

ITI
LAB 06
Differential Amplifier

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Part 1: Differential Amplifier Design

The sizing of the transistors

Plot 1A Plot 1B Plot 1C Plot 1D

Import: Plot 1B OK ?

▼ LUT Settings

LUT pmos_03v3 ?

Corner TT All ?

Temp (°C) 27.0 All ?

Frequency 1 ?

ID 20u ?

Vstar 0.1365 ?

ro 30000*10 ?

VDS 0.9 ?

VSB 0.3 ?

Stack 1 ?

Results:

	Name	TT-27.0
2	IG	N/A
3	L	350n
4	W	30.33u
5	VGS	940.4m

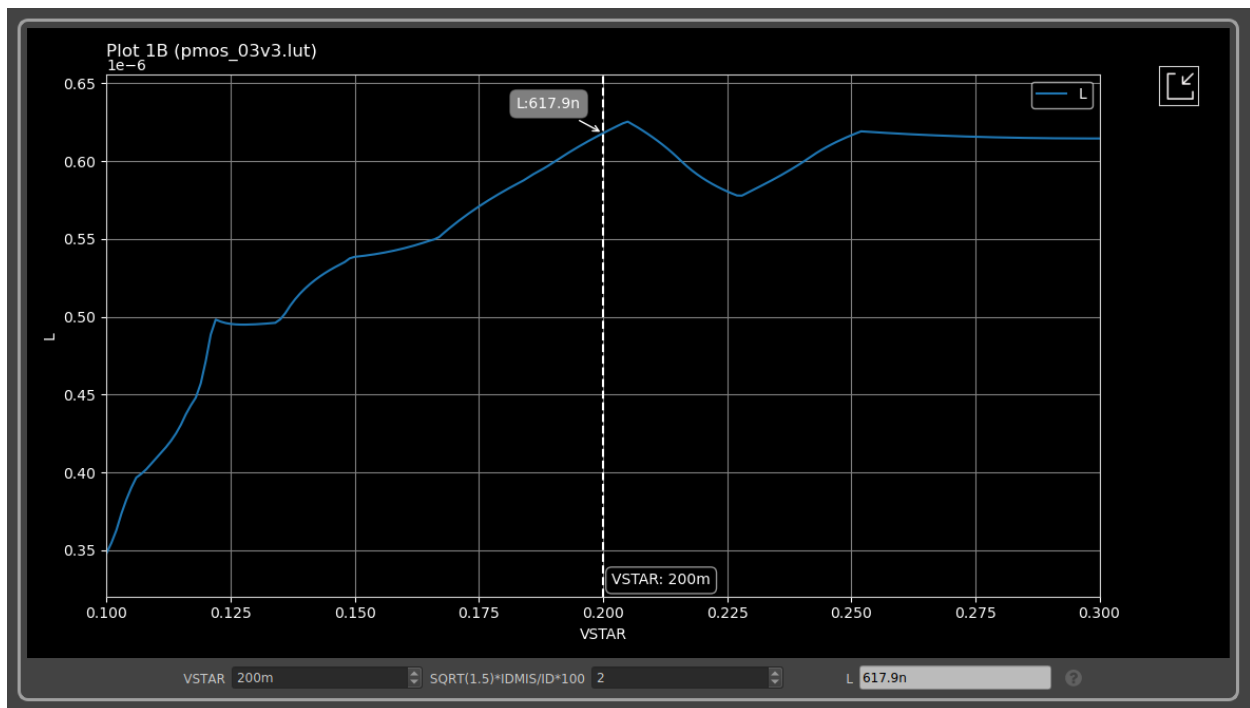
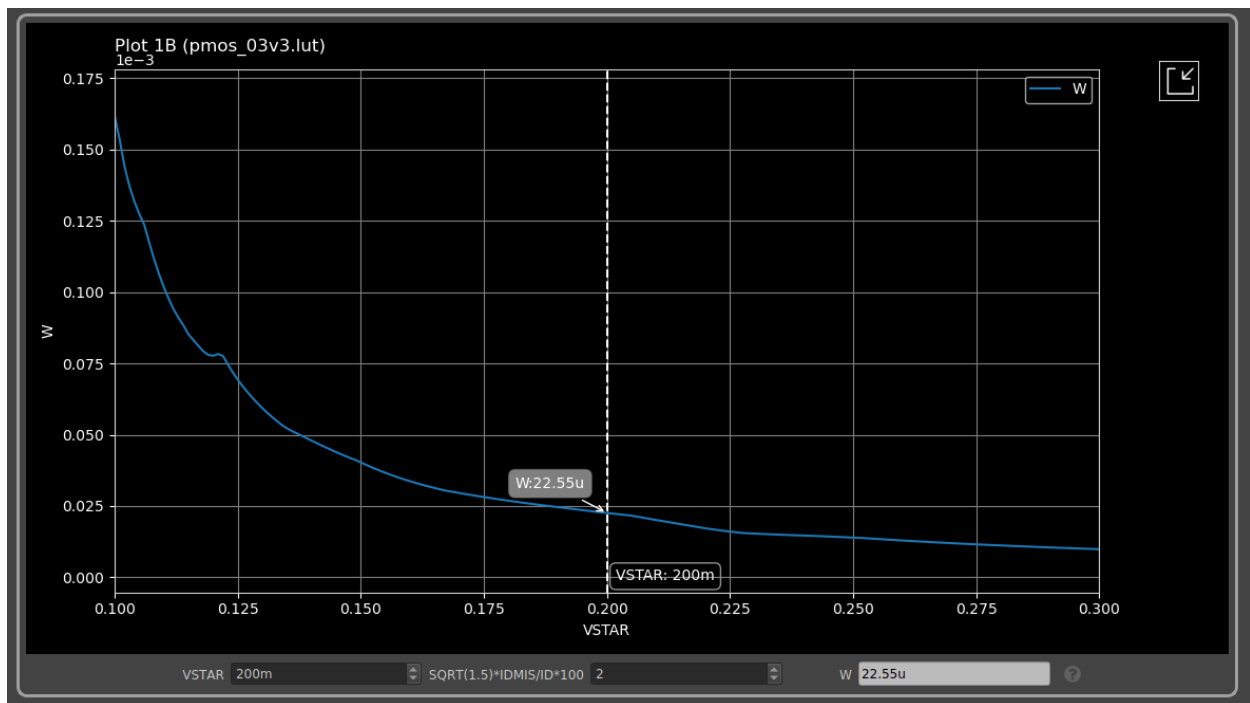
Y-Expr gm/ID*fT ?

