

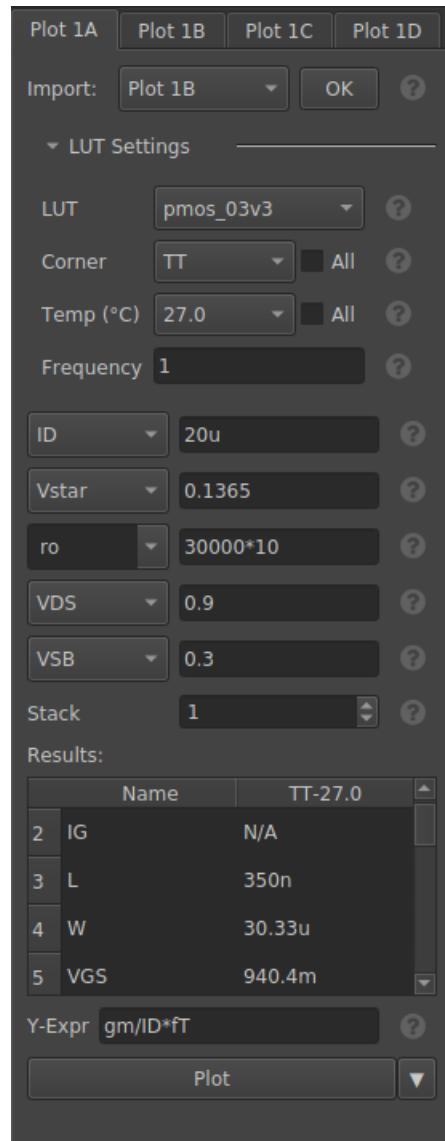
ITI
LAB 06
Differential Amplifier

Contents

Part 1: Differential Amplifier Design	2
Part 2: Differential Amplifier Simulation	5
Diff small signal ccs.....	7
CM small signal ccs	8
Diff large signal ccs	10
