ENEE2360 CH8 Homework Problems

23. **a.** Find the value of R_S to obtain a voltage gain of 2 for the network of Fig. 8.74 using $r_d = \infty\ \Omega$.
b. Repeat part (a) with $r_d = 30\ \text{k}\Omega$. What was the impact of the change in r_d on the gain and the analysis?

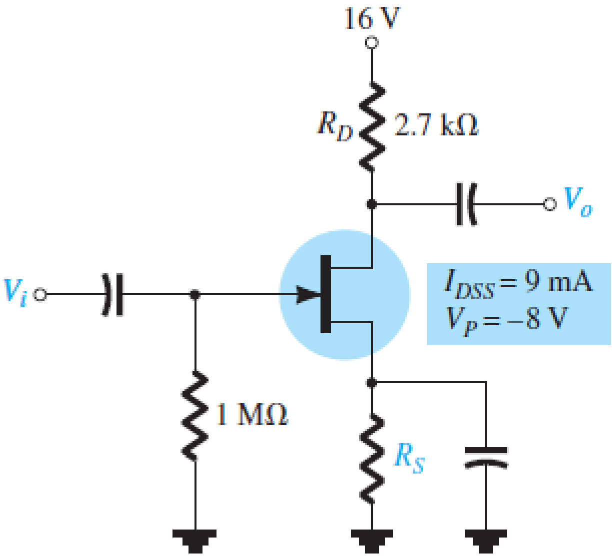


FIG. 8.74

rds = 30KΩ

46. Design the fixed-bias network of Fig. 8.88 to have a gain of 8.

47. Design the self-bias network of Fig. 8.89 to have a gain of 10. The device should be biased at $V_{GS_Q} = \frac{1}{3}V_P$.

rds = 50KΩ

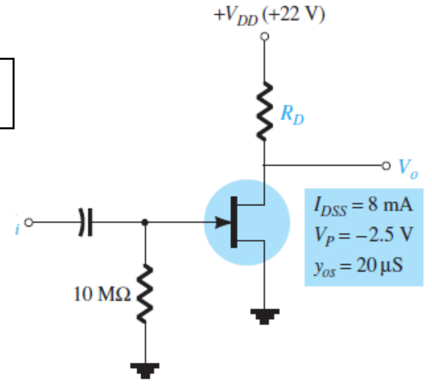


FIG. 8.88

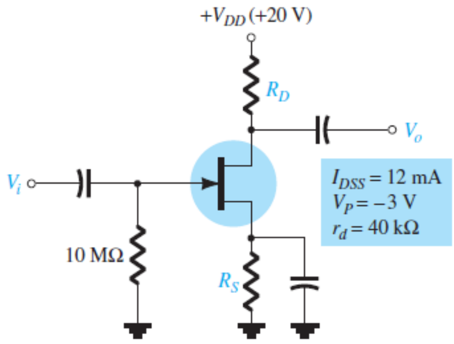


FIG. 8.89

56. For the cascade amplifier of Fig. 8.94, calculate the dc bias voltages currents of each stage.

57. For the amplifier circuit of Fig. 8.94, calculate the voltage gain of each stage and the overall amplifier voltage gain.

