Analog IC Design – Cadence Tools

Lab 03

Cascode Amplifier

Part 1: Sizing Chart

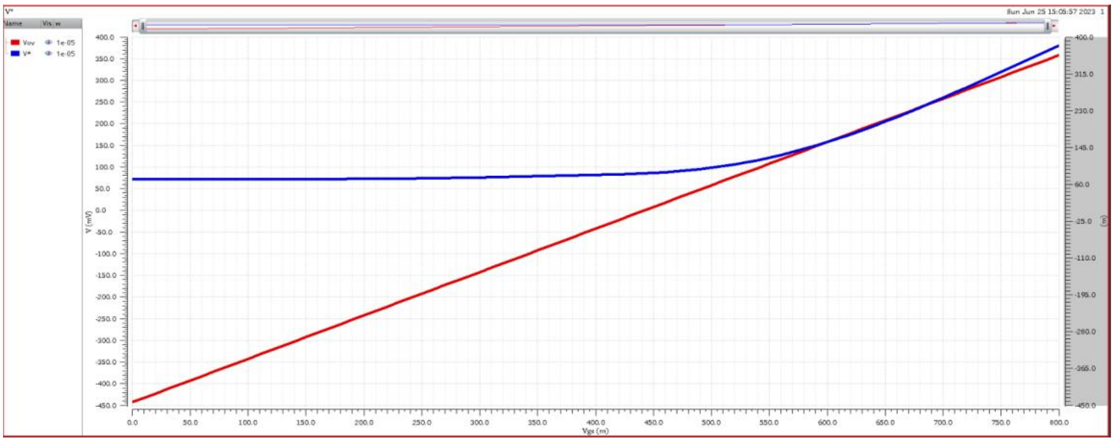

Figure 1 V and Vov VS VGS*

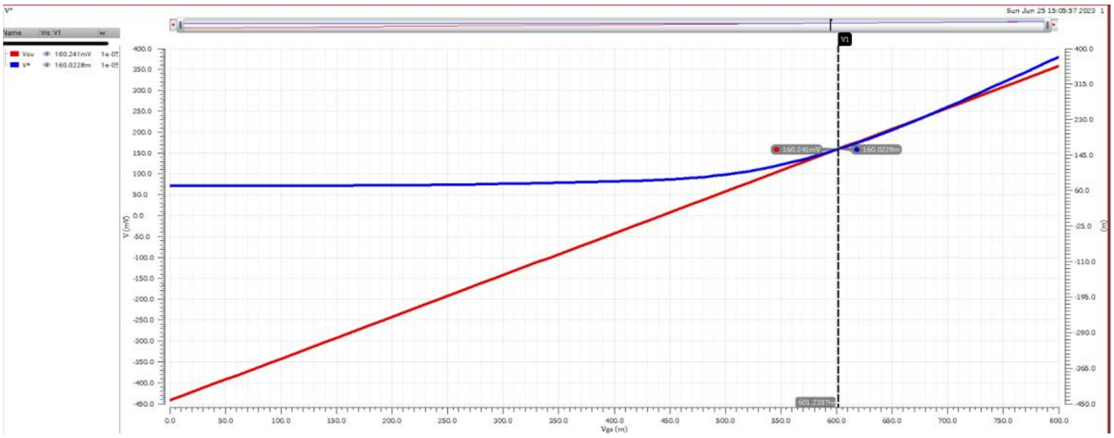

Figure 2 V =160m v*

The corresponding $VovQ =$ 160.241m v and $VGSQ$ = 601.235m v

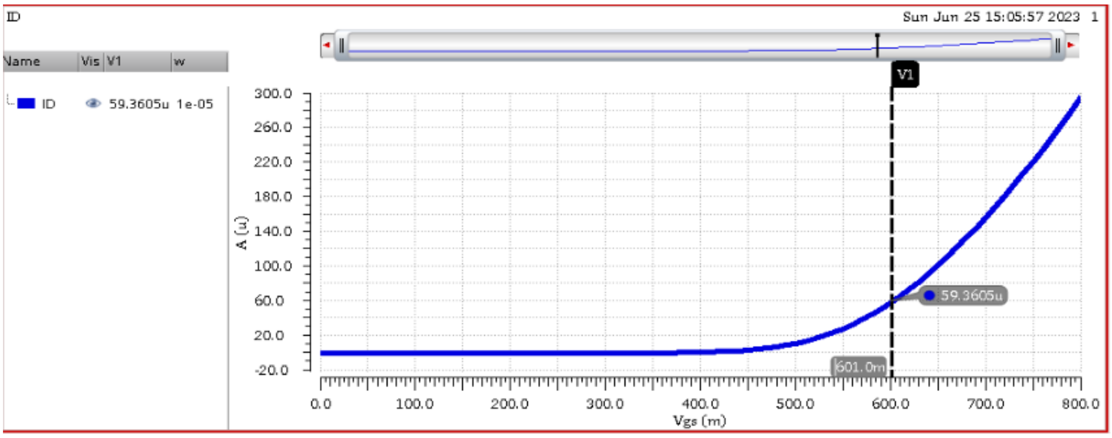

Figure 3 ID VS VGS

The corresponding ID = IDx = 59.3605u

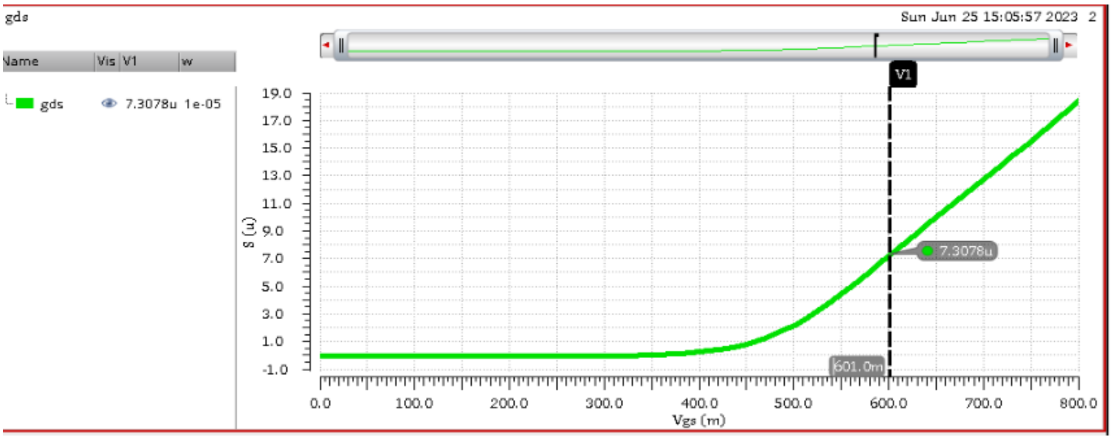

Figure 4 gds VS VGS

The corresponding gds = gdsx = 7.3078u