CM large signal ccs (GBW vs Vicm).....	11
Calculating V_{cmmin} and V_{cmmax} analytically	11

Part 1: Differential Amplifier Design

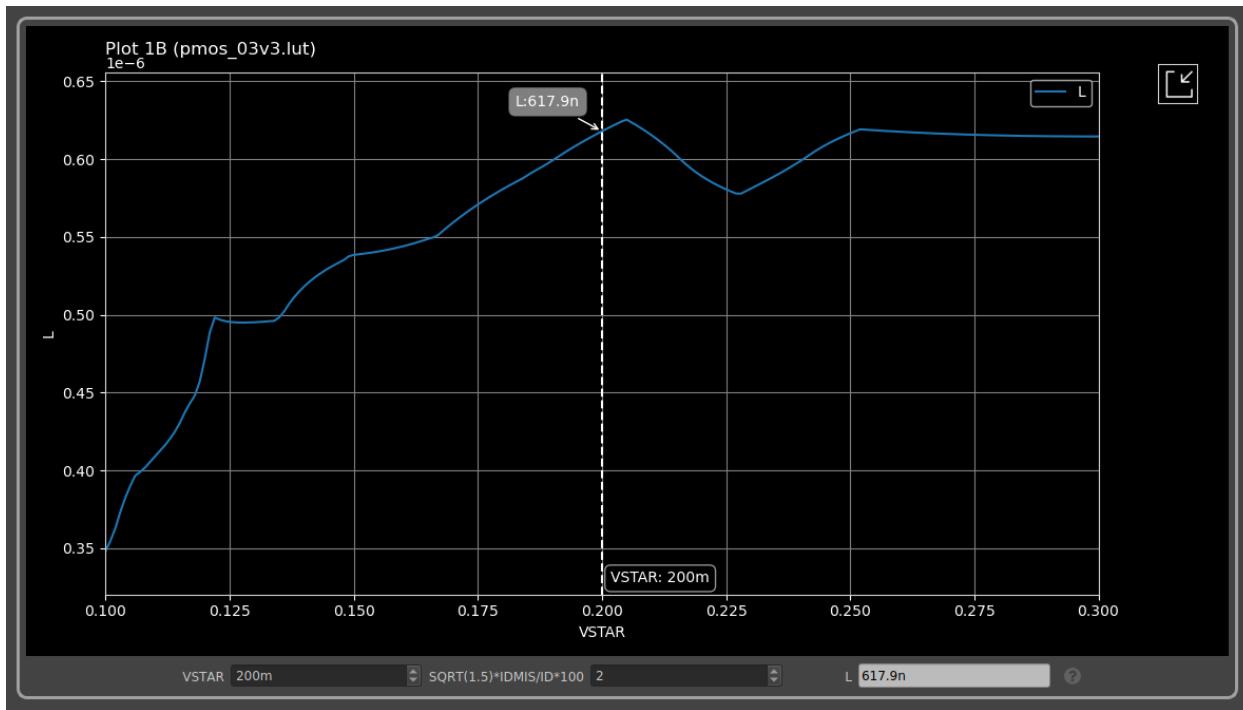
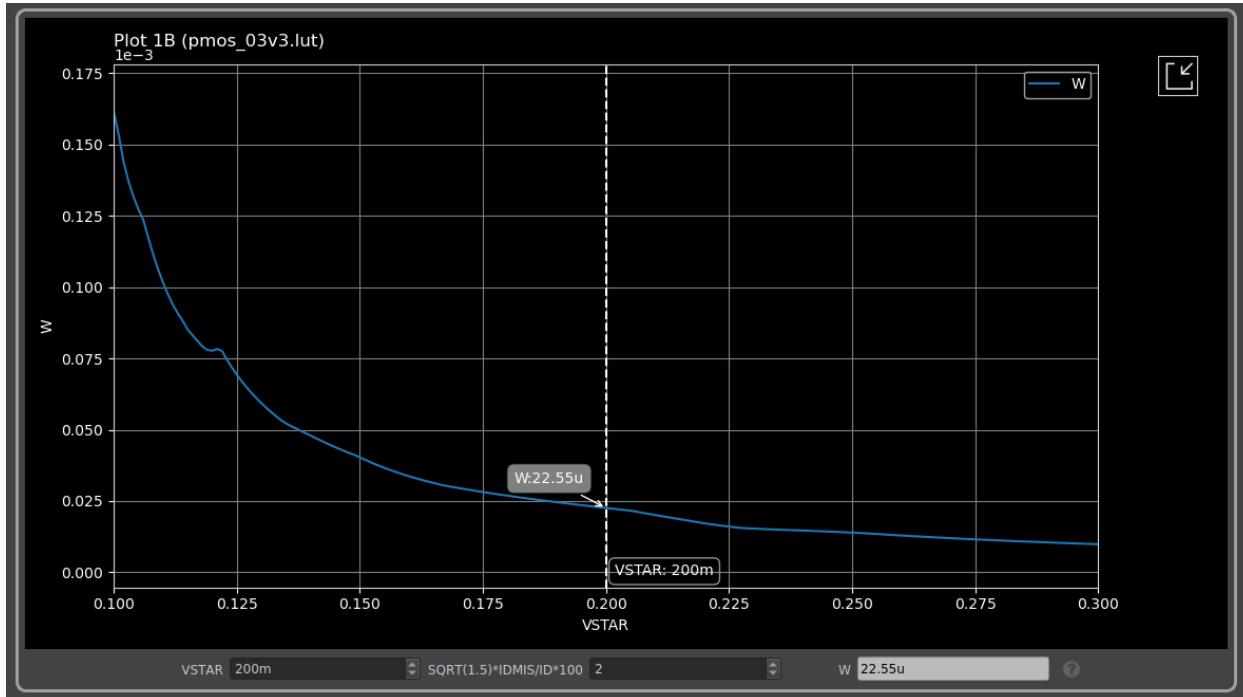
The sizing of the transistors