58. Calculate the input impedance (Z_i) and output impedance (Z_o) for the amplifier circuit of Fig. 8.94.

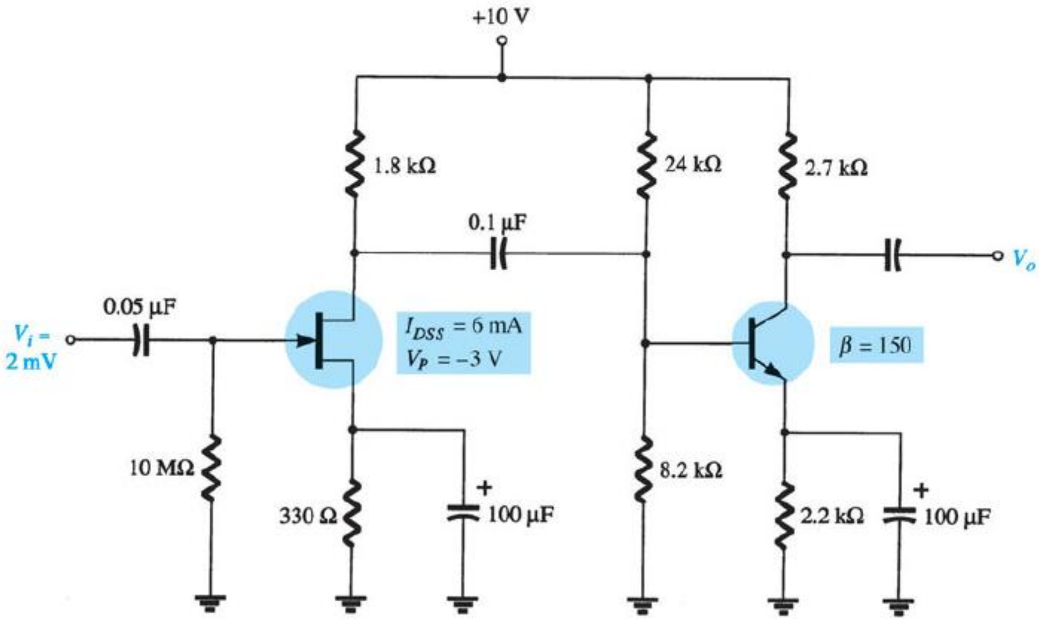
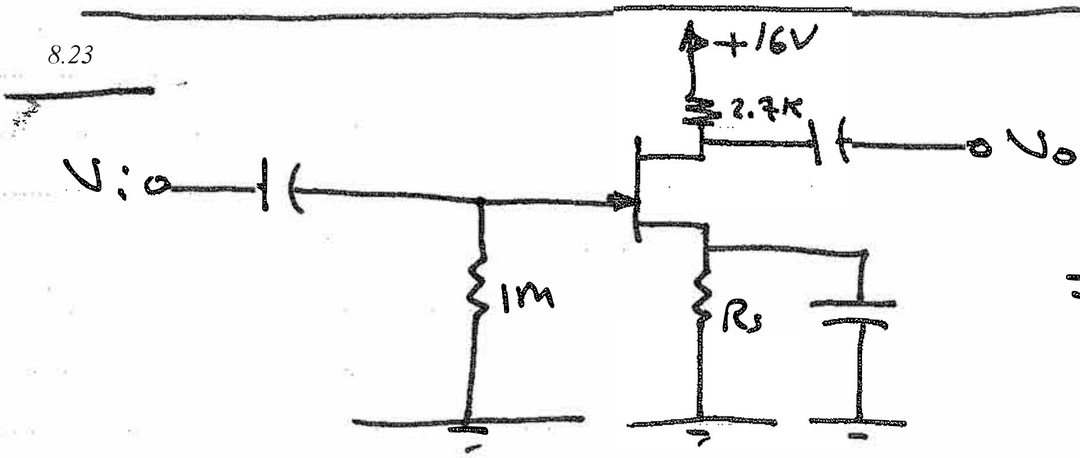


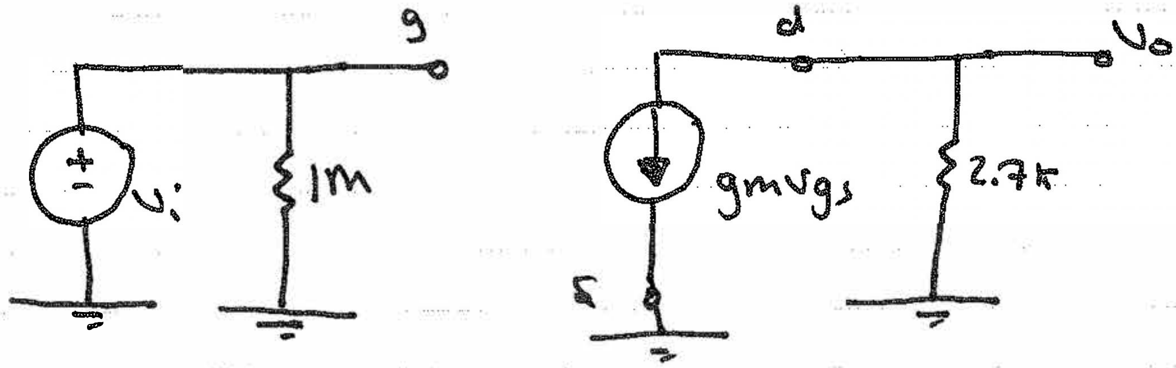
FIG. 8.94

8.23



$I_{DSS} = 9mA$
$V_p = -8V$

ac small signal equivalent circuit :



