

Lab 6

Part 1: Sizing Chart

RD & V* Calculation

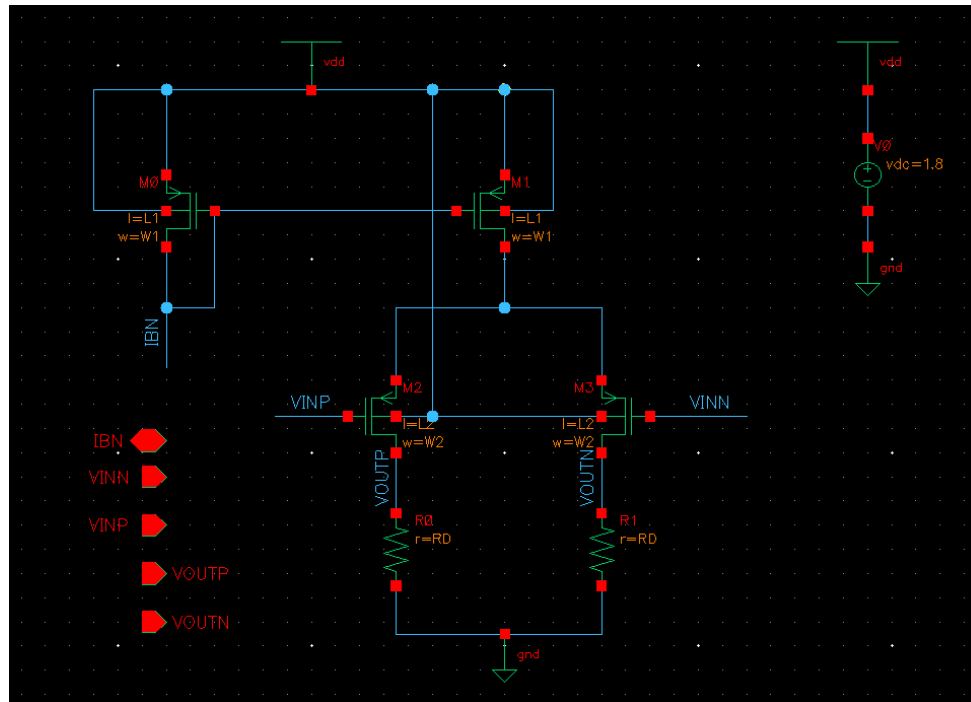
$$I_{SS}RD = 2V_{out} - CM \quad \rightarrow \quad RD = \frac{2(1.8)}{3(40\mu)} = 30k\Omega$$

$$V^* = 1.82(0.6)/8 = 136.5mV$$

The screenshot shows the ADT Sizing Assistant window. It has a red title bar with the text "ADT Sizing Assistant" and standard window controls. Below the title bar are "Settings" and "Help" buttons. A "LUT Settings" section is expanded, showing "LUTs Directory" with a text field containing "ser01/projects/ADT/ex_LUTs/" and a browse button. Below this are dropdown menus for "LUT" (set to "pch"), "Corner" (set to "tt"), and "Temp (°C)" (set to "27.0"). There is a "State1" dropdown and a "Save State" button. A series of dropdown menus and text fields are listed: "ID" (20u), "Vstar" (136.5m), "ro" ((0.6/ID)*10), "VDS" (0.9), "VSB" (0.3), and "Stack" (1). Below these are "Get" and "Apply" buttons. A "Y-Expr" field contains the expression "sqrt(W*L*1e12)*gm/ID*100". At the bottom are "Plot", "Replace", and "Append" buttons. A "Device Parameters" section contains a table with 4 columns: "#", "Parameter", "Value", and an empty column. The table has 4 rows of data.

