Date: 13/3/20

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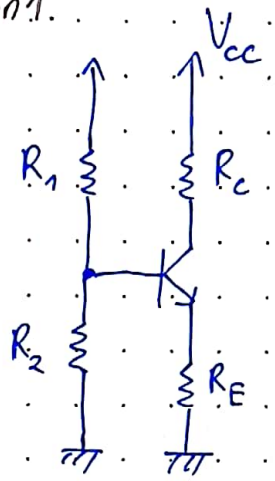
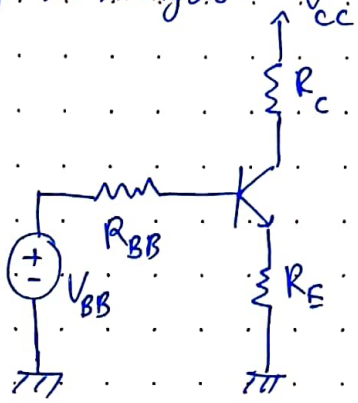
Analog Electronics

Quiz #1

Question 1.



* DC Analysis:



$$V_{BB} = \frac{V_{cc} R_2}{R_1 + R_2} = 5^V \; ; \; R_{BB} = R_1 // R_2 = 2.5^{k\Omega}$$

a) Assume the BJT is active:

$$V_{BB} \simeq I_{BQ} R_{BB} + V_{BE} + \beta I_{BQ} R_E$$

$$\Leftrightarrow 5^V \simeq I_{BQ} (2.5 + 100 \times 4.3) + 0.7$$

$$\Leftrightarrow I_{BQ} \simeq 0.01^{mA}$$

$$\Rightarrow I_{CQ} = \beta I_{BQ} = 1^{mA}$$

b) $V_{CEQ} \simeq V_{cc} - I_{CQ}(R_c + R_E) = 5.7^V > 0.2^V \Rightarrow$ Correct assumption

c) $g_m = \frac{I_{CQ}}{V_T} = 0.04\ A/V = 40\ mA/V$

d) $r_\pi = \beta / g_m = 2.5^{k\Omega}$

e) $r_e = \frac{r_\pi}{\beta + 1} \simeq 25^\Omega$

Question 2.

1. For MOSFET, saturation mode is used for amplification.

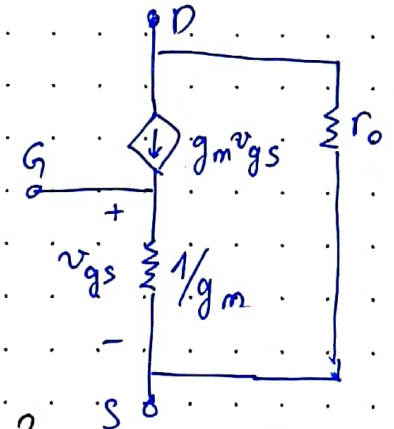
2. $I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$

$\Leftrightarrow 0.64 = \frac{1}{2} \times 1.28 \times (V_{GS} - 1)^2$

$\Leftrightarrow \begin{cases} V_{GS} = 2\,V \\ V_{GS} = 0\,V \end{cases} \Rightarrow V_{GS} = 2\,V$

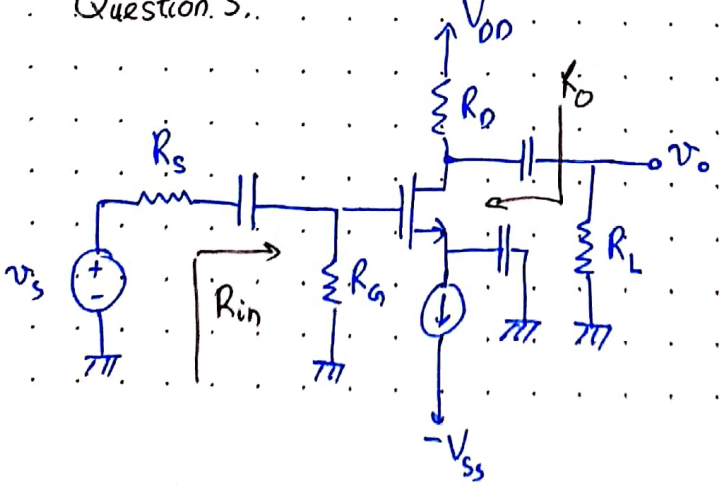
$g_m = \frac{2I_D}{V_{ov}} = \frac{2 \times 0.64\,mA}{V_{GS} - V_t} = 1.28\,mA/V$

