ESc201A Quiz-2 A Oct. 03, 2019 Time: 45mins. Esc201Sec. No……..

Please work on this sheet and the reverse. No extra sheet would be given.

Total marks: 10 Name: ……………………………….. Roll No.: ……………

(1) An R-C coupled amplifier is shown in fig. 1, which uses a BJT transistor of current gain (β) of 50. The d.c. collector current is 2mA. Assume that a conducting diode voltage is 0.7V and the thermal voltage is $V_T = \cancel{0.25V}$. 0.025 V

[2] (a) Find the values of R_1 and R_2 that would bias the transistor in the forward active mode.

[2] (b) Calculate the voltage gain of the amplifier $A_v = (v_o/v_i)$. mid band.

[2] (c) What is the lower cut-off frequency of the amplifier?

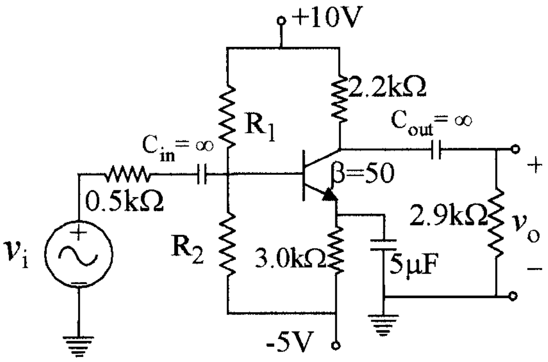


Figure 1.

(2) For the OpAmp circuit shown in fig. 2, supplied with a ±10V sources, where it is required to plot the output voltage V_o as a function of the potentiometer position of the variable resistor R_g. The OpAmp can be assumed to be ideal.

[2] (i) Hence find an expression of V_o, as a function of α.

[2] (ii) What is V_o, at α = 0, α = 0.5, and α = 1?

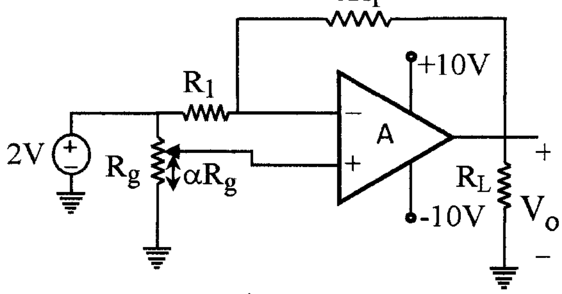


Figure 2.

1) (a) $I_{CQ} = 2\,mA$, $\beta = 50$ $\therefore I_B = (2/50)\,mA = 0.04\,mA = 40\,\mu A$.

$\therefore$ Choose $I_{R_1} = 10 I_B = 0.4\,mA$

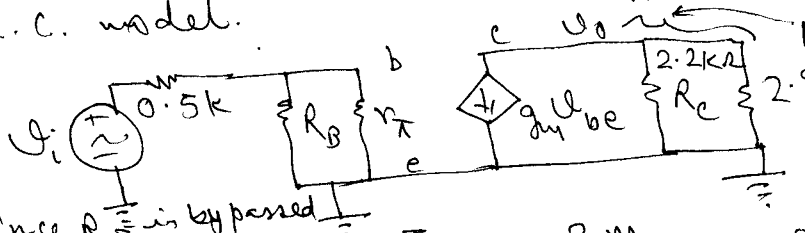
$V_C = 10 - 2.2k \times 2m = 5.6V$, $V_E \cong 3k \times 2m - 5V = +1V$. $\therefore V_B = 1 + 0.7 = 1.7V$.

$V_{R_1} = 10 - 1.7 = 8.3V$ $\therefore R_1 = \frac{V_{R_1}}{I_{R_1}} = \frac{8.3}{0.4m} = 20.75\,k\Omega$

Similarly $V_{R_2} = 1.7 - (-5) = 6.7V$. $\therefore R_2 = \frac{6.7}{9 \times 0.04m} = 18.61\,k\Omega$

(b) For the a.c. model $R_B = R_1 || R_2 = 20.75 || 18.61 = 9.81\,k\Omega$

a.c. model.



