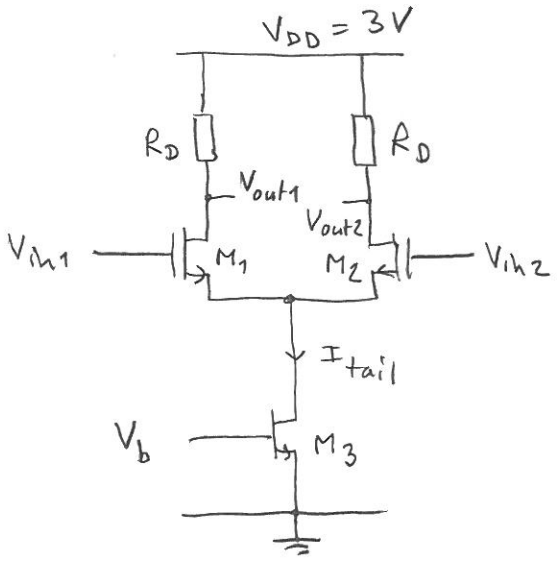
Differential amplifier 2010-01-21 / Bengt M.



$\frac{W}{L} = \frac{50\mu}{0,5\mu}$ for transistors M_1 and M_2

Use data from table 2.1

Design bias

$I_{tail} = 100\mu A \Rightarrow I_{D1} = I_{D2} = 50\mu A$

$V_{DD} = 3V \qquad R_D \cdot I_{D1} = R_D \cdot I_{D2} = 1V$

$R_D = \frac{1V}{50\mu A} = 20k\Omega$

M3: $I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})^2 \qquad L = L_{eff} = L_{drawn} - 2L_D$

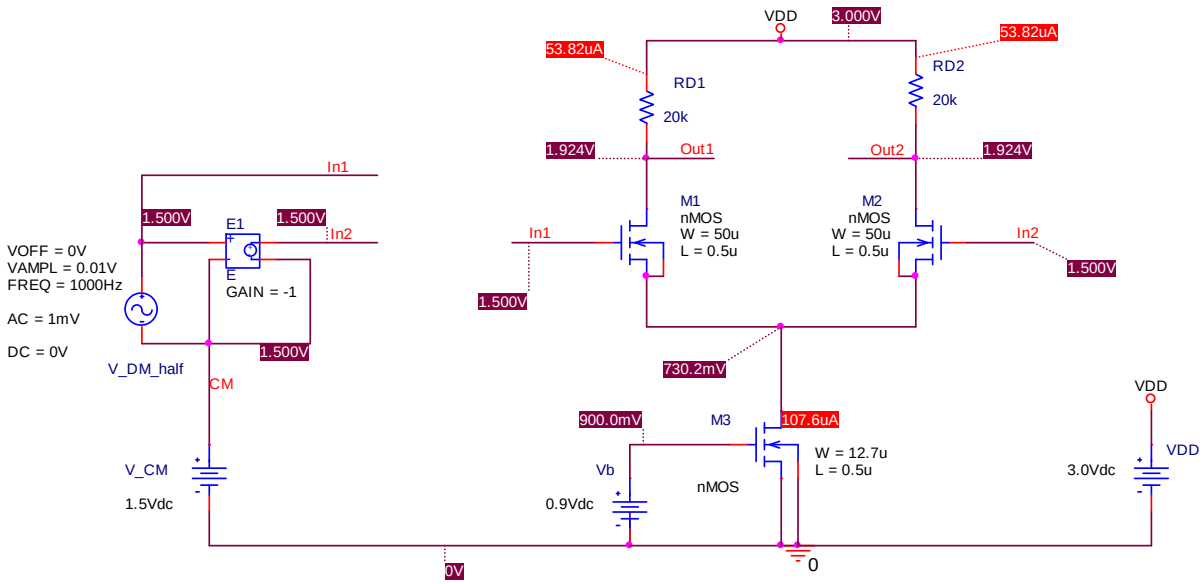
$\therefore V_{OV} = 0,2\ V$ choosen

$\frac{W}{L} = \frac{I_D}{\frac{1}{2} \mu_n C_{ox} (V_{GS} - V_{TH})^2} = \frac{100\mu}{\frac{1}{2} \cdot 134\mu \cdot 0,2^2} = 37,3$

$W = 37,3 \cdot 0,34\mu = 12,7\mu$

Lets evaluate this circuit with simulations!