Plot ▼

$$W = 30.33\mu m$$

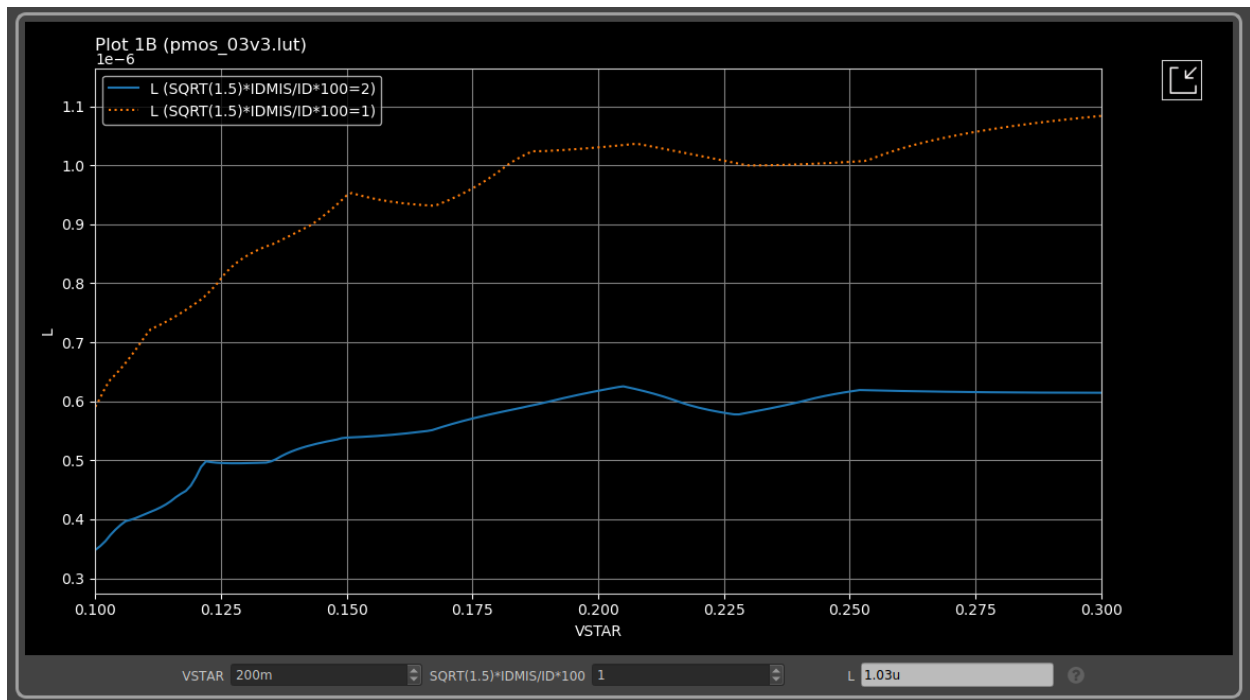
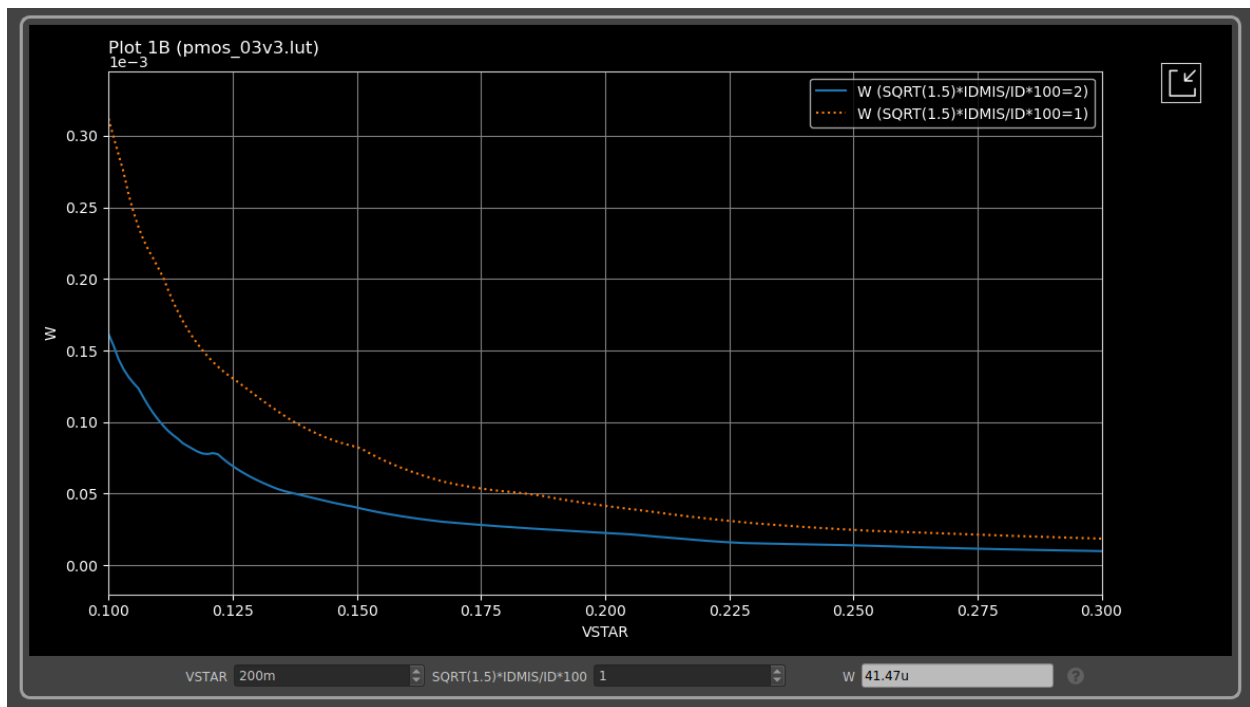
$$L = 350nm$$