$$v_o = -g_m v_{gs} (2.7k)$$

$$v_{gs} = v_g - v_s = v_i$$

$$\therefore A_v = \frac{v_o}{v_i} = -g_m (2.7k) = -2$$

$$\therefore g_m = 0.741 \ mA/V$$

$$g_m = \frac{-2 I_{DSS}}{V_p} \left(1 - \frac{V_{GS}}{V_p} \right)$$

$$\therefore V_{GS} = -5.37V$$

$$I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$\therefore I_{DS} = 0.973 \text{ mA}$

$\therefore V_{GS} = V_G - V_S = 0 - R_S I_{DS} = -5.37V$

$\therefore R_S = \frac{5.37}{0.973} = 5.5K$

b) if $r_{ds} = 30K$

$V_o = -g_m v_{gs} (2.7K \| 30K) = -2$

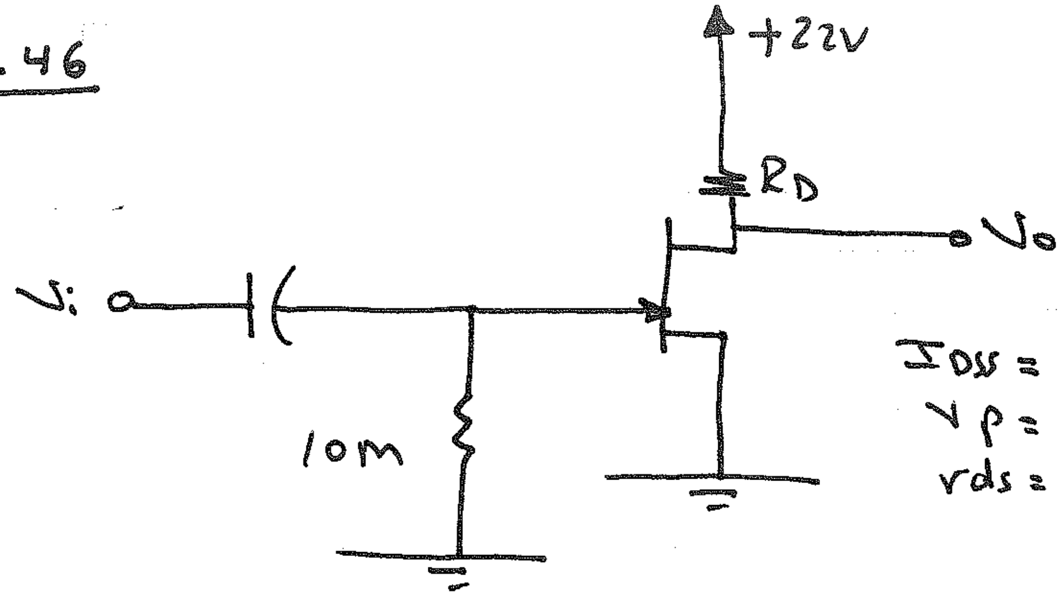
$\therefore g_m = 0.8 \text{ mA/V}$

$\therefore V_{GS} = -5.129 V$

$\therefore I_{DS} = 1.159 \text{ mA}$

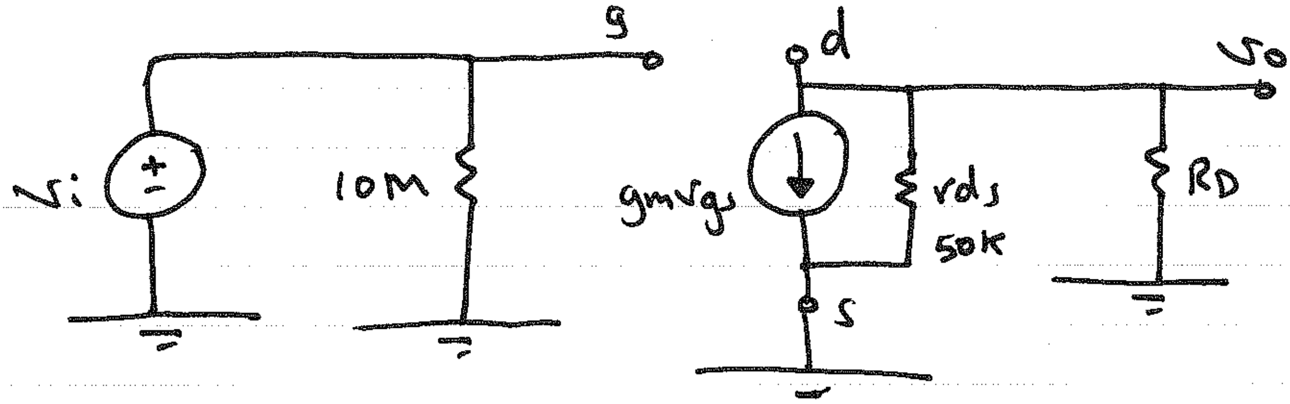
$\therefore R_S = 4.425K$

8.46



IDSS = 8 mA
VP = -2.5V
rds = 50K

ac small signal equivalent circuit:



$$v_o = -g_m v_{gs} (50K \| R_D)$$

$$g_m = \frac{2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

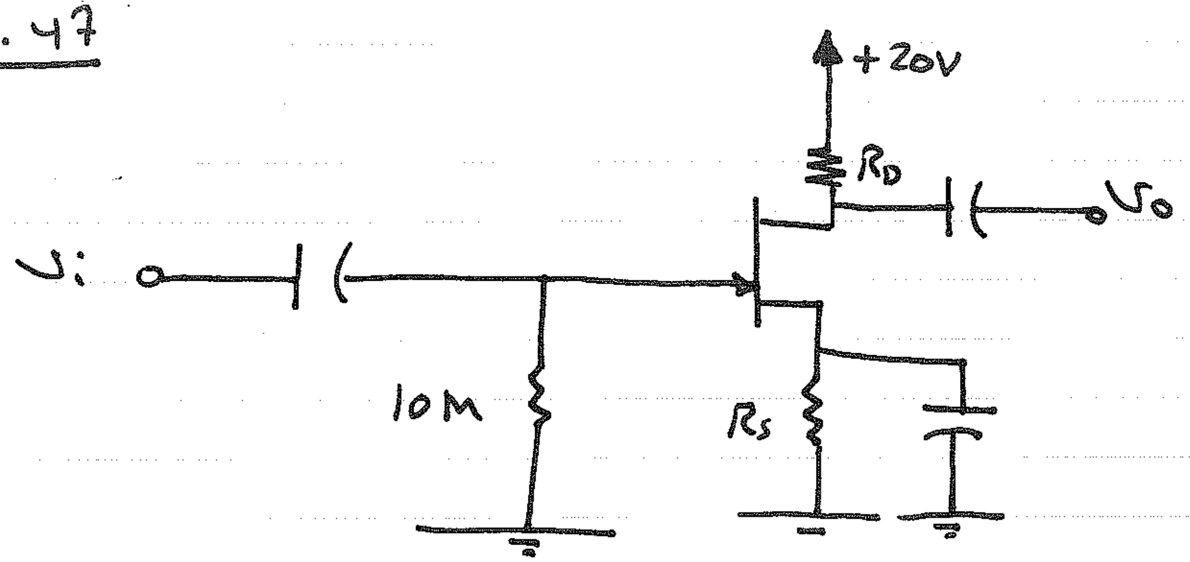
$$V_{GS} = 0$$

$$\therefore g_m = 6.4 \text{ mA/V}$$

$$A_v = -8 = -g_m (50K \| R_D)$$

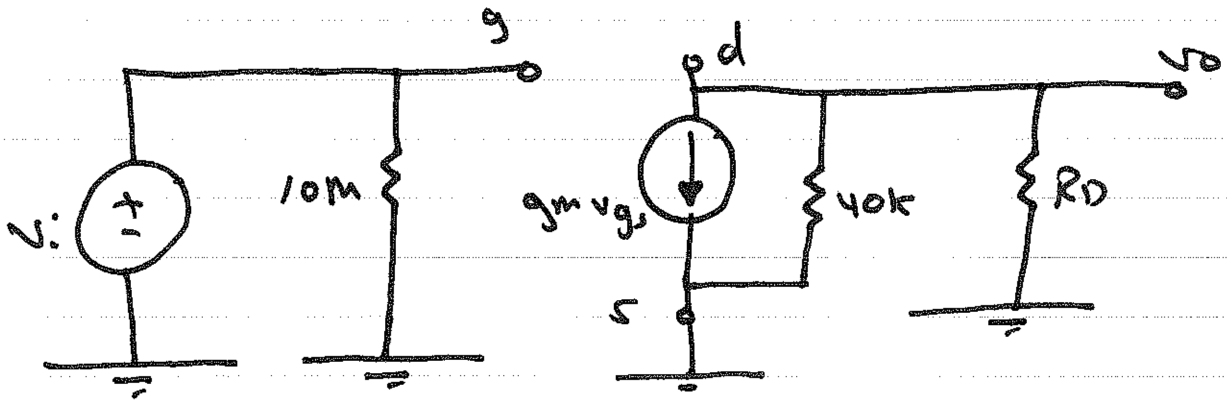
$$\therefore R_D = 1.28 K$$

8.47



$I_{DSS} = 12mA$
$V_P = -3V$
$r_{ds} = 40k$
$V_{GS} = -1V$

ac small signal equivalent circuit :