DC bias



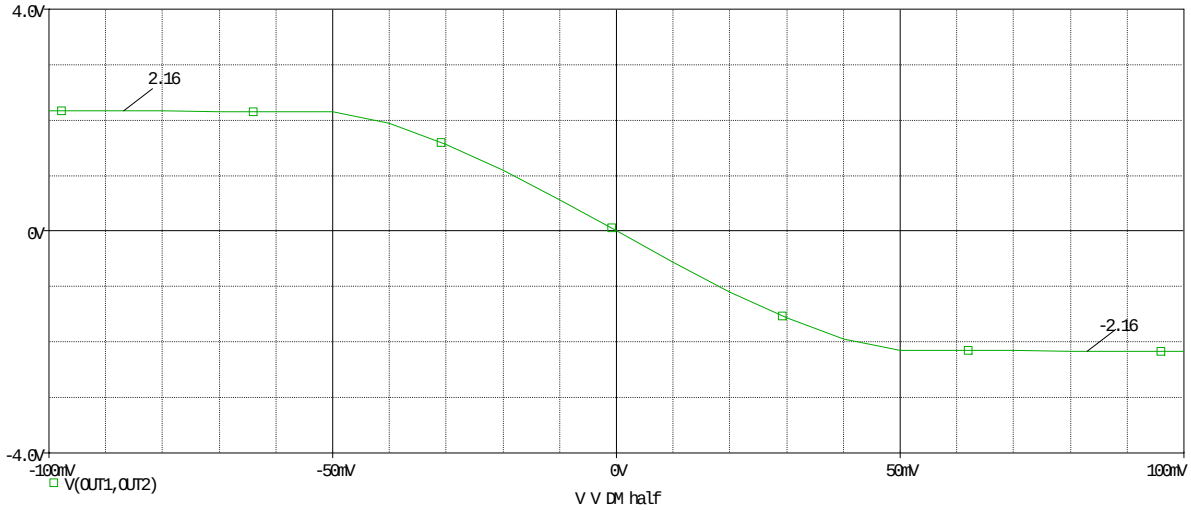
With this arrangement of input voltage source we can change common mode and differential mode input voltages independently of each other.

From output file:

NAME	M_M2	M_M1	M_M3
MODEL	nMOS	nMOS	nMOS
ID	5.38E-05	5.38E-05	1.08E-04
VGS	7.70E-01	7.70E-01	9.00E-01
VDS	1.19E+00	1.19E+00	7.30E-01
VBS	0.00E+00	0.00E+00	0.00E+00
VTH	7.00E-01	7.00E-01	7.00E-01
VDSAT	6.98E-02	6.98E-02	2.00E-01
GM	1.54E-03	1.54E-03	1.08E-03
GDS	4.81E-06	4.81E-06	1.00E-05
GMB	3.66E-04	3.66E-04	2.55E-04
CBD	0.00E+00	0.00E+00	0.00E+00
CBS	0.00E+00	0.00E+00	0.00E+00

$$r_o = \frac{1}{g_{DS}} = \frac{1}{4.81 \cdot 10^{-6}} = 208\ \text{k}\Omega$$

Differential voltage transfer function (VDM= 1.5 V). Compare to figure 4.7b in book.



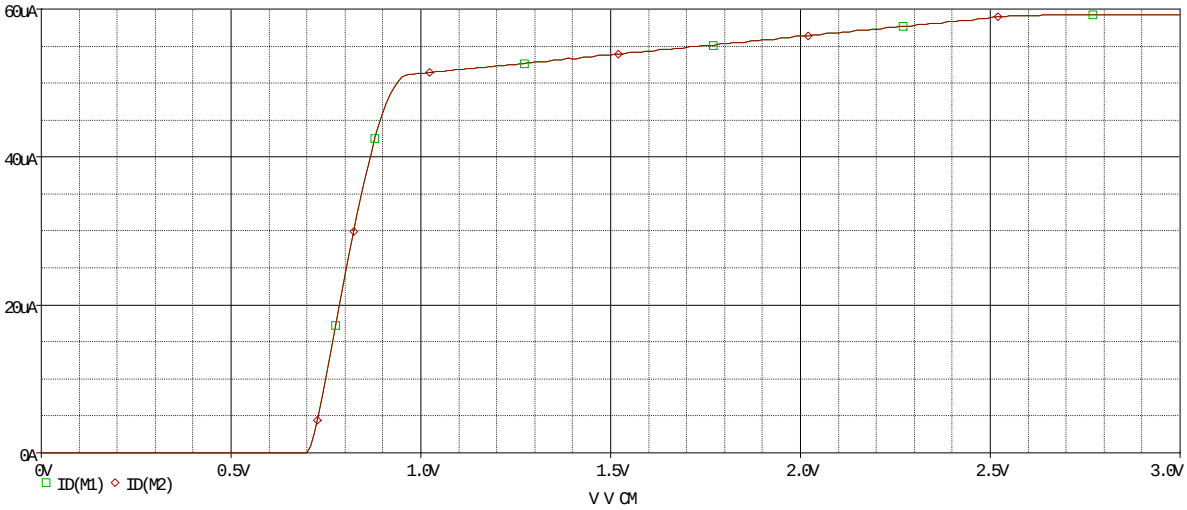
Slope at linear part of transfer function determined to