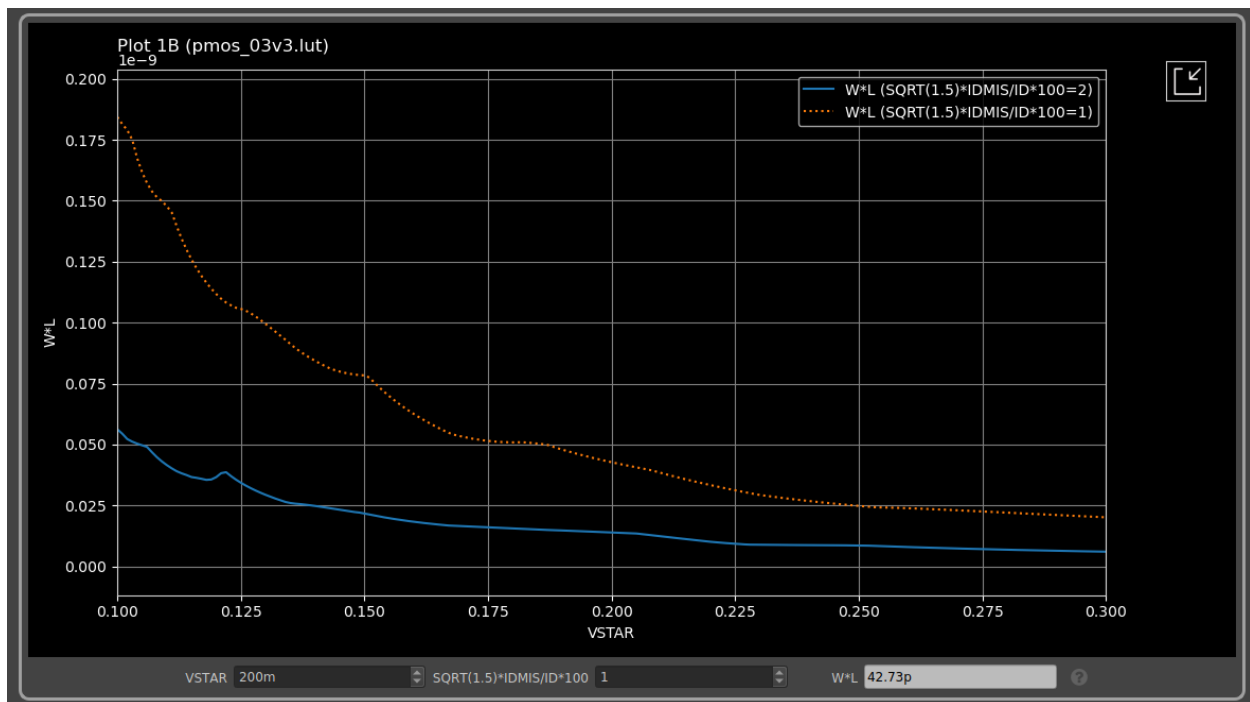
The sizing of the tail current source



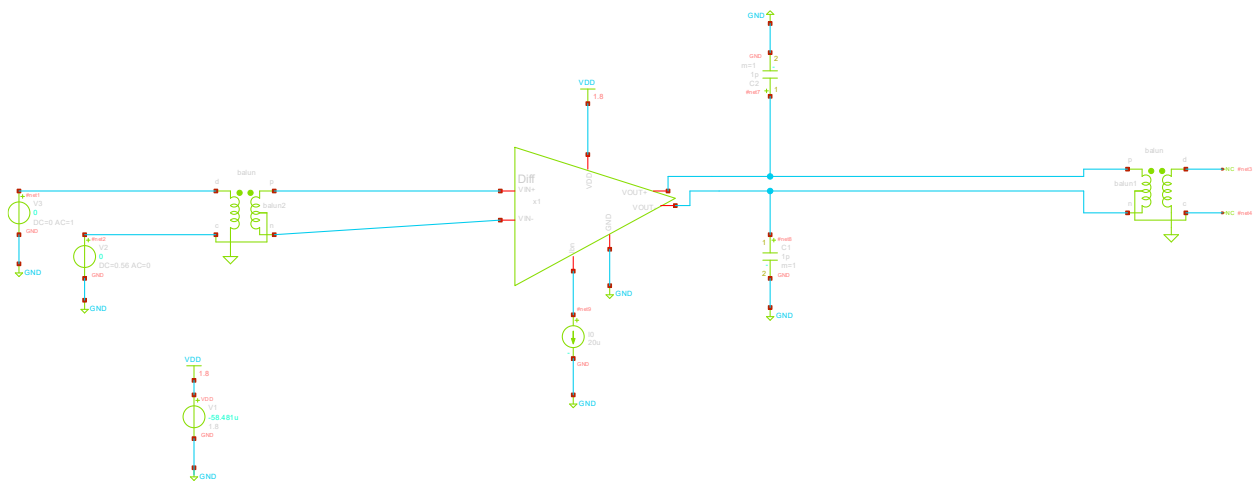
$$W_{tail} = 22.55\mu m$$

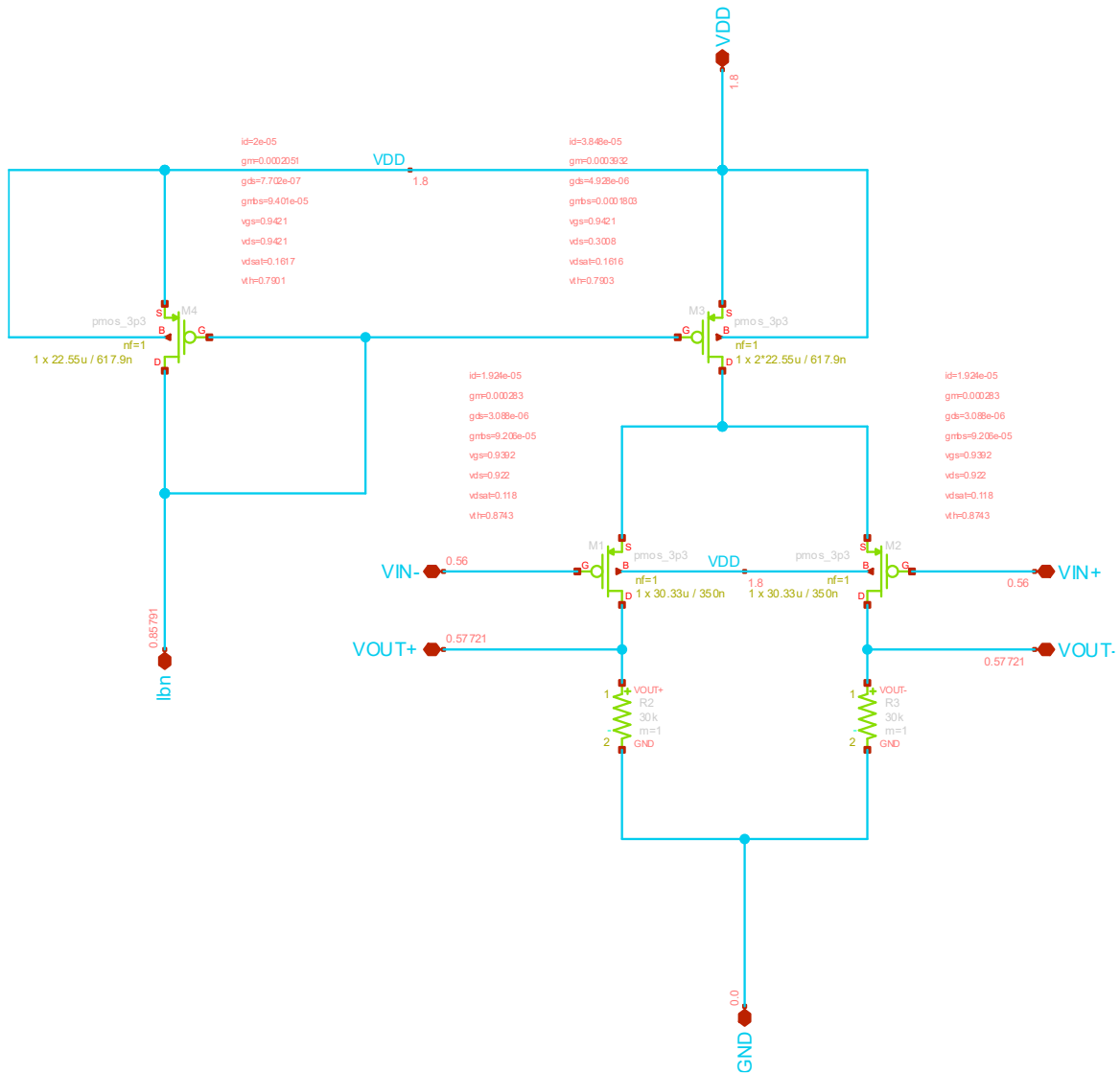
$$L_{tail} = 617.9nm$$





