University of Jordan
Elect. Eng. Dept.

Electronics II 903361 — Second Exam : Second Summer Semester , Thursday 17/8/2017

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Answers should be written in ink — Exam Duration: 70 min — Mark out of 30

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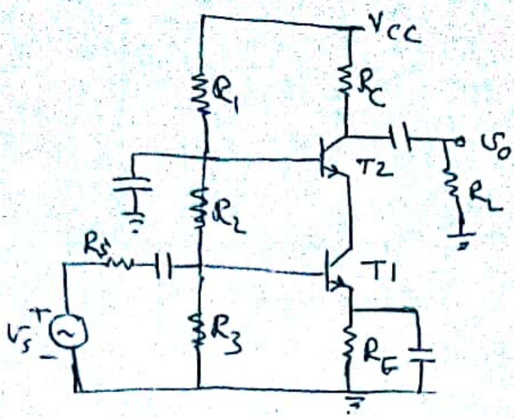
Q1) a) Draw the electronic circuit diagram of the <u>cascode</u> amplifier.



Write down its ac <u>voltage gain</u> .

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$$A_V = -g_{m1}\, R_C \| R_L$$

1

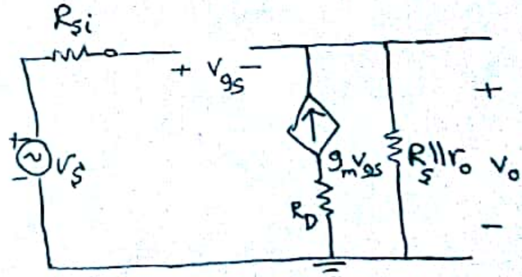
b) Draw the small signal low frequency circuit model of a <u>common drain</u> n-channel MOSFET , and use it to calculate the <u>voltage gain</u> when $R_1 \| R_2 = \infty\ \Omega$, R_S , R_{Si} , and R_D are finite.

$$V_o = g_m v_{gs} (R_S \| r_o)$$

$$V_s = v_{gs} + g_m (R_S \| r_o) v_{gs}$$

$$\therefore v_{gs} = \frac{1}{1 + g_m (R_S \| r_o)} V_s$$

$$\therefore A_V = \frac{V_o}{V_s} = \frac{g_m (R_S \| r_o)}{1 + g_m (R_S \| r_o)}$$



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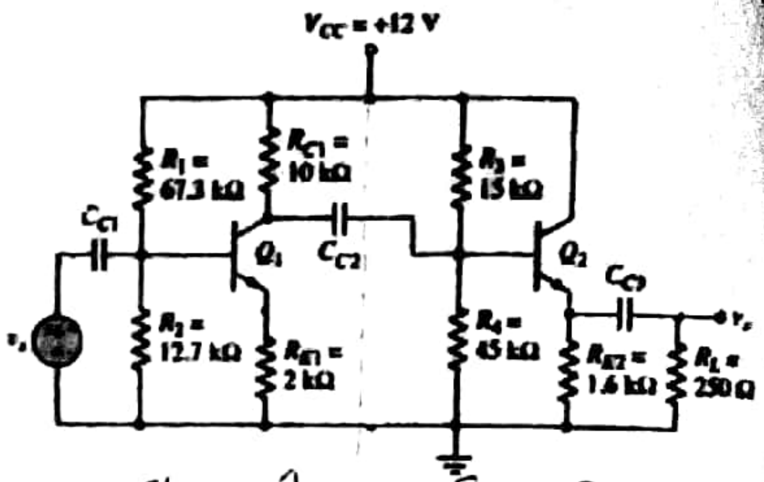
Q2 Given the two-stage amplifier shown opposite with the following information: $I_{BQ1} = 3.2\ \mu A$, $I_{BQ2} = 20\ \mu A$. Furthermore, for both transistors, $\beta_{dc} = \beta_{ac} = \beta = 99$, $V_T = 25$ mV and $V_A = \infty V$. Calculate the overall **voltage gain**.



$r_{\pi 1} = \frac{V_T}{I_{BQ1}} = \frac{25}{3.2} k\Omega = 7.8125\ k\Omega$

Stage 1

Stage 2

$r_o || R_E = R_E$
$\infty || R_E$

$r_{\pi 2} = \frac{25}{20} k\Omega = 1.25\ k\Omega$

$r_o = \frac{V_A}{I_{CQ}} = \frac{\infty}{I_{CQ}} = \infty\ \Omega$

(1)

Stage 1 is CE

$R_{ib1} = r_{\pi 1} + (1+\beta) R_{E1}$
$= 7.8125 + 100 \times 2$
$= 207.8125\ k\Omega$

$R_{i1} = R_1 || R_2 || R_{ib1} = 67.3 || 12.7 || 207.8125$
$= 10.684 || 207.8125 = 10.16\ k\Omega$

$A'_{v1} = -\frac{\beta R_C}{R_{ib1}} = \frac{-990}{207.8125} = -4.764$

$R_{o1} = R_{C1} = 10\ k\Omega$

Stage 2 is CC

$R_{ib2} = r_{\pi 2} + (1+\beta)(r_o || R_E)$
$= 1.25 + 160 = 161.25\ k\Omega$

$R_{i2} = R_1 || R_2 || R_{ib2}$
$= 15 || 45 || 161.25$
$= 11.25 || 161.25$
$= 10.5164\ k\Omega$

(4)

$A'_{v2} = \frac{(1+\beta)(r_o || R_E)}{R_{ib2}}$
$= \frac{160}{161.25} = 0.99225$

$R_{o2} = \frac{r_{\pi 2} + R_{o1}}{1+\beta}$
$= \frac{11.25}{100} k\Omega = 112.5\ \Omega$

