6.2

输出特性曲线：NEMOS的输出特性曲线与NDMOS基本一致；PEMOS的输出特性曲线与PDMOS基本一致。P型MOS管与N型MOS管的电压极性与电流方向相反。

转移特性曲线：NEMOS是增强型，需要给到正的$V_{GS} = V_{TN}$才会有电流I_D；NDMOS是耗尽型，在$V_{GS} < 0$时沟道变窄，直至夹断电压$V_{GS(off)n}$处$I_D = 0$。P型MOS管与N型MOS管的电压极性与电流方向相反。

6.3

物理意义：

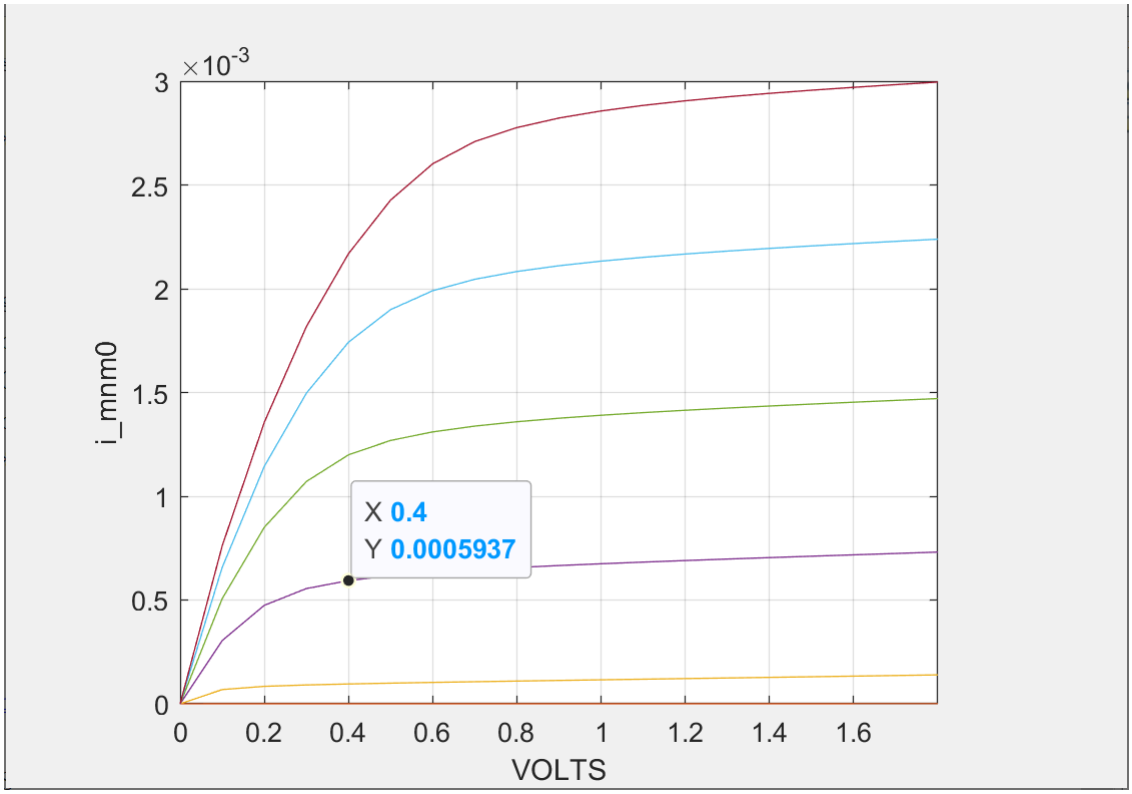
- v_{gs}为G、S极之间的电压交流分量，v_{ds}为D、S极之间的电压交流分量
- i_g是G极流入的电流，i_d是D极流入的电流
- C_{gs}是栅-源电容
- C_{gd}是栅-漏电容
- g_m是跨导
- r_{ds}是漏源电阻