#	Parameter	Value	
1	ID	20u	
2	L	420n	
3	W	15.88u	
4	VGS	643.3m	

Schematic



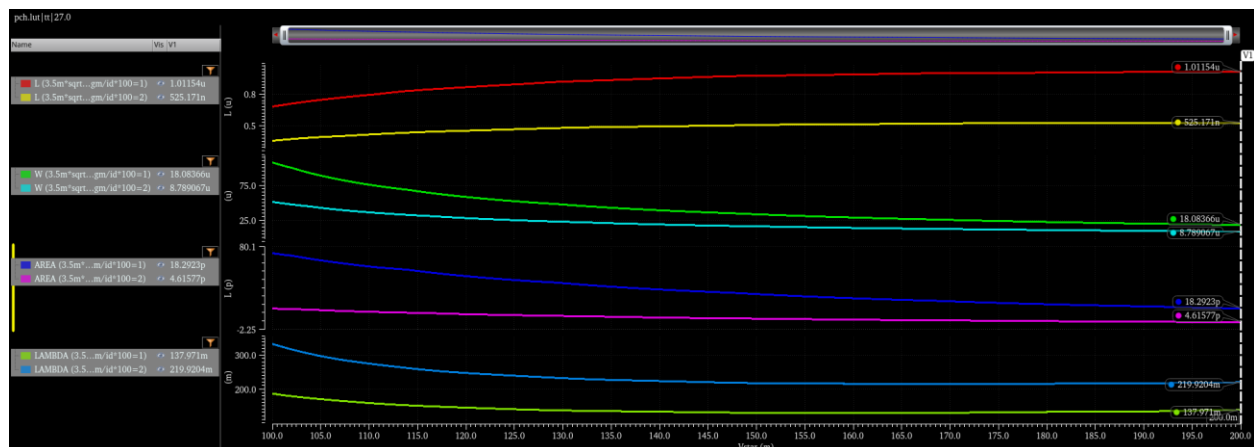
CM Input Level

$$V_{CM_{min}} = (I_{ss}/2)(30k) - 527.4m = 72.6mV$$

$$VICM = 1.8 - 0.3 - 0.6433 = 0.857V$$

$$V_{CM_{max}} = V_{DD} - V^* - V_{GS} = 1.8 - 0.1365 - 0.6433 = 1.02V$$

Parameters Graphs

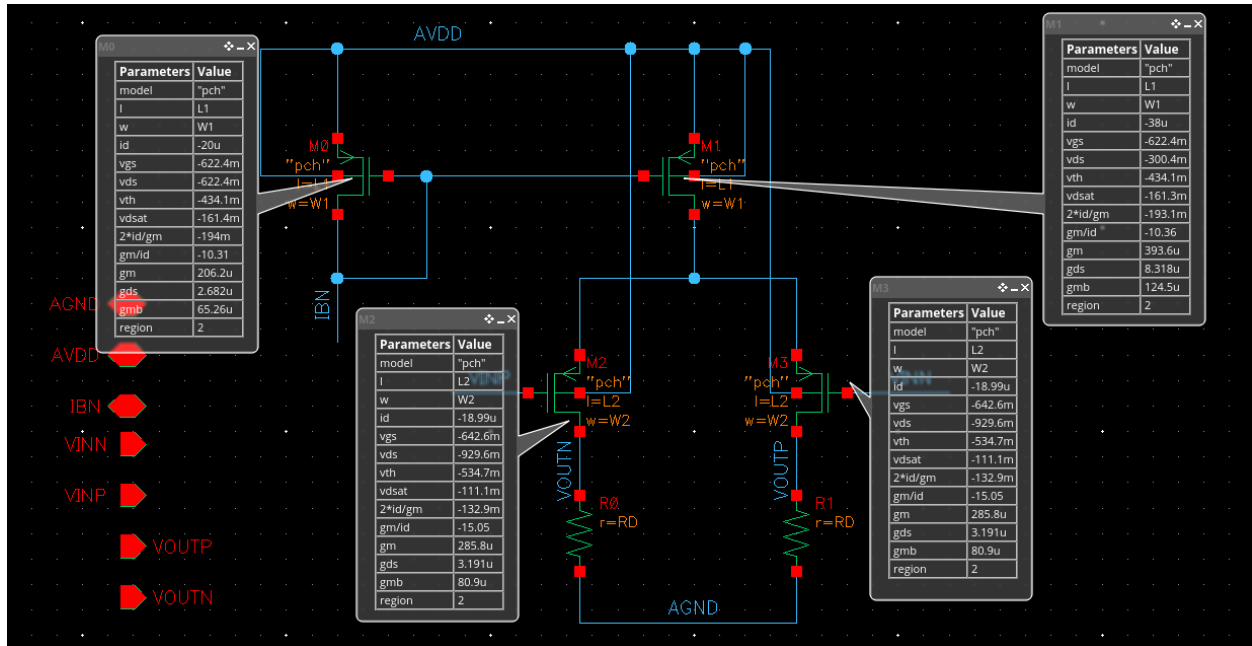


2% mismatch gives lower area, so:

$$L = 525.2nm \quad W = 8.8um$$

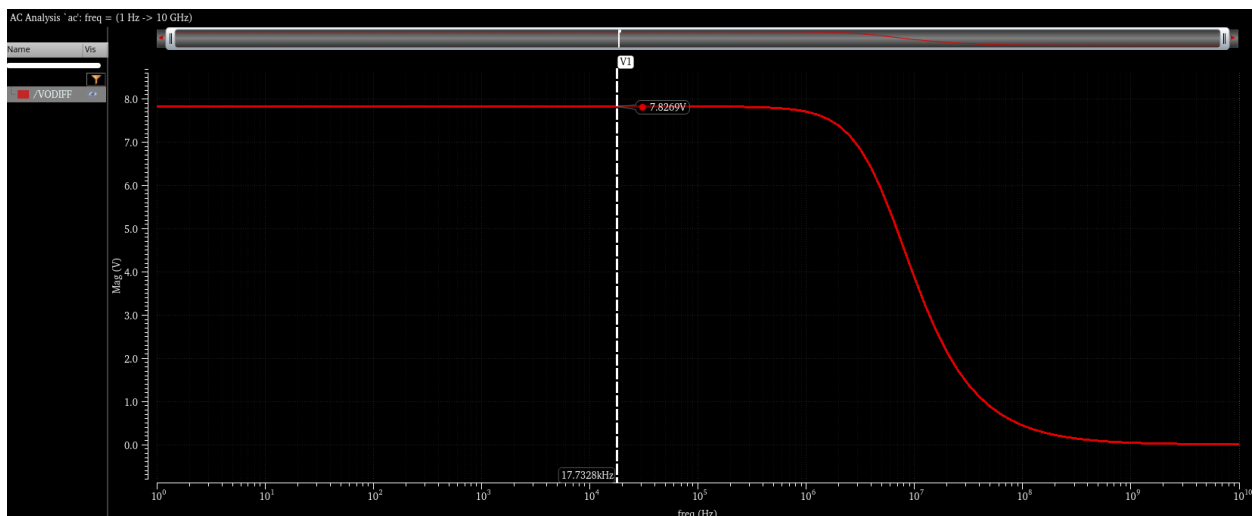
Part 2: Differential Amplifier Simulation

DC OP



Differential Small Signal

Simulation



bandwidth(mag(v1"/VODIFF" ?result ...	
Expression	Value
1 bandwidth(mag(...	5.697E6

