Part 1: sizing chart

- we can get gain is given by:

$$|Av| \approx gmr_O = \frac{2 * I_D * V_A}{V_{OV} * I_D} = \frac{2 * V_A}{V_{OV}}$$

But for real mosfet $V_{OV} \neq \frac{2*I_D}{gm}$ we define new expression $V^* = \frac{2*I_D}{gm}$

•For a square-law device, V^*= V_{OV},however for a real MOSFET they are not equal. The actual gain is now given by $|Av| \approx \frac{2*V_A}{V^*}$

•we have $V^* = 160mV$.

- And we assume that channel length value will be L=0.5µm and W=10µm, to avoid short channel effects.

- from LAB01 we can get value of V_{TH} for NMOS

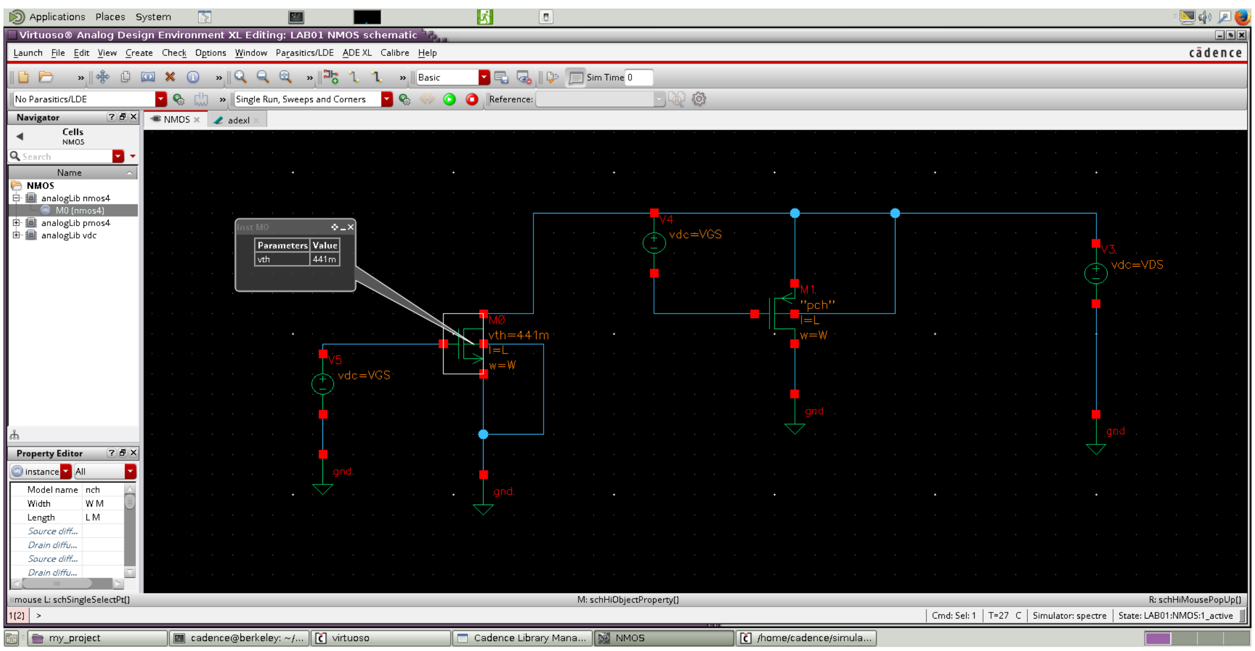

Figure 1 get value of Vth from simulation

•from simulation $V_{TH} = 441mV$

- Sweep V_{GS} from 0 to ≈ V_{TH} + 0.4V 0→ $841mV$ with 10mV step. Set V_{DS} = $\frac{V_{DD}}{2}$ = 0.9V.

- Sweep V^* and V_{OV} *versus* V_{GS} *on same plot* .

