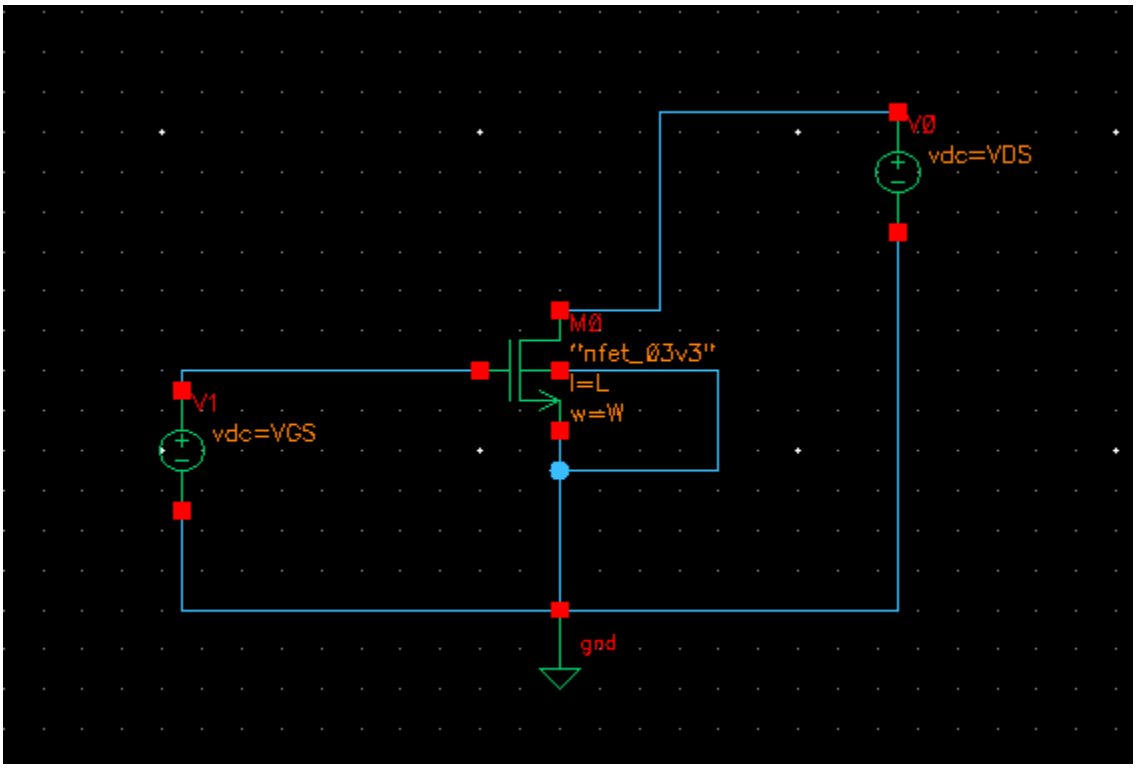
Analog IC Design – Cadence Tools

Lab 03

Cascode Amplifier

Part 1: Sizing Chart:



