Sample Final Exam

VE311 2019 Fall

UM-SJTU Joint Institute 2019FA VE311 Teaching Group

Some tips:

I) This sample exam paper covers the BJT, FET, Amplifier Model, FET Single State Amplifier and Differential Pair.

II) This sample exam is not an assignment.

III) Mention that these problems do not cover all the contents in the courses and exams.

IV) Some problems are designed for you to understand the circuit principle better and will never appear in the exam. Besides, it's better for you to think more than those problems. i.e. generate and analysis circuits in different cases by yourself.

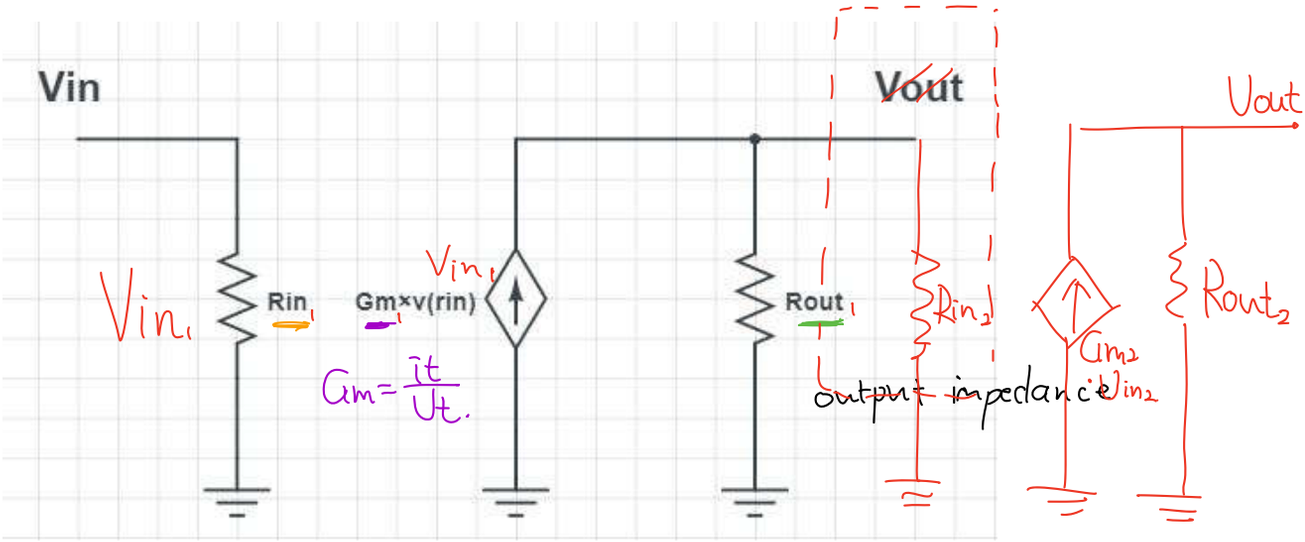
V) The solution to this sample will be posted to CANVAS later. For any problems, please contact the TAs.

Problem I (16marks)

$V_{out} = G_{m2} V_{in2} \cdot R_{out2}$.

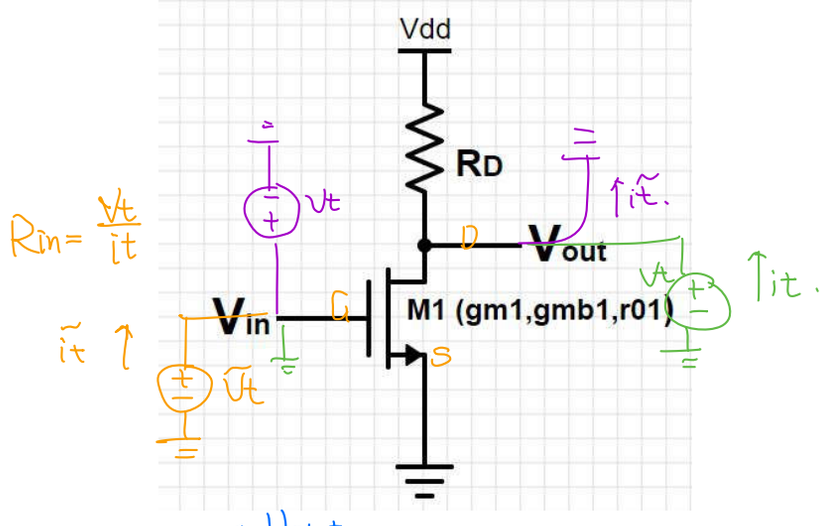
In this problem, you will have experiences of how to transform an arbitrary amplifier into a general model below and how to use this model to analyze complex circuits.