Part 2: Differential Amplifier Simulation



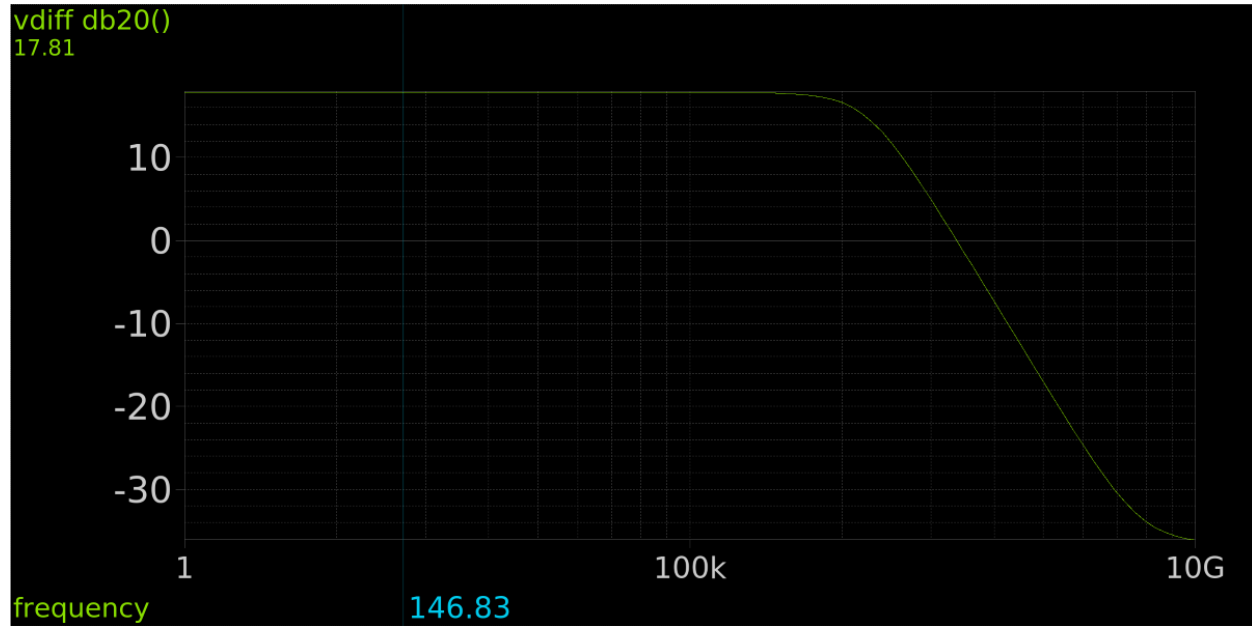


Transistor	V_{ds}	V_{dsat}	Region
M1	0.922	0.118	Saturation
M2	0.9392	0.118	Saturation
M3	0.3008	0.1616	Saturation
M4	0.9421	0.1617	Saturation

