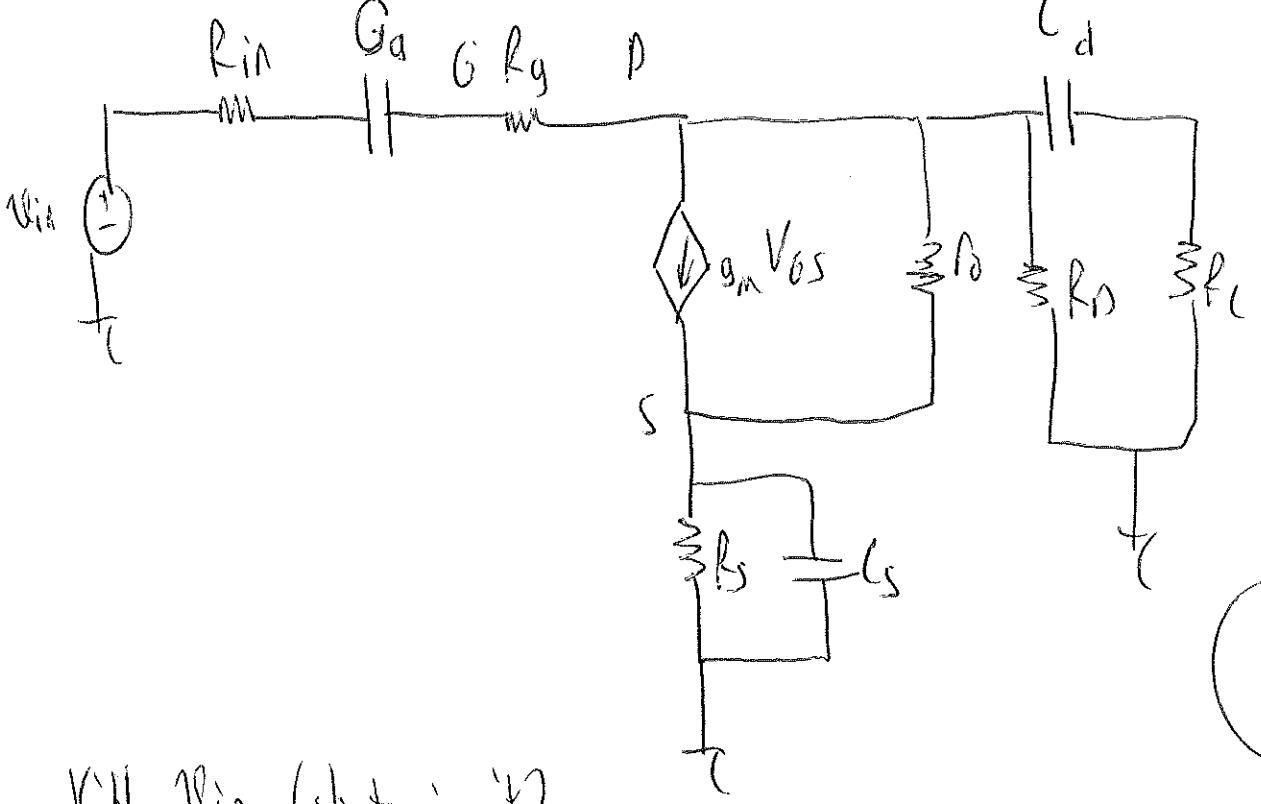
MECE 246 Final
. 2017-2018 spring

01-06-2018

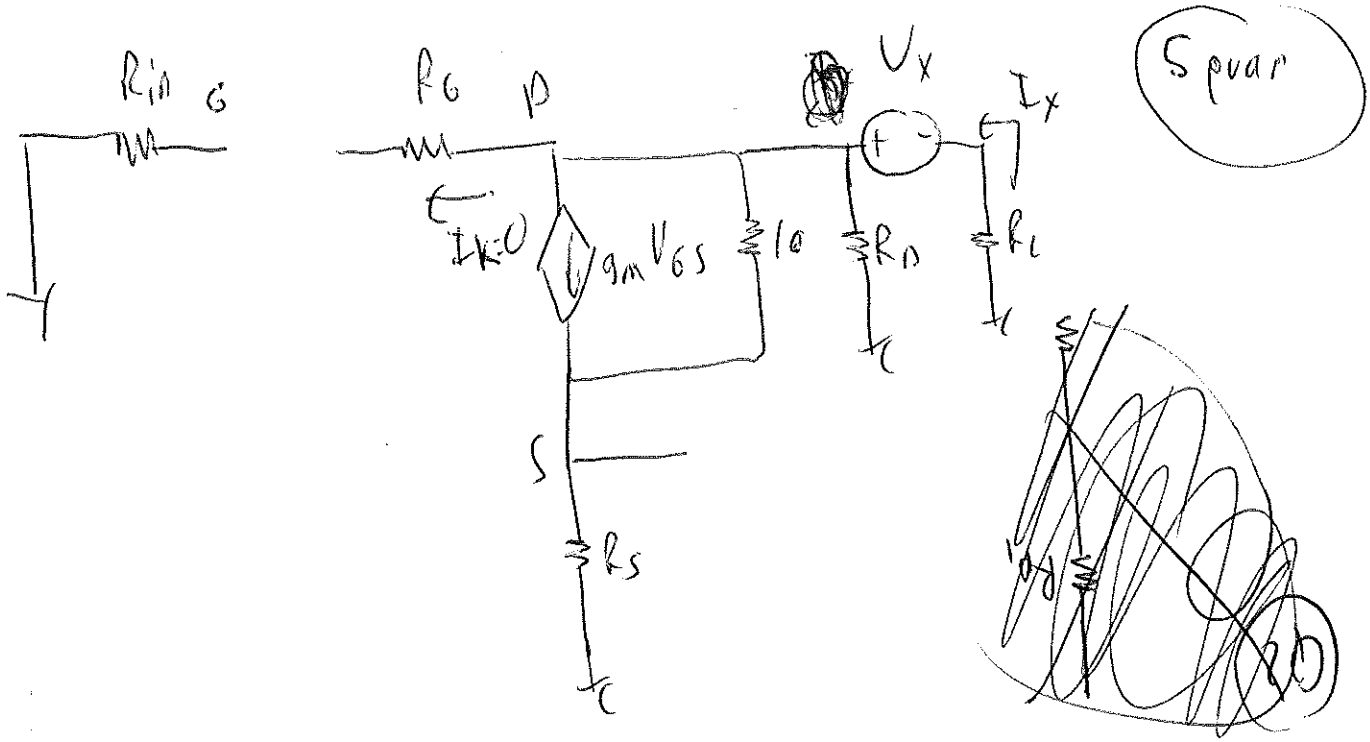
Q1



Sayfa 1

- KiN Vin (short circuit)
- put a test source V_{Test} instead of C_d
- open circuit C_g and C_s a
- Find the current orginating from V_{Test}

Spvar



$V_G = 0$ $\quad I_k = 0$ (open circuited portion) (2 puan)

$$g_m V_{GS} + \frac{V_D - V_S}{r_o} = \frac{V_S}{R_S}$$ (5 puan)

$$g_m(V_G - V_S) + \frac{V_D}{r_o} = V_S\left(\frac{1}{r_o} + \frac{1}{R_S}\right)$$

$$\frac{V_D}{r_o} = V_S\left[\frac{1}{r_o} + \frac{1}{R_S} + g_m\right] \Rightarrow V_S = \frac{V_D}{r_o\left[\frac{1}{r_o} + \frac{1}{R_S} + g_m\right]} = V_D \frac{r_o R_S}{r_o\left[R_S + r_o + r_o R_S g_m\right]}$$

