6.2 6.3 6.6 6.7 6.8 6.9 计算题部分

6-2

NEMOS管的阈值电压大于0，随着工作电压对应的I_D值随V_{GS}增大而增大
NDMOS管的阈值电压小于0，即沟道在加电压前就存在，对应I_D也随着沟道V_{GS}增大而增大
PEMOS管：阈值电压小于0，I_D随V_{GS}的减小而增加
PDMOS管：阈值电压大于0，I_D随V_{GS}的减小而增加

6-3

i_d — 漏极电流 V_{GS} — 栅极电压 V_{ds} — 漏极电压
g_m — 跨导 $\frac{W}{L}$ — 宽长比

$g_m = \frac{\partial I_D}{\partial V_{GS}}|_Q = \mu_0 C_{ox} \cdot \frac{W}{L}(V_{GS} - V_T) = \frac{2I_{DQ}}{V_{GS} - V_T}$

$r_{ds} = \frac{1}{g_{ds}} = \frac{1}{\frac{\partial I_D}{\partial V_{DS}}|_Q} = \frac{1}{\lambda \cdot \frac{\mu_0 C_{ox}}{2} \cdot \frac{W}{L}(V_{GS} - V_t)^2} = \frac{1}{\lambda \frac{\beta}{2}(V_{GS} - V_t)^2}$

6-6

$I_{D_1} = \frac{\beta_1}{2}(V_{GS} - V_T)^2 = 8405 \mu A$

$I_{D_2} = 1 mA = 1 \times 10^3 \mu A$

$\therefore \frac{\beta_1}{\beta_2} = I_{D_1} : I_{D_2}$

$\therefore \beta_2 = 119$

$\therefore M_2; \mu_P C_{ox} = 2.38 \mu A/V^2$

6.7

$I_{ref} = \frac{\beta_1}{2}(V_{GS} - V_{TN})^2 = \frac{\beta_1}{2}(V_{DD} - V_{TN})^2 = 0.25 mA$

$\frac{W_1}{L_1} = \frac{W_4}{L_4} = 转$

$V_{GS1} = V_{GS2} = 1.85 V$

$\therefore I_0 = \frac{\beta_2}{2}(V_{GS2} - V_{TN})^2 = 0.1 mA$

$\frac{W_2}{L_2} = 四7$

$\because \frac{W_1}{L_1} : \frac{W_2}{L_2} = I_{ref} : I_0 \quad I_{ref} : I_0$

$\therefore \frac{W_2}{L_2} = 转17.5$

$I_{ref} = \frac{\beta_3}{2}(V_{GS3} - V_{GS2} - V_{TN})^2 = 0.25mA \quad \therefore \frac{W_3}{L_3} = 2.7$

6.8

$I_{ref} = k_{n4} \cdot (V_{GS4} - V_{TN4})^2 = 0.2 mA$

$\because M_2; k_{n2} = k_{n3}, M_3, M_2$构成电流镜

$\therefore I_0 = I_{ref} = 0.2 mA$

$V_{GS3} = V_{GS2}$

$I_0 = k_{n2}(V_{GS2} - V_{TN2})^2 \circ$

$\therefore V_{GS2} = 2 V$

$\therefore V_{GS2} = 1 V$

$I_0 = k_{n1}(V_{GS1} - V_{TN})^2$

$\therefore V_{GS1} = 1.7 V$

$\therefore V_{DS1} = 3.3 V$

6.9

$\because V_{GS,NMOS} = V_{GS,PMOS} \leq 1.5V$

$\therefore$ 取等时，

$1.5 = V_{TN} + \sqrt{\frac{I_{ref}}{\frac{W_R}{L_R} \cdot \frac{1}{2}\mu_n C_{ox}}}$

$\therefore \frac{W_R}{L_R} = 1.6$

$\because I_2 = 10 \mu A$

$\therefore \frac{W_R}{L_R} : \frac{W_2}{L_2} = I_1 : I_2 \quad \therefore \frac{W_2}{L_2} = 1.6$