2.19/40.2m = $A_v = -\dfrac{2.19}{80.4m} = -27.2$

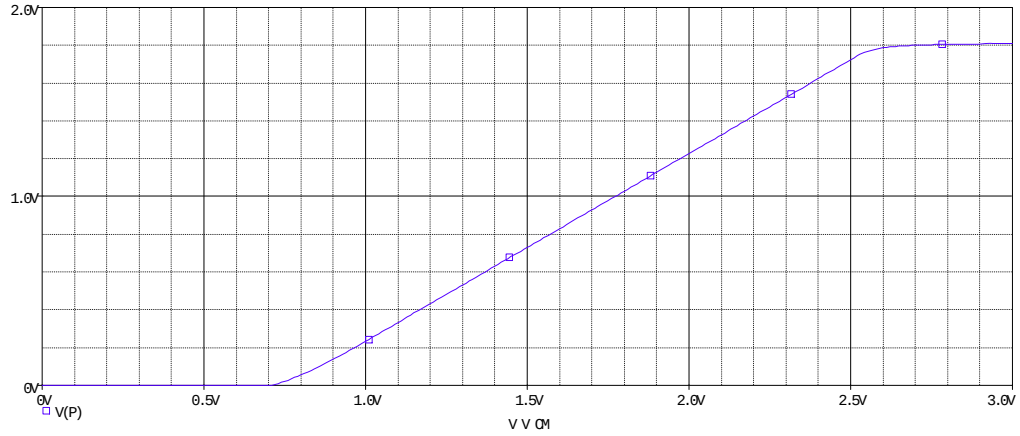
compared to $A_v = -g_m\left(R_D \,//\, r_o\right) = -1.54\text{m}\left(20\text{k} \,//\, 208\text{k}\right) = -28.1$ OK!

Common mode input voltage characteristics, compare to figure 4.8 in book.

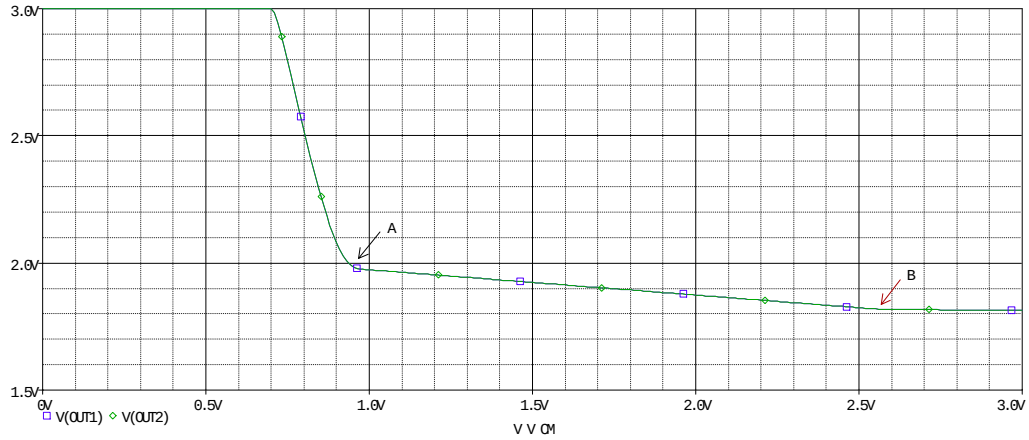
VCM sweep from 0V to 3V, drain current M1 and M2



VCM sweep from 0V to 3V, voltage at connected source V(P), follows VCM when transistors in saturated region



VCM sweep from 0V to 3V, voltage at output Vout1, Vout2



Exercise to check with simulation: What happens at A, What happens at B?

AC analysis, gain 28.1