$V_{in2} = G_{m1} V_{in1} (R_{in2} \| R_{out1})$.

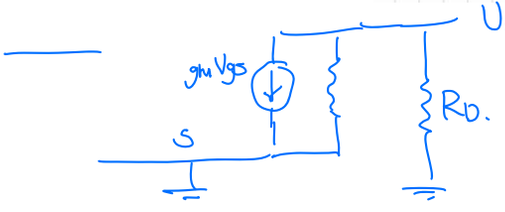


(The General Amplifier Model)

1) Please transform the amplifier circuit(1) into general amplifier model using analytical expression. The MOSFET is in saturation region and you need to consider the channel length modulation and body effect.

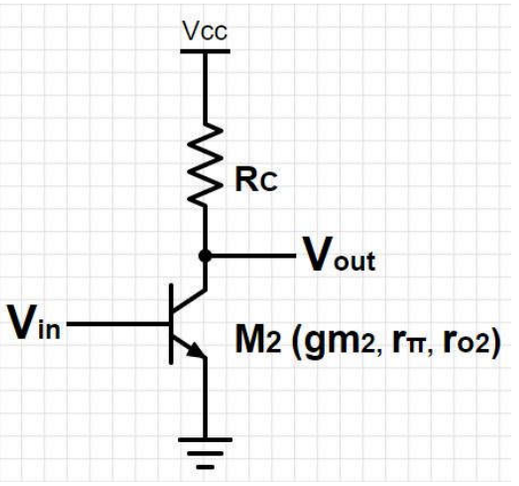


Circuit (1)



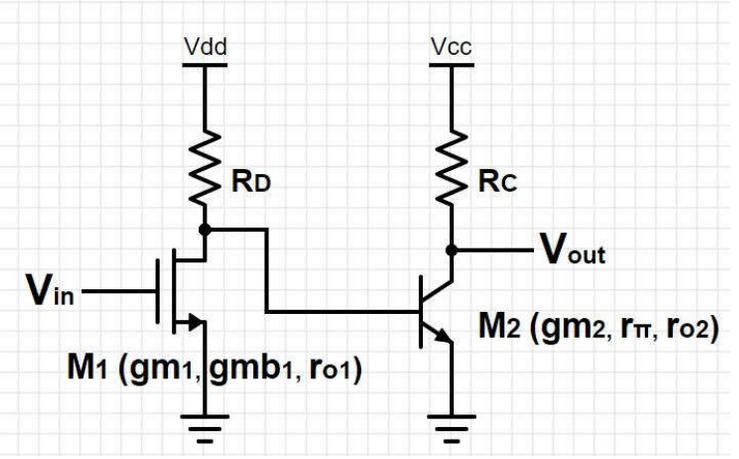
2) Please transform the amplifier circuit (II) into general amplifier model using analytical expression. You need to consider the body current leakage and early effect.

FET Rin ∞.
BJT 有 rπ.



Circuit (2)

3) Please calculate the small signal gain A_V of circuit(3) using analytical expression. The MOSFET is in saturation region.



Circuit (3)

level shifter?

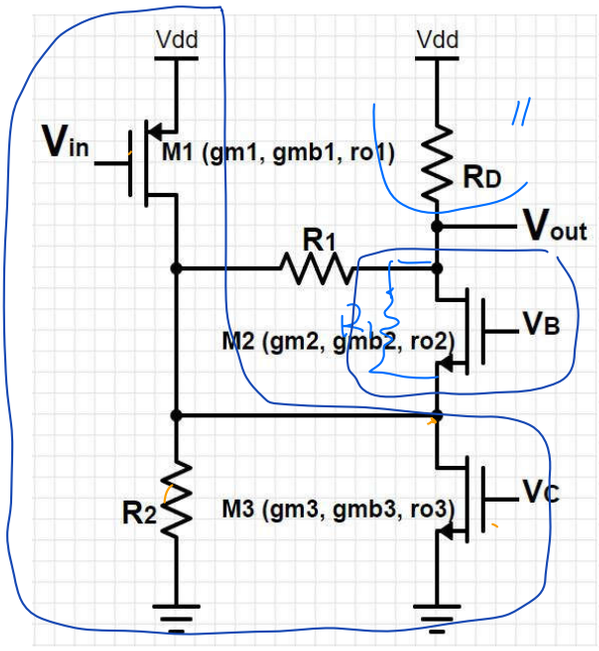
$R_{out} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$