spec	0.18um CMOS
L	0.5um
V*	160mV
Supply	1.8VA
Current consumption	10 μA

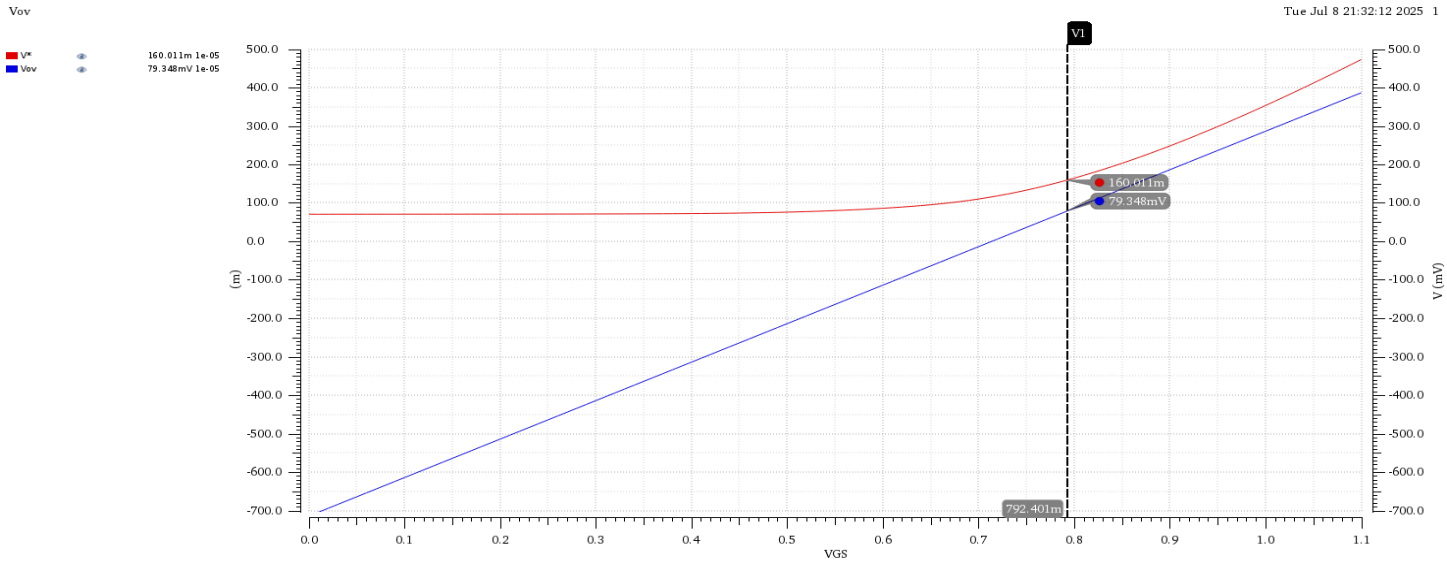


Figure 1:V and Vov VS Vgs*

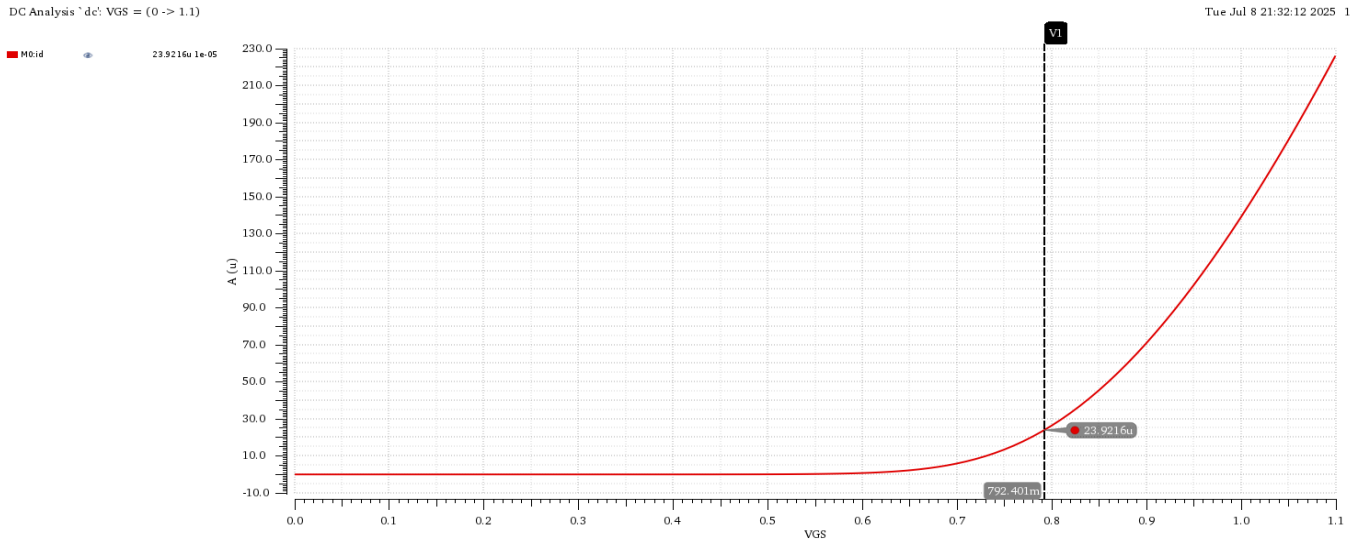