计算：

- $g_m = 2\sqrt{K_n I_{DQ}}$
- $r_{ds} = \frac{V_A}{I_{DQ}}$

6.4

输出特性曲线



g_m　2.0424m

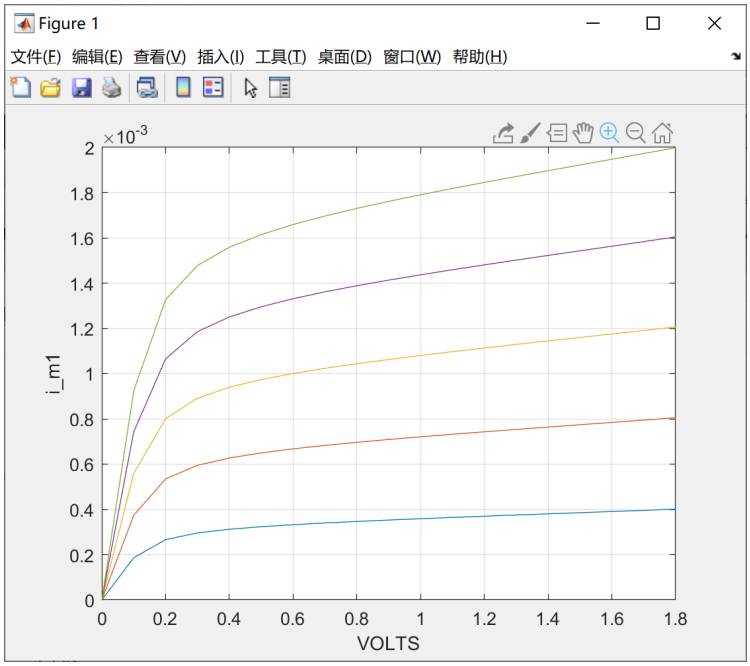
g_{ds}　51.8797u

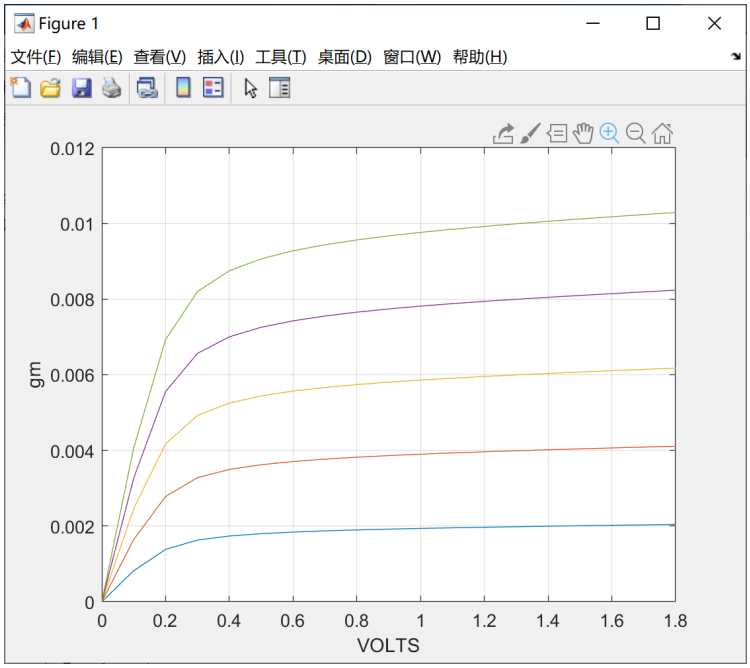
C_{gs} 6.5727f

C_{gd} 1.7714f

6.5

不同W对应的输出特性





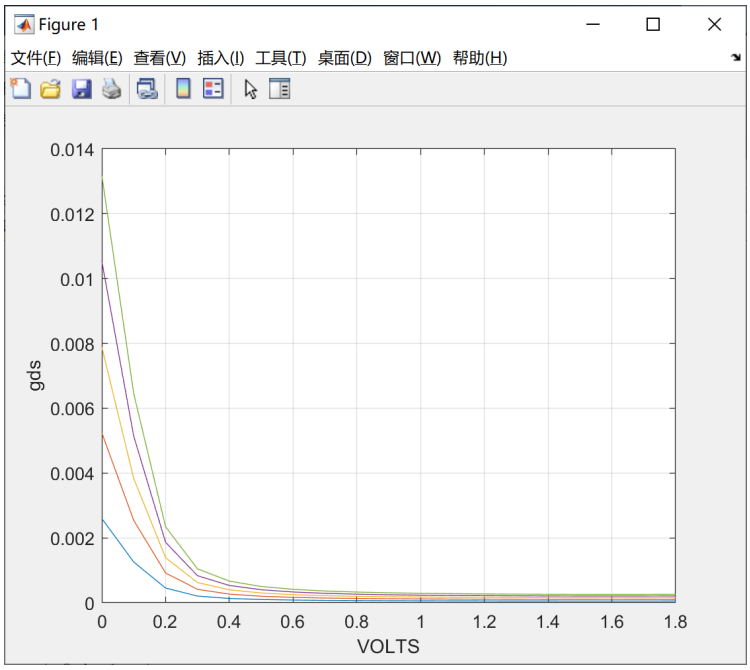


Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
gds
VOLTS

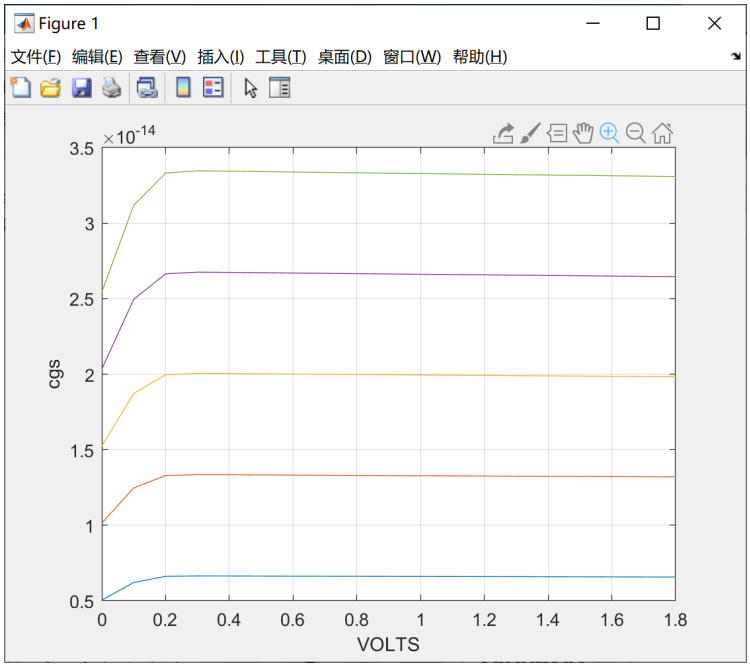


Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