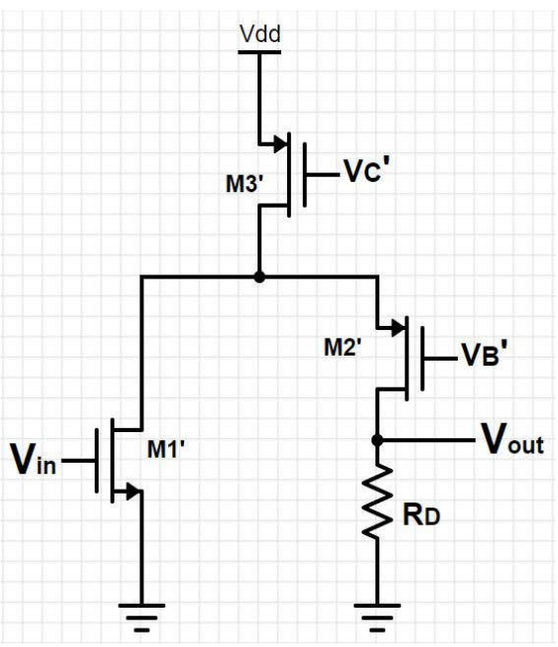
Problem 2 (22marks)

For the following amplifiers, suppose all the MOSFETS are saturate and their λ, γ both not equal to zero.

1) Please find the small signal voltage gain A_V of circuit (1) using analytical expression.

2) Suppose the small signal voltage gain for circuit (2) is A'_V and $R_1 \neq R_2$. If $R'_1 = R_1$ and $R'_2 = R_2$, please connect R'_1 and R'_2 to the proper location of circuit (2) to make A_V and A_V' have the same analytical expression.



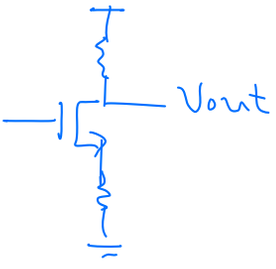


circuit(1) circuit(2)

