Analog IC Design

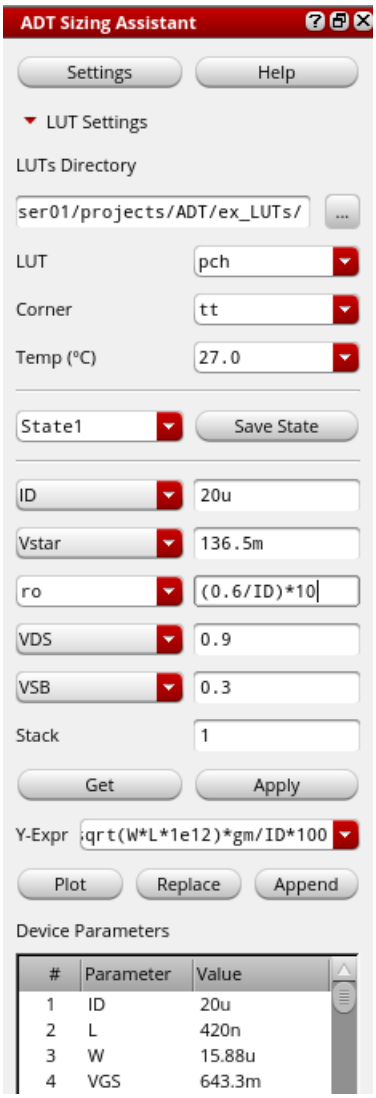
Lab 6

Part 1: Sizing Chart

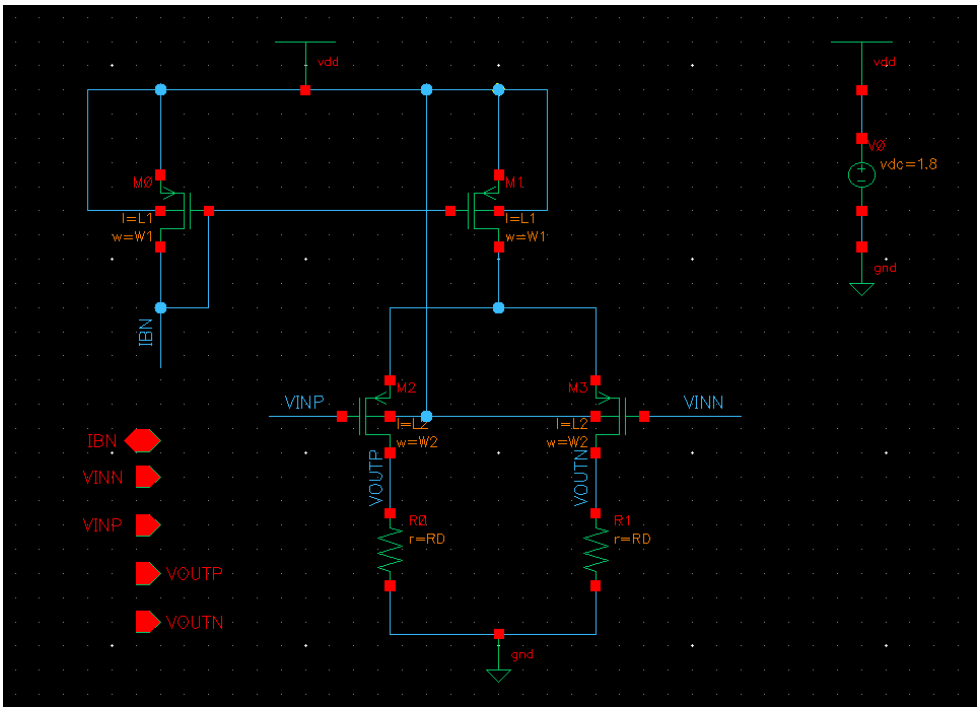
RD & V* Calculation

$I_{SS}RD=2Vout-CM$ → RD = $\frac{2(1\cdot 8)}{3(40u)}$ = 30kΩ

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



Schematic