×10^-14
cgs
VOLTS

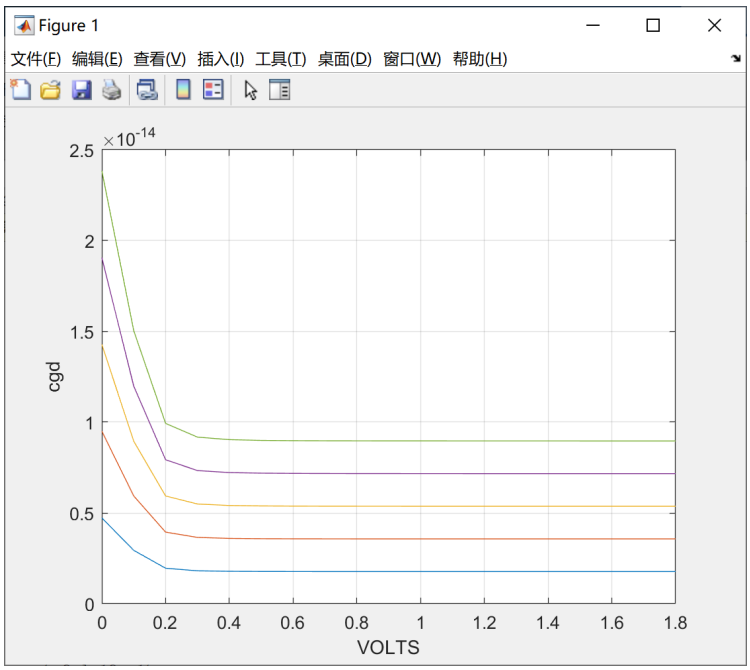


Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
×10^-14
cgd
VOLTS

随着W增大，I_D、g_m、g_{ds}、C_{gs}、C_{gd}增大。

解释：$\because K_n = \frac{W}{L}\frac{\mu_0 C_{ox}}{2}$

$\therefore$随着W增大，K_n增大

$\because I_D$在线性区和饱和都与K_n成正比

$\therefore I_D$增大

又$\because g_m = 2\sqrt{K_n I_{DQ}}$、$g_{ds} = \lambda K_n (V_{GS} - V_{TN})^2$、

$\therefore g_m$、g_{ds}也增大