$$A_v = -g_m (R_D \| 40k) = -10$$

$$g_m = \frac{-2I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$V_{GS} = -1V$

$\therefore g_m = 5.33 \ mA|V$

$\therefore$ for $A_v = -10$

$R_D = 1.97\ K$

$$I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

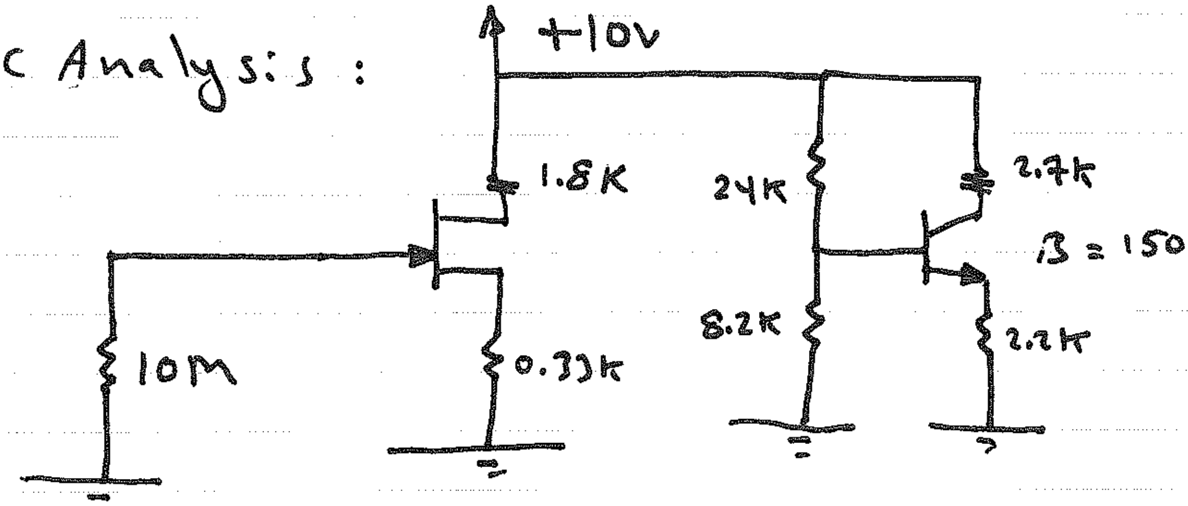
$\therefore I_{DS} = 5.33\ mA$

$V_{GS} = -1 = V_G - V_S = 0 - R_S I_{DS}$

$$\therefore R_S = \frac{1V}{5.33mA} = 0.187\ K$$

8.56

DC Analysis:



$I_{DSS} = 6mA$, $V_P = -3V$

$$I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$V_{GS} = V_G - V_S = (-0.33k)\, I_{DS}$

solving for I_{DS}, we get

$I_{DS} = 2.84 mA$

$R_{TH} = 24k \| 8.2k = 6.11k$

$$V_{TH} = \frac{8.2k}{8.2k+24k}(+10) = 2.55V$$

$$\therefore I_E = \frac{2.55 - 0.7}{2.2k + \frac{6.11k}{151}} = 0.824 mA$$

$V_{CE} = 10 - 2.7k\, I_C - 2.2k\, I_E \approx 5.96V$

$V_{DS} = 10 - (1.8k + 0.33k) I_{DS} = 3.95V$

$V_D = 10 - (1.8k)(2.84mA) = 4.89V$

$V_S = (0.33k)(2.84mA) = 0.937V$

$\therefore V_{DS} = 3.95V \quad ; \quad V_G = 0$

$|V_{DS}| > |V_P| - |V_{GS}|$

$|V_{DS}| > 3 - 0.937 = 2.063$ ✓

8.57

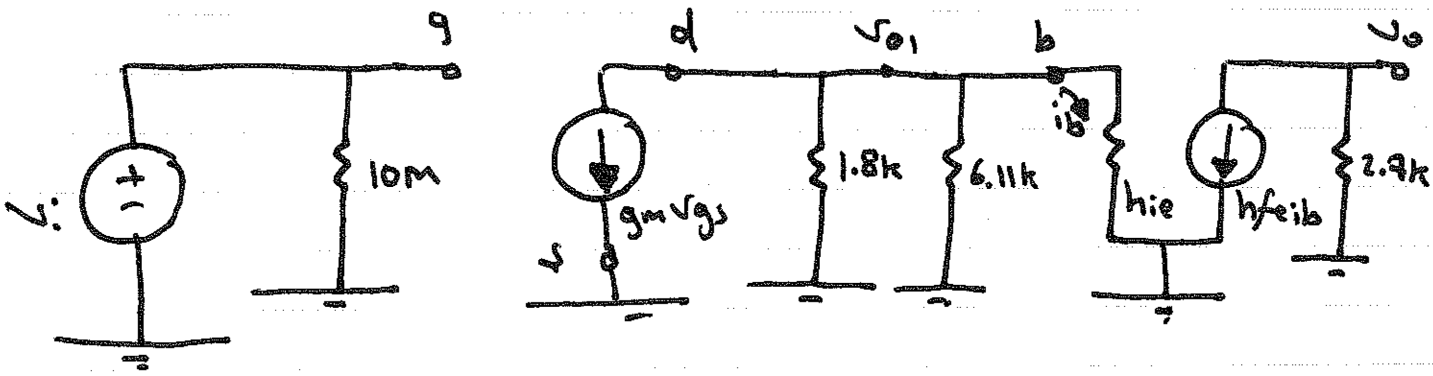
$$h_{ie} = \frac{(\beta+1) V_T}{I_E} = 4.71k$$

$$g_m = \frac{-2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$g_m = 2.75 \ mA/V$$

$$V_{GS} = -0.33k \ I_{DS} = -0.937V$$

ac small signal equivalent circuit:



$$A_{v1} = \frac{v_{o1}}{v_i} \ ; \quad v_{o1} = -g_m v_{gs}\left(1.8k \| 6.11k \| h_{ie}\right)$$

$$v_{gs} = v_g - v_s = v_g = v_i$$

$$\therefore A_{v1} = -2.75$$

$$A_{v2} = \frac{v_o}{v_{i2}} = \frac{v_o}{v_{o1}} \ ; \quad v_o = -h_{fe} i_b (2.7k)$$

$$i_b = \frac{v_{o1}}{h_{ie}}$$

$$\therefore A_{v2} = -85.98$$

$$A_{vT} = A_{v1} \cdot A_{v2} = 236.5$$

8.58

$Z_i = 10 M\Omega$

$Z_o = 2.7K\ \Omega$