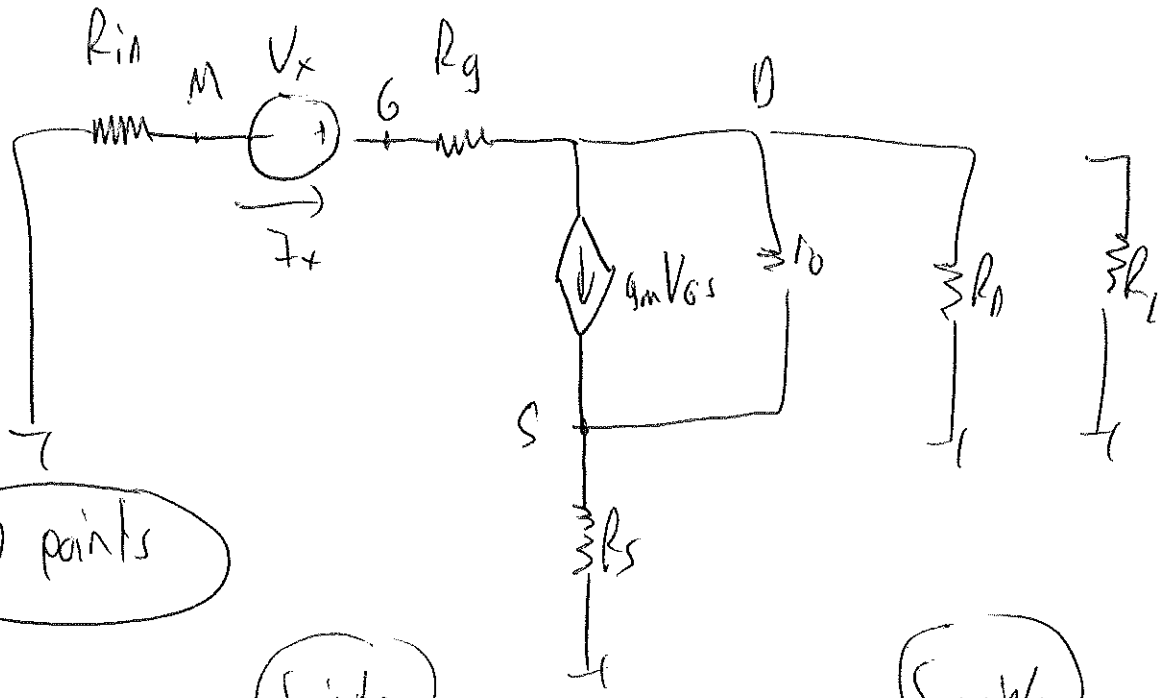
Solutions

MECE 246 Final 2018-2019

MECE 246 Resit 2018-2019

Q1

$R_G = 500$ $R_{in} = 500$



10 points

5 points

$$\frac{G-D}{R_G} = g_m V_{GS} + \frac{V_D - V_S}{r_o} + \frac{V_D}{R_D}$$

$$\frac{G-D}{500} = \frac{1}{1000}(G-S) + \frac{D-S}{1000} + \frac{D}{1000}$$

$$2G - 2D = G - S + D - S + D$$

$$2G = 4D - 2S + G$$

$$G = 4D - 2S$$

5 points

$$g_m V_{GS} + \frac{D-S}{r_o} = \frac{S}{R_S}$$

$$\frac{1}{1000}(G-S) + \frac{D-S}{1000} = \frac{S}{100}$$

$$G - S + D - S = S$$

$$G + D = 3S$$

$G = 4D - 2S \qquad G = 3S - D$

$4D - 2S = 3S - D$

$5D = 5S$

$D = S$, $G = 2S = 2D$

4 puan

$G - M = V_x$

$M = -R_{in} I_x$

$G = M + V_x$

$I_x = \frac{M + V_x}{1000}$

$1000 I_x = M + V_x$

$1000 I_x = (-R_{in} I_x) + V_x$

$(1000 + R_{in}) I_x = V_x$

$I_x = g_m V_{GS} + \frac{D-S}{r_o} + \frac{D}{R_D}$

$I_x = \frac{1}{1000}(G-S) + \frac{D-S}{1000} + \frac{D}{1000}$

$I_x = \frac{1}{1000}[G + 2D - 2S] = \frac{G}{1000}$

9 puan

$R_{cg} = \frac{V_x}{I_x} = 1000 + R_{in} = 1500\ \Omega$

5 puan

$\omega_{cut-off\ G_g} = \frac{1}{C_g R_{cg}}$

$\omega_{cut-off} = \frac{1}{10^{-6} f + 1500\Omega}$

$\omega_{cut\ off} = \frac{10^6}{1500} = \frac{10^3}{1.5}\ \frac{rad}{sec}$

Q2

(a) $R_{in} = \frac{v_{in}}{i_{in}}$

$(i_b + K_1 i_b) r_e = v_b$

$i_b (1 + K_1) r_e = v_b$

$i_{in} = \frac{v_b}{R_x} + i_b$

$i_{in} = \frac{v_b}{R_x} + \frac{v_b}{(K_1+1) r_e}$

$i_{in} = \frac{v_{in} - v_b}{R_a}$

$i_{in} = \frac{v_{in} - v_b}{R_a} = \frac{v_b}{R_x} + \frac{v_b}{(K_1+1) r_e}$ (5 marks)

