6.22

（1）

反馈网络通过密勒补偿电容C_c增大二级运放电路的相位裕度。

（2）

$C_c \geq 0.22C_L$

$\frac{g_{m6}}{g_{m2}}>10$

$GBW = \frac{g_{m1}}{C_c}$

$SR \approx \frac{I_5}{C_c}$

$A_d = \frac{g_{m1}}{g_{ds2}+g_{ds4}}$

$A_2 = -g_{m6}\frac{1}{g_{ds6}+g_{ds7}}$

$A_t = A_dA_2 = -\frac{g_{m1}}{g_{ds2}+g_{ds4}}\frac{g_{m6}}{g_{ds6}+g_{ds7}}$

$V_{cm,max} = V_{DD} - \sqrt{\frac{I_5}{\beta_3}} - V_{T03}(max) + |V_{T01}|(min)$

$V_{cm,min} = V_{SS} + V_{DS5,sat} + V_{GS1}$

$\therefore V_{cm,min} = V_{SS} + \sqrt{\frac{I_5}{\beta_1}} + V_{T01}(max) + V_{DS5,sat}$

$CMRR = \frac{2g_{m1}g_{m3}}{(g_{ds2}+g_{ds4})g_{ds5}}$

$P = (V_{DD} - V_{SS})(I_5 + I_6)$

6.23

（1）选定补偿电容C_c

$$C_c \geq 0.22C_L \text{且} C_L = 10pF$$
$$\therefore C_c = 3pF$$

（2）计算$(W/L)_3$、$(W/L)_4$

$$SR \approx \frac{I_5}{C_c}$$
$$\therefore I_5 = C_c \cdot (SR) = 30\mu A$$
$$(W/L)_3 = \frac{I_5}{\mu_n C_{ox}[V_{DD} - V_{in}(max) - V_{T03}(max) + |V_{T01}|(min)]^2}$$
$$\because \mu_n C_{ox} = 110\mu A/V^2, V_{DD} = 2.5V,$$
$$V_{T03}(max) = 0.85V, |V_{T01}|(min) = 0.55V$$
$$\therefore (W/L)_3 = (W/L)_4 \approx 6.82$$
$$\text{取}(W/L)_3 = (W/L)_4 = 7$$

（3）计算$(W/L)_1$、$(W/L)_2$

$$g_{m1} \approx 94.3\mu s$$
$$(W/L)_1 = (W/L)_2 = \frac{g_{m1}^2}{2\mu_p C_{ox} I_1} \approx 5.92$$
$$\text{取}(W/L)_1 = (W/L)_2 = 6$$

（4）计算$(W/L)_5$

$$V_{DS5,sat} = V_{cm,min} - V_{SS} - V_{GS1} = -0.33V$$
$$(W/L)_5 \approx 11$$

（5）计算$(W/L)_6$

$$g_{m6} \geq 10g_{m2}$$
$$\text{取}g_{m6} = 943\mu s$$
$$g_{m4} = 2\sqrt{\frac{110 \times 10^{-6}}{2} \times 7 \times (15 \times 10^{-6})} \approx 152\mu s$$
$$\text{取}(W/L)6 = 44$$

（6）计算$(W/L)_7$

$$I_6 = \frac{g_{m6}^2}{2\mu_n C_{ox} \cdot (W/L)_6}$$
$$\therefore I_6 = 93.04\mu A$$
$$(W/L)_7 = (W/L)_5 \times \frac{I_6}{I_5} \approx 34$$

（7）计算$(W/L)_8$

设电流源电流为$45\mu A$

$$(W/L)_8 = (W/L)_5 = 11$$

$\therefore A_t = A_d A_2 = \frac{g_{m1}}{g_{ds2}+g_{ds4}} \frac{g_{m6}}{g_{ds6}+g_{ds7}} \approx 78dB$