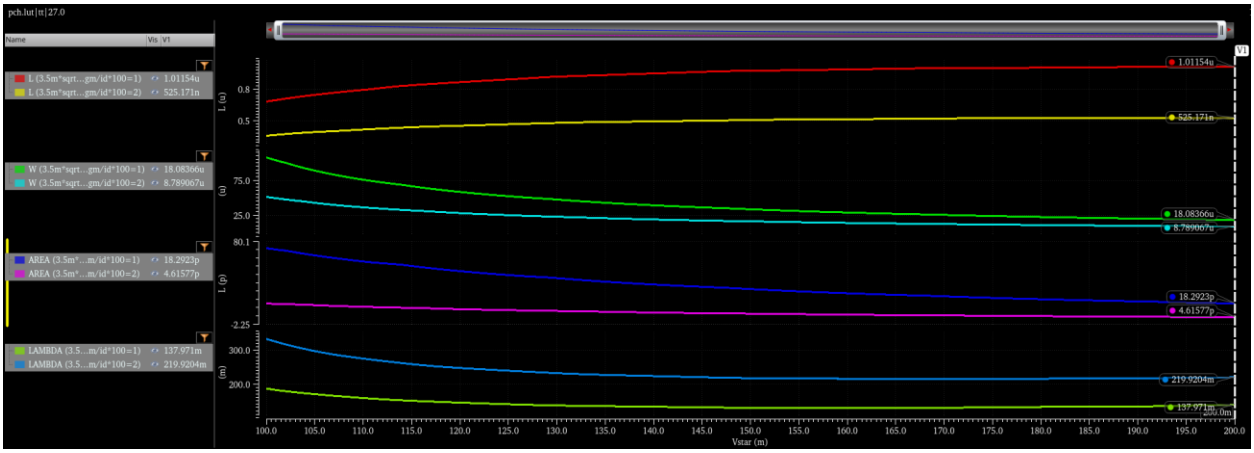
CM Input Level

VCM_{min} = (Iss/2)(30k) – 527.4m = 72.6mV

VICM = 1.8-0.3-0.6433 = 0.857V

VCM_{max} = VDD-V*-VGS = 1.8 – 0.1365 – 0.6433 = 1.02V

Parameters Graphs

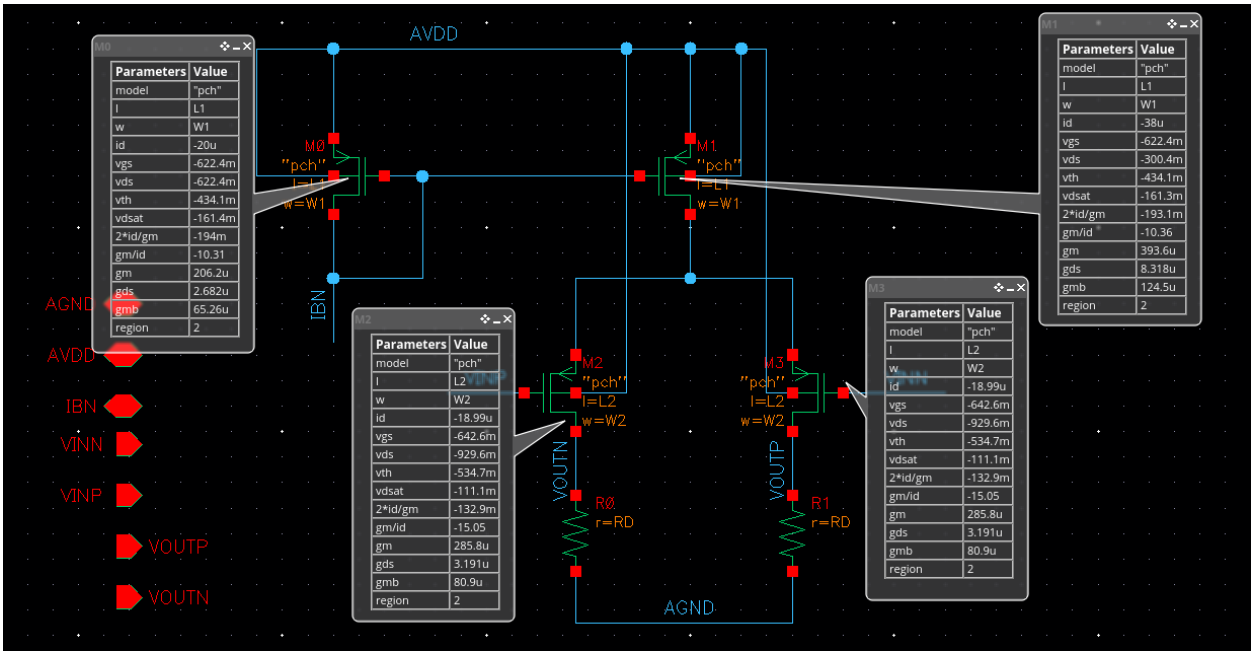


2% mismatch gives lower area, so:

L= 525.2nm W = 8.8um

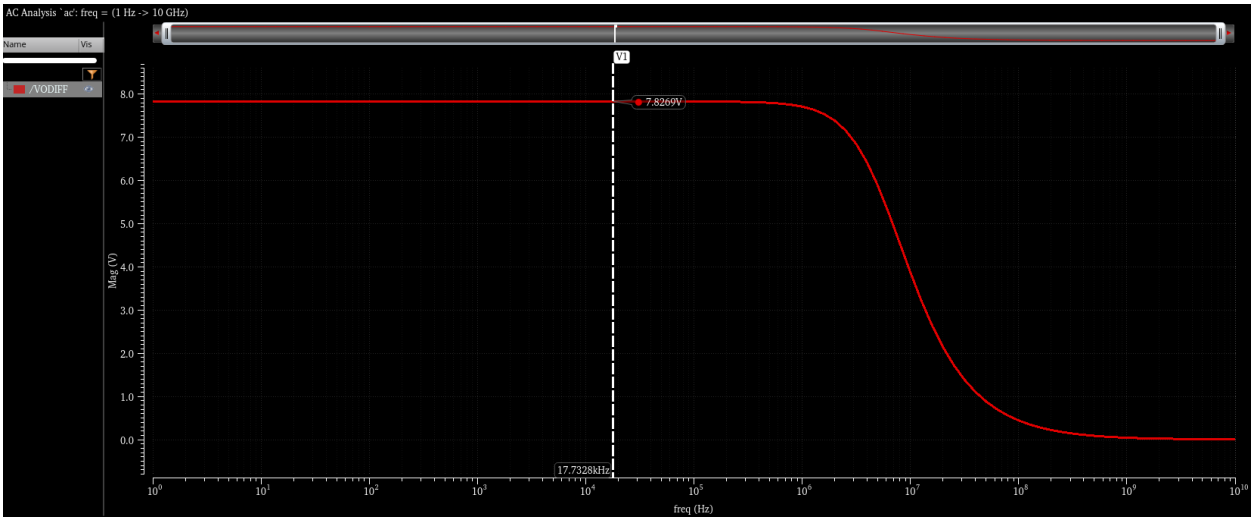
Part 2: Differential Amplifier Simulation

DC OP



Differential Small Signal

Simulation



bandwidth(mag(v("/VODIFF" ?result ...

	Expression	Value
1	bandwidth(mag(...	5.697E6

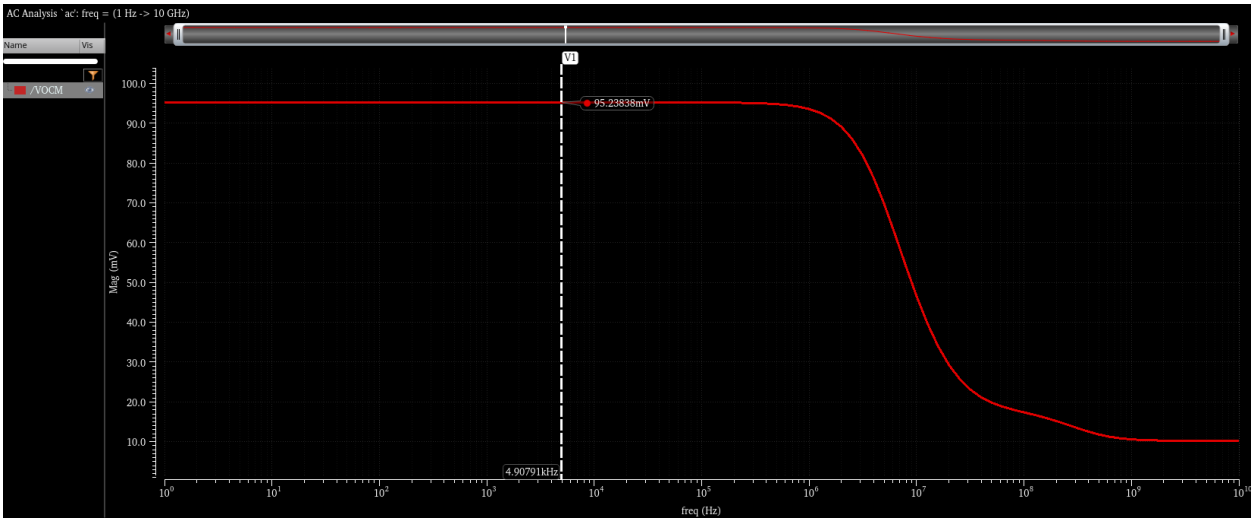
Hand Analysis

Av = gm*(RD||ro) = (285.8u)*(30k || 313.4k) = 7.825

BW = 1/[2π*(RD||ro)*CL] = 5.81MHz (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