在截止区，$C_{gs} = C_{gd} = WC_{ol}$；在饱和区，$C_{gs} = \frac{2}{3}\frac{W}{L}C_{ox} + WC_{ol}$，均与W成正比

$\therefore C_{gs}$、C_{gd}增大

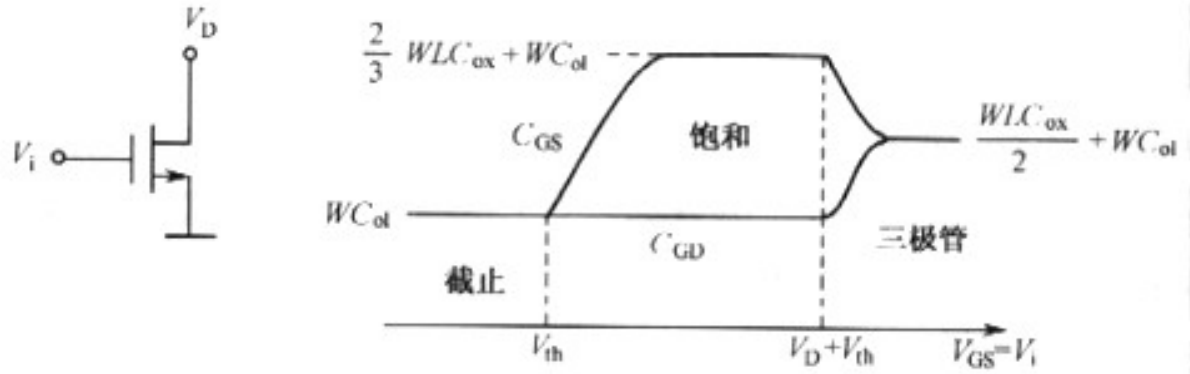


图 1.7　栅/源、栅/漏的电容量变化与 V_{GS} 的关系曲线

6.6

$I_{D1} = (\frac{W}{L})_1 \frac{\mu_0 C_{ox}}{2}(V_{GS} - V_T)^2$

$I_{D2} = 5I_{D1} = 1mA \quad \therefore I_{D1} = 0.2mA$

$\therefore V_{GS} = -1.432V$

$V_G = V_{DD} - 1.432V = 1.868V$

又$\because V_G = I_{D1} \cdot R_D \therefore R_D = \frac{1.868}{0.2\times10^{-3}} = 9.34k\Omega$