Figure 2:ID VS Vgs

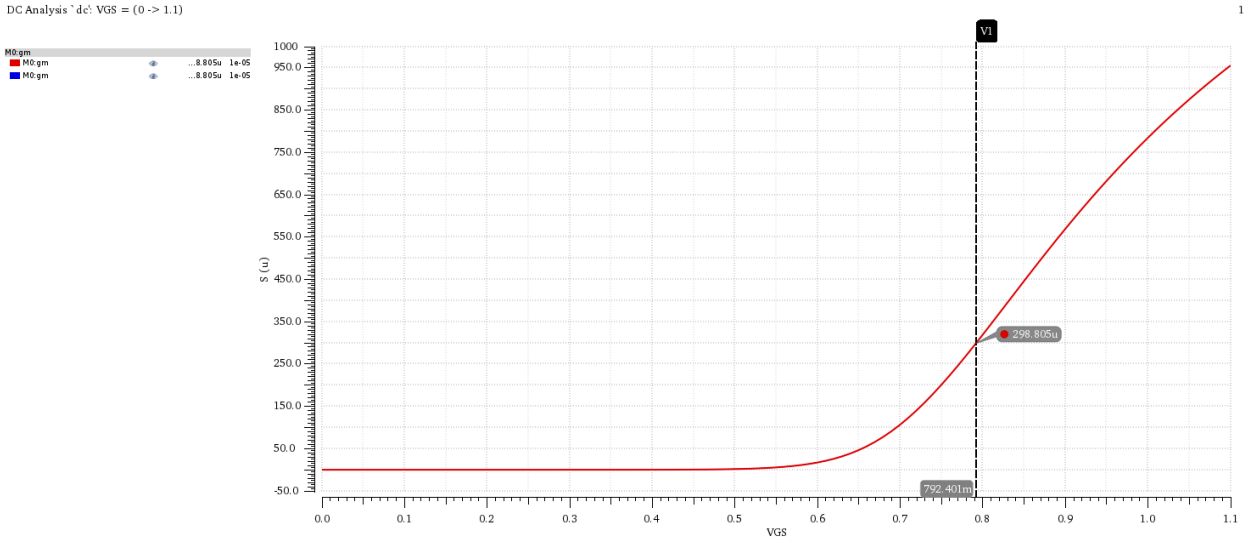


Figure 3: gm VS Vgs

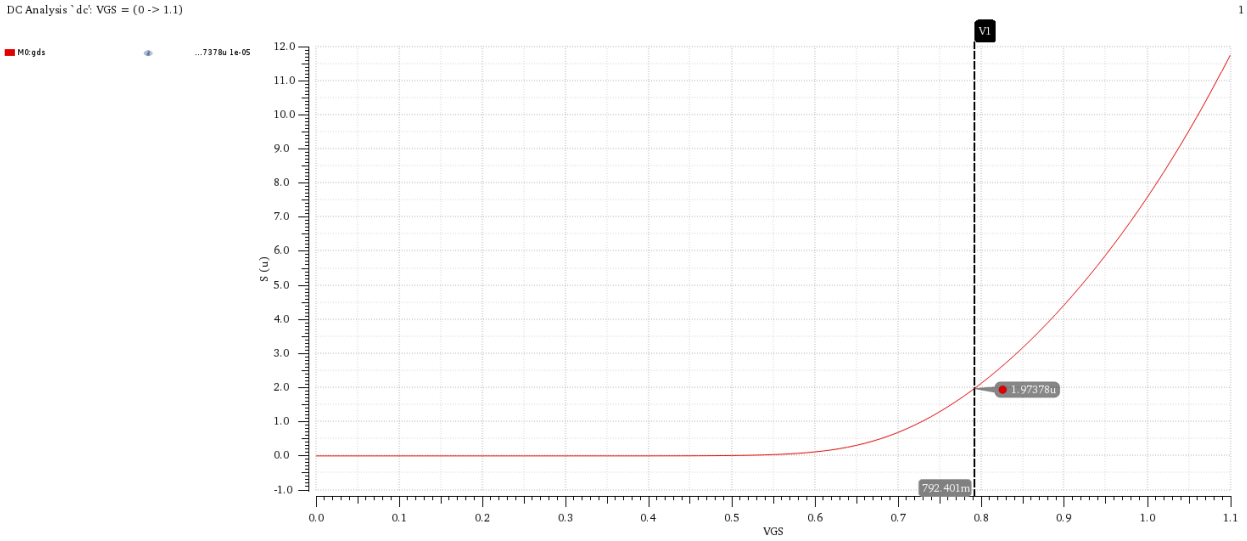


Figure 4:gds VS Vgs