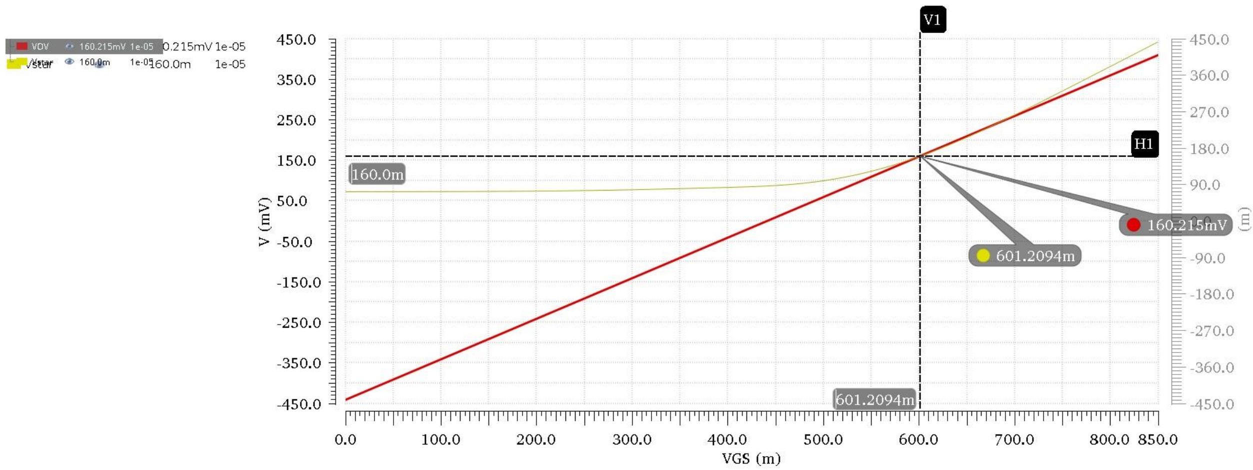

*Figure 2 simulation V*and Vov vs VGS*

- from simulation we found at $V_{GSQ} = 601.2094mV$, $V_{OVQ} = 160.215mV$, $V_Q^* = 160mV$.
- plot $I_D \& gm$ and gds versus V_{GS}:

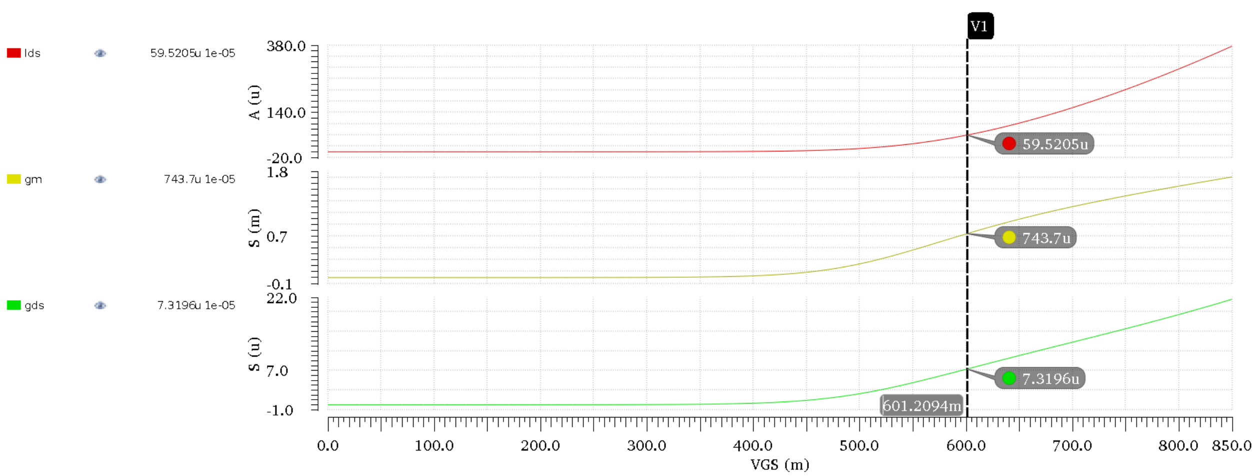

Figure 3 plot ID&gm and gds versus VGS:

Parameter	Simulator value
V_{OVQ}	160.215mV
V_Q^*	160mV
I_{DQ}	$59.5205\mu A$
gm_Q	$743.7\mu S$
gds_Q	$7.3196\mu S$

- I want current equal $150\mu A$ but at W=$10\mu m$ $I_{DQ} = 49.66\mu A$

W	I_D
$10\mu m$	$59.5205\mu A$
?	$15\mu A$

Then W=$\frac{15\mu * 10\mu}{59.5205\mu} = 2.52\mu m.$

- get parameters at this W:

$$\frac{gm}{gm_Q} = \frac{W}{W_Q} \qquad \frac{gm}{743.7\mu} = \frac{2.52}{10} \qquad gm = 187.4124\mu S$$

$$\frac{g_{ds}}{gds_Q} = \frac{W}{W_Q} \qquad \frac{gds}{7.3196\mu} = \frac{2.52}{10} \qquad gds = 1.845\mu S$$

$$I_D = 15\mu A$$

$$r_o = \frac{1}{gds} = 542.141K\Omega$$

So common source parameters are:

Parameter	Value
L	0.5µm
W	2.52µm
V_{GSQ}	601.2094mV
I_D	15μA
gm	187.4124μS
gds	1.845μS
r_o	542.141$K\Omega$

Part 2: Cascode for Gain:

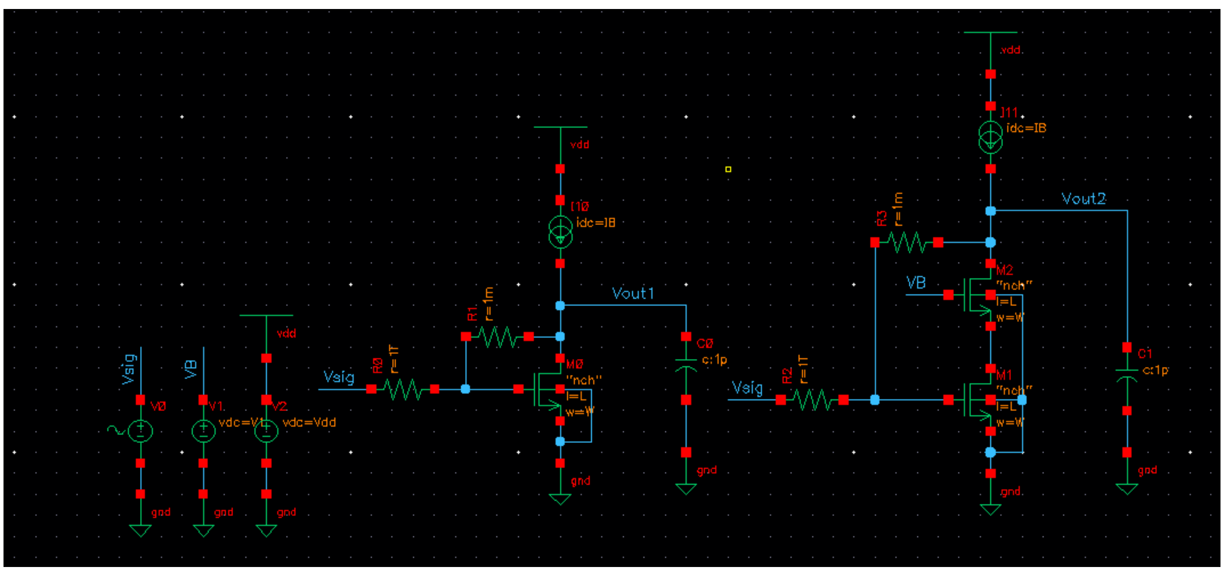

Figure 4 Cascode circuit schematic

- Select value of voltage bias for M1 mosfet :

$V_{DS} \approx V^* + 100mV$ =160m+100m=260mV .

By making sweep of V_{DS} *versus* V_B *to get value of voltage bias* .