$$W = 30.33\mu m$$

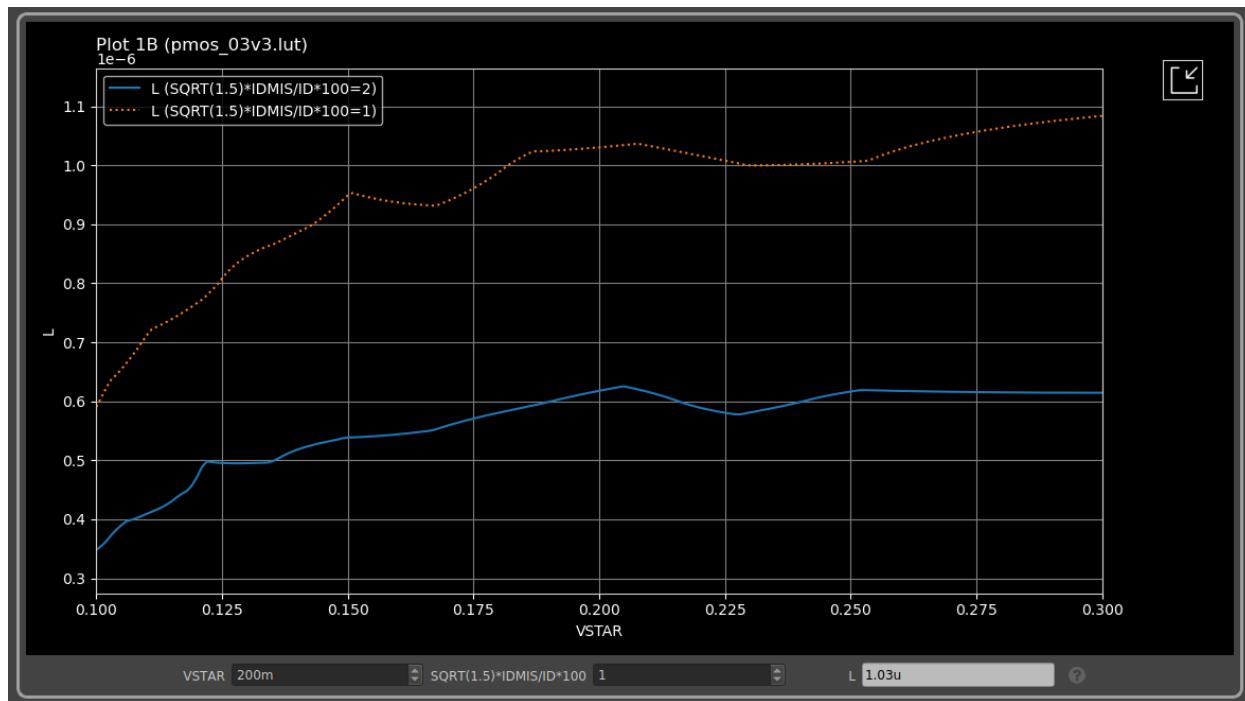
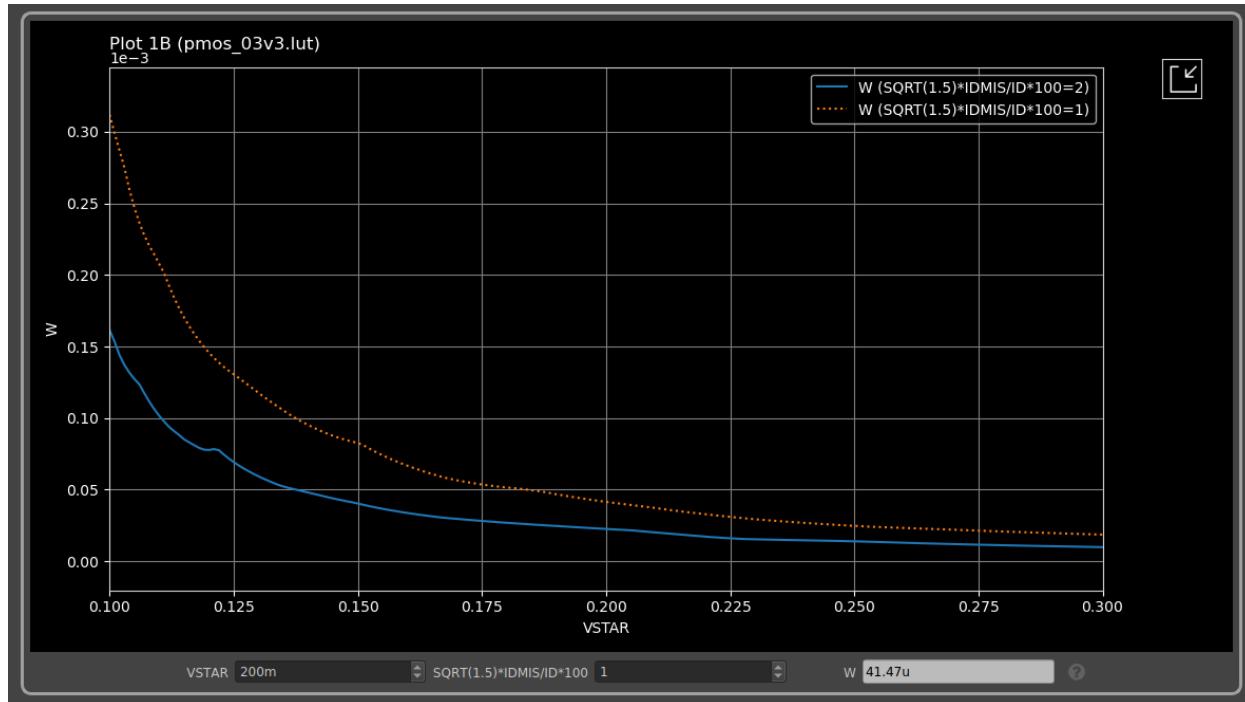
$$L = 350nm$$