$$I_x = \frac{V_D}{R_D} + \frac{V_D - V_S}{r_o} + g_m V_{GS}$$ (5 puan) (2 puan)

$$V_S = V_D \frac{R_S}{R_S + r_o + r_o R_S g_m}$$

$$I_x = V_D\left[\frac{1}{R_D} + \frac{1}{r_o}\right] - V_S\left[\frac{1}{r_o} + g_m\right]$$

$$I_x = \frac{-(V_D - V_x)}{R_L} = \frac{V_x - V_D}{R_L}$$ (3 puan)

(Sayfa 2)

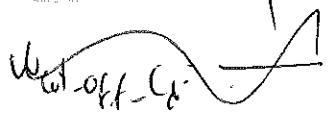
$$I_x = V_D\left[\frac{r_o + R_D}{r_o R_D}\right] - \left(\frac{R_S}{R_S + r_o + r_o R_S g_m}\right)\left(\frac{1 + g_m r_o}{r_o}\right) V_D$$

$$I_x = V_D\left(\frac{r_o + R_D}{r_o R_D} - \frac{R_S(1 + g_m r_o)}{r_o\left(R_S + r_o + r_o R_S g_m\right)}\right) =$$ (3 puan)

$$I_x = \frac{V_x - V_D}{R_L} \qquad V_x = I_x R_L + V_D$$

$$\frac{V_x}{I_x} = R_L + \frac{V_D}{I_x} \qquad \frac{V_x}{I_x} = R_L$$

(3 puan)



