$\boxed{72}$ $\boxed{5}$

$$R_o = r_{o1} // r_{o2} = \frac{r_o}{2} = \frac{|V_A|}{2 I_{REF}}$$

$$1\ M\Omega = \frac{50\ V}{2\ I_{REF}}$$

$$I_{REF} = \frac{50}{2} = \underline{\underline{25\ \mu A}}$$

$$A_v = -g_{m1}(r_{o1} // r_{o2})$$

$$= -g_{m1} R_o$$

Thus, $-100 = -g_{m1} \times 1 M\Omega$

$$g_{m1} = \frac{100}{1}\ \mu A/V = 100\ \mu A/V$$

But, $g_{m1} = \sqrt{2 k_n' \left(\frac{W}{L}\right)_1 I_{REF}}$

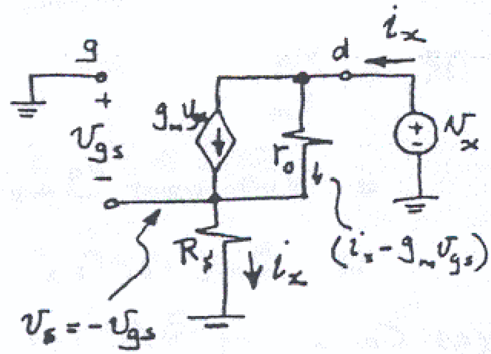
Thus, $100 = \sqrt{2 \times 50 \times \left(\frac{W}{L}\right)_1 \times 25}$

$$= 50 \sqrt{\left(\frac{W}{L}\right)_1}$$

$$\left(\frac{W}{L}\right)_1 = \underline{\underline{4}}$$

79

$$v_x = r_o\,(i_x - g_m v_{gs}) + v_s$$
$$= i_x r_o - g_m r_o\, v_{gs} - v_{gs}$$
$$= i_x r_o - (1+g_m r_o)\,v_{gs}$$
$$= i_x r_o + (1+g_m r_o)\,i_x R_S$$



Thus $i_x R_S = -v_{gs}$

$$R_o = \frac{v_x}{i_x} = r_o + (1+g_m r_o)\,R_S$$
$$= R_S + r_o\,(1+g_m R_S)$$

Q.E.D.

80 Refer to Fig. 5.48. 5

$$g_{m1} = \sqrt{2 k_n' \left(\frac{W}{L}\right)_1 I_{REF}}$$

$$= \sqrt{2 \times 20 \times 10 \times 200} = \underline{\underline{0.28 \ mA/V}}$$

$$r_{o1} = r_{o2} = \frac{|V_A|}{I_{REF}} = \frac{100 \ V}{0.2 \ mA} = \underline{\underline{500 \ k\Omega}}$$

$$A_v = \frac{g_{m1}}{g_{m1} + g_{mb1} + \frac{1}{r_{o1}} + \frac{1}{r_{o2}}}$$

$$= \frac{0.28}{0.28 + 0.1 \times 0.28 + \frac{1}{500} + \frac{1}{500}}$$

$$= \underline{\underline{0.9 \ V/V}}$$

$$R_o = (1/g_{m1}) // (1/g_{mb1}) // r_{o1} // r_{o2}$$

$$= \frac{1}{0.28 + 0.028 + \frac{1}{500} + \frac{1}{500}}$$

$$= \underline{\underline{3.2 \ k\Omega}}$$

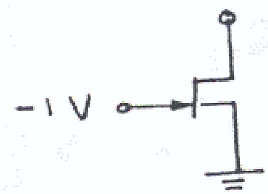
With a 10-kΩ load,

$$A_v = 0.9 \frac{R_L}{R_L + R_o} = 0.9 \times \frac{10}{10 + 3.2}$$

$$= \underline{\underline{0.68 \ V/V}}$$

$\boxed{118}$ $v_{DS} \geq v_{GS} - V_P$

Thus, $v_{DS_{min}} = -1 - (-2) = \underline{\underline{+1\ V}}$



Correspondingly,

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

$$= 4\left(1 - \frac{-1}{-2}\right)^2$$

$$= \underline{\underline{1\ mA}}$$

For a 10-V increase in drain voltage, I_D increases by $\frac{10\ V}{r_o}$ where $r_o = \frac{1}{\lambda I_D} = \frac{1}{0.01 \times 1} = 100\ k\Omega$.

Thus, I_D increases by $\underline{\underline{0.1\ mA}}$ to $\underline{\underline{1.1\ mA}}$.

$\boxed{123}$ Refer to Fig. P 5.123.

(a) $V_G = V_{DD} \frac{R_{G2}}{R_{G1} + R_{G2}} = 20 \frac{0.6}{1.4 + 0.6} = \underline{\underline{6\ V}}$

$V_S = I_D R_S \qquad V_{GS} = 6 - I_D R_S = 6 - 2.7 I_D$

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

$$I_D = 12\left(1 - \frac{6 - 2.7 I_D}{-4}\right)^2$$

$$= 12\left(1 + \frac{6}{4} - \frac{2.7}{4} I_D\right)^2$$

$$\Rightarrow I_D \simeq \underline{\underline{3\ mA}}$$

$$V_{GS} = \underline{\underline{-2V}}$$

$$V_D = 20 - I_D R_D = 20 - 3 \times 2.7$$

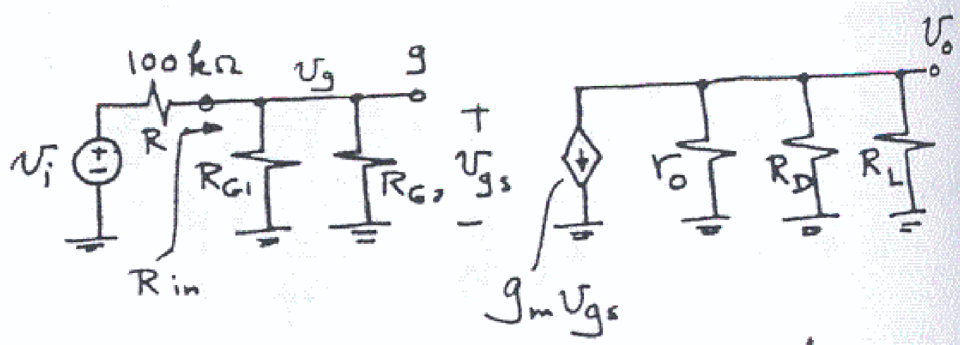
$$= \underline{\underline{11.9\ V}}$$

(b) $$g_m = \frac{2 I_{DSS}}{-V_P}\sqrt{\frac{I_D}{I_{DSS}}}$$

$$= \frac{2 \times 12}{4}\sqrt{\frac{3}{12}} = \underline{\underline{3\ mA/V}}$$

$$r_o = \frac{|V_A|}{I_D} = \frac{12 \times 25}{3} = \underline{\underline{100\ k\Omega}}$$

(c)



(d) $$R_{in} = R_{G1} // R_{G2} = 1.4 // 0.6 = \underline{\underline{420\ k\Omega}}$$

$$\frac{v_g}{v_i} = \frac{R_{in}}{R + R_{in}} = \frac{420}{100 + 420} = \underline{\underline{0.808\ V/V}}$$