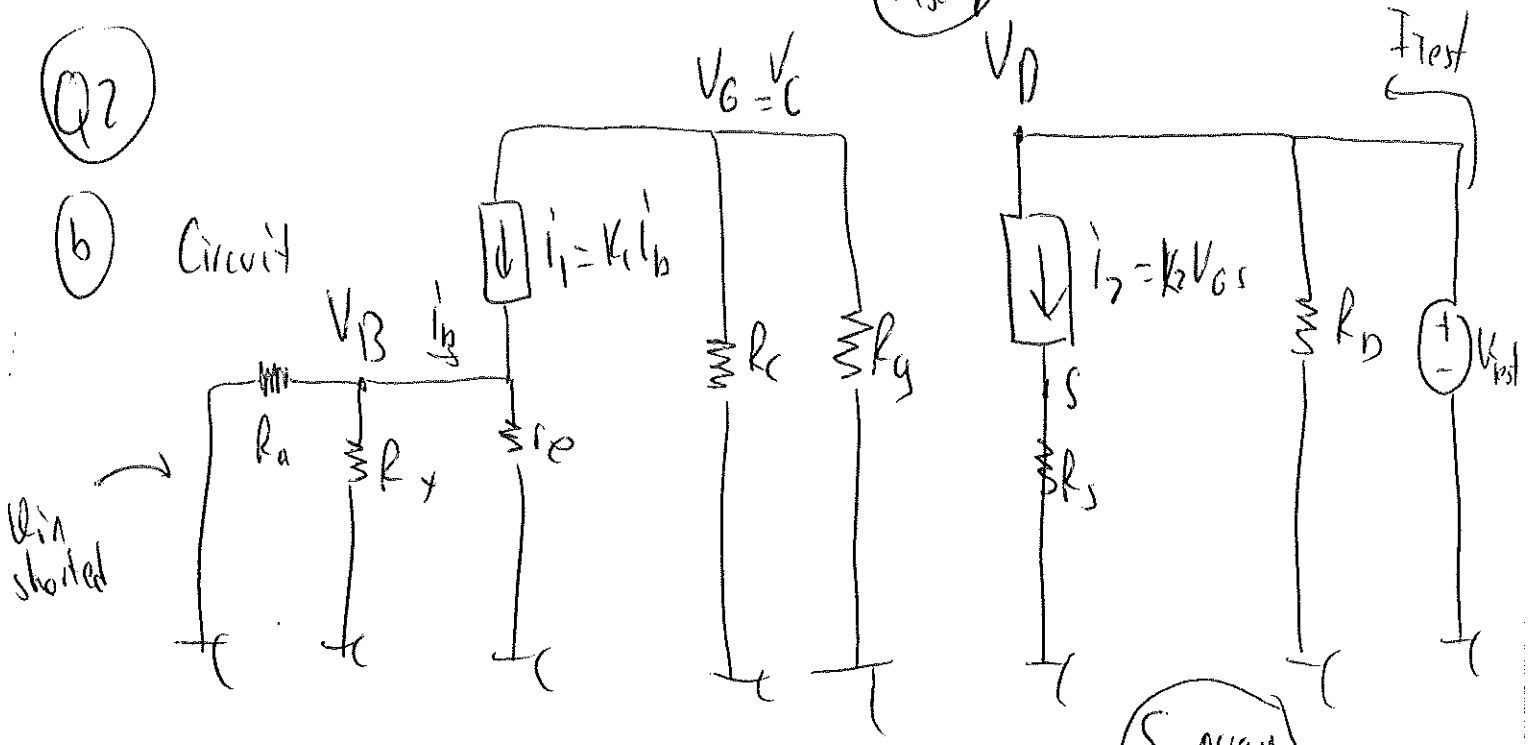
$v_{in} = R_a i_{in} + v_b$

$\frac{v_{in}}{i_{in}} = R_a + \frac{v_b}{i_{in}} = R_a + (R_x // (K_1+1) r_e)$ (1 mark)

$= R_a + \frac{R_x r_e (K_1+1)}{R_x + r_e (K_1+1)}$ (1 mark)

Q2

(b) Circuit



5 puan

$$v_b = \left(i_b + K_1 i_b\right) r_e = (K_1 + 1)\, i_b\, r_e$$

5 puan

$$\frac{v_b}{R_a} + \frac{v_b}{R_x} + i_b = 0 \qquad v_B\left[\frac{1}{R_a} + \frac{1}{R_x} + \frac{1}{(K_1+1) r_e}\right] = 0 \qquad v_B = 0$$

2 puan

if $v_B = 0$ $\quad i_b = 0$ $\quad i_1 = K_1 i_b = 0$ $\quad V_G = V_C = 0$

2 puan

$$I_{Test} = \frac{V_{test}}{R_D} + i_2 = \frac{V_{test}}{R_D} + K_2 (V_{GS})$$

$$I_{Test} = \frac{V_{test}}{R_D} + K_2 (V_G - V_S)$$

$$V_S = I_2 R_S$$

$$V_S = K_2 V_{GS} R_S$$

$$V_S = K_2 [0 - V_S] R_S$$

$$V_S \left[1 + K_2 R_S\right] = 0 \qquad V_S = 0$$

2 puan