6.7

$V_{GS2} = 2V$

$I_o = (\frac{W}{L})_2 \frac{\mu_0 C_{ox}}{2}(V_{GS2} - V_{TN})^2$

$\therefore (\frac{W}{L})_2 = 5$

$I_{ref} = (\frac{W}{L})_1 \frac{\mu_0 C_{ox}}{2}(V_{GS1} - V_{TN})^2$

$V_{GS1} = V_{GS2}$

$\therefore (\frac{W}{L})_1 = 12.5$

$I_{ref}=(\frac{W}{L})_3\frac{\mu_0C_{ox}}{2}(V_{GS3}-V_{TN})^2$

$\because V_{GS3}=V_{DD}-V_{SS}-V_{GS1}=3V$

$V_{GS1}=V_{GS2}$

$\therefore (\frac{W}{L})_3=3.125$

6.8

$I_{ref}=K_{n3}(V_{GS3}-V_{TN3})^2=K_{n4}(V_{GS4}-V_{TN4})^2$

$\therefore V_{GS3}=V_{GS4}$

$\because V_{GS3}+V_{GS4}=5V$

$\therefore V_{GS3}=V_{GS4}=2.5V$

$I_o=(\frac{W}{L})_2\frac{\mu_0C_{ox}}{2}(V_{GS2}-V_{TN2})^2$

$\therefore V_{GS3}=V_{GS2}$

$\therefore I_o=0.225mA$

$I_o=(\frac{W}{L})_1\frac{\mu_0C_{ox}}{2}(V_{GS1}-V_{TN1})^2$

$\therefore V_{GS1}=2.06V$

$V_{DS2}=-V_{GS1}-V_{SS}=2.94V>V_{GS2}-V_{TN2}=1.5V$

$\therefore M2$工作在饱和区

6.9

$I_{ref}=(\frac{W}{L})_R\frac{\mu_nC_{ox}}{2}(V_{GSR}-V_{TN})^2$，取$V_{GS}=1.5V$

$\therefore (\frac{W}{L})_R=1.6$

使$(\frac{W}{L})_1=(\frac{W}{L})_2=(\frac{W}{L})_R=1.6$

由电流镜特点得$I_{D1}=I_{D2}=I_{ref}=10\mu A$

$\because I_{D3}=40\mu A$

$\therefore (\frac{W}{L})_3=6.4$

$\because V_{GS,PMOS}=-V_{TP}+\sqrt{\frac{I_{ref}}{\frac{W}{2L}\mu_pC_{ox}}}$

$\therefore (\frac{W}{L})_4=3.2$

$\because I_{D5}=10\mu A, I_{D6}=20\mu A$

$\therefore (\frac{W}{L})_5=3.2, (\frac{W}{L})_6=6.4$

$\because L=1\mu m$时，$r_o=1M\Omega$

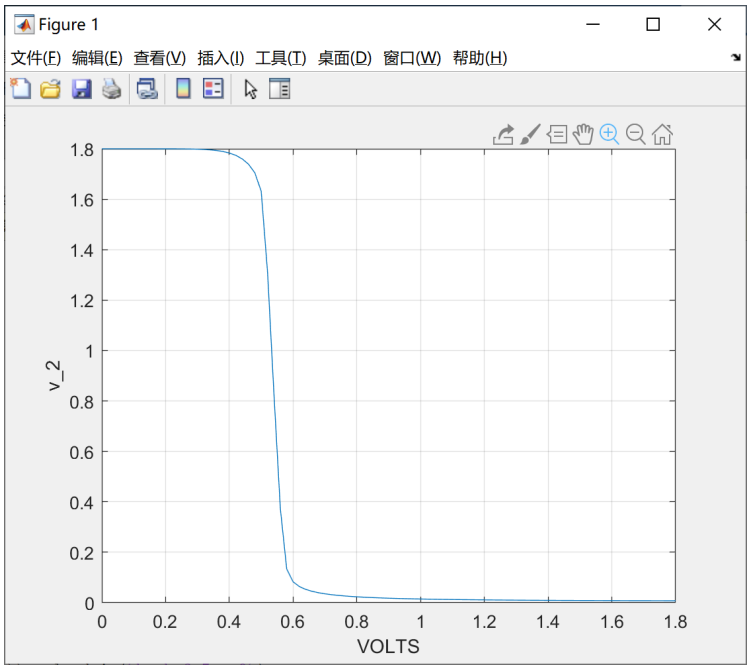
$\therefore$取$L=10\mu m$

对于M_6取$L=20\mu m$，对于M_3取$L=40\mu m$

6.11

(1)