1-

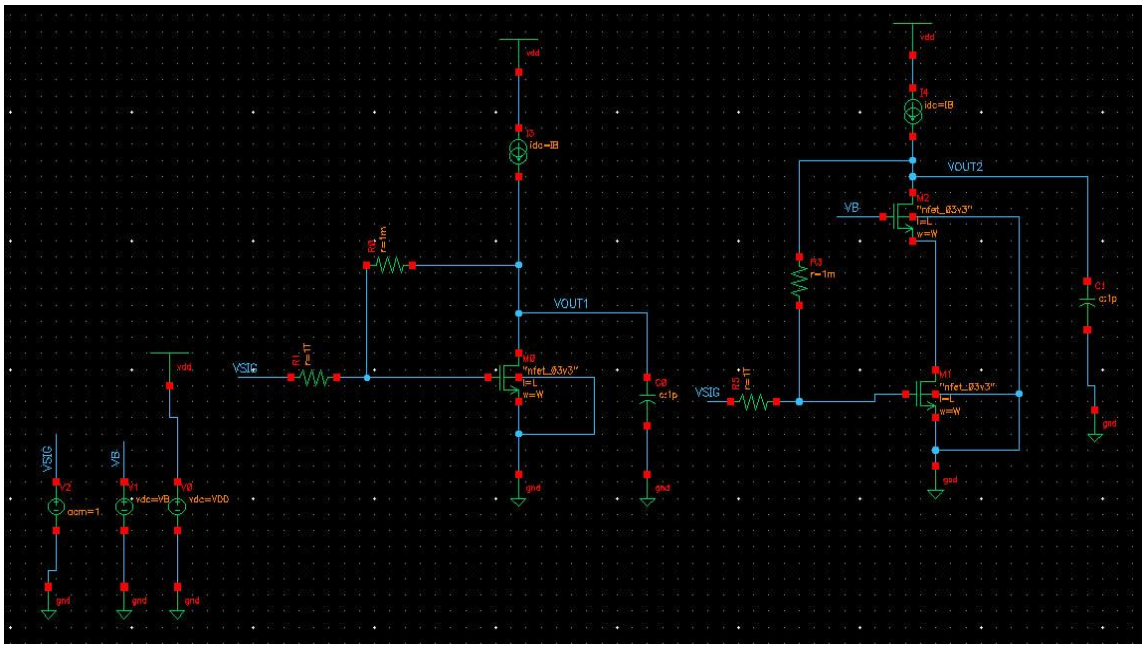
V^*	160 mV
V_{ovQ}	**79.348** mV
V_{GSQ}	**792.401** mV
I_{Dx}	**23.9316** μA
g_{mx}	**298.805** μS
g_{dsx}	1.79378 μS