$$I_x = V_D \left(\frac{(r_o + R_D)[R_s + r_o + r_o R_s g_m] - R_D R_s (1 + g_m r_o)}{r_o R_D [R_s + r_o + r_o R_s g_m]} \right)$$

$$I_x = V_D \left(\frac{r_o R_s + r_o^2 + r_o^2 R_s g_m + r_o R_s + R_D R_s + r_o R_D R_s g_m - R_D R_s - r_o R_D R_s g_m}{r_o R_D [R_s + r_o + r_o R_s g_m]} \right)$$

$$I_x = V_D \left(\frac{r_o R_s + r_o^2 + r_o^2 R_s g_m + r_o R_D}{r_o R_D (R_s + r_o + r_o R_s g_m)} \right) = \frac{R_s + r_o + r_o R_s g_m + R_D}{R_D [R_s + r_o + r_o R_s g_m]}$$

~~$I_x = V_D$~~ $\quad \frac{V_D}{I_x} = \frac{R_D [R_s + r_o + r_o R_s g_m)}{R_s + r_o + r_o R_s g_m + R_D} = R_D // [R_s + r_o + r_o R_s g_m]$

(3 puan)

$$R_{C_d} = \frac{V_x}{I_x} = R_L + \frac{V_D}{I_x} = R_L + \left[R_D // [R_s + r_o + r_o R_s g_m] \right]$$

$$R_{C_d} = 1000 + \left[1000 // [1000 + 1000 + 10^3 \cdot 10^3 \cdot 10^{-3}] \right]$$

(Sayfa 3)

$$R_{C_d} = 1000 + [1000 // 3000]$$

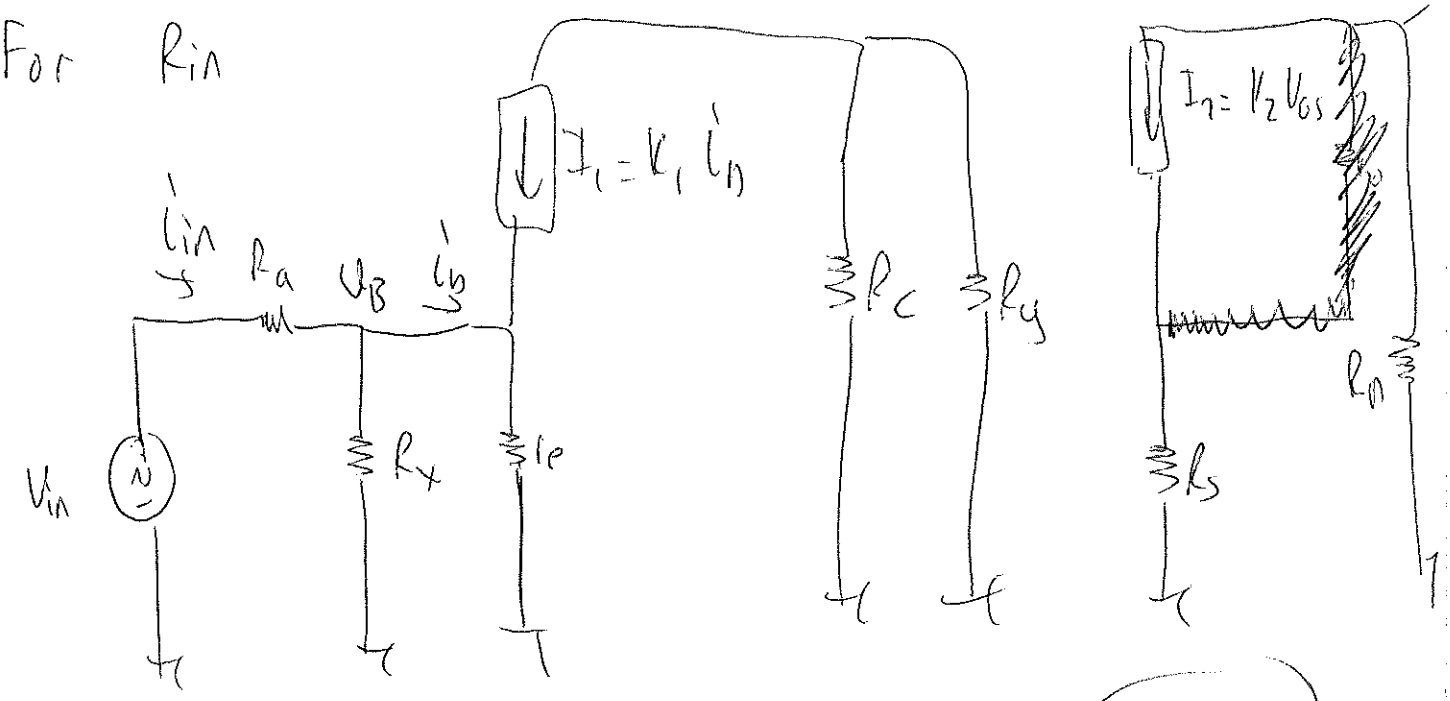
$$R_{C_d} = 1000 + \frac{1000 \times 3000}{1000 + 3000} = 1000 + \frac{3 \times 10^6}{4 \times 10^3} = 1000 + \frac{3}{4} \times 10^3$$

