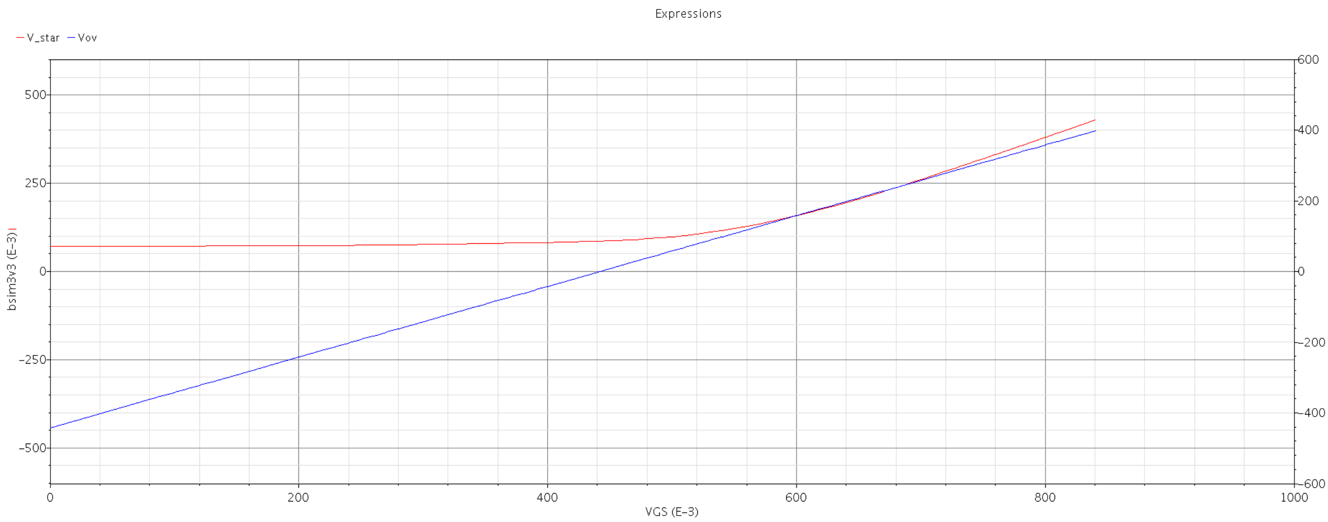
Lab 03
Cascode Amplifier

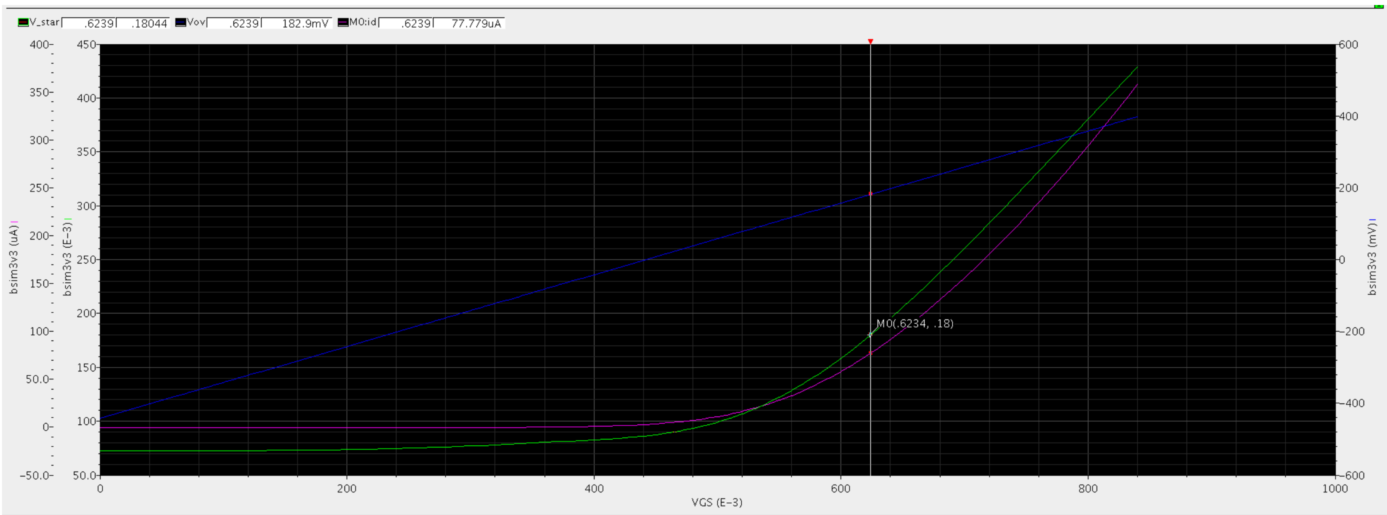
Part 1: Sizing Chart

V*=180mv, ID=25uA

Sweep VGS from 0 to ≈ $VTH + 0.4V$ with 10mV step. Set $VDS = VDD/2$. We want to compare $V* = 2ID/gm$ and $Vov = VGS - VTH$ by plotting them overlaid. Use the calculator to create expressions