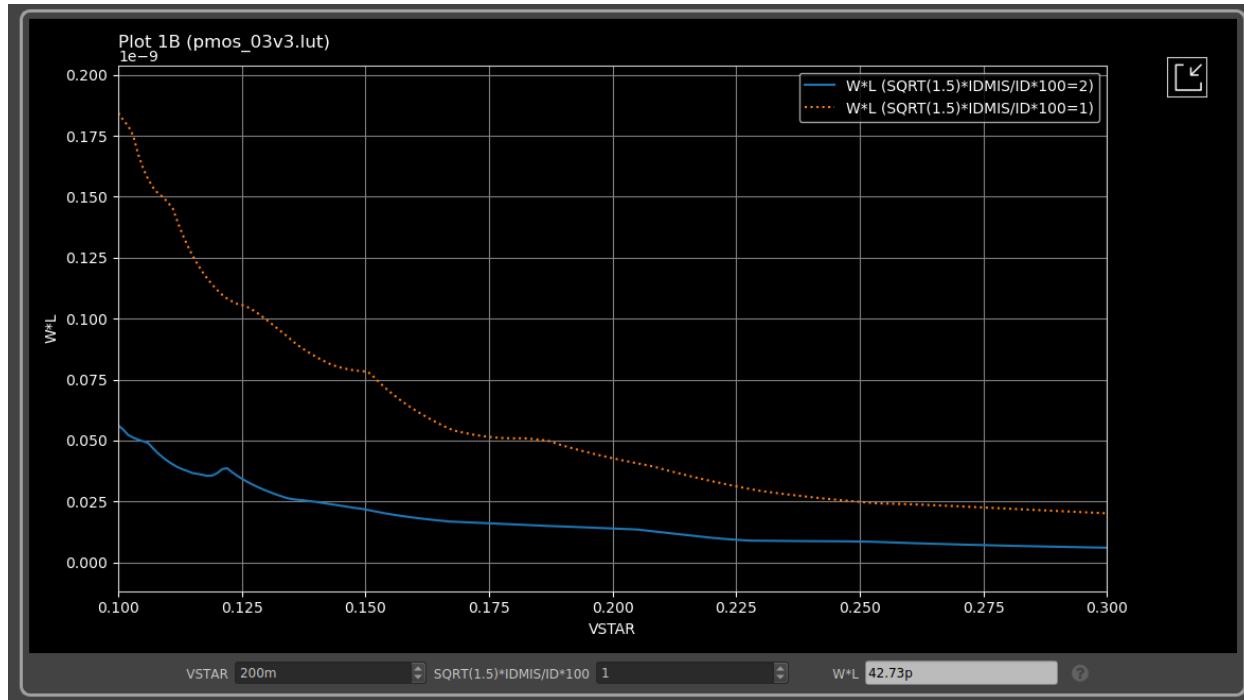
The sizing of the tail current source



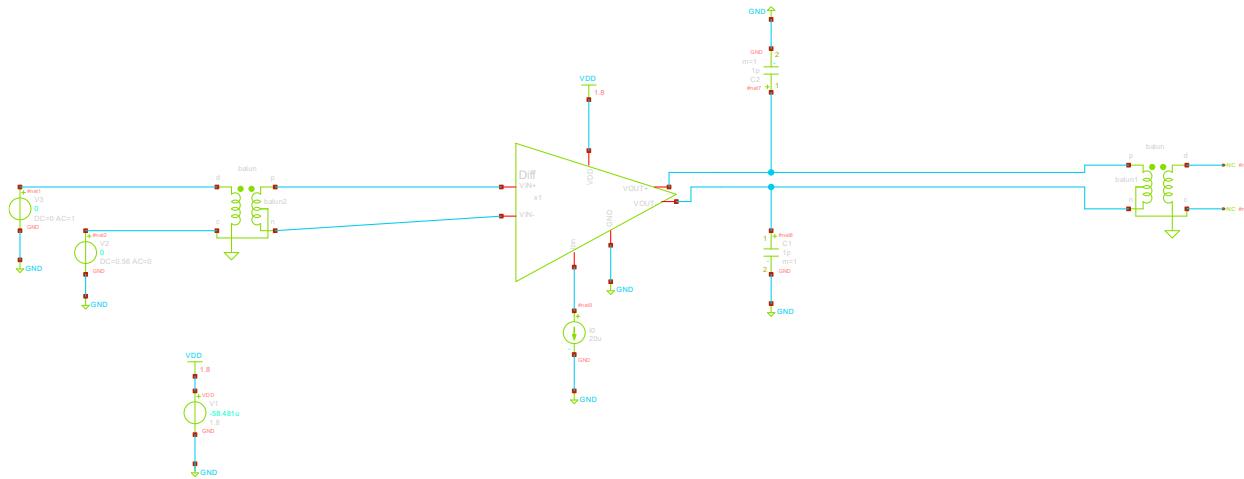
$$W_{tail} = 22.55 \mu m$$

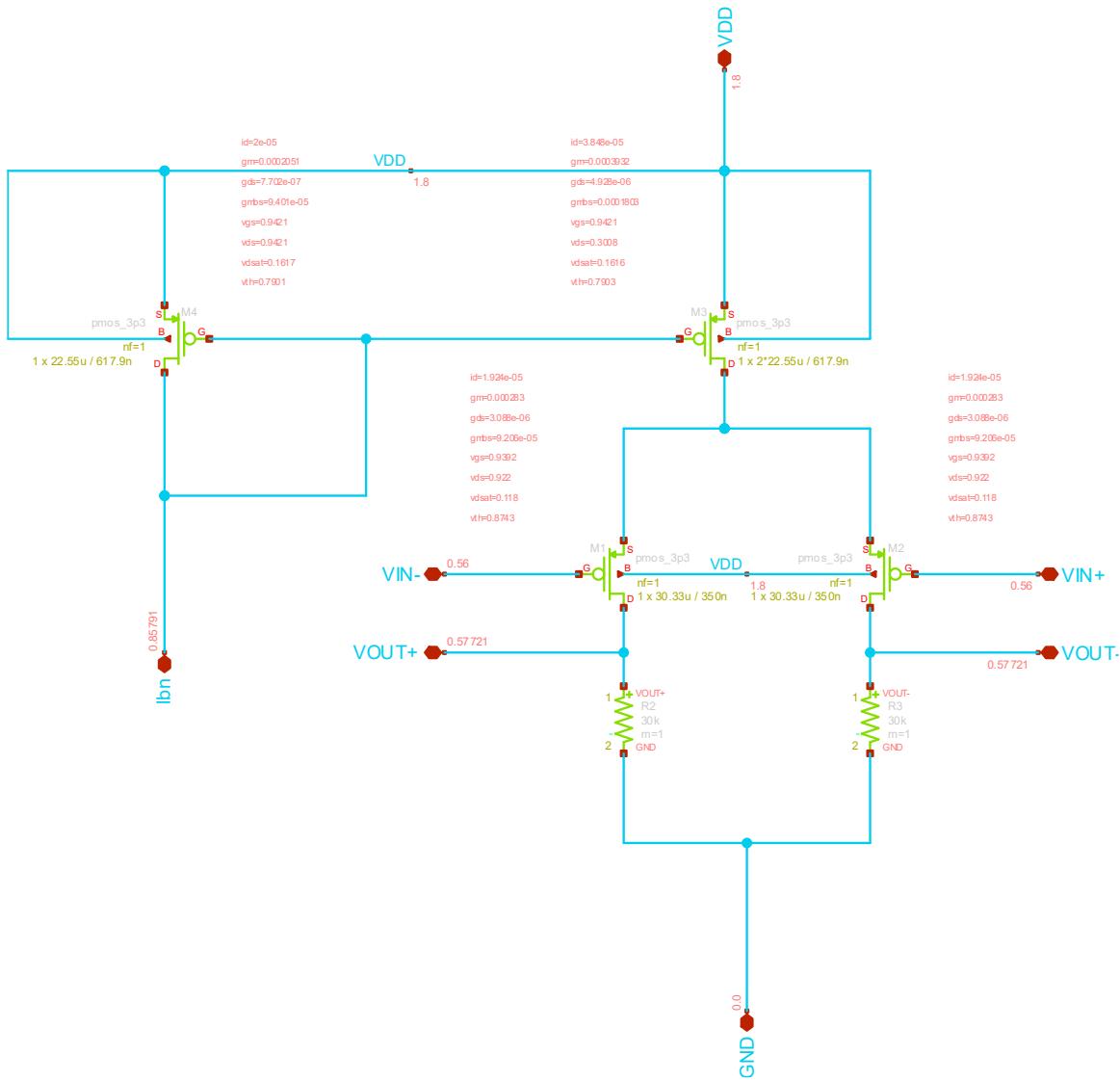
$$L_{tail} = 617.9 nm$$