Diff small signal ccs

`bw = 5.678329e+06`

`diffgain_db = 1.780926e+01`



$$Gain = g_{m1}(r_{o1} // R)$$

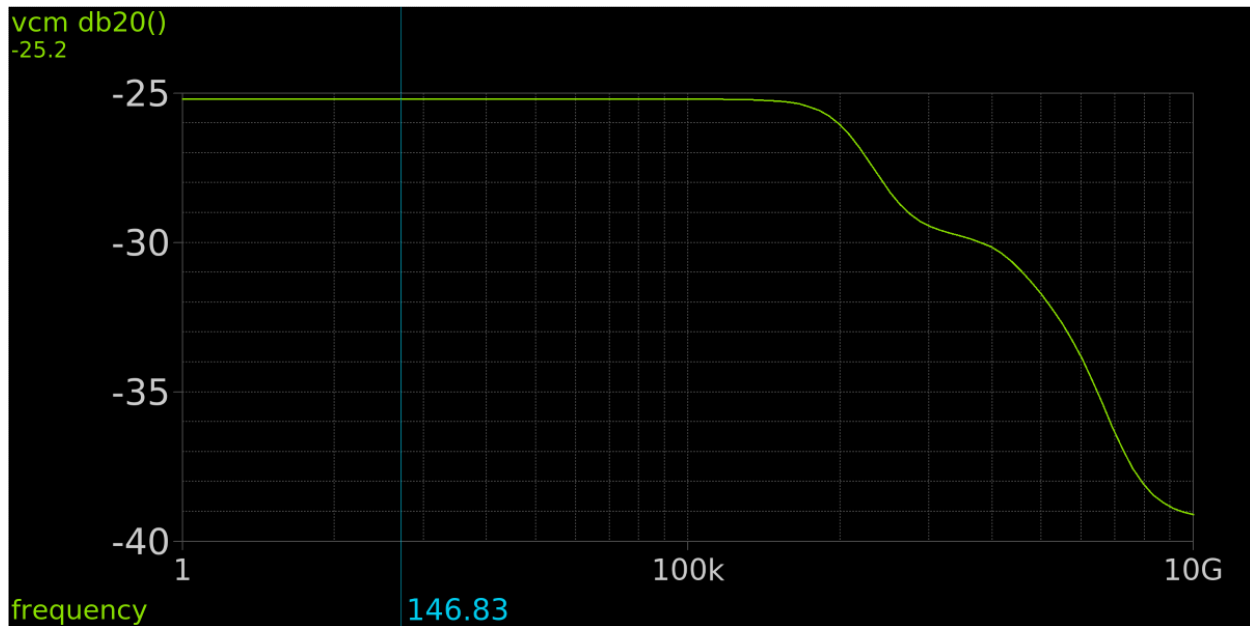
Gain=7.4 , gain=17.4 dB

$$BW = \frac{1}{2\pi R_{out} C_L}, C_L = 1pF, R_{out} = (r_{o1} // R)$$

BW=5.79MHz

CM small signal ccs

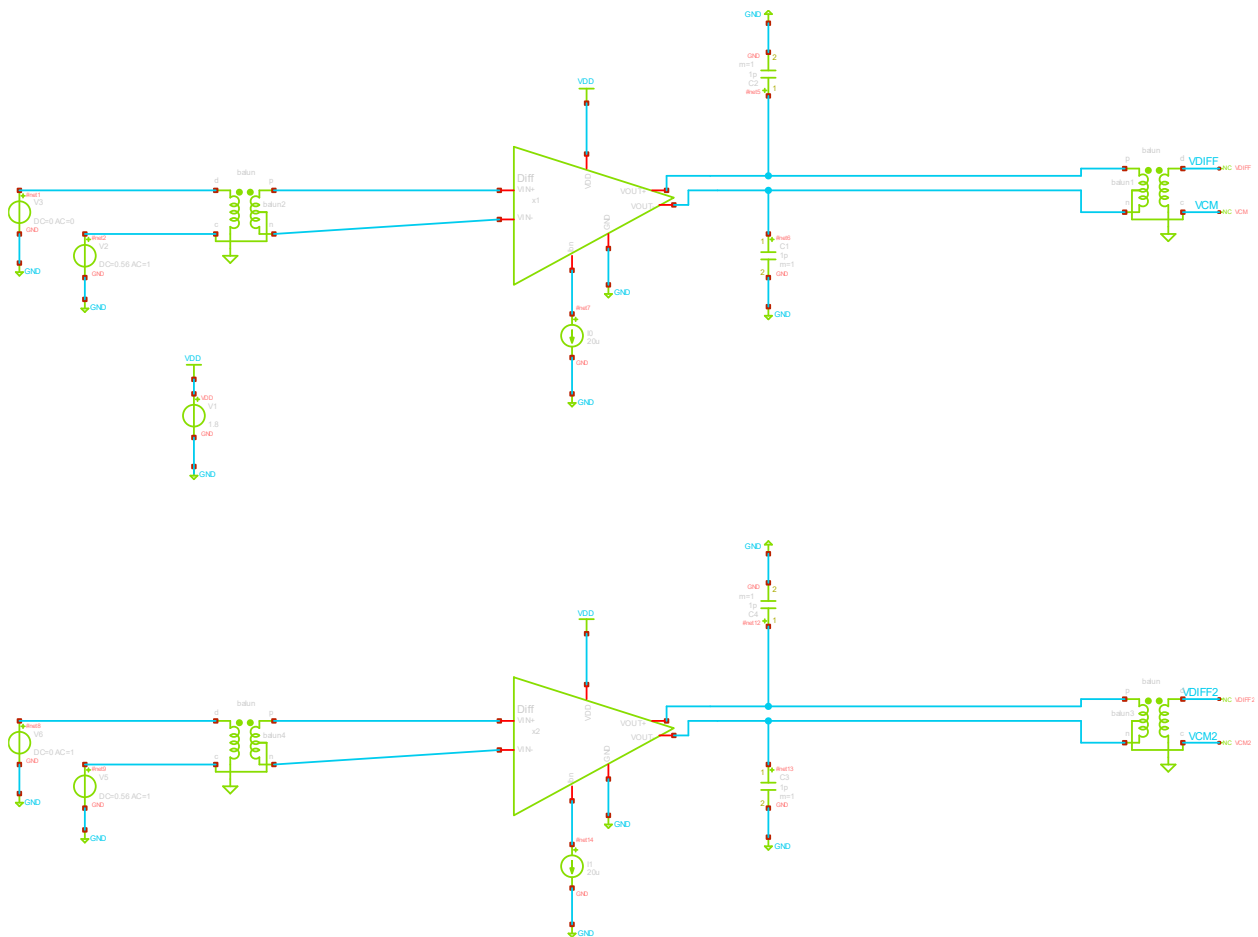
cmgain db = -2.52033e+01