$\because I_3 = 40 \mu A$

$\therefore \frac{W_3}{L_3} = 6.4$

同理，$\frac{W_4}{L_4} = 3.2$

$\because I_{D5} = 10 \mu A \quad \therefore \frac{W_5}{L_5} = 3.2$

$\because I_{D8} = 20 \mu A \quad \therefore \frac{W_8}{L_8} = 6.4$

6.4

```
.title NMOS_DC

VVDS net2 0 DC 1.8V
VVGS net1 0 DC 0.75V
MNM0 net2 net1 0 0 n18 W=5u L=180n m=1

.op
.dc VVDS 0 1.8 0.1

.probe i(MNM0)

.temp 27
.option post accurate probe
.lib '..\models\ms018.lib' tt

.end
```
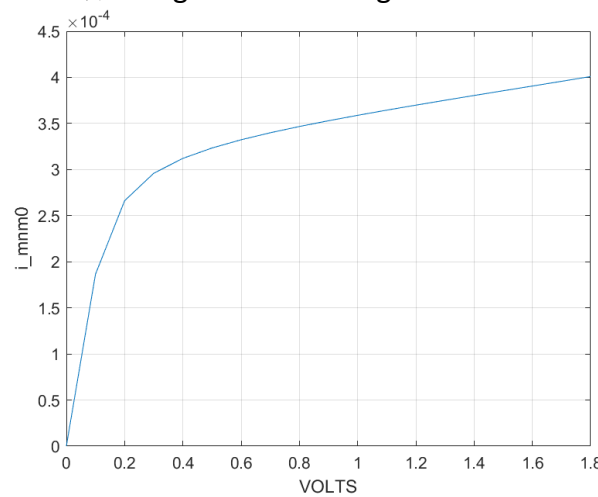
```
**** mosfets

subckt
element    0:mnm0
model      0:n18
region      Saturati