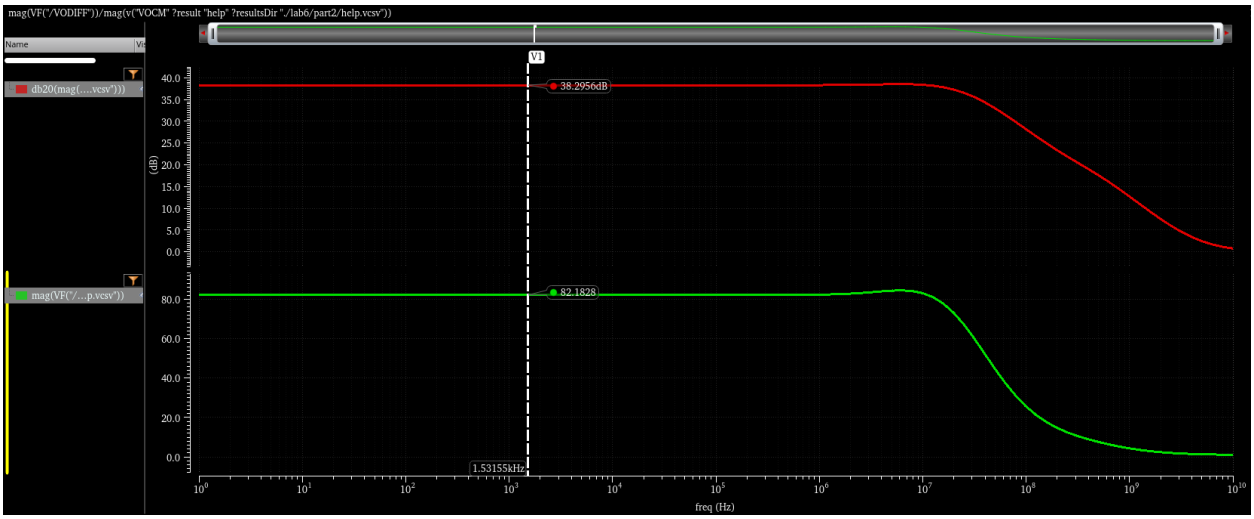
$Av_{CM} = \frac{gmRD}{1+2(gmb+gm)ro1} = \frac{285.8u*30k}{1+2(80.9u+285.5u)(\frac{1}{8.32u})}$ = 96.2m

	Simulation	Hand Analysis
Gain	0.095	0.096

Comments

- Both simulated & calculated gain are attenuating (Av_{CM} << 1), due to the presence of large degeneration resistance (2*ro1).
- At higher frequency, the capacitor shunts both RD & RSS, but the effect of shunting RSS reduces the common mode rejection because Avcm increases.

Avd/Avcm Graph



Hand Analysis

Avd/Av_{CM} = 7.825/0.096 = 81.4

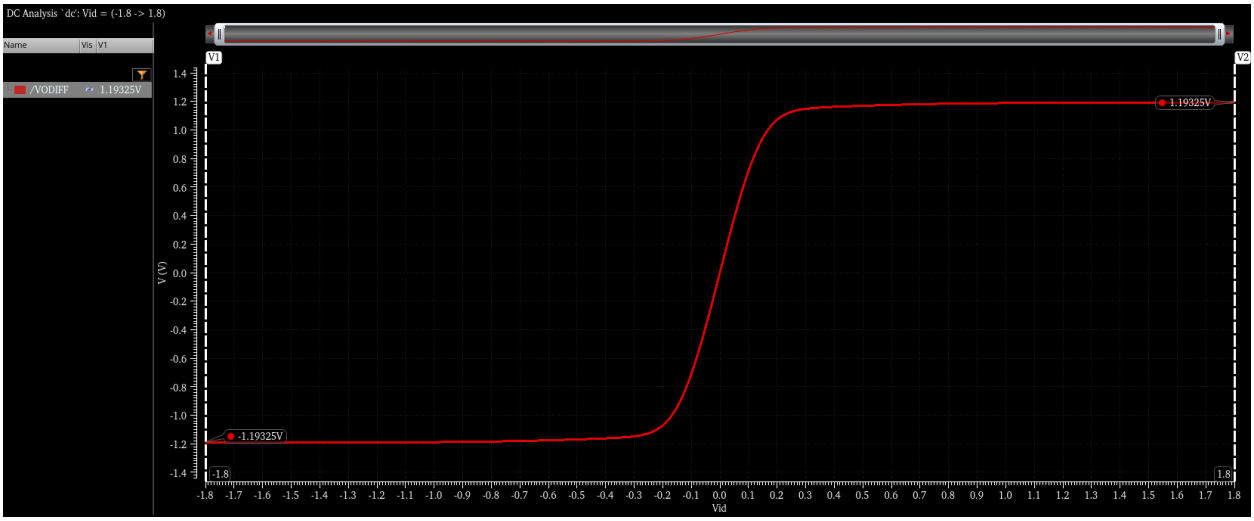
	Simulation	Hand Analysis
dB Gain	38.3	38.2
Gain	82.2	81.4