(a)



(b)

取直流工作点为0.5V

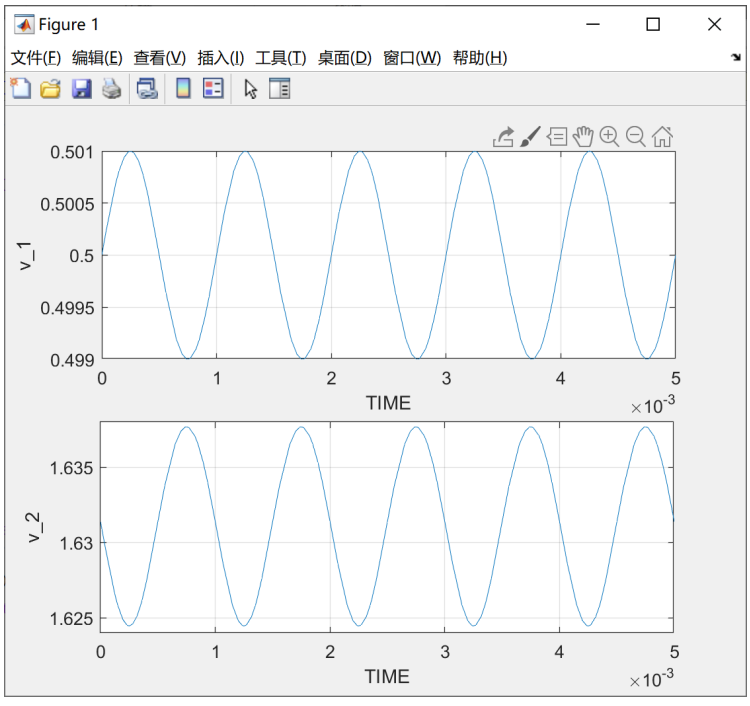
$V_{DS1} = 1.6314V, V_{GS1} = 500mV, I_{D1} = 7.2591\mu A$

(c)

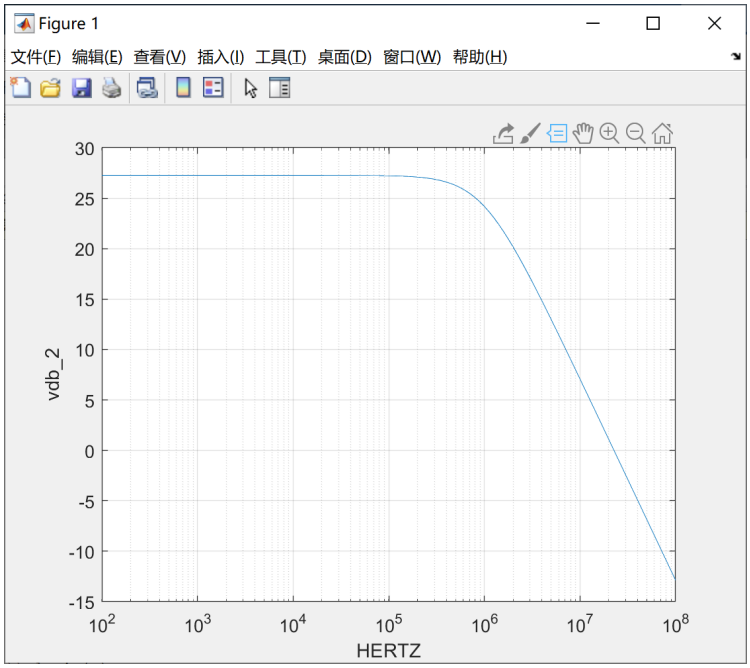
$g_{m1} = 112.3016u, g_{ds1} = 2.4165u, C_{gs1} = 904.5415a, C_{gd1} = 308.8128a$