2-

W	Id
10 μm	**23.9316** μA
4.1786 μm	10 μA
g_m	0.1249 mS
g_{ds}	0.7495 μS
r_o	1.3341 MΩ

PART 2: Cascode for Gain :

1. OP Analysis :



Global Variables	
L	0.5u
W	4.1786u
IB	10u
VB	1
VDD	3

Figure 5:schematic

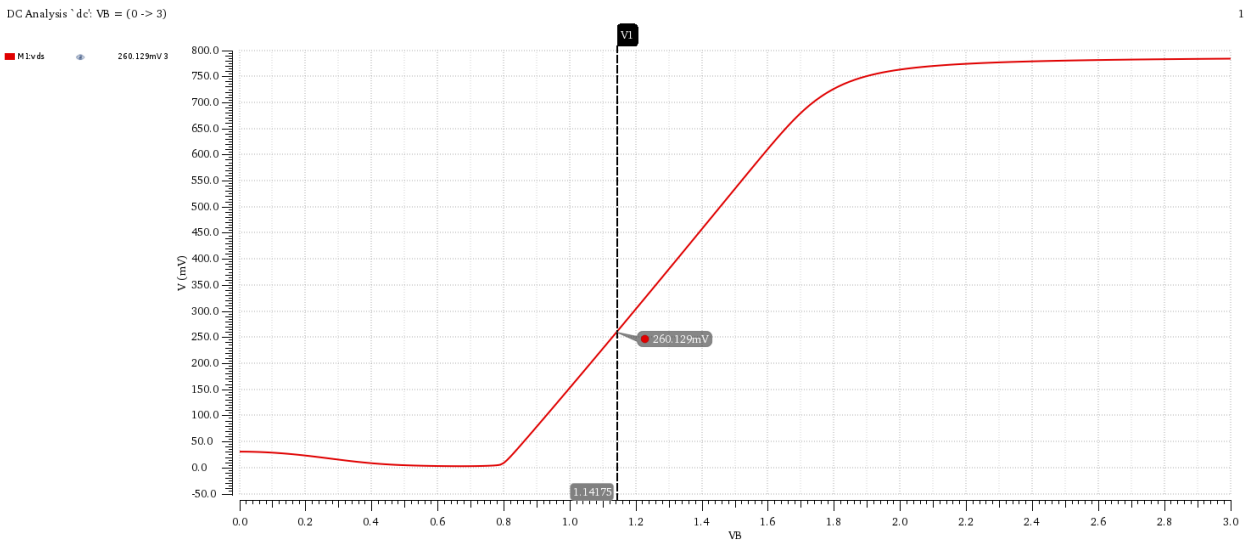


Figure 6:VB VS VDS

AS SHOWN VB from graph = 1.14175 V

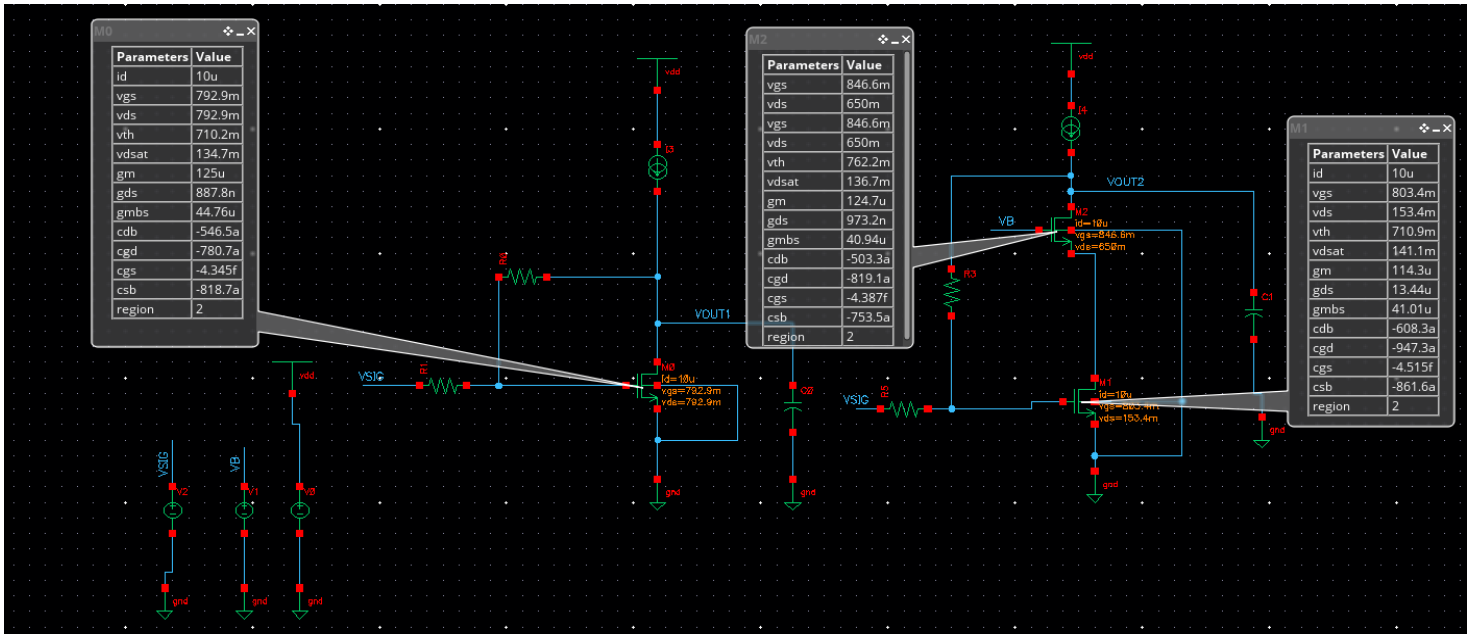


Figure 7: schematic with annotation

As we see all transistors work in region (2) " saturation region"

Do all transistors have the same vth? Why?

Transistors have not the same Vth The threshold voltage (Vth) of a transistor can vary due to several factors, even among transistors of the same type. Here are the key reasons for the observed differences in Vth in your data:

1. Process Variations

   Manufacturing Tolerances: During fabrication, slight variations in doping concentrations, oxide thickness, or channel length/width can occur, leading to differences in Vth.

   Random Dopant Fluctuations (RDF): Random distribution of dopant atoms in the channel can cause localized variations in Vth.

2- Body Effect (Substrate Bias)

   The threshold voltage depends on the voltage between the source and the substrate (VSB). If the substrate bias varies, Vth will also change

3-Drain-Induced Barrier Lowering (DIBL)

   At higher drain-to-source voltages (VDS), the electric field from the drain can lower the potential barrier in the channel, effectively reducing Vth. This is more pronounced in short-channel devices.

What is the relation (≪, <, =,>, ≫) between gm and gds?

gm>>gds

What is the relation (≪, <, =,>, ≫) between gm and gmb?

gm>gmb

What is the relation (≪, <, =,>, ≫) between cgs and cgd?

cgs>cgd

What is the relation (≪, <, =,>, ≫) between csb and cdb?