$$= 1750\ \Omega$$ (2)

$$\omega_{cut\text{-}off\text{-}C_d} = \frac{1}{R_{C_d} C_c} = \frac{1}{1750 \times 10^{-6}} = \frac{10^6}{1750} = \frac{100000}{175} = 571.42 \frac{rad}{sn}$$

Q2

(a) For R_{in}



$$V_B = (K_1+1) r_e i_b$$ (2 puan)

$$R_{in} = \frac{v_{in}}{i_{in}} =$$ Sayfa 4

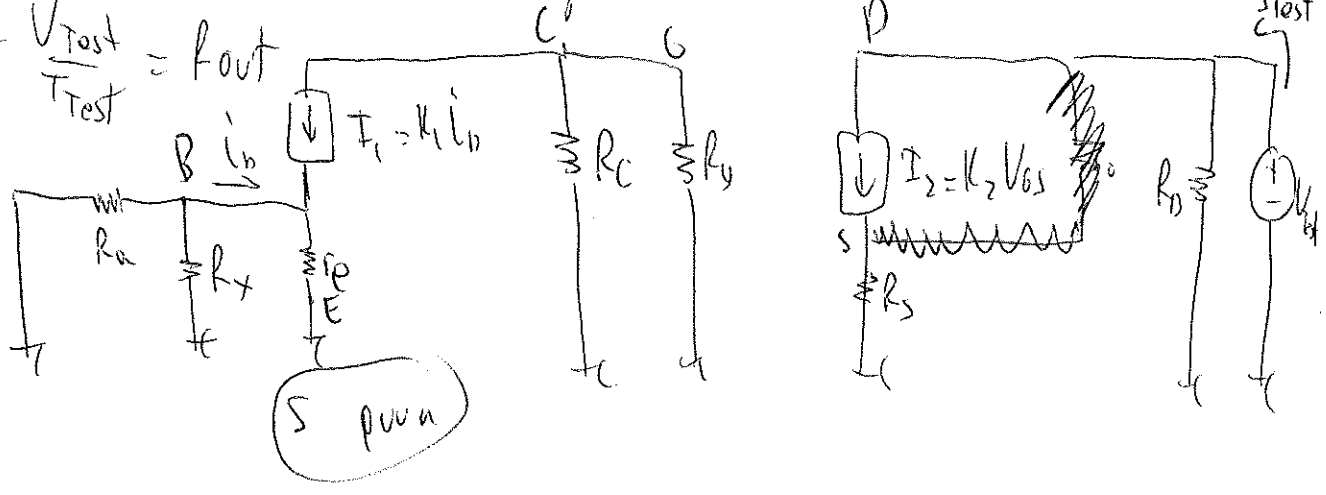
$$\frac{v_{in} - v_B}{R_a} = \frac{v_B}{R_x} + i_b$$ (3 puan)

$$\frac{v_{in}}{i_{in}} = R_a + \left[R_x // (K_1+1) r_e \right]$$ (1 puan)

$$i_{in} = v_B \left[\frac{1}{R_x} + \frac{1}{(K_1+1) r_e} \right]$$ (1 puan)

(b) For R_{out}

- Kill V_{in}
- Put a test source V_{Test} to V_{out}
- Calculate current originating from V_{Test} (that is I_{Test})
- $\frac{V_{Test}}{I_{Test}} = R_{out}$



5 puan

$v_B = (K_1+1) i_b r_e$ $\quad \frac{v_B}{(K_1+1) r_e} = i_b$

$i_B + \frac{v_B}{R_x} + \frac{v_B}{R_A} = 0$ (1 puan) $\quad \frac{v_B}{(K_1+1) r_e} + \frac{v_B}{R_x} + \frac{v_B}{R_A} = 0 \Rightarrow v_b = 0$ (1 puan)