$r_e = \frac{V_T}{I_C} = \frac{0.025}{2m}$

$r_\pi = (\beta+1) r_e = \frac{51 \times 0.025}{2m} = 0.6375\,k\Omega$

Since R_E is bypassed by C_E $g_m = \frac{I_C}{V_T} = \frac{2m}{25m} = 0.08 = 80\,mS$.

$R_L = 2.2k || 2.9k = 1.251 \cong 1.25\,k\Omega$, $A_v = \frac{v_o v_b}{v_b v_i} = -g_m R_L \times \frac{R_B || r_\pi}{0.5k + R_B || r_\pi}$

$\therefore R_B || r_\pi = 9.8k || 0.6375k = 0.5986 \cong 0.6\,k\Omega$

$\therefore A_{v_{mid}} = -80m \times 1.25k \times \frac{0.6}{0.5 + 0.6} = -100 \times 0.545 = -54.5$

Approximate; Neglect R_B with respect to r_π $\rightarrow$ $A_{v_{mid}} = -100 \times \frac{0.6375}{1.1375} = -56$

2) For ideal OpAmp $i_- = i_+ = 0$, $v_- = v_+$

$\therefore v_+ = \frac{2V}{R_g} \times \alpha R_g = 2\alpha\ V = v_-$

KCL at node v_- gives $\frac{v_- - 2}{R_1} + \frac{v_- - v_o}{6R_1} = 0$.

or $6v_- - 12 + v_- = v_o$. or $v_o = 7v_+ - 12$

$\therefore v_o = 7 \times 2\alpha - 12 = 14\alpha - 12$.

$\alpha = 0$, $v_o = -12$, but supply is only $-10V$

$\therefore$ due to saturation $\underline{v_o = -10V}$

$\alpha = 0.5$, $v_o = 14 \times 0.5 - 12 = 7 - 12 = \underline{-5V}$

$\alpha = 1$, $v_o = 14 - 12 = \underline{+2V}$.

ESc201A   Quiz-2 B   Oct. 03, 2019   Time: 45mins. Esc201Sec. No……..

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(1) An R-C coupled amplifier is shown in fig. 1, which uses a BJT transistor of current gain (β) of 80. The d.c. collector current is 2mA. Assume that a conducting diode voltage is 0.7V and the thermal voltage is V_T=~~0.25V~~. 0.025V

[2] (a) Find the values of R_1 and R_2 that would bias the transistor in the forward active mode.

[2] (b) Calculate the mid band voltage gain of the amplifier $A_V=(v_o/v_i)$.

[2] (c) What is the lower cut-off frequency of the amplifier?

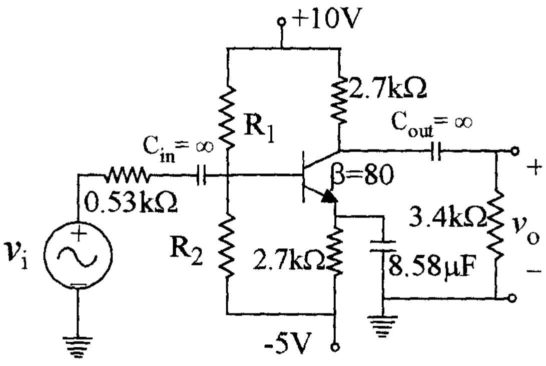


Figure 1.

(2) For the OpAmp circuit shown in fig. 2, supplied with a ±8V sources. It is required to know the output voltage V_o as a function of the potentiometer position of the variable resistor R_g. The OpAmp can be assumed to be ideal.

[2] (i) Hence find an expression of V_o, as a function of α.

[2] (ii) What is V_o, at α = 0, α = 0.5, and α = 1?

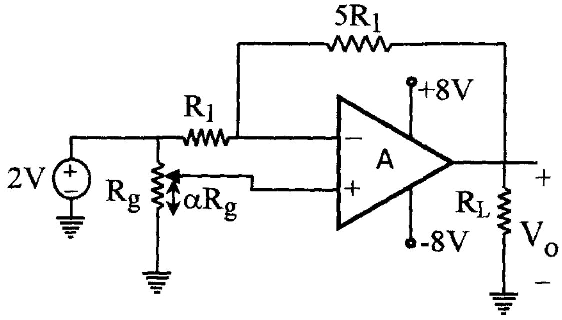


Figure 2.