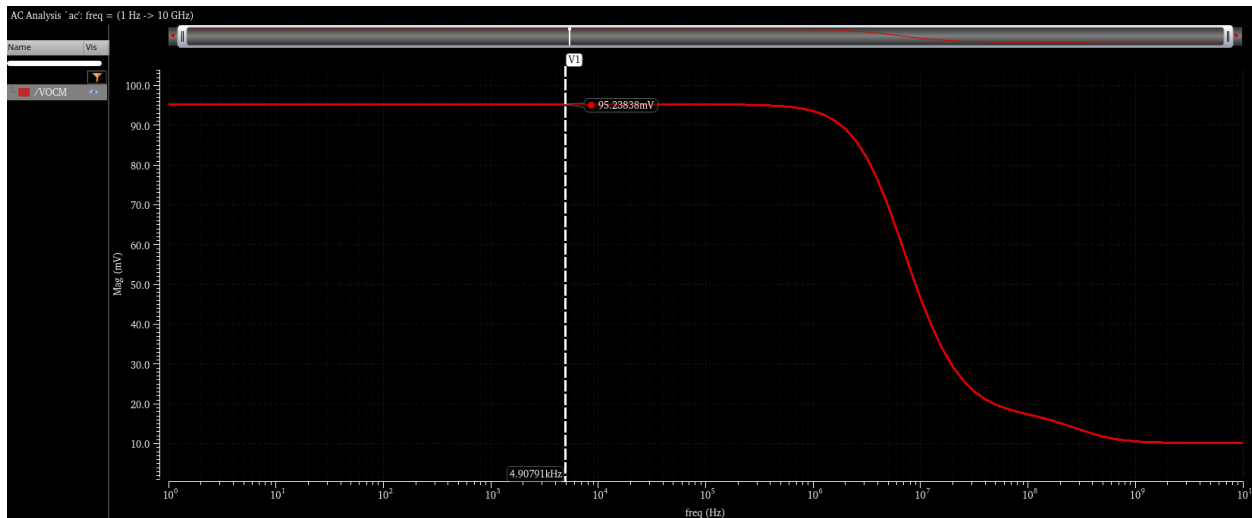
Hand Analysis

$$A_v = g_m \cdot (R_D \parallel r_o) = (285.8\mu) \cdot (30k \parallel 313.4k) = 7.825$$

$$BW = 1/[2\pi \cdot (R_D \parallel r_o) \cdot C_L] = 5.81\text{MHz (cgd is ignored in this calculation)}$$

	Simulation	Hand Analysis
Gain	7.827	7.825
Bandwidth (MHz)	5.70	5.81

CM Small Signal



Hand Analysis

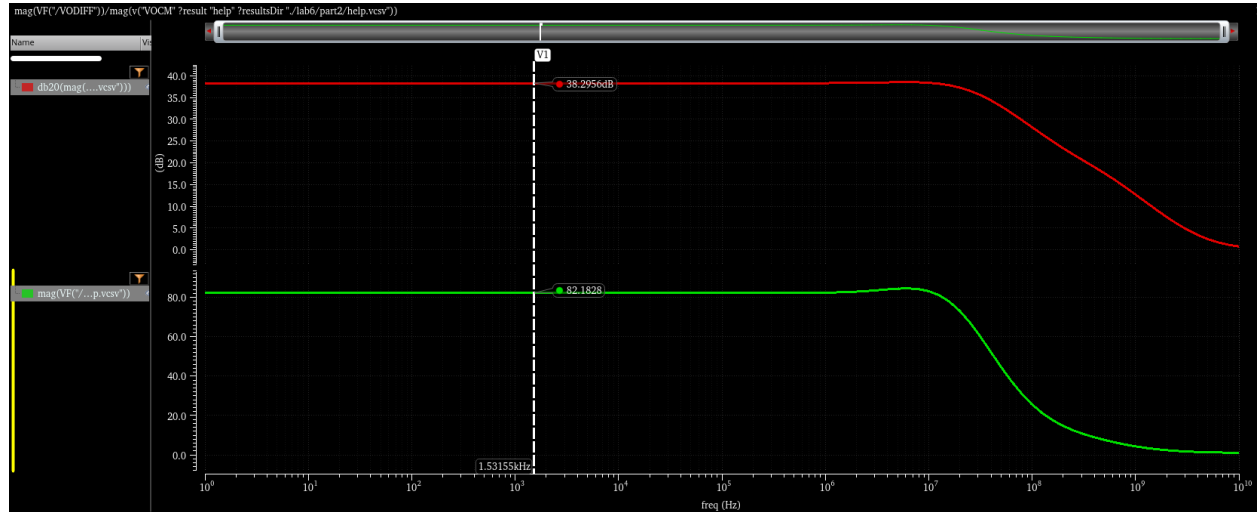
$$A_{V_{CM}} = \frac{g_m R_D}{1 + 2(g_{mb} + g_m)r_{o1}} = \frac{285.8\mu \cdot 30k}{1 + 2(80.9\mu + 285.5\mu)\left(\frac{1}{8.32\mu}\right)} = 96.2\text{m}$$

	Simulation	Hand Analysis
Gain	0.095	0.096

Comments

- Both simulated & calculated gain are attenuating ($A_{V_{CM}} \ll 1$), due to the presence of large degeneration resistance ($2 \cdot r_{o1}$).
- At higher frequency, the capacitor shunts both R_D & R_{SS} , but the effect of shunting R_{SS} reduces the common mode rejection because A_{vcm} increases.