Part 2: Differential Amplifier Simulation



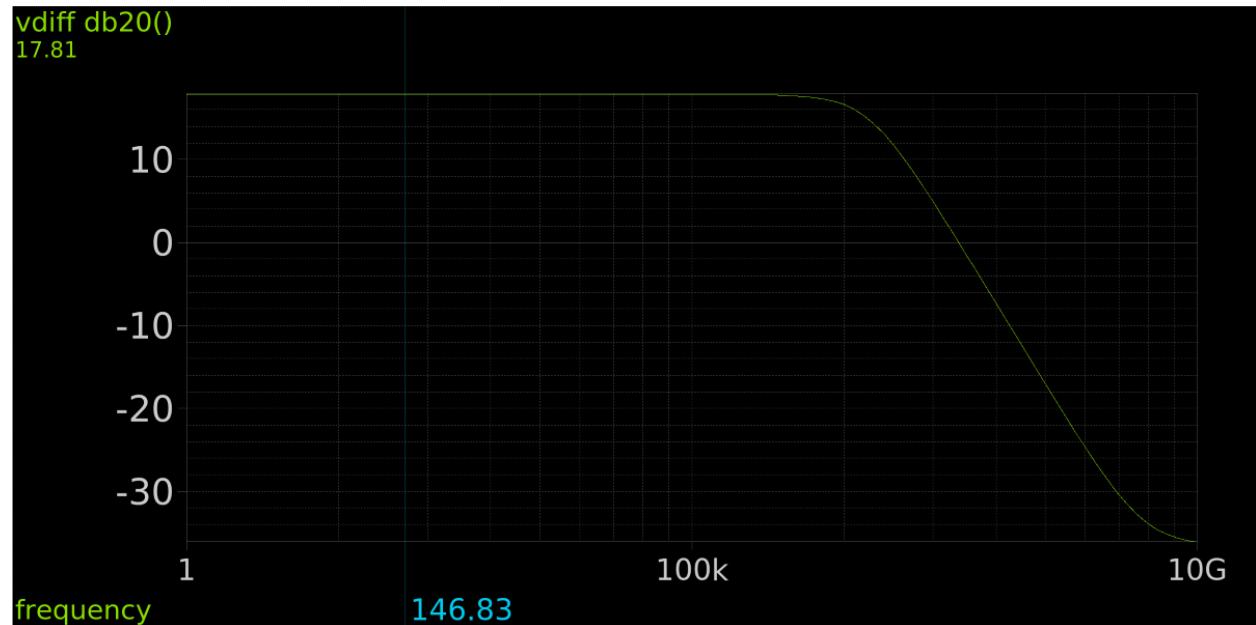


Transistor	Vds	Vdsat	Region
M1	0.922	0.118	Saturation
M2	0.9392	0.118	Saturation
M3	0.3008	0.1616	Saturation
M4	0.9421	0.1617	Saturation