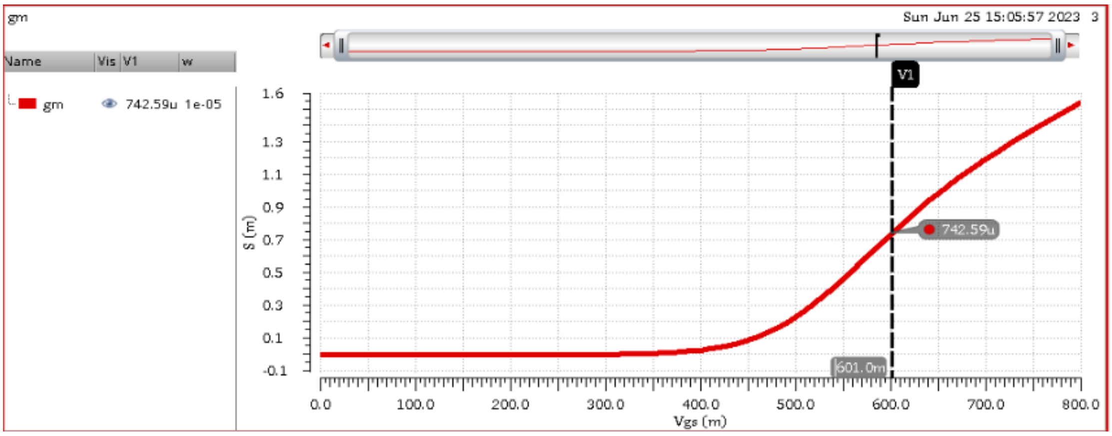

Figure 5 gm VS VGS

The corresponding gm = gmx = 742.59u

W	ID
10u	59.3605u
2.52693u	15 u

W=2.52693u

gm	ID
742.59u	59.3605u
187.6475u	15 u

g_{mQ}=187.6475u

gds	ID
7.3078u	59.3605u
1.846632u	15 u

g_{dsQ}=1.846632u

PART 2: Cascode for Gain

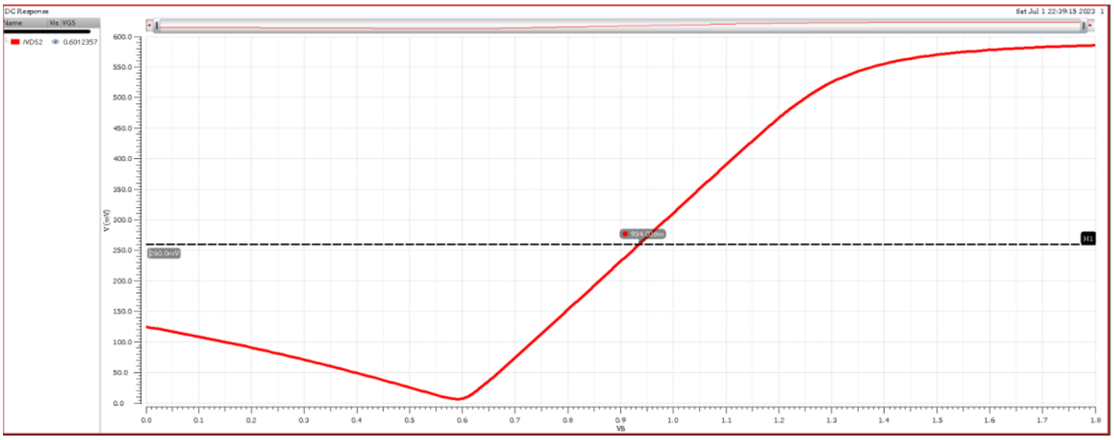

Figure 6 VDS2 VS VB

VB = 934m v

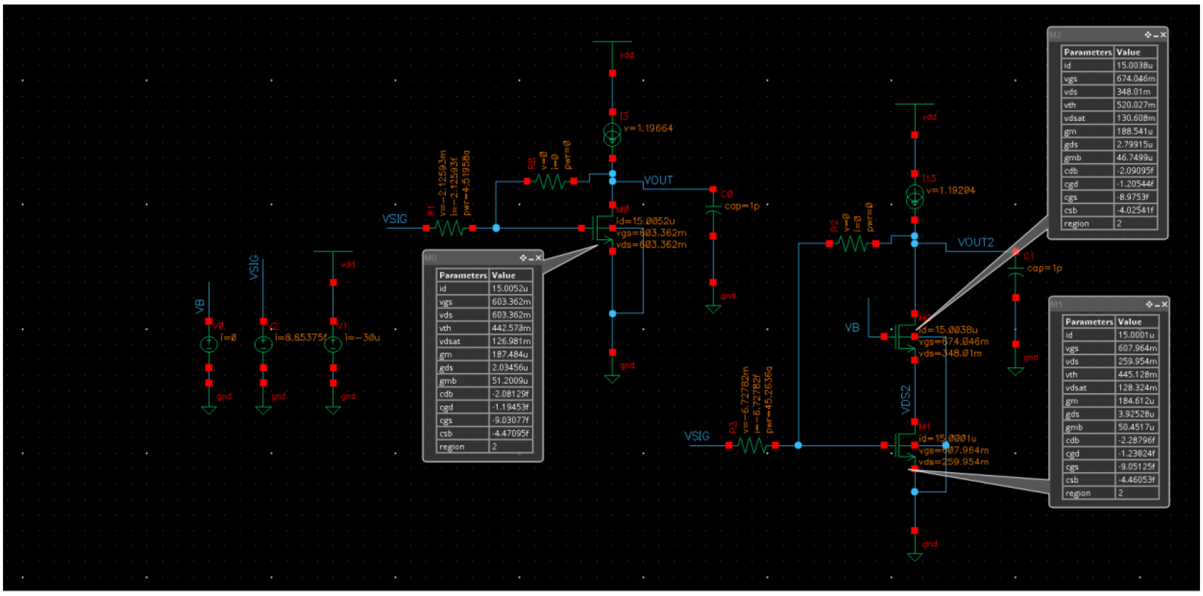

Figure 7 OP points

All transistors are in saturations (region = 2)

	Actual for CS	Designed for CS
gm	187.484u	187.6475u
gds	2.0346u	1.846632u

Vth for M1 & M2 & M3

$$V_{TH} = V_{THo} + \gamma\left(\sqrt{2\varphi_F + V_{SB}} - \sqrt{|2\varphi_F|}\right)$$

Transistors have the different V_{th}, because Vth depend on the value of V_{SB} and as V_B is grounded, so the value of V_{th} will depend only on V_S, so as shown V_{th1} and V_{th2} are equal because V_S is equal and V_{th3} is different from them because its value of V_s is different.