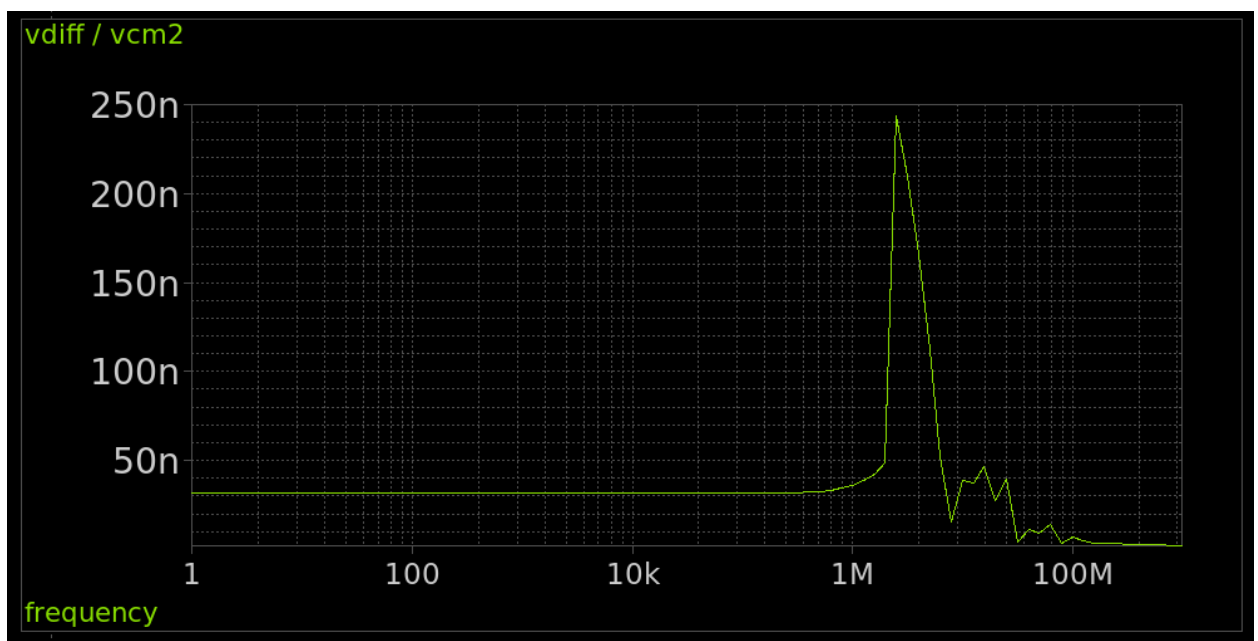
$$Gain = \frac{g_{m_1}}{1 + (g_{m_1} + g_{mb_1})r_{o3}} (r_{o1} // R)$$

Gain=-0.0507 , gain=-25.9dB

Comment: The common-mode typically increases at low frequencies due to the high impedance of the current source tail, ideally rejecting common-mode signals. However, as frequency increases, parasitic capacitances start to