Diff small signal ccs

bw = 5.678329e+06

diffgain_db = 1.780926e+01



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

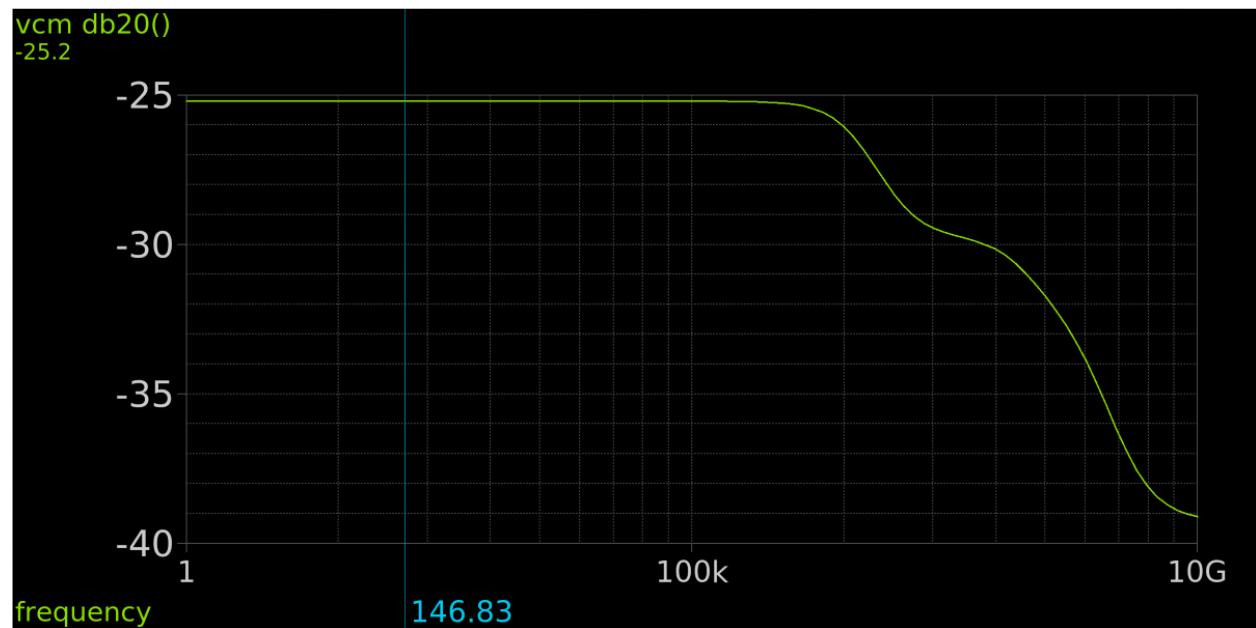
Gain=7.4 , gain=17.4 dB

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

BW=5.79MHz