(Note that all transistors are identical)

gm >> gds

gm > gmb

cgs > cgd

csb > cdb

gm	187.484u
gds	2.03456u
gmb	51.2009u
cdb	-2.08129f
cgd	-1.19453f
cgs	-9.03077f
csb	-4.47095f

2. AC Analysis

Test	Output	Nominal
Lab_1:LAB_3:1	Vout_dB	
Lab_1:LAB_3:1	max_Vout_dB	39.29
Lab_1:LAB_3:1	max_Vout_mag	92.15
Lab_1:LAB_3:1	BW_Vout	322.4k
Lab_1:LAB_3:1	GBW1	29.78M
Lab_1:LAB_3:1	UGF1	30.03M
Lab_1:LAB_3:1	Vout2_dB	
Lab_1:LAB_3:1	max_Vout2_dB	72.04
Lab_1:LAB_3:1	max_Vout 2_mag	4k
Lab_1:LAB_3:1	BW_Vout2	7.206k
Lab_1:LAB_3:1	GBW2	28.9M
Lab_1:LAB_3:1	UGF2	29.16M

Figure 8 circuit parameters

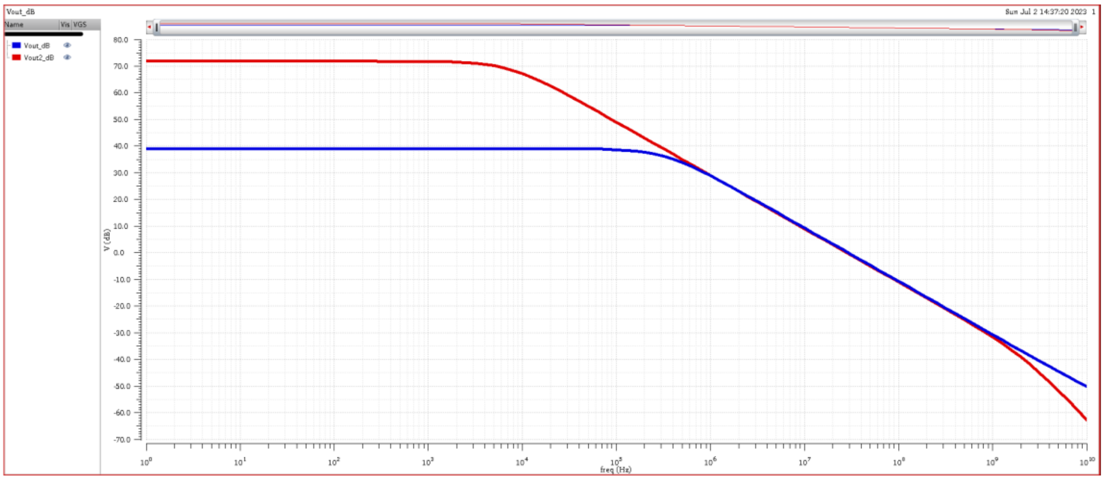

Figure 9 Bode plot (magnitude) of CS and cascode

Hand analysis:

C (out) =1P, as all parasitic capacitances << 1P , and in parallel with it.

$$r_o = \frac{1}{g_{ds}}$$

$$DC\ gain\ (CS) = -g_m * r_o = \frac{-g_{m1}}{g_{ds1}} = \frac{-187.5}{2.035} = -92.137$$

$$r_{o2t} = (r_{o1} + r_{o2} + (g_{m2} + g_{mb2}) * r_{o1} * r_{o2})$$

$$r_{o2t} = \left(\frac{1}{3.9528u} + \frac{1}{2.79915u} + (188.5u + 46.75u) * \frac{1}{3.9528u} * \frac{1}{2.8u}\right) = 21.9M$$

$$DC\ gain\ (Cascode) = -g_{m1} * r_{o2t} = -184.612u * 21.9M = -4240.65 = -4.039K$$

$$BW(CS) = \frac{1}{2*\pi*r_o*C} = \frac{2.035u}{2\pi*1p} = 323.88K$$

$$BW(Cascode) = \frac{1}{2*\pi*r_{o2t}*C} = \frac{1}{2\pi*21.9M*1p} = 7.267K$$

*GBW(CS) = BW1 * DC gain 1 =29.84133M*

*GBW(Cascode) = BW2 * DC gain 2 = 29.3514M*

GPW analytically is UGF (unity gain frequency)

Lab_1:LAB_3:1	UGF1	30.03M

Lab_1:LAB_3:1	UGF2	29.16M

Comments:

The Cascode amplifier Gain is higher than the common-source amplifier Gain, as The Cascode amplifier has higher Rout and $DC\,gain = -g_m * r_o$.

The Cascode amplifier Bandwidth is lower than the common-source amplifier Bandwidth, as The Cascode amplifier has higher Rout and $BW = \frac{1}{2*\pi*r_o*C}$.