Csb>cdb

The dc gain,BW, UFG and GBW of both circuits from simulation

Test	Output	Nominal	Spec	Weight	Pass/Fail
LAST_LAB:last:1	VOUT1_DB				
LAST_LAB:last:1	GAIN DB 1	42.97			
LAST_LAB:last:1	GAIN MAG 1	140.8			
LAST_LAB:last:1	BW1	140.8k			
LAST_LAB:last:1	GBW 1	19.88M			
LAST_LAB:last:1	UFG1	19.84M			
LAST_LAB:last:1	VOUT2 DB				
LAST_LAB:last:1	GAIN DB 2	77.15			
LAST_LAB:last:1	GAIN MAG	7.205k			
LAST_LAB:last:1	BW2	2.655k			
LAST_LAB:last:1	GBW2	19.18M			
LAST_LAB:last:1	UFG2	19.27M			

Figure 8: table of requirements

Bode plot :

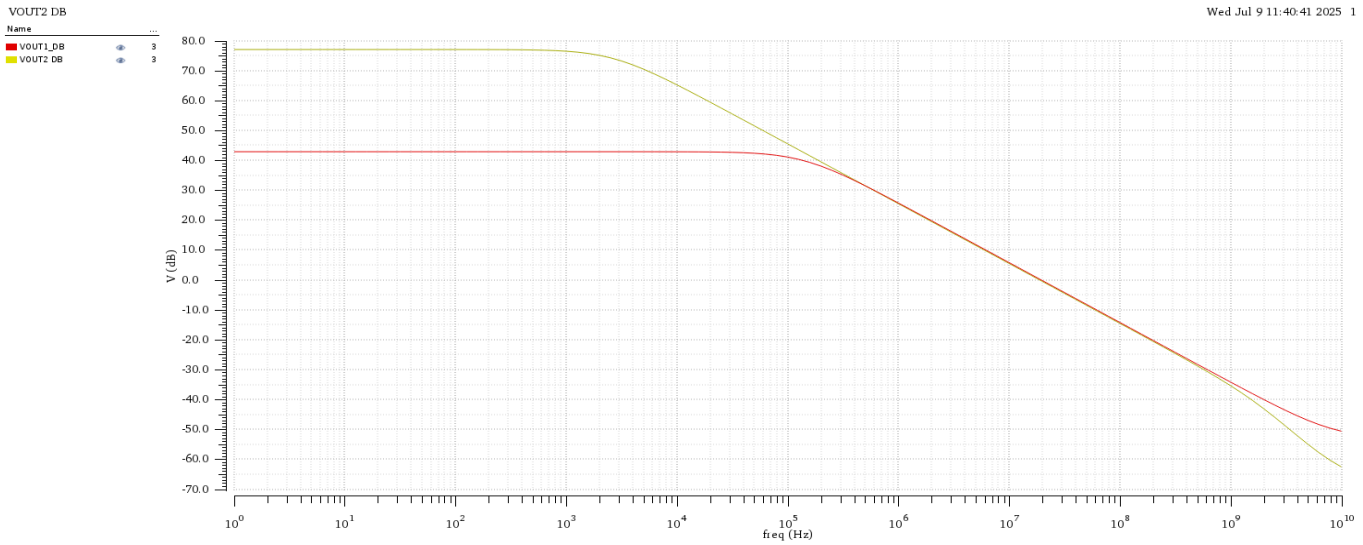


Figure 9:vout1db_vout2db VS freq

Hand analysis:

In a common source amplifier , dc gain (mag) given by :

$$A_V = gm \times r_o = gm \times \frac{1}{gds} = 140.797$$

But In a cascode amplifier , dc gain (mag) given by:

$$A_V = gm \times Rout = -gm1 \times ro2(gm2 + gmb2)ro1 \approx 7.45\ K$$

	CS	Cascode
DC gain hand analysis	140.797	7.45 K
DC gain from simulation	140.8	7.205 K

COMMENT

The **cascode amplifier** provides **much higher DC gain** than a common-source (CS) stage because it **boosts the** output resistance.

CS Amplifier: Gain is limited by ro1*ro*1 (drain-source resistance of single transistor).

Cascode Amplifier: Adds a second transistor to multiply r*oro*, dramatically increasing output resistance and gain.