$CMRR \approx 83dB$

仿真结果

CMRR

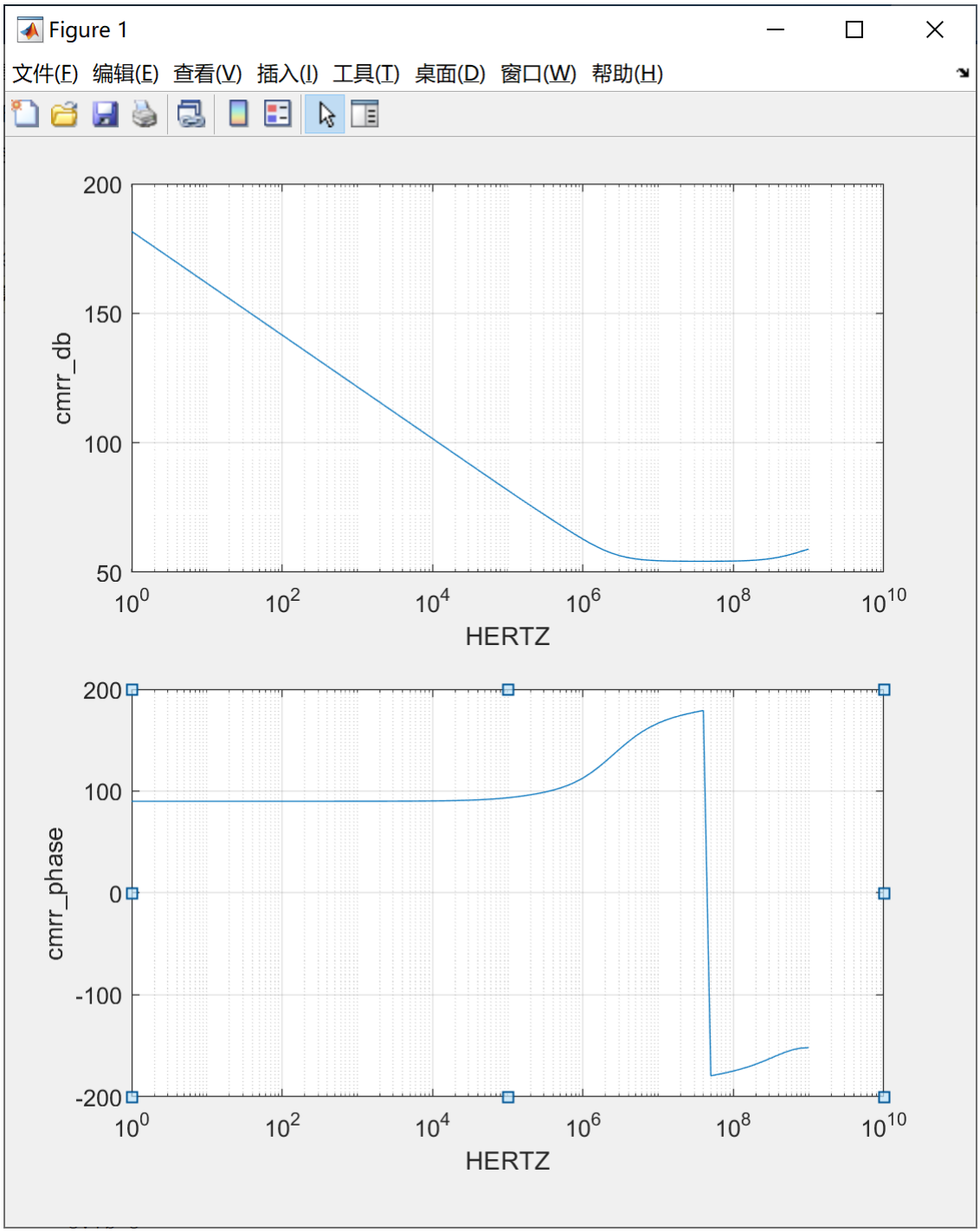
Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
cmrr_db
200
150
100
50
10^0
10^2
10^4
10^6
10^8
10^{10}
HERTZ
cmrr_phase
200
100
0
-100
-200
10^0
10^2
10^4
10^6
10^8
10^{10}
HERTZ

