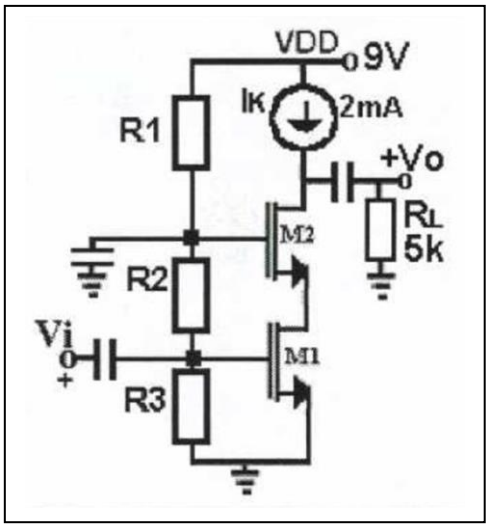
For the transistors, $\beta=4mA/V^2$ and $V_{TH}=1V$ are given.



a) For DC case, IR1=IR2=IR3=1µA and VDG1=1V.
Find the resistor values.

b) Find ri.

C) Find ac gain (vo/vi) for VA=∞.

d) Give ac model of the circuit for VA=100V.

e)For vi=20mVxCosωt, find total ac powers on the transistors and check if the transistors operates as active components or not.

1) a) $I_D=\frac{\beta}{2}(V_{GS}-V_T)^2$

$2mA=\frac{4mA/V^2}{2}(V_{GS1}-1)^2 \Rightarrow V_{GS_{1,2}}=2V$

$V_{GS1}=R_3\cdot 1\mu A \Rightarrow R_3=\frac{2V}{1\mu A}=2M\Omega$

$V_{G2}=2+1+2=5V=(R_2+R_3)1\mu A \Rightarrow R_2=3M\Omega$

$9V-5V=R_1\cdot 1\mu A \Rightarrow R_1=4M\Omega$

b) $r_i=R_3 // R_2=3M // 2M=1.2M\Omega$

c) $\frac{V_o}{V_i}=-g_{m1}\left(\underbrace{\frac{1}{g_{m2}}// r_{o1}}_{\approx 1/g_{m2}}\right)\cdot g_{m2}\left(\underbrace{5k // g_{m2}r_{o1}r_{o2}}_{\approx 5k}\right)$