dominate. These capacitances shunt part of the common-mode signal to ground, reducing the effectiveness of common-mode rejection. Additionally, the tail current source exhibits finite output impedance, which decreases with frequency, further degrading common-mode rejection.

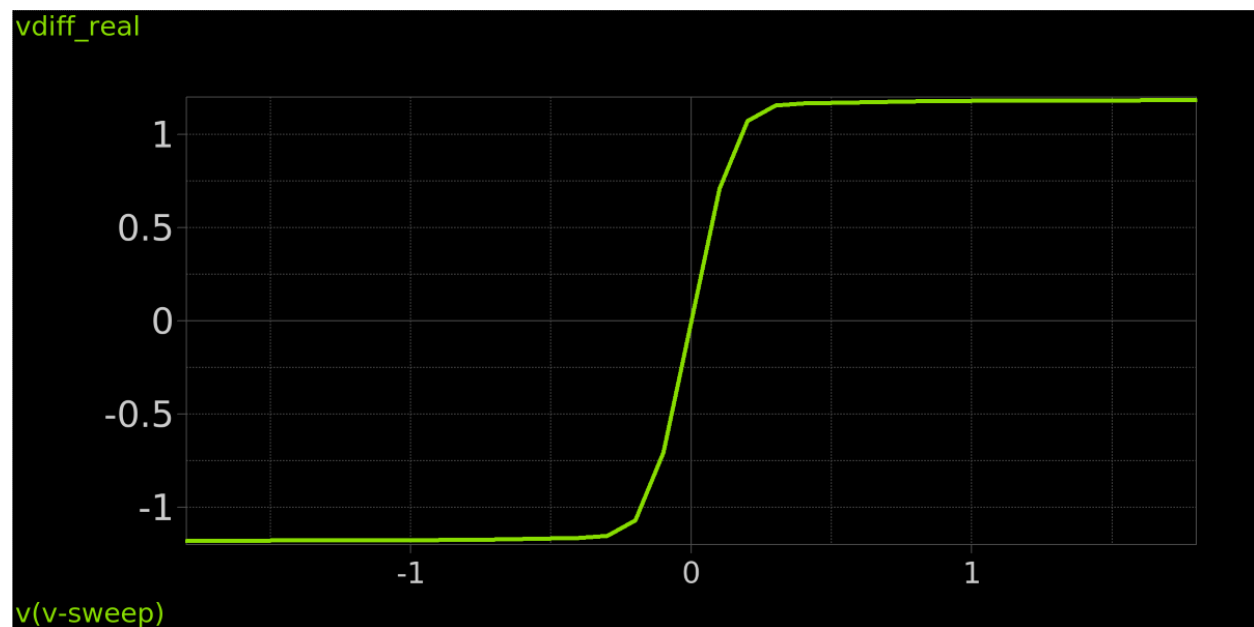
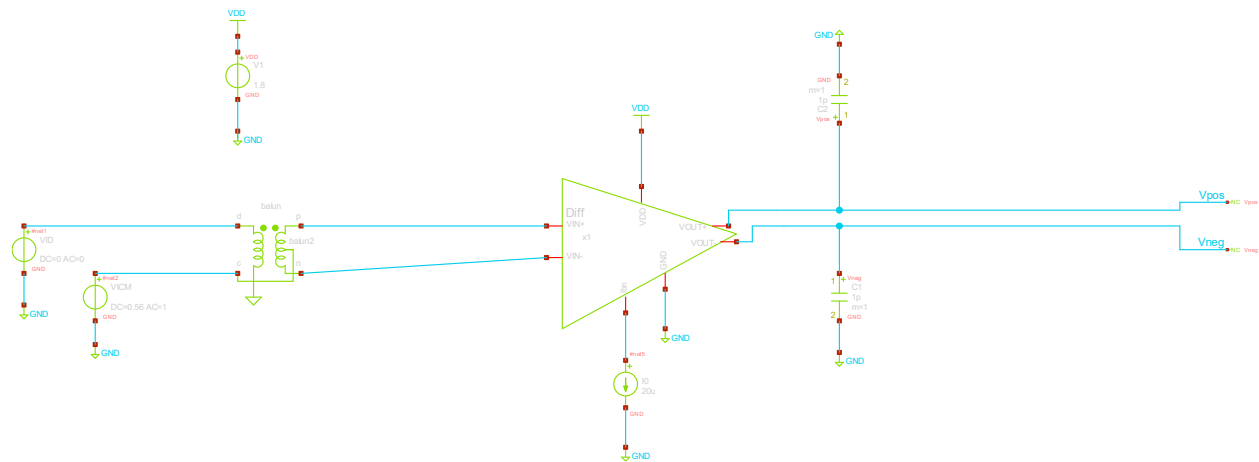