$$I_{Test} = \frac{V_{test}}{R_D} + \left(-\frac{V_S}{1} \| r_2\right)$$

$$I_{Test} = \frac{V_{Test}}{R_D} + K_2 V_{OS} = \frac{V_{Test}}{R_D} + K_1 (0 - 0)$$

$$I_{Test} = \frac{V_{Test}}{R_D} \qquad R_{out} = \frac{V_{Test}}{I_{Test}} = R_D$$

(2 pairs)

(Q3)

$$\frac{V_D - V_o}{R_1} = \frac{V_o}{R_2}$$ (10 puan)

$$\frac{10 - V_o}{5\times10^7} = \frac{V_o}{5\times10^7} \qquad V_o = 5\ Volt$$ (5 puan)

$I_D = 0.5\,(V_{GS} - V_T)^2$

$R_S = 100\Omega$

$R_D = 100\Omega$

$I_D = 0.5\,(5 - V_S - 1)^2 = \frac{V_S}{R_S}$ (13 puan)

$0.5\,(4 - V_S)^2 = \frac{V_S}{1}$

$(0.5)(4 - V_S)^2 = V_S$

$(4 - V_S)^2 = 2V_S$

$16 - 8V_S + V_S^2 = 2V_S$

(4 puan) $V_S^2 - 10V_S + 16 = 0$

$(V_S - 2)(V_S - 8)$

$V_S = 2$ (valid)

$V_S = 8$ (not valid) → (3 puan)

$I_D = \frac{V_S}{R_S} = \frac{2}{1k\Omega} = 2mA$ → (5 puan)

$\frac{10 - V_D}{R_D} = I_D = 2$

$V_D = 8\ Volt$

$\frac{10 - V_D}{1000} = 2mA$