  id      400.7171u
  ibs     -1.581e-19
  ibd     -198.5012n
  vgs     750.0000m
  vds       1.8000
  vbs        0.
  vth     463.8470m
  vdsat   206.7342m
  vod     286.1530m
  beta     10.8271m
  gam eff 771.0519m
  gm        2.0424m
  gds      51.8797u
  gmb     475.4409u
  cdtot     4.5399f
  cgtot     9.1868f
  cstot    11.7318f
  cbtot     9.0992f
  cgs       6.5727f
  cgd       1.7714f
```
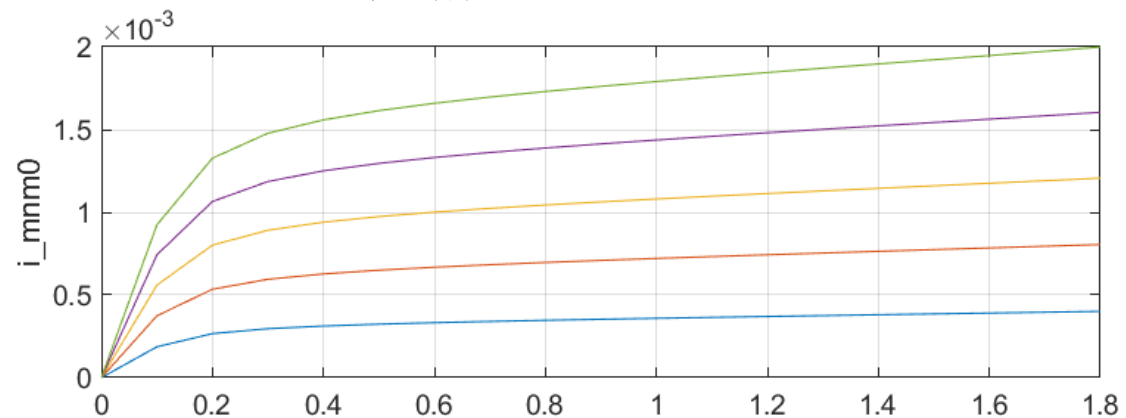
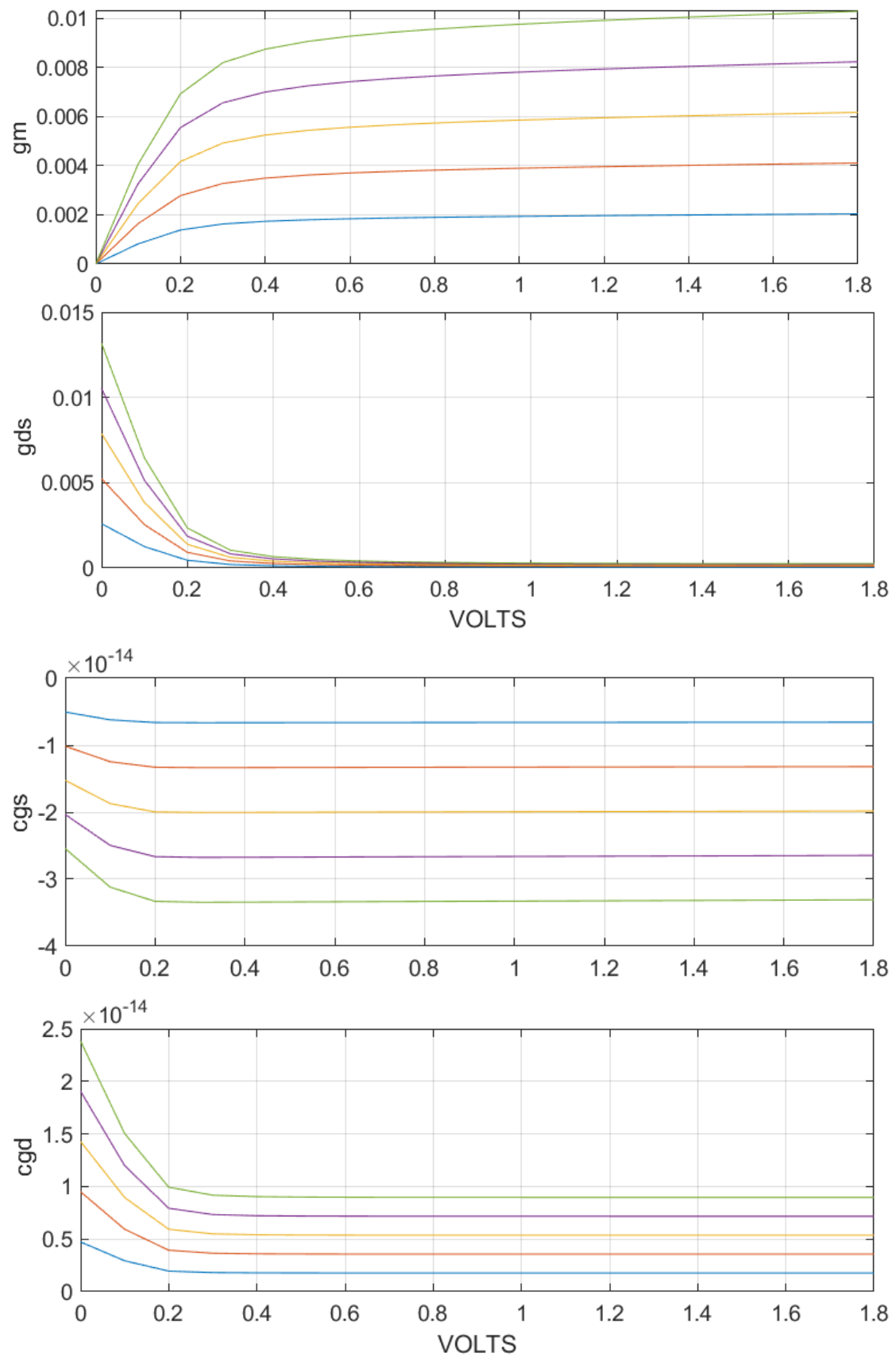可以看出：gm=2.0424m   gds=51.8797u   cgs=6.5727f   cgd=1.7714f
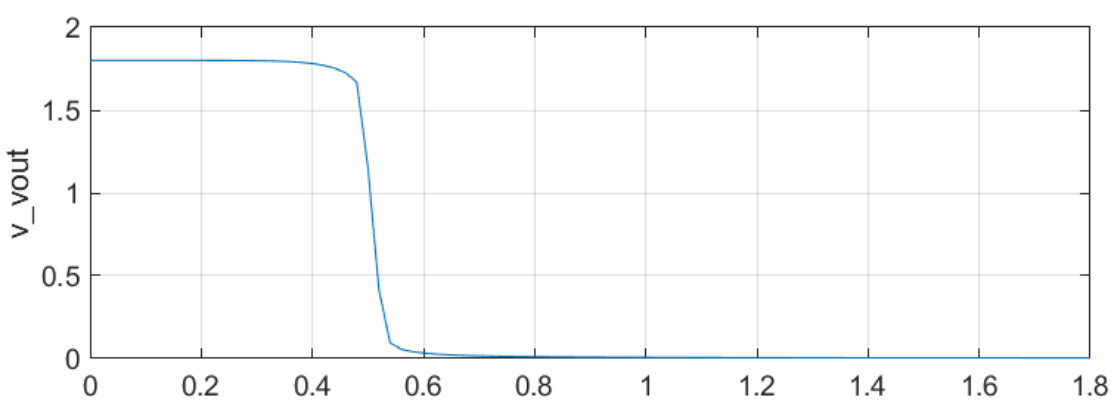