Avd/Avcm Graph



Hand Analysis

$$A_{vd}/A_{v_{CM}} = 7.825/0.096 = 81.4$$

	Simulation	Hand Analysis
dB Gain	38.3	38.2
Gain	82.2	81.4

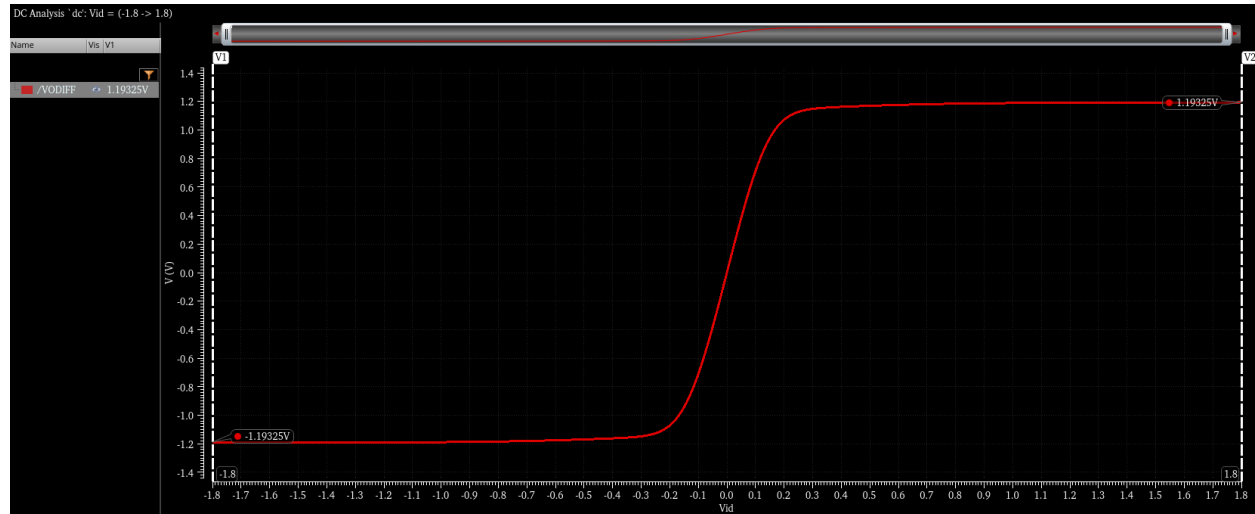
Comment:

$$CMRR = \frac{A_{vd}(s)}{A_{v_{CM2d}}(s)} \approx \left[1 + 2g_{m1,2} \left(R_{SS} \parallel \frac{1}{sC_P} \right) \right] \frac{g_{m1,2}}{\Delta g_m}$$

$$\approx \frac{1 + s \frac{C_P}{2g_{m1,2}}}{1 + sR_{SS}C_P} \cdot 2g_{m1,2}R_{SS} \frac{g_{m1,2}}{\Delta g_m}$$

There is a pole at $\frac{1}{r_{o1} \cdot C_L}$ causing -20dB per decade, followed by a zero at $\frac{2gm}{C_L}$ causing a +20dB per decade.