Comment:

$$CMRR = \frac{A_{vd}(s)}{A_{vCM2d}(s)} \approx \left[1 + 2g_{m1,2}\left(R_{SS}||\frac{1}{sC_P}\right)\right]\frac{g_{m1,2}}{\Delta g_m}$$
$$\approx \frac{1 + s\frac{C_P}{2g_{m1,2}}}{1 + sR_{SS}C_P} \cdot 2g_{m1,2}R_{SS}\frac{g_{m1,2}}{\Delta g_m}$$

There is a pole at $\frac{1}{ro1*CL}$ causing -20dB per decade, followed by a zero at $\frac{2gm}{CL}$ causing a +20dB per decade.

Diff Large Signal ccs

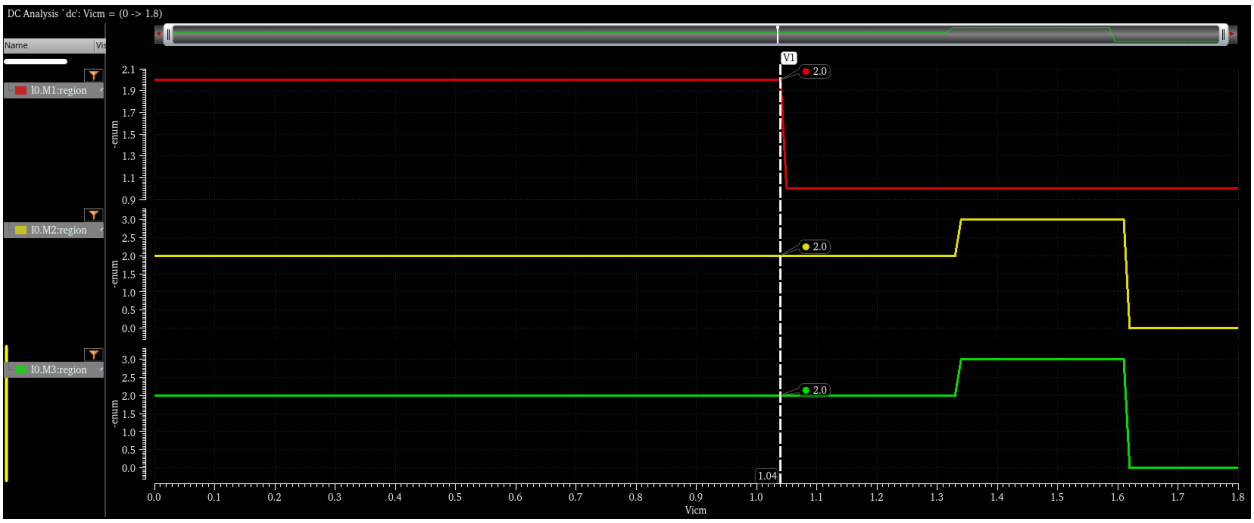


Hand Analysis