输出特性曲线如右图所示。

6.5

选取不同宽长比时，mos 管的特征曲线：

对于 id、gm、gds、cgs、cgd 的影响：

在栅极电压一定时，栅极宽长比变化，导致 i 发生变化，则导致电压与电流的比值发生改变，过会使电导、电容等发生改变。

6.11 仿真结果不太对，但是也不知道错在哪里了/(ㄒ o ㄒ)/~~
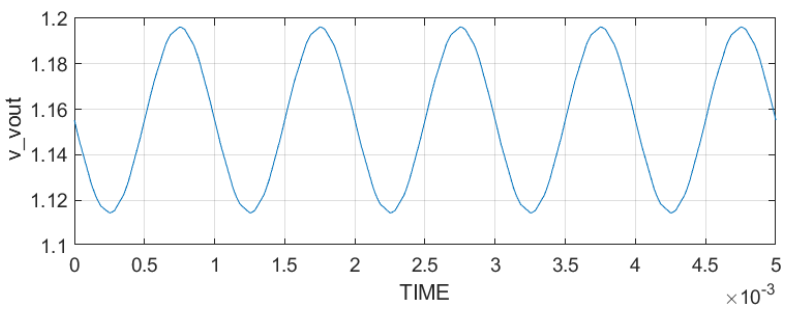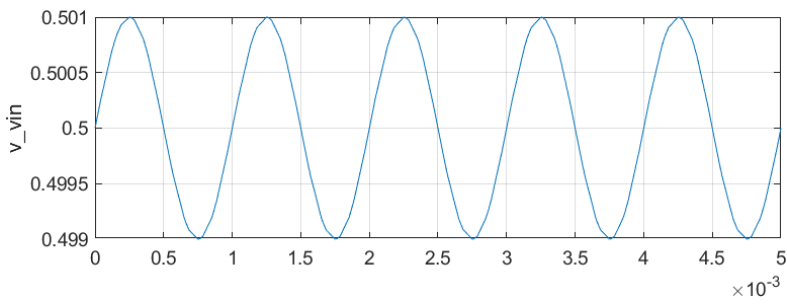

有图可得：0.55V 可作为合适的直流偏置电流

```
subckt    x1         x1
element   1:mm1      1:mm2
model     0:n18      0:p18
region      Saturati   Saturati
 id          63.4178u  -63.4185u
 ibs        -4.563e-20  9.223e-20
 ibd       -733.1166p   26.0073a
 vgs        500.0000m -600.0000m
 vds          1.1553  -644.7331m
 vbs          0.         0.
 vth        472.5030m -425.2597m
 vdsat       79.7140m -174.1581m
 vod         27.4970m -174.7403m
 beta        22.3093m    4.2527m
 gam eff    772.6355m  577.4186m
 gm           1.0583m  635.4975u
 gds         23.6345u    2.2378u
 gmb        258.5964u  203.9426u
 cdtot        9.7757f   74.2698f
 cgtot       15.4840f  411.4351f
 cstot       19.5483f  483.1730f
 cbtot       18.7000f  240.2132f
 cgs          9.6150f  352.8751f
 cgd          3.6066f   25.3152f
```
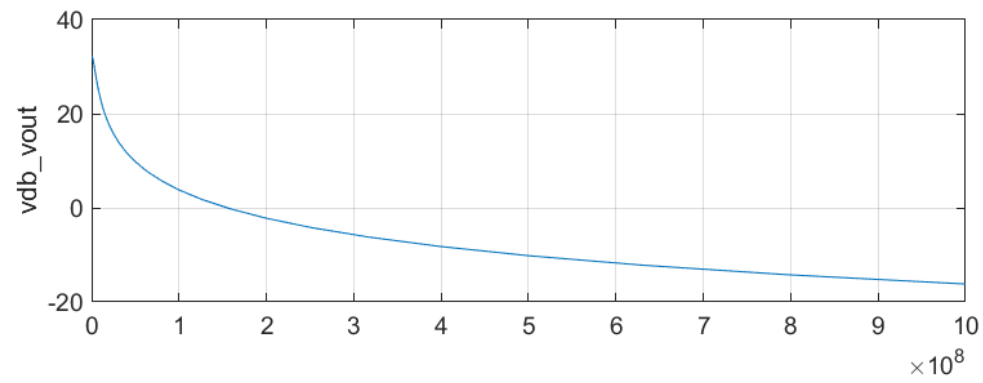
gm、gds、cgs、cgd 可由右图给出

瞬态仿真：

交流仿真：

6.12　11 题出问题，导致这题算不对

6.12 取 $V_{in}=0.55$

(1) 由低频交流小信号模型知：

$$\therefore A_0 = \frac{g_{m1}}{g_{ds1}+g_{ds2}}$$

(2) 高频交流小信号 要加上电容 可忽略

电容以 C_L 为主

$$A(s) = \frac{A_0}{1+s\cdot R_C} \qquad R = \frac{1}{g_{ds1}+g_{ds2}}$$