R_1, M_2 并

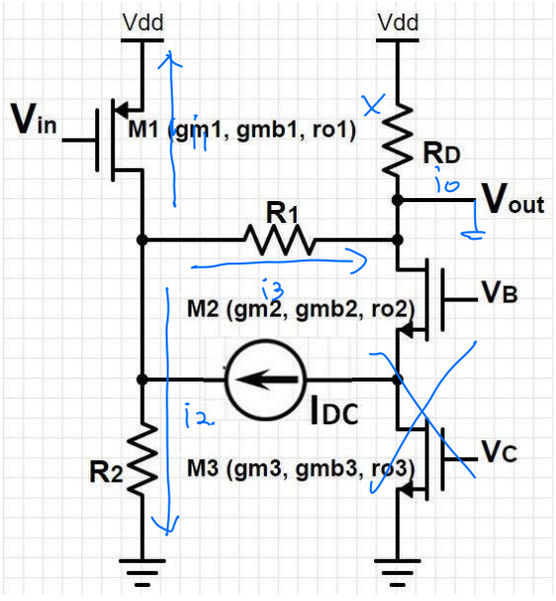
M_1, R_2, M_3 并

source degradation

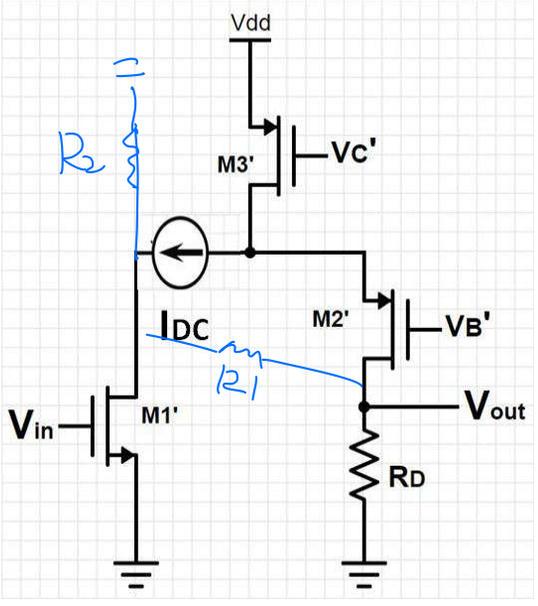


3) Please find the small signal voltage gain A_V'' of circuit (III) using analytical expression.

4) Suppose the small signal voltage gain for circuit (4) is A_V''' and $R_3 \neq R_4$. If $R_3' = R_3$ and $R_4' = R_4$, please connect R_3' and R_3' to the proper location of circuit (4) to make A_V'' and A_V''' have the same analytical expression.



circuit(3)



circuit(4)

$G_m = \frac{i_{out}}{V_{in}}$

$i_{out} =$

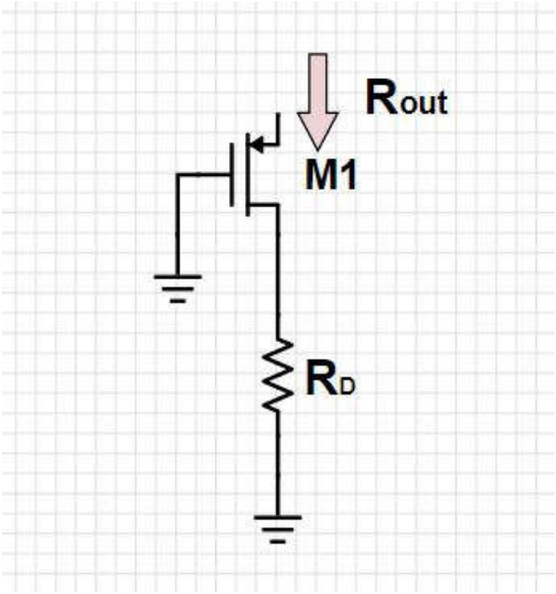
$i_t = i_3 \cdot$

$(-g_{m1} V_{in}) \cdot i_3 \cdot \frac{1}{i_1 + i_2 + i_3} \cdot$

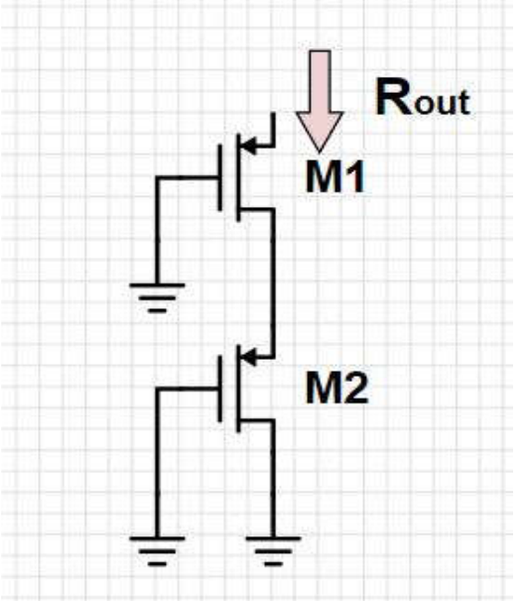
$(-g_{m1}) \frac{R_3 // r_{o1}}{R_3 // r_{o1} + R_1} \cdot$

Problem 3 (18marks)