Vmax = -Vmin = ISS*RD = (40u)(30k) = 1.2V

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

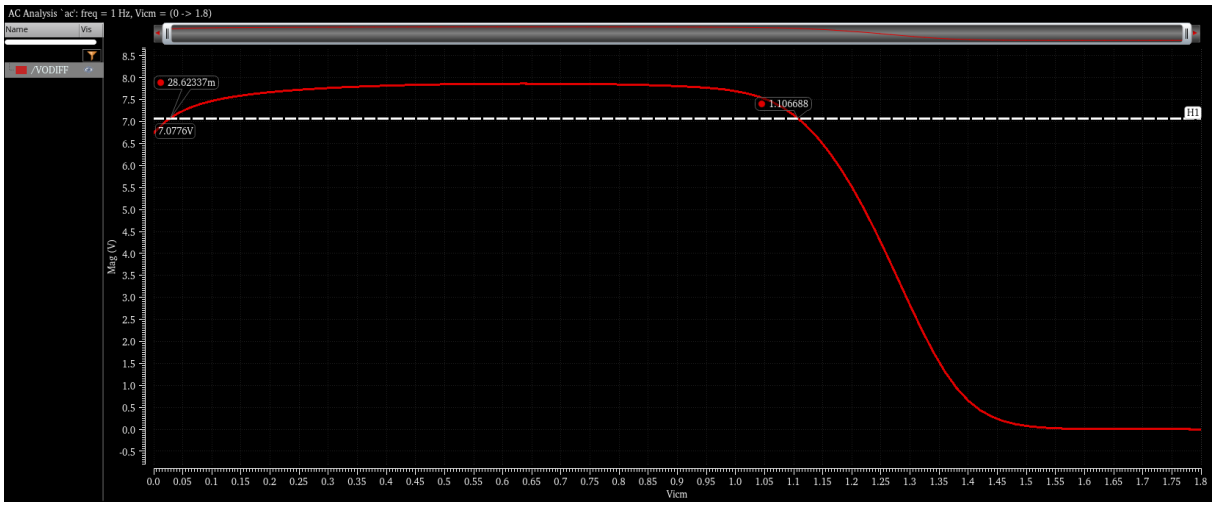
CM Large Signal (Region vs VICM)

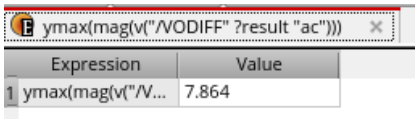


Hand Analysis

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

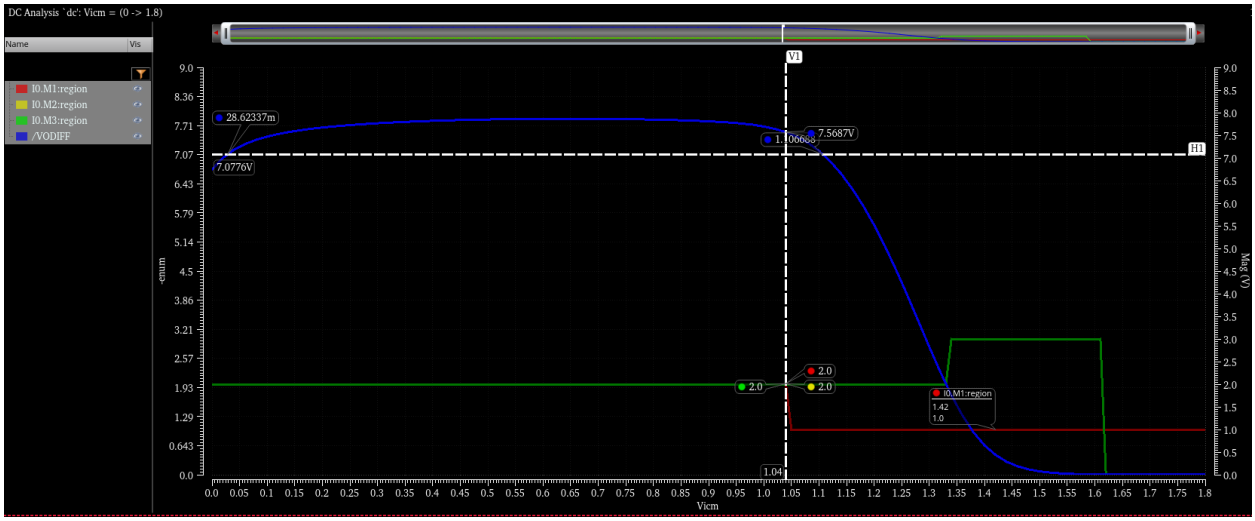
CM large signal (GBW vs Vicm)





@ 0.9*Av = 7.08: VCM_{IR} = 1.11-0.0286 = 1.08

Overlaid Graphs



	Region Method	GBW Method
VCM_{IR} (V)	1.04	1.08