open_loop

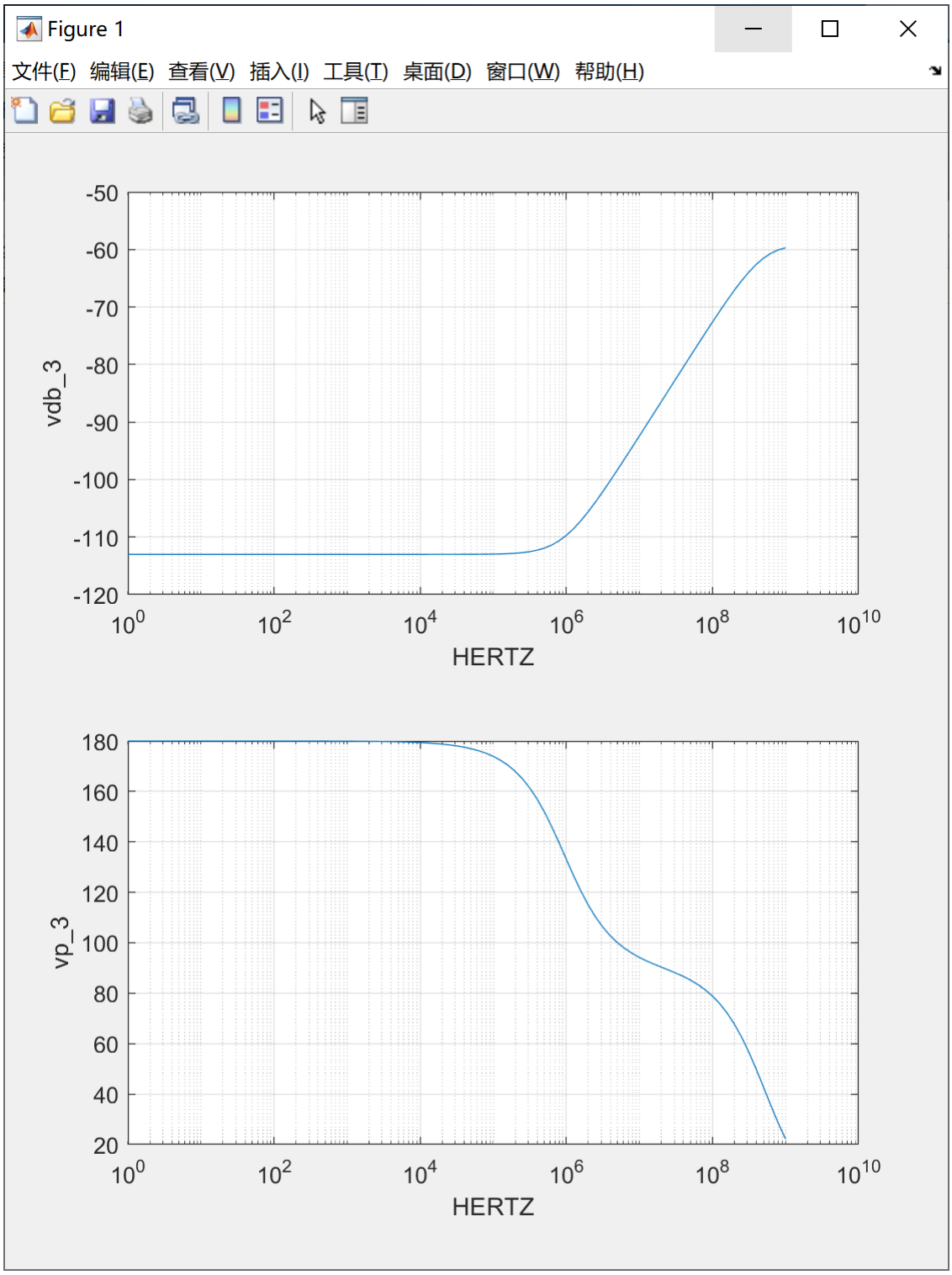
Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
vdb_3
-50
-60
-70
-80
-90
-100
-110
-120
10^0
10^2
10^4
10^6
10^8
10^{10}
HERTZ
vp_3
180
160
140
120
100
80
60
40
20
10^0
10^2
10^4
10^6
10^8
10^{10}
HERTZ