for $V*$ and Vov. You can save the expressions to reuse them later.

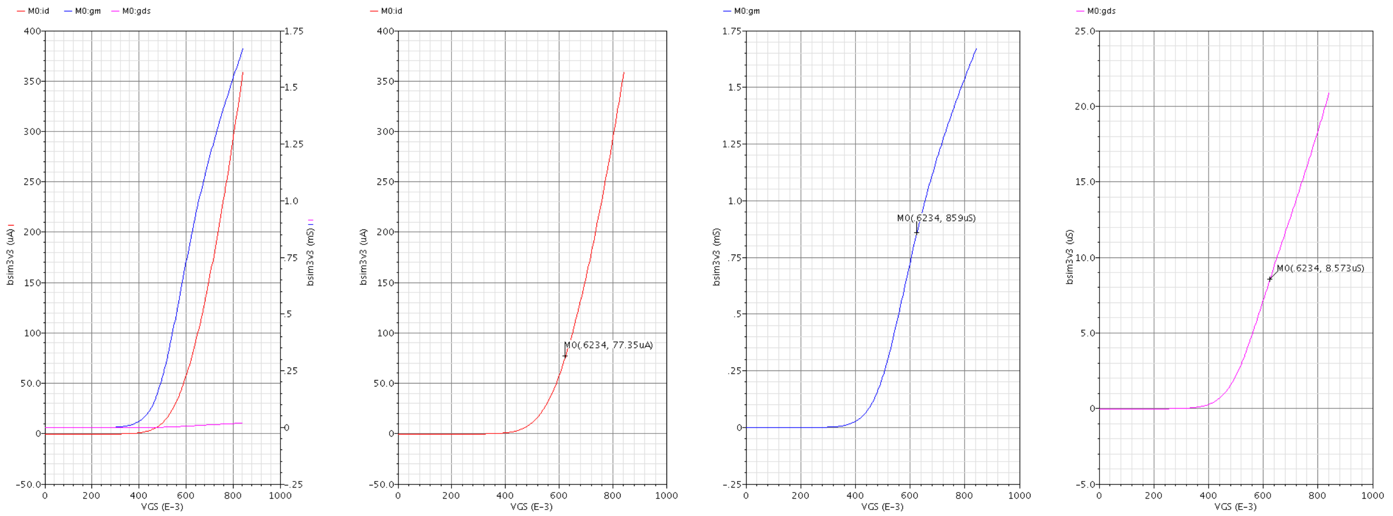
<u>Plot V_* and V_{ov} overlaid vs VGS. Make sure the y-axis of both curves has the same range.</u>





From the above graph it shows that at V*=180mV, Vgs=623.4mV which is our operating point.

Plot I_D, g_m, and g_{ds} vs V_{GS}.