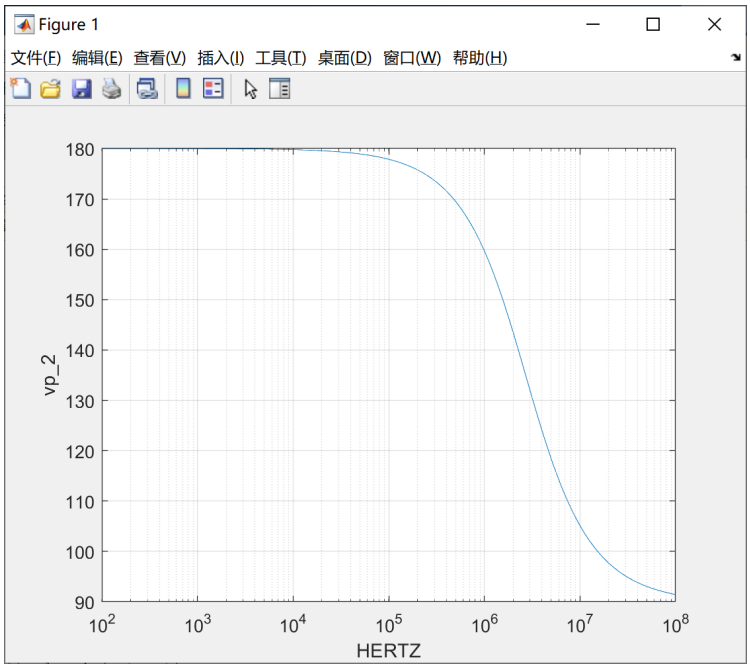
等效电阻为$r_{ds2} = \frac{V_{DS2}}{I_{D2}} = 23.22k\Omega$

(2)



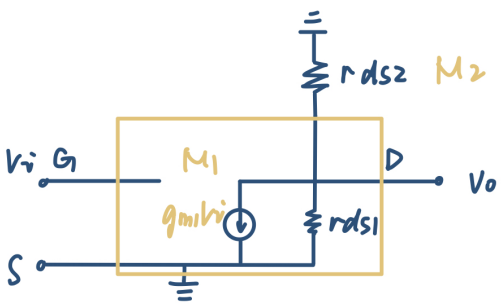
(3)





6.12

(1)

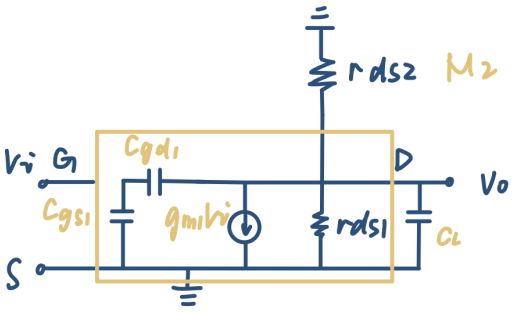


取 $V_i = 0.5V$.

$$A_0 = \frac{g_{m1}}{g_{ds1} + g_{ds2}} = \frac{143.1006\mu}{(4.011)\mu + 2.1777\mu)} = 23.1$$

仿真结果为27.2717 dB.

(2)



$C_{out} \approx C_L = 1pF$

$\frac{1}{R_{out}} = g_{ds1} + g_{ds2} = 6.1894uS$

$A(s) = \frac{A_0}{1+SRC}$ $\qquad f_{3dB} = 0.98 \times 10^6 Hz$

仿真结果为 1 MHz. 基本一致