1)(a) $V_C = 10 - 2m \times 2.7k = 10 - 5.4 = 4.6V$

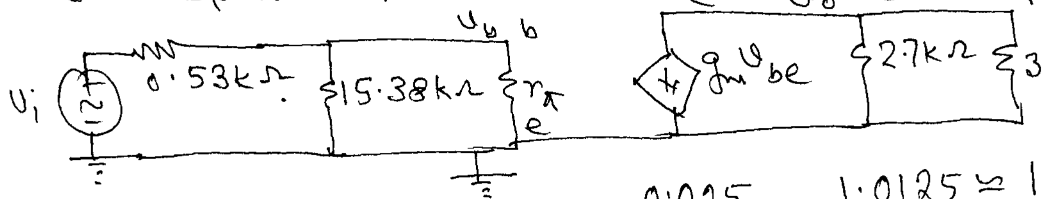
$V_E = 2.7k \times 2m - 5 = 0.4V$ $V_B = 0.4 + 0.7 = 1.1V$. $V_{R_1} = 10 - 1.1 = 8.9V$ $V_{R_2} = 1.1 + 5 = 6.1V$

Choose $I_{R_1} = 10 I_B$ & $I_{R_2} = 9 I_B$ where $I_B = \frac{2m}{80} = 0.025m = 25\mu A$.

$\therefore R_1 = \frac{8.9}{250\mu} = 35.6k\Omega$, $R_2 = \frac{6.1}{9 \times 25\mu} = 27.1k\Omega$, $R_B = R_1 || R_2 = 15.38k\Omega$

(b) As R_E is by-passed by C_E everywhere except at low frequencies, a.c. equivalent is:

$R_L = 2.7k || 3.4k\Omega = 1.5k\Omega$



$r_\pi = (\beta+1) r_e = (\beta+1)\frac{V_T}{I_C} = 81 \times \frac{0.025}{2m} = 1.0125 \simeq 1k\Omega$, $g_m = \frac{I_C}{V_T} = 80mS$

$A_{v_{mid}} = -80m \times 1.5k \times \frac{15.38k||1k}{0.53k + 15.38k||1k} \simeq -120 \times \frac{1k}{1.53k} = -78.43$

Exact: $= -120 \times \frac{0.94}{0.53 + 0.94} = -120 \times 0.64 = \underline{\underline{-76.6}}$

(c) Cin & Cout capacitors have no effect. $\therefore f_L = \frac{1}{2\pi C_E R_{CE\,short}}$ with v_i shorted.

$R_{CE\,short} = R_E || \left(\frac{r_\pi + R_B||R_i}{\beta+1}\right) = 2.7k || \frac{1.51k}{81} = 2.7k || 0.0185k = 0.0184k$

$R_B || R_i = 15.38k || 0.53k \simeq 0.51k$

$f_L = \frac{10^3}{2\pi \times 8.58 \times 0.0184} = 1kHz$

Approx: neglect 15.38k with respect to 0.53k

$(1 + 0.53)/81 \simeq 0.019k$ neglect 2.7k with respect to this $\rightarrow f_{L_{approx}} = \frac{10^3}{2\pi \times 8.58 \times 0.019} = 973.6Hz$

$\therefore R_{CE\,short} \simeq 0.019k$

2) For ideal OpAmp $\quad i_- = i_+ = 0, \quad v_- = v_+$

$v_+ = \frac{2V}{R_g} \times \alpha R_g = 2\alpha \; V = v_-$

$\therefore$ KCL at v_- node gives $\quad \frac{v_- - 2}{R_1} + \frac{v_- - v_o}{5R_1} = 0$

or $5v_- - 10 = -v_- + v_o \quad \therefore v_o = 6v_- - 10$

or $v_o = 6v_+ - 10 = 6 \times 2\alpha - 10 = 12\alpha - 10.$

$\alpha = 0, \quad v_o = -10$ but supply is at $-8. \quad \therefore v_o(\alpha = 0) = \underline{\underline{-8V}}$

$\alpha = 0.5, \quad v_o = 12 \times 0.5 - 10 = 6 - 10 = \underline{\underline{-4V}}.$

$\alpha = 1, \quad v_o = 12 - 10 = \underline{\underline{+2V}}.$