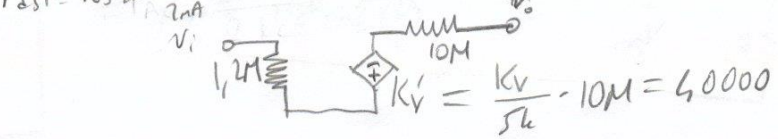
$=-g_{m1}\cdot 5k$

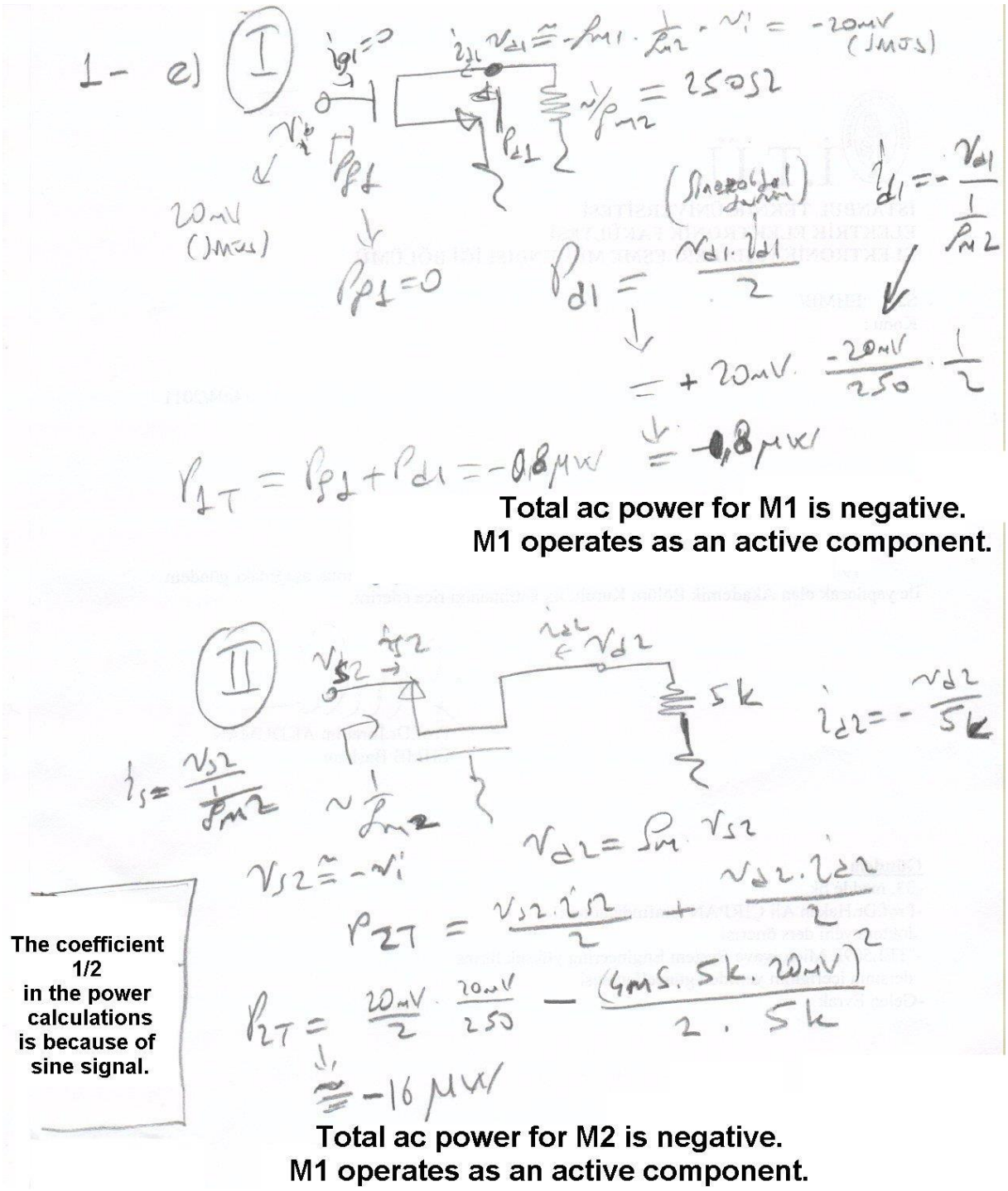
$g_{m1}=\sqrt{2.4mA/V^2\cdot 2mA}=4mS$

$K_V=\frac{V_o}{V_i}=-20\ V/V$

d) $r_{od2}=r_{ds1}+r_{ds2}+g_{m2}r_{ds1}r_{ds2}$

$r_{ds1}=r_{ds2}=\frac{V_A}{2mA}=50k$ $\quad r_{od2}\cong 10M\Omega$




1- a)
I
$i_{g1}=0$
$v_{d1} \cong -\mu_{M1} \cdot \frac{1}{r_{M2}} \cdot v_i = -20mV$ (JMOS)
$r_{M2} = 250\Omega$
r_{d1}
v_i
20mV (JMOS)
p_{g1}
$p_{g1}=0$
(Small Signal)
$p_{d1} = \frac{v_{d1} \cdot i_{d1}}{2}$
$i_{d1} = -\frac{v_{d1}}{\frac{1}{r_{M2}}}$
$= +20mV \cdot \frac{-20mV}{250} \cdot \frac{1}{2}$
$= -0,8\mu W$
$p_{1T} = p_{g1} + p_{d1} = -0,8\mu W$
Total ac power for M1 is negative.
M1 operates as an active component.
II
v_{s2}
i_{s2}
i_{d2}
v_{d2}
5k
$i_{d2} = -\frac{v_{d2}}{5k}$
$i_s = \frac{v_{s2}}{\frac{1}{r_{M2}}}$
$\sim \frac{1}{r_{M2}}$
$v_{d2} = \mu_M \cdot v_{s2}$
$v_{s2} \cong -v_i$
$p_{2T} = \frac{v_{s2} \cdot i_{s2}}{2} + \frac{v_{d2} \cdot i_{d2}}{2}$
$p_{2T} = \frac{20mV}{2} \cdot \frac{20mV}{250} - \frac{(4mS \cdot 5k \cdot 20mV)^2}{2 \cdot 5k}$
$= -16\mu W$
Total ac power for M2 is negative.
M1 operates as an active component.
The coefficient 1/2 in the power calculations is because of sine signal.