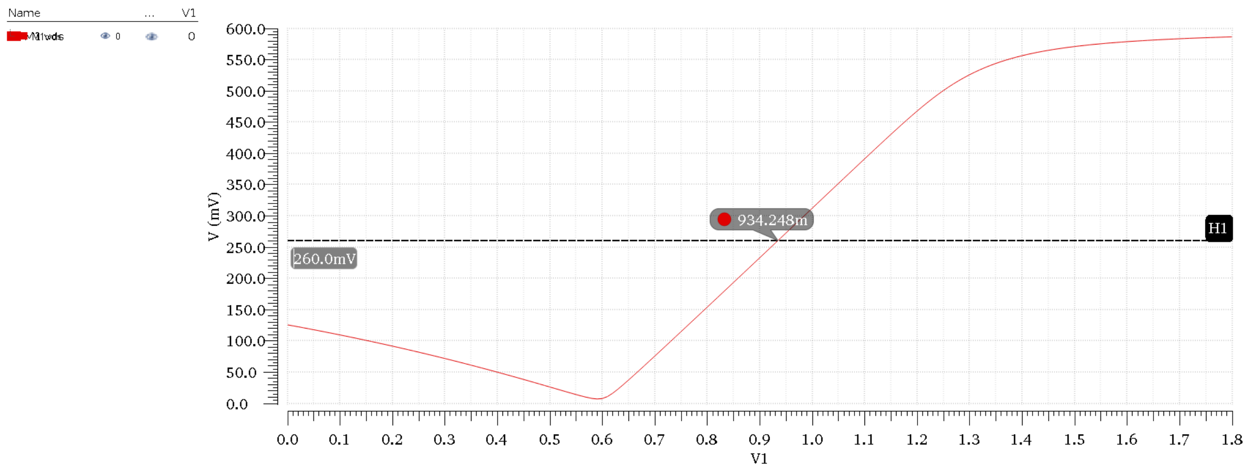

Figure 5 plot vds for M1 versus VB

•$V_B = 934.248mV$.

•DC operating point for CS and cascode amplifiers:

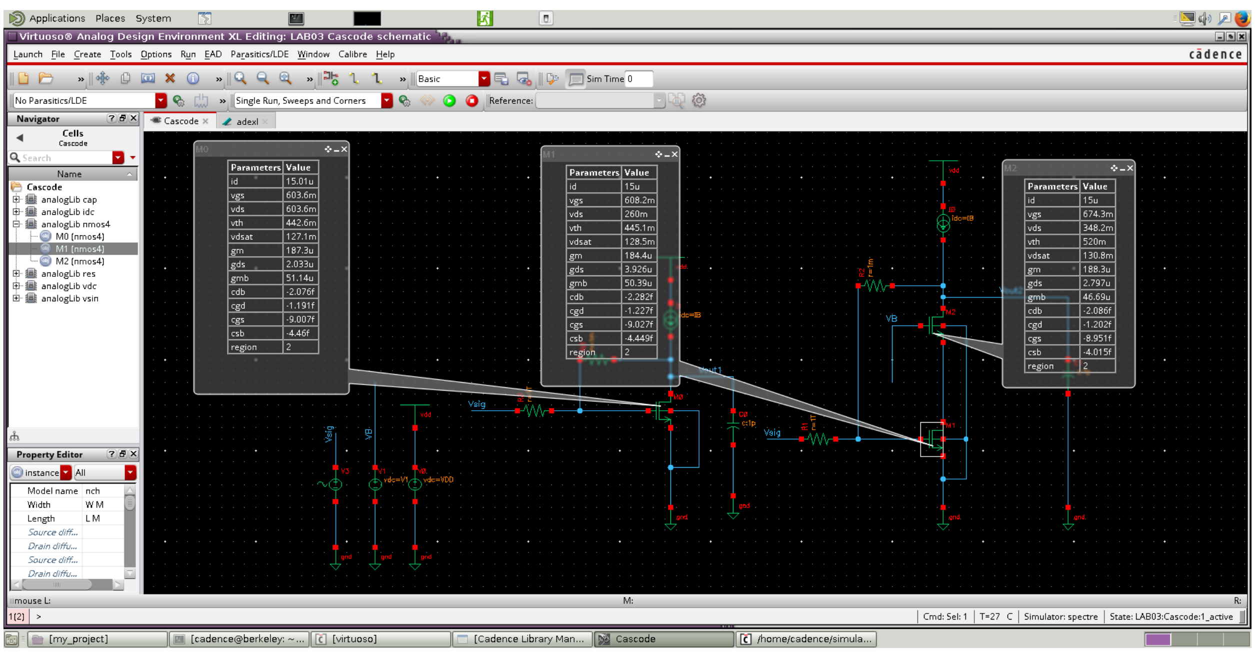

Figure 6 operating point parameters from simulation

5) as shown in fig (6) all transistors in region 2 (saturation region).

6) All transistors don't have the same threshold voltage even they have the same channel length L, this due to body effect as shown in fig (6) we notice that M0 and M1 have V_{TH} is almost the same, but M2 have different V_{TH} because of body effect as source and bulk are not connected to each other so we will have voltage V_{sb} *between* them which increase value of V_{TH}.

7)gm >> gds .

8)gm > gmb .

9)$C_{gs} > C_{gd}$.

10) $C_{sb} > C_{db}$.