Diff Large Signal ccs



Hand Analysis

$$V_{\max} = -V_{\min} = I_{SS} \cdot R_D = (40\mu)(30k) = 1.2V$$

	Simulation	Hand Analysis
Vmax	1.19V	1.20V
Vmin	-1.19V	-1.20V

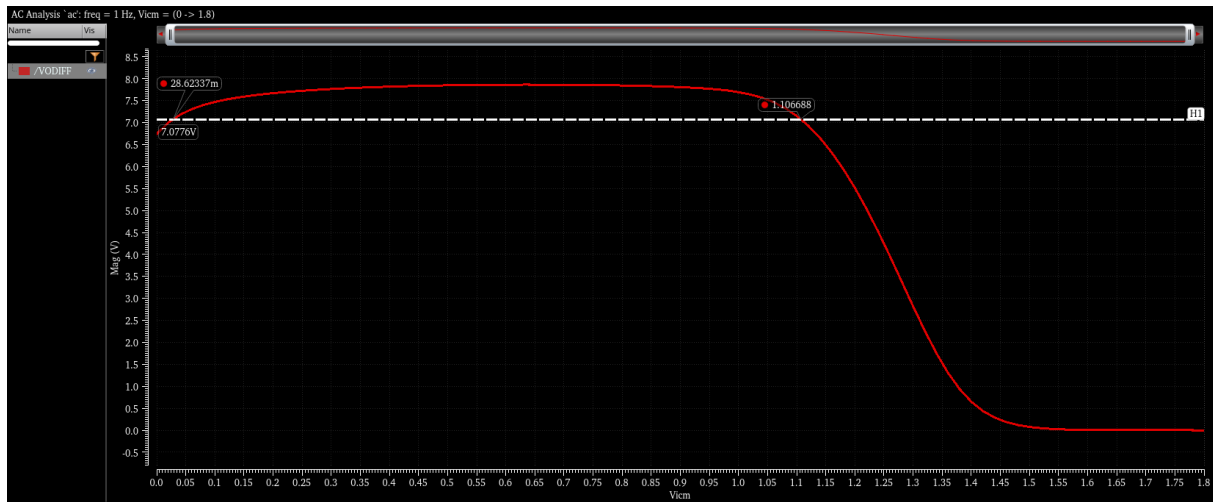
CM Large Signal (Region vs VICM)



Hand Analysis

	Simulation	Hand Analysis
$V_{CM_{min}}$ (V)	0	0.0726
$V_{CM_{max}}$ (V)	1.04	1.02
$V_{CM_{IR}}$ (V)	1.04	0.95

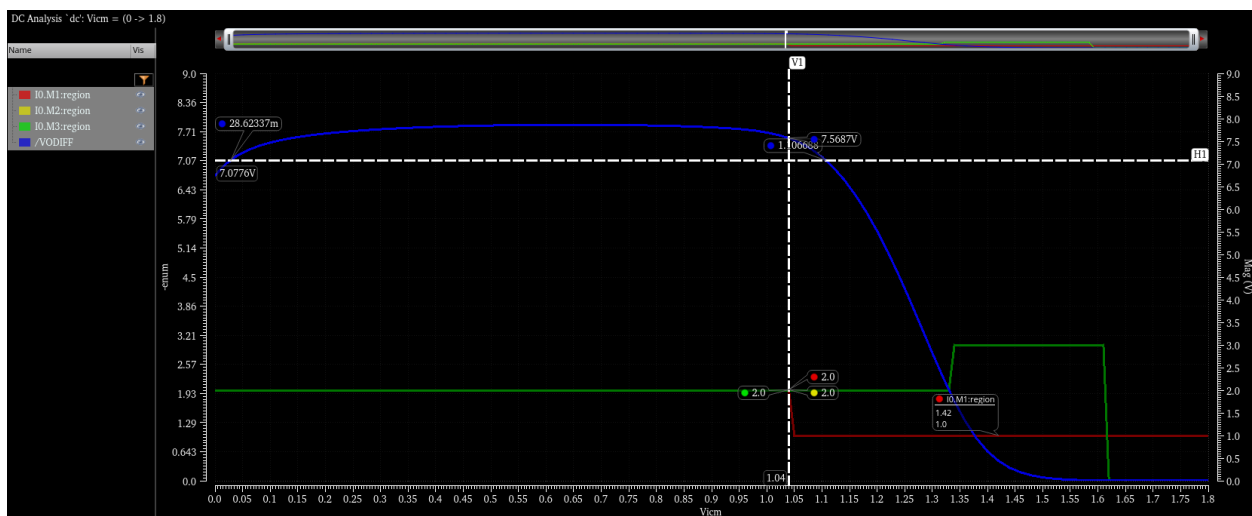
CM large signal (GBW vs Vicm)



Expression	Value
1 ymax(mag(v"/VODIFF" ?result "ac"))	7.864

@ $0.9 \cdot A_v = 7.08$: $V_{CM_{IR}} = 1.11 - 0.0286 = 1.08$

Overlaid Graphs



	Region Method	GBW Method
$V_{CM_{IR}}$ (V)	1.04	1.08