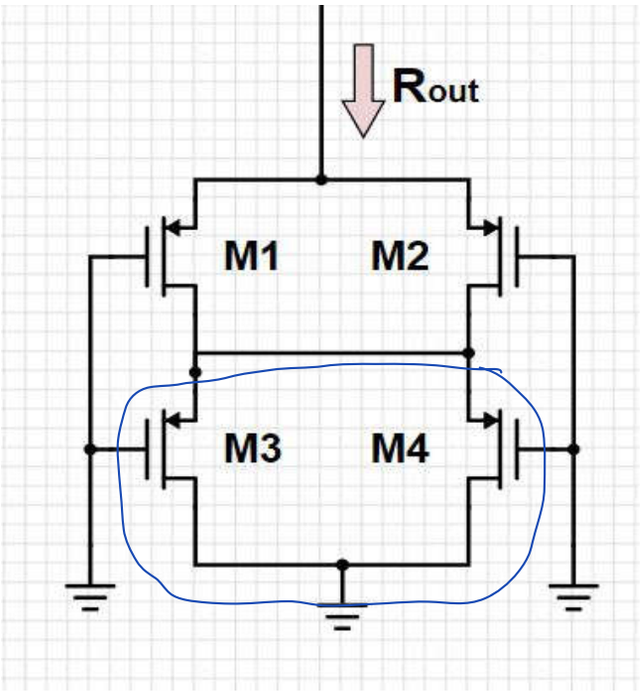
Suppose for the following circuits, λ, $\gamma \neq 0$, please calculate the output impedance of the three circuits. Mention that all the bodies of P-MOSFETs are connected to the DC power supply V_{dd}.



circuit(1)



circuit(2)



circuit(3)

Problem 4 (22marks)

The following circuit shows a trans-impedance FET single state amplifier circuit whose input is a current signal and output is a voltage signal.

1) Please calculate the small signal trans-impedance $\mathrm{Gain} = \frac{V_{out}}{i_{in}}$ using analytical expression while M saturates ($\gamma = 0,\ \lambda \neq 0$).

2) Please calculate the maximum DC current supply I_{IN} to make the circuit work (M stays in the saturation region) and the corresponding value of trans-impedance. Some useful coefficients are given in the table:

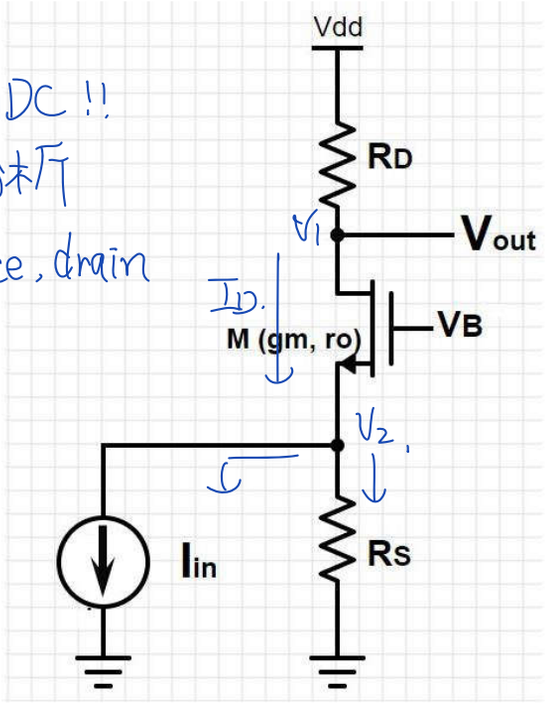
$V_{dd} = 5V$	$V_B = 2V$	$W_{drawn} = 75mm$	$L_{drawn} = 75mm$
$V_{THN} = 0.7V$	$R_D = 1k\Omega$	$R_S = 100\Omega$	$t_{ox} = 9e-9\ m$
$\epsilon_{sio2} = 3.9$	$\gamma = 0$	$\lambda = 0.1$	$\mu = 350 \times 10^{-4} \frac{m^2 s}{V}$

AV 小信号.

gm, gmb, ro 用KCL. 用DC !!

gm, ro 要 ID, 见 DC 分析

用2次 KCL 分析 source, drain



all MOS are saturated.

$\frac{W}{L}$ ← ?

triode region 无 channel-length modulation ?

28" 饱和区 ??

2解 ?

Problem 5 (22marks)

The following circuit is a differential pair amplifier. Suppose all the MOSFETS are in saturation region and for M_1 and M_3, both λ and γ are not equal to zero. Besides, we have adjusted the DC power supply V_{IN1} equals to V_{IN2}.

1) Please find A_{CM}, A_{DM} and A_{CM-DM} using analytical expression if $\gamma_{o5} = \infty$.

2) Please find A_{CM}, A_{DM} and A_{CM-DM} using analytical expression if $\gamma_{o5} \neq \infty$.