CM small signal ccs

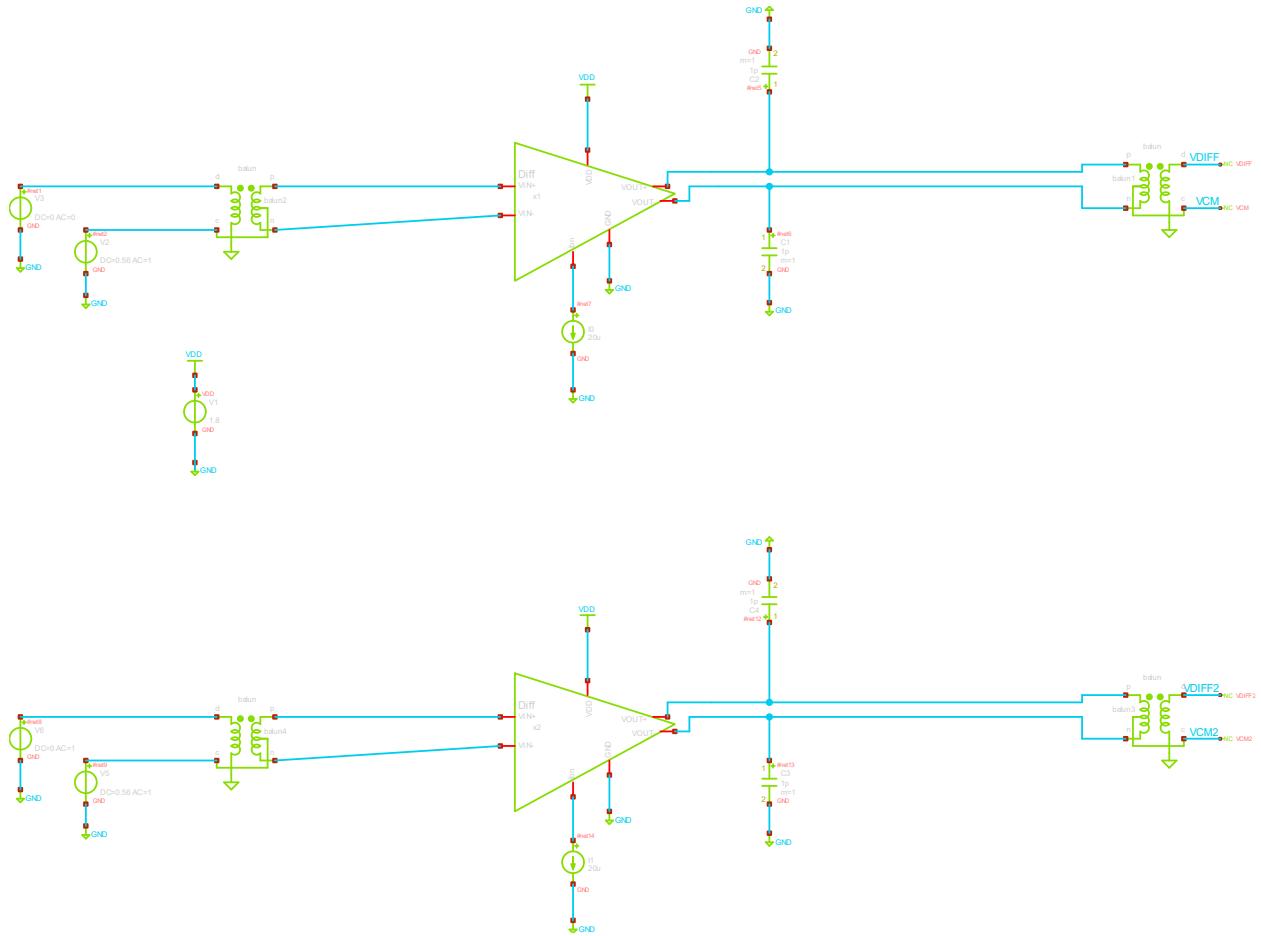
```
cmgain db = -2.52033e+01
```



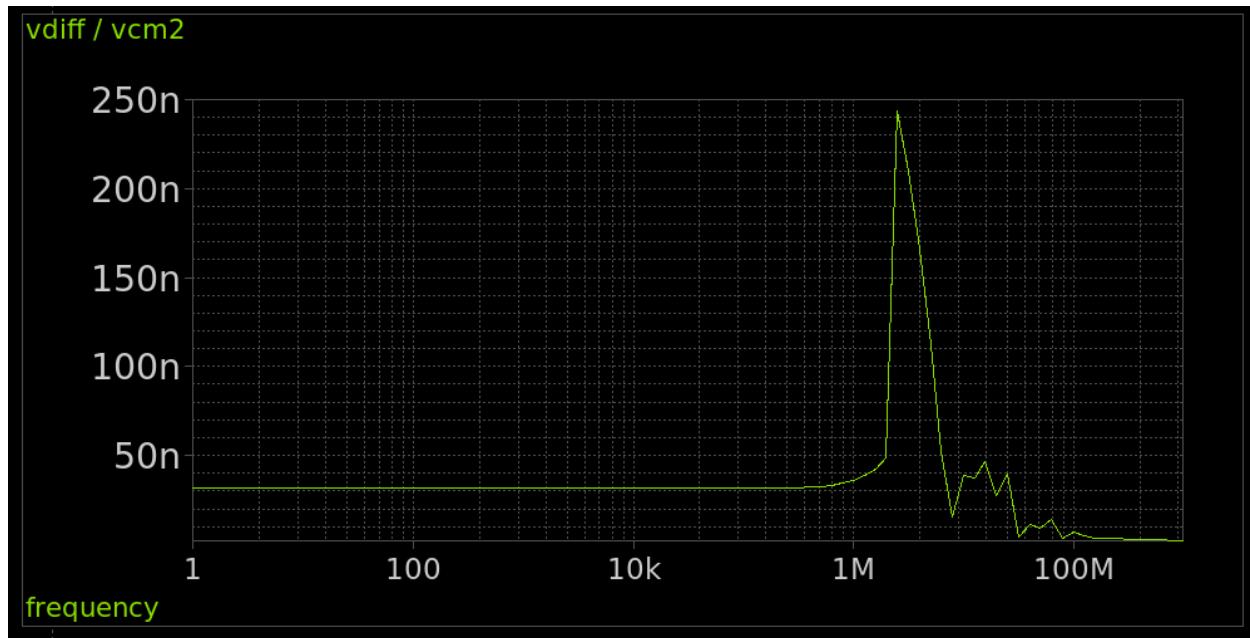
$$Gain = \frac{g_{m_1}}{1 + (g_{m_1} + g_{mb_1})r_{o3}} (r_{o1}/R)$$

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.