cmrr_db = 4.301253e+01



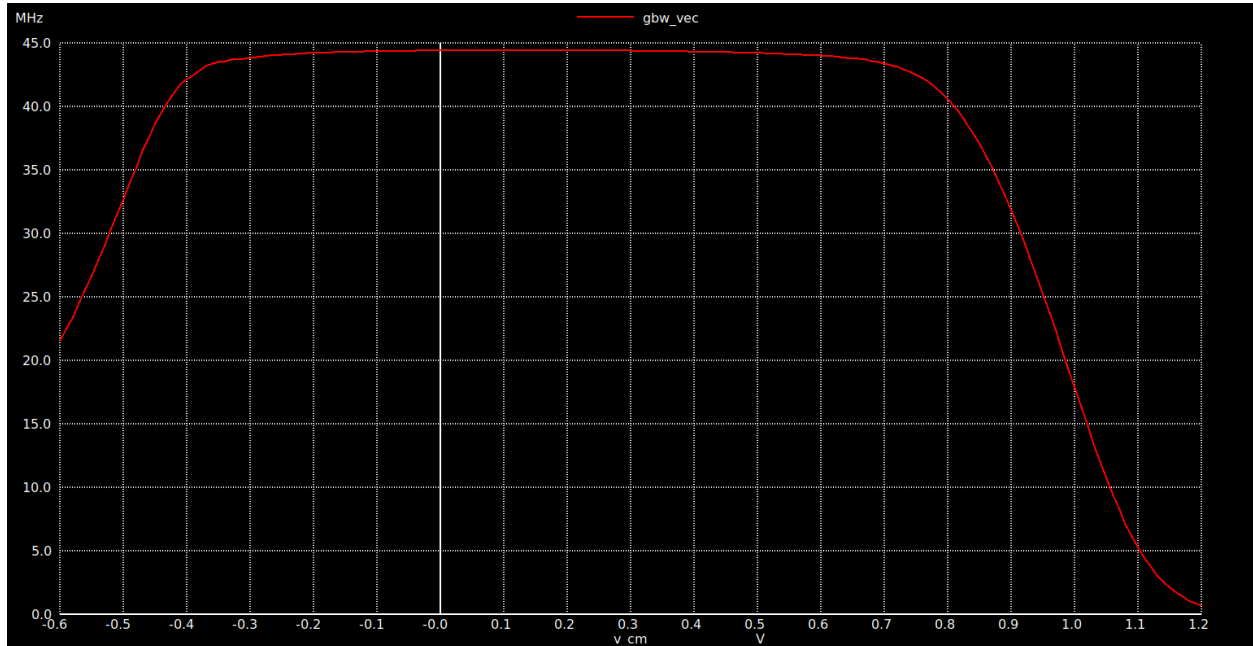
Comment: The ratio CMRR, typically decreases with increasing frequency. This is because CMRR is proportional to the impedance of the current source, r_{o3} which ideally presents a high impedance to suppress common-mode signals. However, at higher frequencies, the parasitic capacitance across the current source becomes significant, effectively shunting and reducing its impedance. As a result, the circuit becomes less effective at rejecting common-mode signals, leading to a decrease in $A_{v_{cm}}$, and thus a drop in CMRR

Diff large signal ccs



CM large signal ccs (GBW vs Vicm)

```
vcm_min = -4.30000e-01  
vcm_max = 8.10000e-01
```



Calculating $V_{cm_{min}}$ and $V_{cm_{max}}$ *analytically*

$$V_{cm_{min}} = V_{DD} - V^* - V_{gs_{3,4}}$$

$$V_{cm_{min}} = 0.6579V$$

$$V_{cm_{max}} = V_{RD} - V_{th_{1,2}}$$

$$V_{cm_{max}} = -0.2743V$$