$v_b = 0 \Rightarrow i_b = 0 \Rightarrow V_C = v_o = 0$ (1 puan)

$V_D = V_{Test}$ $\quad V_G = 0$ (1 puan)

$I_{Test} = \frac{V_D}{R_D} + [\quad] + K_2 V_{GS}$ (1 puan)

$I_{Test} = V_D \left[\frac{1}{R_D} + [\quad] \right] - [\quad + K_2] V_S$

$I_2 [\quad] = \frac{V_S}{R_S}$

$K_2 V_{GS} [\quad] = \frac{V_S}{R_S}$ (1 puan)

$-K_2 V_S + [\quad] = V_S \left[[\quad] + \frac{1}{R_S} \right]$

$V_D = \left[r_o [\quad] + \frac{r_o}{R_x} \right] V_S$

$V_D = \frac{[\quad]}{R_S} V_S$

$V_S = V_D \frac{R_S}{r_o R_S [\quad] + R_S r_o}$

$0 [\quad] = \left[K_2 [\quad] + \frac{1}{R_S} \right] V_S \quad V_S = 0$ (1 puan)

$I_{Test} = V_D \left(\frac{r_o + R_D}{R_D r_o} \right) - \left[\frac{1 + r_o K_2}{r_o} \right] \frac{R_S}{r_o R_S K_2 + R_S r_o}$ (1 puan)

$I_{Test} = V_D \left[\frac{1}{R_D} \right] - K_2 V_S$ (1 puan)

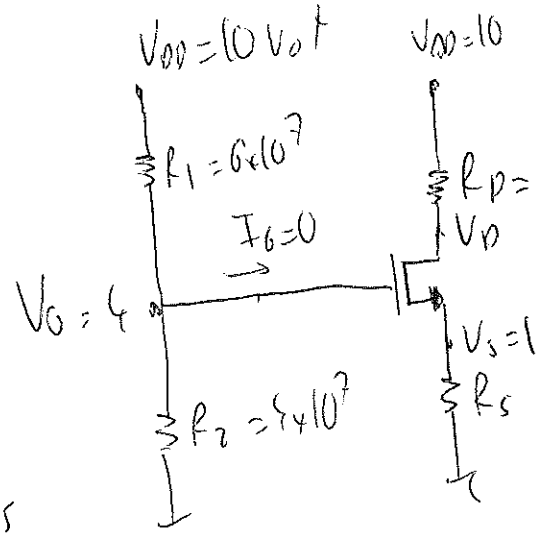
$I_{Test} = V_D \left[\frac{1}{R_D} \right] \quad \frac{V_D}{I_{Test}} = \frac{V_{Test}}{I_{Test}} = [\quad]$ (1 puan)

$R_{out} = R_P$

(Q3)

$I_D = A(V_{GS} - V_T)^2$ $\quad A = 0.5 \frac{mA}{V^2}$

$I_D = 0.5(V_{GS} - V_T)^2$ $\quad R_1 = 6\times10^7$ $\quad R_2 = 4\times10^7$



$I_G = 0 \Rightarrow \frac{V_{DD} - V_G}{R_1} = \frac{V_G}{R_2}$

$\frac{10 - V_G}{6\times10^7} = \frac{V_G}{4\times10^7}$

$40 - 4V_G = 6V_G$

$V_G = 4$ (10)

$\frac{10 - V_D}{500} = \frac{V_S}{500}$

$10 = V_D + V_S$

(2 pwan)

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

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

$0.5\frac{mA}{V^2}(3 - V_S)^2 = \frac{V_S}{0.5k\Omega}$ (10)

$0.5 \times 0.5 (4 - V_S - 1)^2 = V_S$

$0.25(4 - V_S - 1)^2 = V_S$

$(4 - V_S - 1)^2 = 4V_S$

$(3 - V_S)^2 = 4V_S$

$9 - 6V_S + V_S^2 = 4V_S$

$V_S^2 - 10V_S + 9 = 0$

$(V_S - 1)(V_S - 9)$

$0.5(2)^2 = \frac{1}{R_S}$

$0.5\ 4 = \frac{1}{R_S}$

$R_S = \frac{1}{4\times0.5} = \frac{1}{2} = 500\ \Omega$

(8)

(4) $\Rightarrow V_S = 1$ (valid)

$V_S = 9$ (not valid)

$I_D = 2mA = I_S$ (5)

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

$R_D = 500\ \Omega$

$V_D = 9$ Volt

(5) $V_S = 1$ Volt