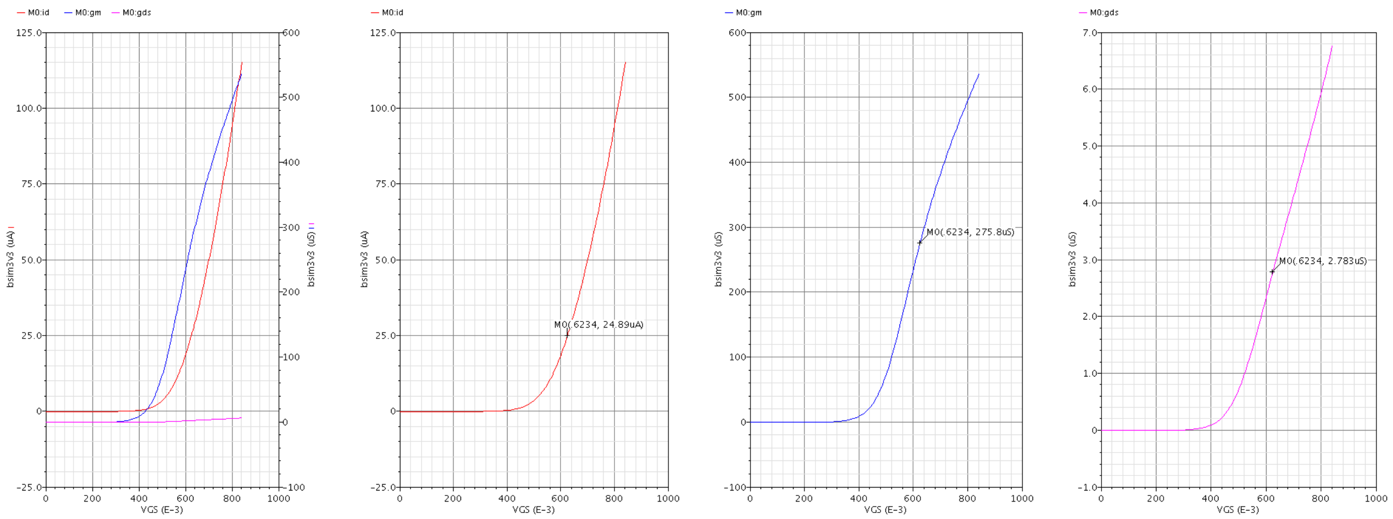
The above graph shows the values of gm,Id,gds at our operating point Vgs.

Now we will use the table to find W and hence find the values of the rest of the parameters that will achieve our design

W	Id
10uM	77.35uA
W_new	25uA

Therefore W_new=3.23u M

Hence I can get the rest of the values of gm,gds the same way by substituting in the table above or also can get it by simulating results at W=3.23u M



Here we can find that:

Id=25uA

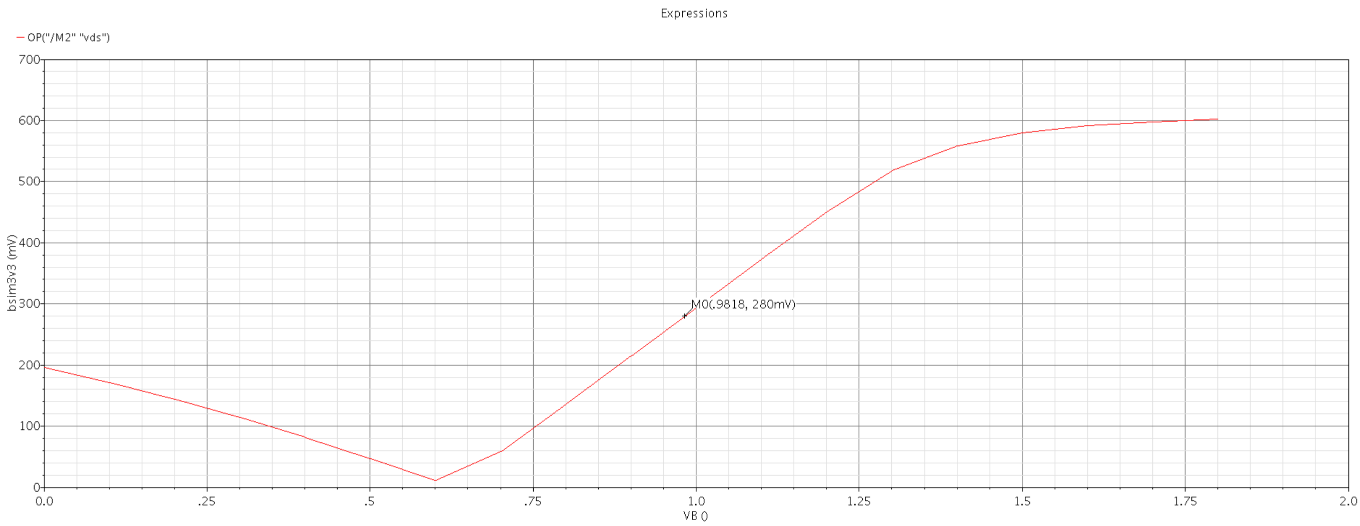
Gm=275.8uS

Gds=2.783uS

PART 2: Cascode for Gain

OP Analysis

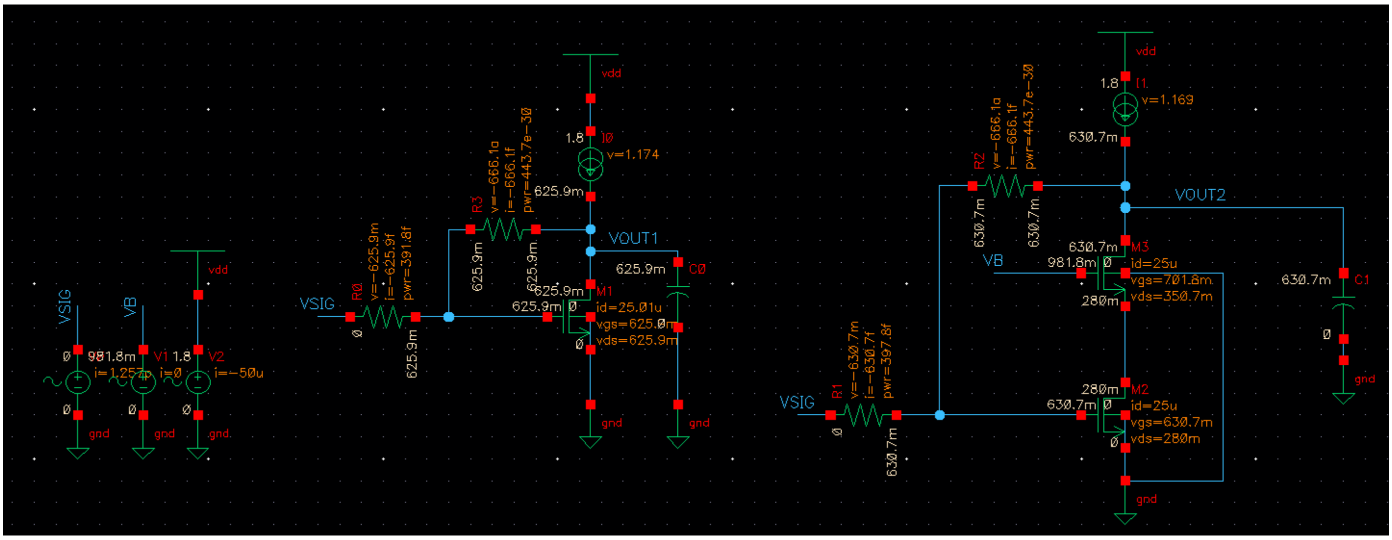
<u>Choose VB (the cascode device bias voltage) such that M2 has $VDS \approx V* + 100mV$ (you may sweep VB and plot VDS vs VB to help you choose a good value for VB).</u>



To satisfy our condition of VDS=280mV

VB=0.9819V

<u>Simulate the DC OP point of the above CS and cascode amplifiers. Report a snapshot showing the following parameters for M1, M2 and M3 in addition to DC node voltages clearly annotated</u>



M1:

Names	Value
M1:cdb	-2.573E-15
M1:cgd	-1.528E-15
M1:cgs	-11.62E-15
M1:csb	-5.654E-15
M1:gds	3.049E-6
M1:gm	277.1E-6
M1:gmbs	75.45E-6
M1:id	25.01E-6
M1:region	2
M1:vds	625.9E-3
M1:vdsat	142.1E-3
M1:vgs	625.9E-3
M1:vth	442.6E-3

M2:

Names	Value
M2:cdb	-2.829E-15
M2:cgd	-1.574E-15
M2:cgs	-11.64E-15
M2:csb	-5.641E-15
M2:gds	6.015E-6
M2:gm	272.6E-6
M2:gmbs	74.26E-6
M2:id	25.0E-6
M2:region	2
M2:vds	280.0E-3
M2:vdsat	143.5E-3
M2:vgs	630.7E-3
M2:vth	445.1E-3

M3:

Names	Value
M3:cdb	-2.588E-15
M3:cgd	-1.546E-15
M3:cgs	-11.54E-15
M3:csb	-5.05E-15
M3:gds	4.512E-6
M3:gm	277.9E-6
M3:gmbs	68.37E-6
M3:id	25.0E-6
M3:region	2
M3:vds	350.7E-3
M3:vdsat	146.3E-3
M3:vgs	701.8E-3
M3:vth	525.8E-3

<u>Check that all transistors operate in saturation</u>

It's shown that the region of the three transistors region=2 (saturation region)

<u>Do all transistors have the same Vth? Why?</u>

No, not all transistors have the same Vth

M3 has higher Vth than M1 and M2 due to the body effect since the VSB of M3 ≠ 0.

gm>>gds

gm>>gmb

cgs>cgd

csb>cd

SIDE NOTE:

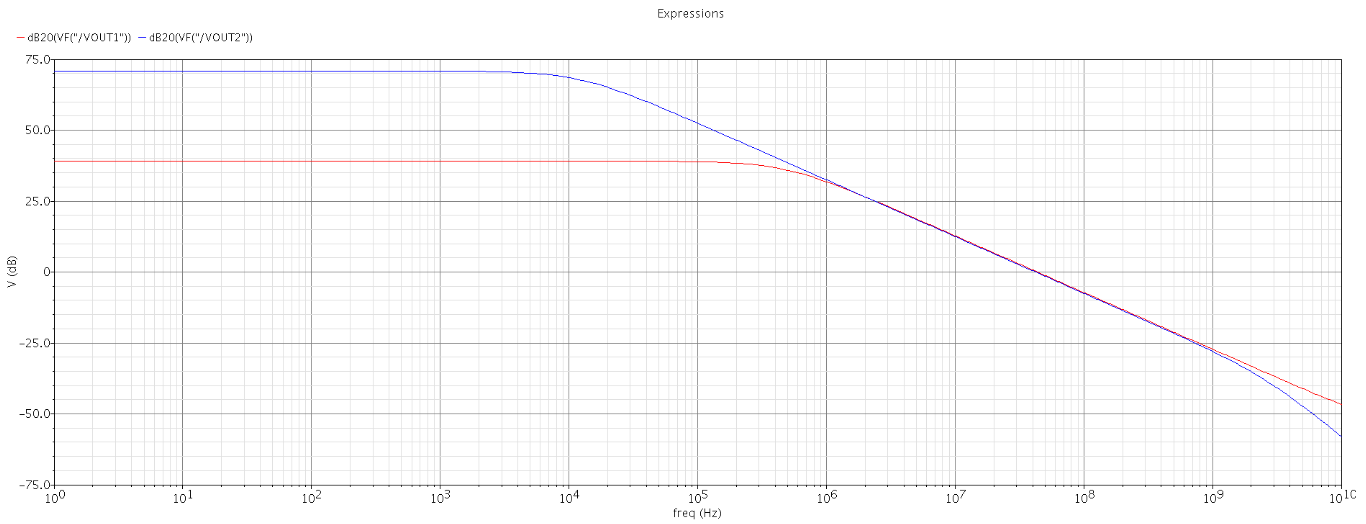
It's the doctor's permission to skip the hand analysis part in AC analysis point 4,5

AC Analysis

<u>Create a new simulation configuration. Perform AC analysis (1Hz:10GHz, logarithmic, 10points/decade) to simulate gain and bandwidth. Use calculator to create expressions for circuit parameters (DC gain, BW, GBW, and UGF) and export them to adexl.</u>

<u>Report the Bode plot (magnitude) of CS and cascode appended on the same plot.</u>

<u>Using</u>



<u>Report a table comparing the DC gain, BW, UGF, and GBW of both circuits from simulation and hand analysis.</u>

Test	Output	Nominal	Spec	Weight	Pass/Fail
AIC_Training:Cascode_Amplifier:1	dB20(VF("/VOUT1"))				
AIC_Training:Cascode_Amplifier:1	ymax(dB20(VF("/VOUT1")))	39.17			
AIC_Training:Cascode_Amplifier:1	ymax(mag(VF("/VOUT1")))	90.89			
AIC_Training:Cascode_Amplifier:1	bandwidth(VF("/VOUT1") 3 "low")	482.9k			
AIC_Training:Cascode_Amplifier:1	gainBwProd(VF("/VOUT1"))	43.99M			
AIC_Training:Cascode_Amplifier:1	ymax(mag(VF("/VOUT2")))	3.523k			
AIC_Training:Cascode_Amplifier:1	bandwidth(VF("/VOUT2") 3 "low")	12.04k			
AIC_Training:Cascode_Amplifier:1	dB20(VF("/VOUT2"))				
AIC_Training:Cascode_Amplifier:1	ymax(dB20(VF("/VOUT2")))	70.94			
AIC_Training:Cascode_Amplifier:1	gainBwProd(VF("/VOUT2"))	42.53M			

<u>Comments:</u>

-Cascode amplifiers are used to boost the gain of a single stage CS amplifier

-Cascode amplifier provide a very high output impedance

-Due to the very high output impedance of the cascode, it has a much smaller bandwidth than the single stage CS amplifier

-The GBW is constant therefore, we have a gain-bandwidth tradeoff.