3. $r_o = \frac{V_A}{I_D} = \frac{200\,V}{0.64\,mA} = 312.5\,k\Omega$

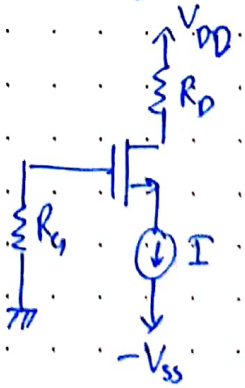


T-model

Question 3.



* DC analysis



a) $I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2$

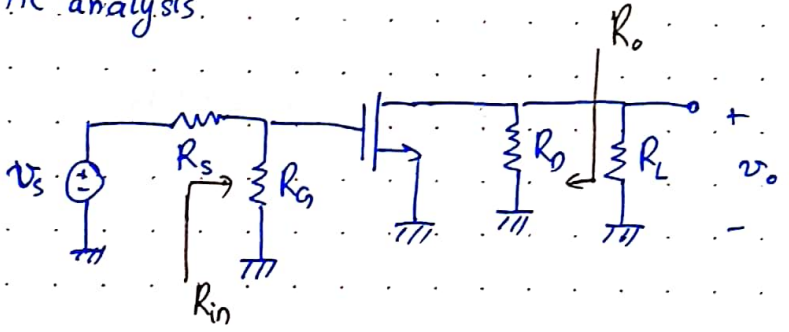
$\Rightarrow 1 = \frac{1}{2} 1.28 (V_{GS} - 1)^2 \Leftrightarrow \begin{cases} V_{GS} = 2.25^V \\ V_{GS} = -0.25^V \end{cases}$

$\Rightarrow V_{GS} = 2.25^V \Rightarrow V_S = 0 - 2.25 = -2.25^V$

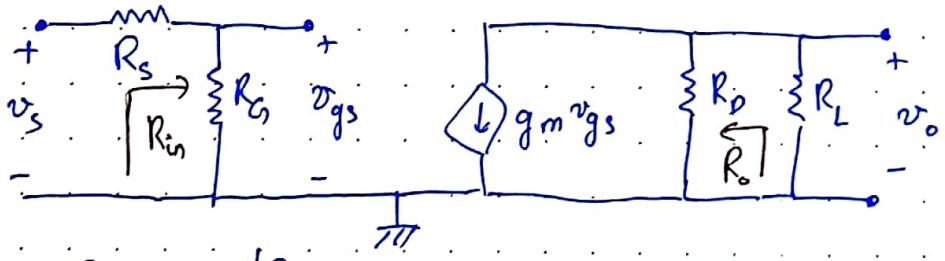
$V_{DS} = V_{DD} - I_D R_D - V_S = 12 - 1 \times 4 + 2.25 = 10.25^V$

$g_m = \frac{2I_D}{V_{OV}} = \frac{2I_D}{V_{GS} - V_t} = \frac{2 \times 1}{1.25} = 1.6\ mA/V$

b) * AC analysis. (Ignore r_o)



* Small signal equivalent circuit:



c) $R_{in} = R_G = 500\ k\Omega$

$R_o = R_D = 4\ k\Omega$

d) $\begin{cases} v_{gs} = v_s \frac{R_G}{R_s + R_G} = \frac{25}{26} v_s \\ v_o = -g_m v_{gs} R_D // R_L = -1.6 v_{gs} (4 // 1) = -1.28 v_{gs} \end{cases}$

$\Rightarrow v_o / v_s \approx -1.23$