unity_gain

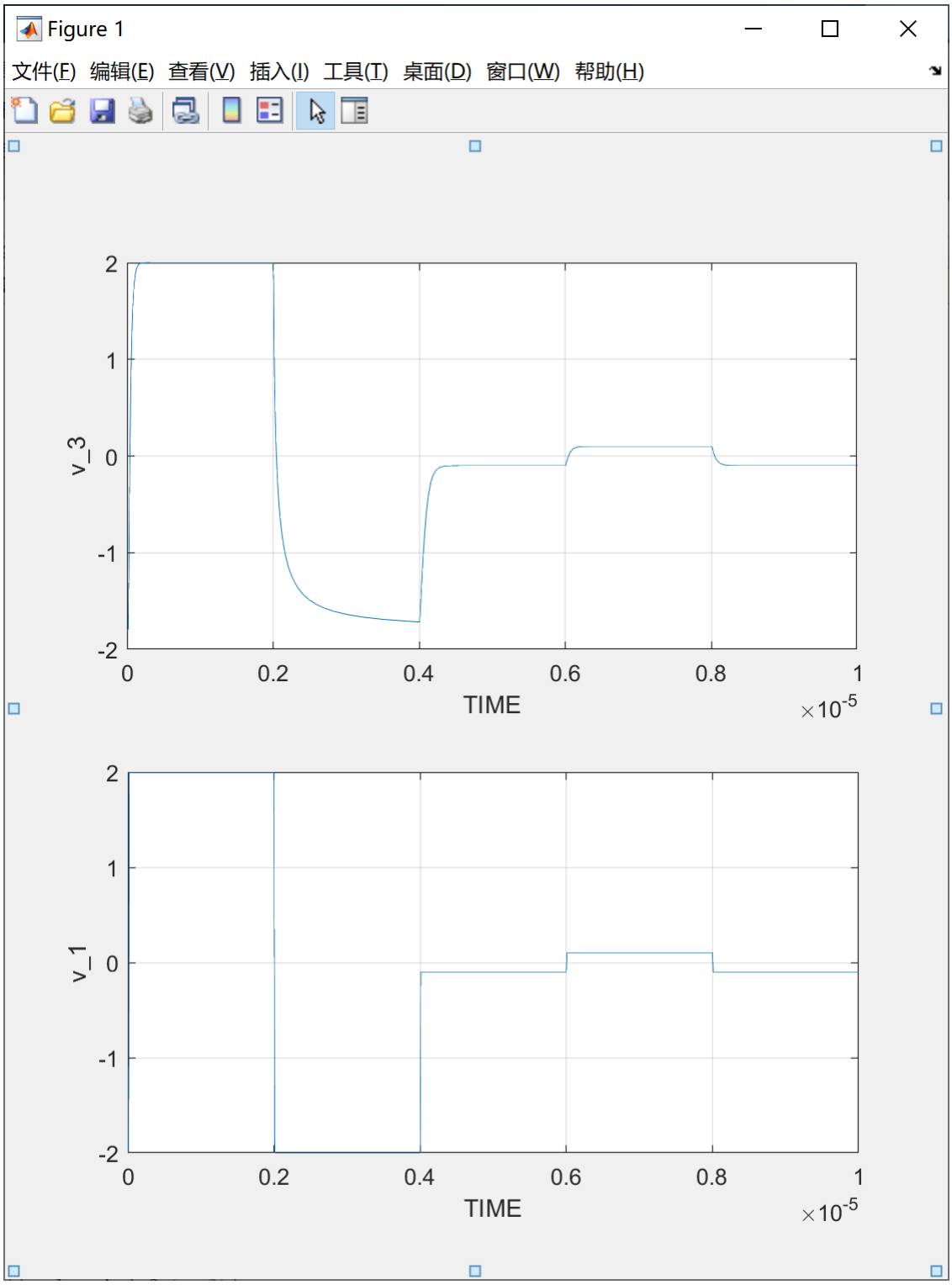
Figure 1
文件(F) 编辑(E) 查看(V) 插入(I) 工具(T) 桌面(D) 窗口(W) 帮助(H)
v_3
2
1
0
-1
-2
0
0.2
0.4
0.6
0.8
1
TIME
×10^-5
v_1
2
1
0
-1
-2
0
0.2
0.4
0.6
0.8
1
TIME
×10^-5