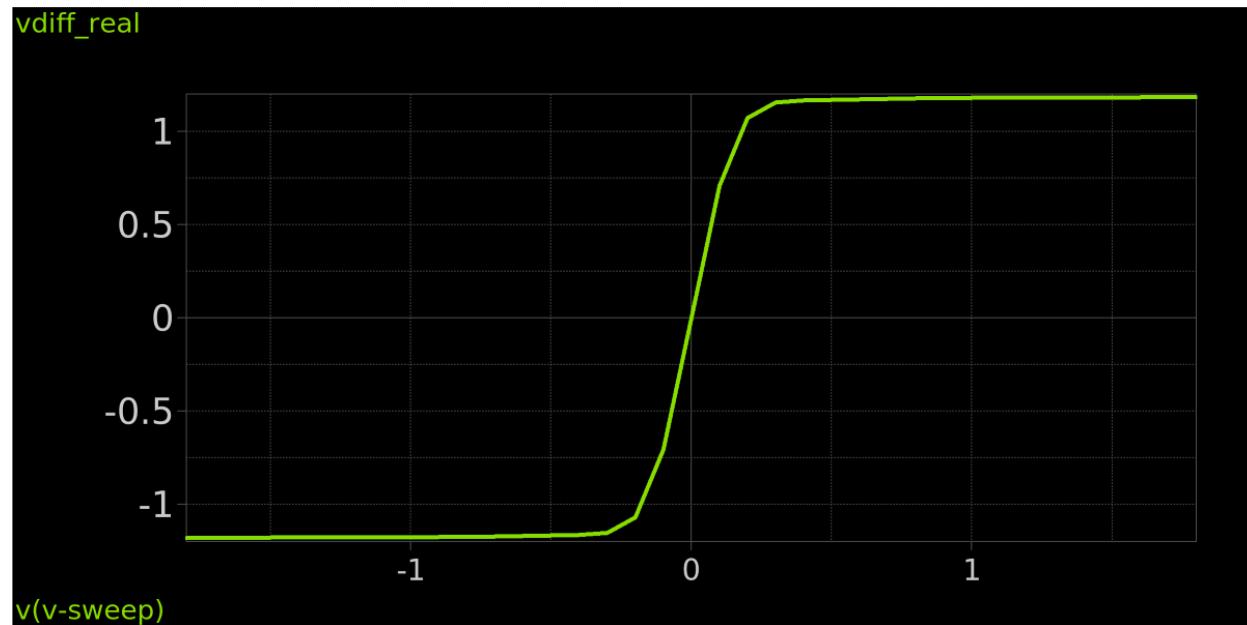
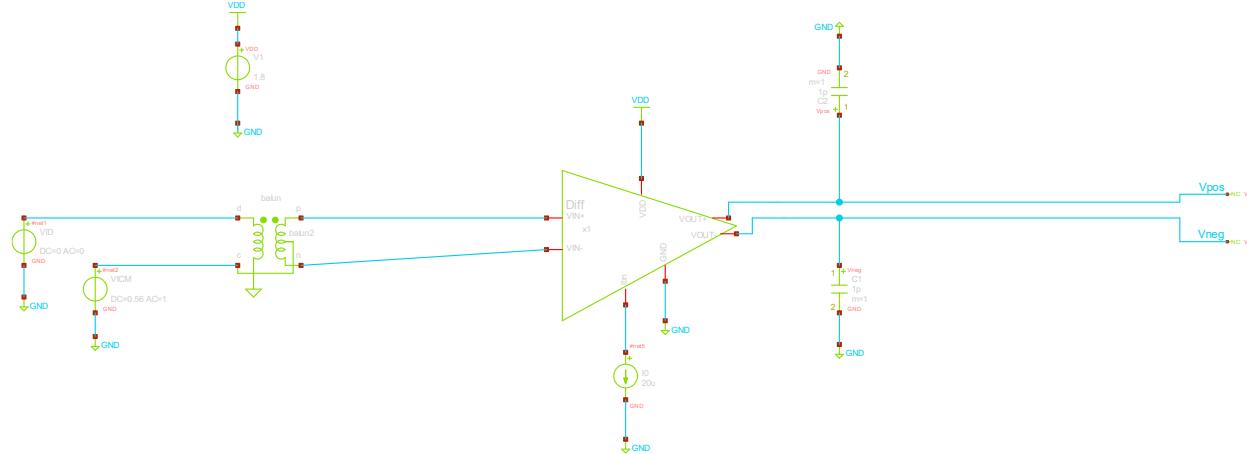


`cmrr_db = 4.301253e+01`



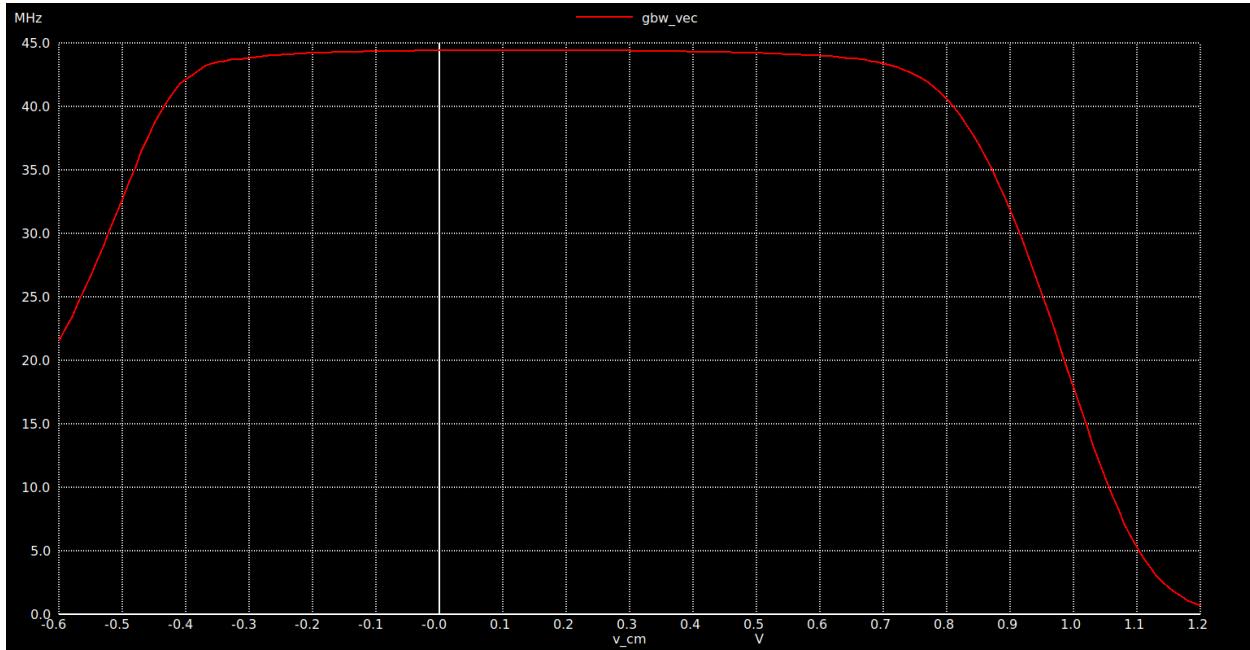
Comment: The ratio CMRR, typically decreases with increasing frequency. This is because CMRR is proportional to the impedance of the current source, r_{o3} which ideally presents a high impedance to suppress common-mode signals. However, at higher frequencies, the parasitic capacitance across the current 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

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

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

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

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