$V_o = \frac{R_L}{R_L + R_{o2}} A'_{v2} \frac{R_{i2}}{R_{i2} + R_{o1}} A'_{v1} \frac{R_{i1}}{R_{i1} + R_s} V_s$

$\frac{V_o}{V_s} = \frac{0.25}{0.25 + 0.112} \times 0.99255 \frac{10.5}{10.5 + 10} \times -4.764 \frac{10.16}{10.16 + 0}$

$= \frac{0.25}{0.362} \times 0.99255 \frac{10.5}{20.5} \times -4.764 \times 1$

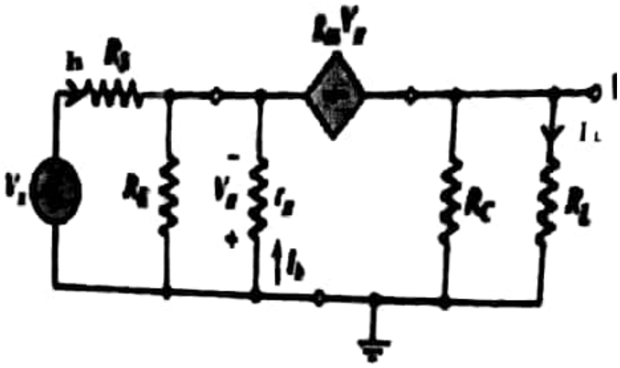
(3)

$= -1.6729$

Q3) a) Given the circuit shown.

i) Classify the circuit using the following words and abbreviations which fit the circuit :

pMOSFET , nMOSFET , pnp , npn , CE , CC , CB , CS , CD, CG , low frequency , high frequency loaded, unloaded.



This circuit represent

a loaded, low frequency, npn, common base (CB) amplifier

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ii) **Derive** the relationship which gives the **current gain** defined as $A_i = \frac{I_L}{I_s}$.

$$I_L = -\frac{R_C}{R_C + R_L} g_m V_\pi$$

$$-I_s = \frac{V_\pi}{R_E \| r_\pi} + g_m V_\pi = \left(\frac{1}{R_E \| r_\pi} + g_m\right) V_\pi$$

$$\therefore A_i = \frac{I_L}{I_s} = \frac{-I_L}{-I_s} = \frac{\frac{R_C}{R_C + R_L} g_m}{g_m + \frac{1}{R_E \| r_\pi}}$$

$$= \frac{R_C}{R_C + R_L} \frac{g_m (R_E \| r_\pi)}{1 + g_m (R_E \| r_\pi)} < 1$$

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b) In an ***npn*** transistor amplifier circuit involving coupling and bypass capacitors, and **operated at high frequency**.

i)What capacitances account for the high frequency response?

the internal capacitances of the transistor : C_π and C_μ

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ii)What capacitors account for the low frequency response?

the coupling and bypass capacitors

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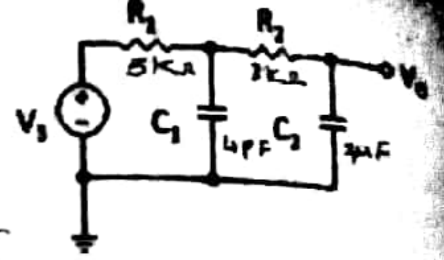
Q4 a) consider the circuit shown, where $R_1 = 5K\Omega$, $R_2 = 3K\Omega$, $C_1 = 4pF$, $C_2 = 2\mu F$. If the method of approximate time constants applies, use it to calculate f_L and f_H. Hence, or otherwise, calculate the midband gain.



since the resistances R_1 and R_2 are of the same order and C_1 and C_2 are order of magnitude different, then the time constants are well far apart. Hence, the method applies

$$\tau_L = (R_1 + R_2)C_2 = 8\times10^{3}\times2\times10^{-6} = 16\ ms$$

$$\Rightarrow f_L = \frac{1}{2\pi\tau_L} = \frac{10^3}{2\pi\times16} = 9.947\ Hz$$

$$\tau_F = (R_1 \| R_2)C_1 = (3k\|5k)C_1 = 1.875\times10^{3}\times4\times10^{-12} = 7.5\times10^{-9}\ s = 7.5\ ns$$

$$\Rightarrow f_H = \frac{1}{2\pi\tau_F} = \frac{10^9}{2\pi\times7.5} = \frac{1000}{15\pi}\ MHz = 21.221\ MHz$$

Mid-band gain is obtained when $Z_{C_1} = \infty\Omega$ & $Z_{C_2} = 0\Omega$

Hence equals to zero volt

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b) A particular transistor short circuit current gain is given by $A_i = \dfrac{0.05 - j\,10^{-12}f}{0.0005 + j\,10^{-11}f}$

Represent A_i in the form $A_i = \dfrac{K(1 - j\frac{f}{f_z})}{(1 + j\frac{f}{f_p})}$. What are the values of K, f_z, and f_p

$$A_i = \frac{0.05\left(1 - j\frac{10^{-12}}{0.05}f\right)}{0.0005\left(1 + j\frac{10^{-11}}{0.0005}f\right)} = 100\,\frac{1 - j\frac{f}{\frac{0.05}{10^{-12}}}}{1 + j\frac{f}{\frac{0.0005}{10^{-11}}}}$$

$$= 100\,\frac{1 - j\frac{f}{50\times10^9}}{1 + j\frac{f}{50\times10^6}}$$

$\Rightarrow K = 100$

$f_z = 50\times10^9 = 50\ GHz$

$f_p = 50\times10^6 = 50\ MHz$

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Draw the Bode diagram. Don't draw the phase plot.