frac{1}{2\pi\ Rsig\ Cgs} = \frac{1}{2\pi(2M)(59f)}$ = 1.35 MHz
- $f_{p1} = \frac{1}{2\pi\ Rsig\ Cgd} = \frac{1}{2\pi(2M)(5.75f)}$ = 13.8 MHz
- $f_{p2} = \frac{gm}{2\pi\ Cgs} = \frac{101.2\mu}{2\pi(59f)}$ = 273 MHz (ro negelected)
- $f_{p2} = \frac{gm+gds}{2\pi\ [Rsig.gds.Cgs+Cgs]}$ = 103.7 MHz (ro taken into account)

Magnitude

- At low frequency, Zout = $\frac{1}{g_m}\left(\frac{1+sR_{sig}Cgs}{1+s\frac{Cgs}{gm}}\right)$.
- At higher frequencies, replace Rsig with (Rsig||Cgd).
- Let low frequency = 10 Hz → Magnitude at f_L = 9.88k
- Let high frequency = 40 MHz → Magnitude at f_H = 75.3k

Comparison

	Simulation	**Analytic Calculations**
fz	1.17 MHz	1.35 MHz
fp1	13.48 MHz	13.8 MHz
fp2	115.9 MHz	103.7 MHz
$Zout_{fL}$	9.80k	9.88k
$Zout_{fH}$	100.8k	75.3k