2. AC Analysis

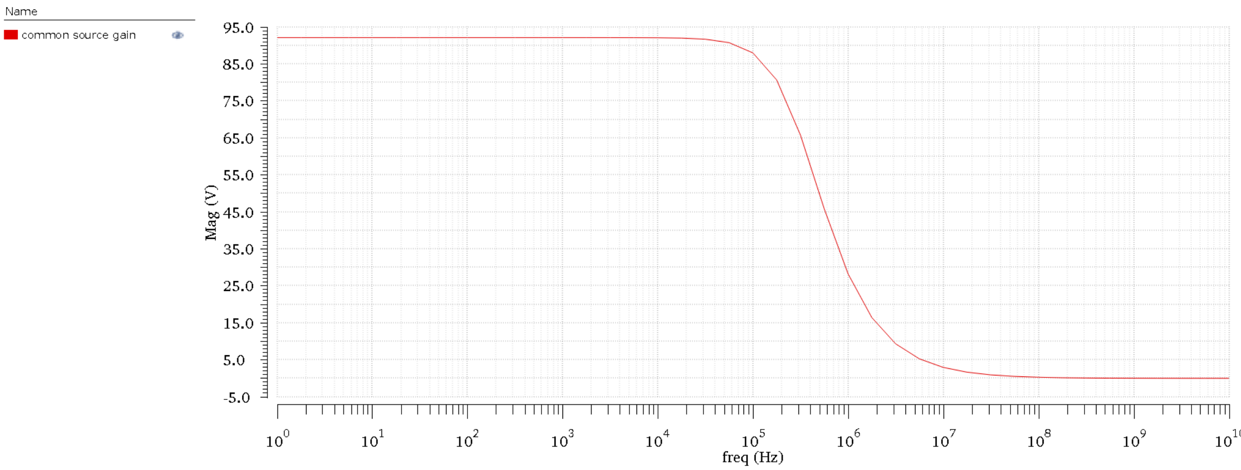

Figure 7 common source gain versus frequency

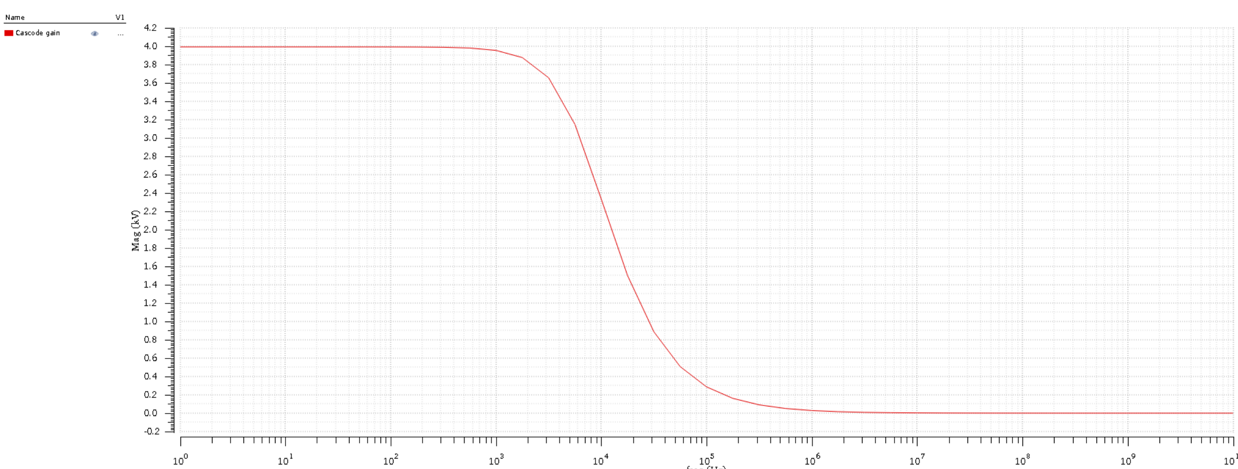

Figure 8 cascode amplifier gain versus frequency

• from simulation we found:

$A_{vcs} = 92.13$

$A_{vcascode} = 3.993k$

Comment: cascode amplifier gain is greater than common source amplifier gain .

• parameters from simulation ADEXL:

Test	Output	Nominal	Spec	Weight	Pass/Fail
LAB03:Cascode:1	common source gain				
LAB03:Cascode:1	dB20(VF("/Vout1"))				
LAB03:Cascode:1	dc gain	92.13			
LAB03:Cascode:1	dc gain in dB	39.29			
LAB03:Cascode:1	cs bandwidth	323k			
LAB03:Cascode:1	cs gbw	29.85M			
LAB03:Cascode:1	cs ugf	30.47M			
LAB03:Cascode:1	cascode gain in dB				
LAB03:Cascode:1	cascode dc gain	3.993k			
LAB03:Cascode:1	cascode dc gain in dB	72.03			
LAB03:Cascode:1	cascode bandwidth	7.35k			
LAB03:Cascode:1	cascode gbw	29.42M			
LAB03:Cascode:1	cascode ugf	29.86M			

Figure 9 results of parameters from simulation

RESULTS from ADEXL:

	Common source	Cascode amplifier
Gain	92.13	3.993K
Gain in dB	39.29	72.03
BW	323K	7.35K
GBW	29.85K	29.42M
UGF	30.47M	29.86M

• Bode plot of common source amplifiers in dB:

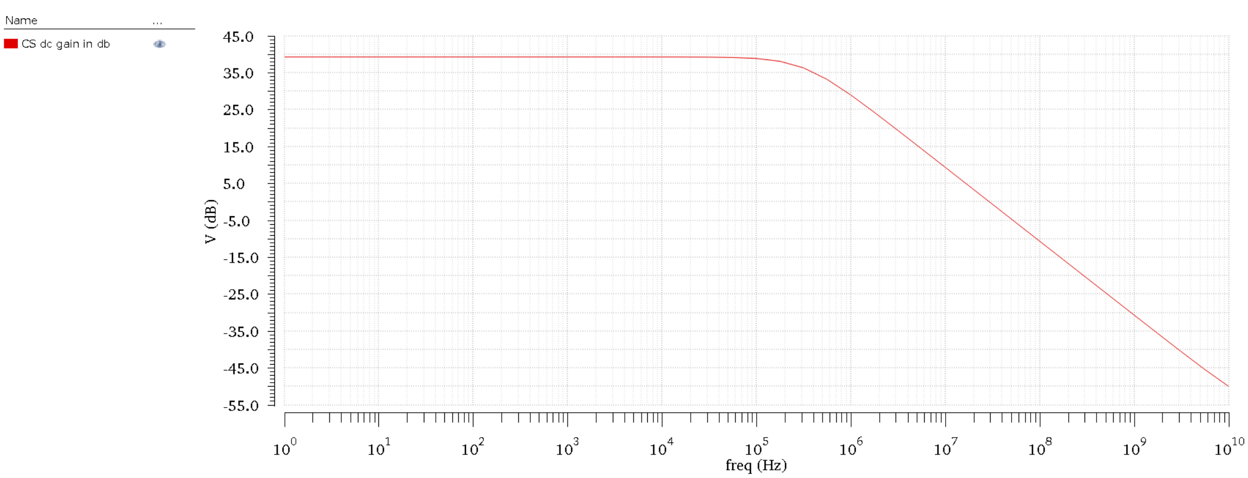

Figure 10 Bode plot of cs ib dB

• Bode plot of cascode amplifiers in dB:

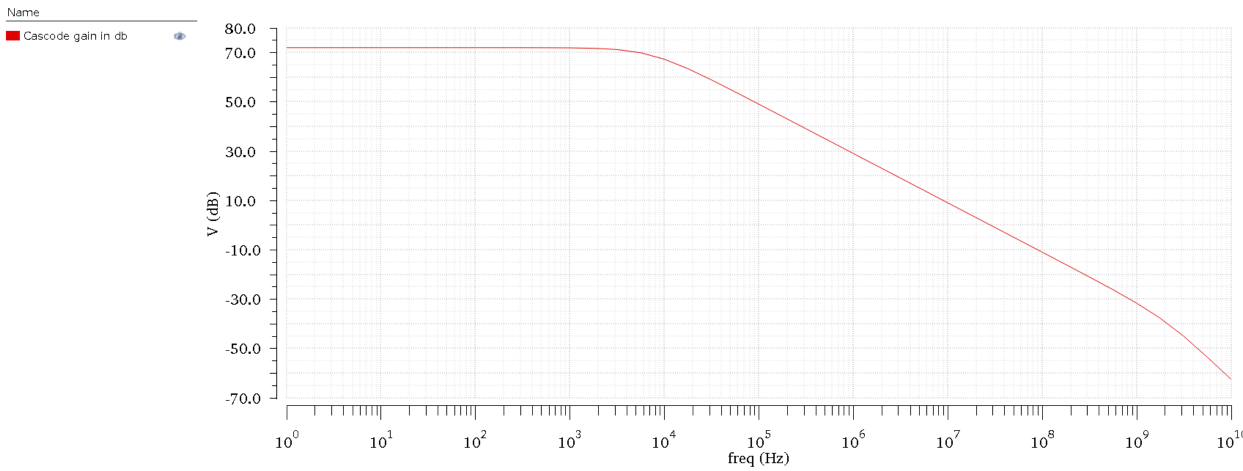

Figure 11 Bode plot of cascode in Db

Hand analysis:

$$|A_{VCS}| = gm1 * r_o = gm1 * \frac{1}{gds} = 187.3\mu * \frac{1}{2.033\mu} = 92.129$$

$$|A_{VCascode}| = gm1 * (r_{o1} + r_{o2} + (gm2 + gmb2) * r_{o1} * r_{o2})$$

$$=184.4\mu * \left(\frac{1}{3.926\mu} + \frac{1}{2.797\mu} + (188.3\mu + 46.69\mu) * \frac{1}{3.926\mu} * \frac{1}{2.797\mu}\right) = 4.059K$$

$$BW_{CS} = \frac{1}{2\pi * R * C} = \frac{1}{2\pi * \frac{1}{2.033\mu} * 10^{-12}} = 323.562KHZ$$

$$BW_{Cascode} = \frac{1}{2\pi * R * C} = \frac{1}{2\pi * 22.012 * 10^{-12}} = 7.23HZ$$

$$GBW_{CS} = BW_{CS} * Gain_{CS} = 9.129 * 323.562K = 29.81MHZ$$

$$GBW_{Cascode} = BW_{cascode} * Gain_{Cascode} = 7.23 * 4.059K = 29.347MHZ$$

Comment:

As shown in previous results The cascode amplifier has a higher gain than the common source amplifier because the common base transistor in the cascode amplifier effectively multiplies the output resistance of the common source transistor. This is because the common base transistor has a very high output resistance, which is not affected by the input voltage because of higher resistance of cascode amplifier than common source,cascode has lower bandwidth as bandwidth