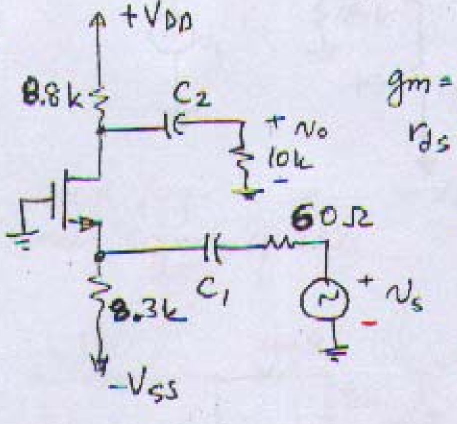
Electronics II   Arasınav 1 * 28 Temmuz 2003 * 90 dakika

Adı soyadı: SOLUTIONS   İmza: ____________   Öğrenci No: ____________

1) Select the values of C_1 and C_2 in the ckt below such that the 3-dB low cut-off frequency is 200 Hz or less.

40 pts



$g_m = 12\ mA/V$ $C_{gs} = 1pF$

$r_{ds} \to \infty$ $C_{ds} = 1pF$

$C_{gd} = 1pF$

$C_1 = \underline{5.63 \times 10^{-6}}\ F$

$C_2 = \underline{8.46 \times 10^{-6}}\ F$

There are two LF poles f_1 and f_2

Let $f_1 = 199\ Hz$, $f_2 = 1\ Hz$ so that

$f_1 + f_2 = 200\ Hz$.

$$R_{th_1} = 8.3k \parallel \frac{1}{g_m} + 60\Omega$$

$$= \left(8.3k \parallel \frac{1}{12}k + 0.060k\right) = 0.142\ k\Omega$$

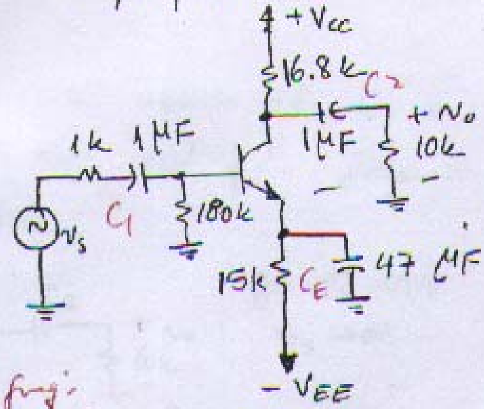
$$R_{th_2} = 8.8 + 10 = 18.8\ k\Omega$$

$$C_1 = \frac{1}{2\pi f_1 R_{th_1}} = \frac{1}{2\pi \times 199 \times 142} = 5.63 \times 10^{-6} F$$

$$C_2 = \frac{1}{2\pi f_2 R_{th_2}} = \frac{1}{2\pi \times 1 \times 18800} = 8.46 \times 10^{-6} F$$

2) Using Miller's theorem, find the high and low cut-off frequencies of the amplifier given below.

60 pts



$\beta = 300$

$I_c = 1.25\ mA$

$V_T = 0.025\,V$

$V_A \simeq \infty$

$f_T = 500\ MHz$

$C_\mu = 0.5\ pF$

$r_x = 100\ \Omega$

$\omega_L = \underline{943\ rad/s}$

$\omega_H = \underline{6.24 \times 10^6\ rad/s}$

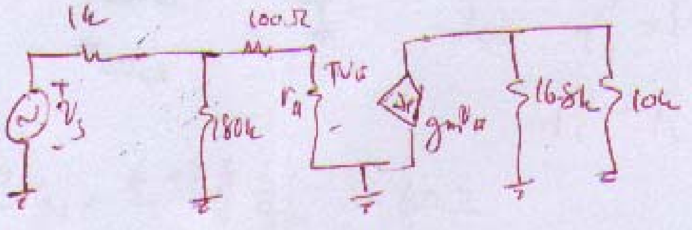
$g_m = \frac{1.25}{0.025} = 50\ mA/V$

$r_\pi = \frac{300}{50} = 6\ k\Omega$

$R_{sh} = 16.8k \| 10k = 6.26k$

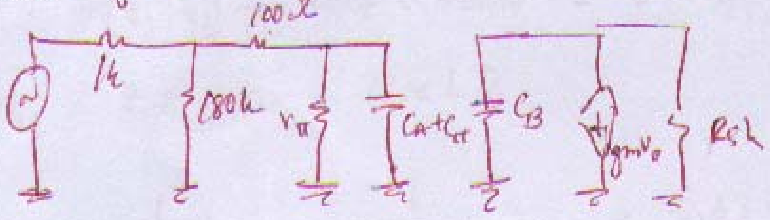
$g_m R_{sh} = \underline{313}$

mid freq. small signal eq. ckt.



$C_\pi = \frac{g_m}{2\pi f_T} - C_\mu = \frac{50 \times 10^{-3}}{2\pi \times 500 \times 10^6} - 0.5 \times 10^{-12}$

HF eq. ckt



$C_\pi = 15.9 \times 10^{-12} - 0.5 \times 10^{-12} = 15.4\,pF$

$C_A = C_\mu(1 + g_m R_{sh}) = 157\ pF$

$C_B \simeq C_\mu = 0.5\ pF$

Two HF poles → $\omega_A = \frac{1}{(C_\pi + C_A) R_{thA}}$, $\omega_B = \frac{1}{C_B R_{thB}}$

$R_{thA} = r_\pi \| (0.1 + 1\|180) = 6 \| 1.1 = 0.929\ k\Omega$

$R_{thB} = R_{sh} = 6260\ \Omega$

$\omega_A = \frac{1}{(15.4 + 157) \times 10^{-12} \times 929} = 6.24 \times 10^6\ rad/s$

$\omega_B = \frac{1}{0.5 \times 10^{-12} \times 6260} = 319 \times 10^6\ rad/s$

$\omega_H = \frac{1}{\frac{1}{\omega_A} + \frac{1}{\omega_B}} \simeq \omega_A$ since $\omega_A \ll \omega_B$.

$\omega_L \simeq 37.3 + 552 + 901 \times 943\ rad/s$

For low freq.

$R_{th1} = 1k + (180k \| 6k) \simeq 7k$ (C_E - short)

$R_{th2} = 16.8k + 10k = 26.8k$ &

$R_{thE} = 15k \Big\| \frac{r_\pi + r_x + (180\|1)k}{\beta + 1} = 15k \Big\| \frac{(6.1 + 1)k}{301} \simeq 23.6\ \Omega$

$\omega_1 \simeq \frac{1}{1 \times 10^{-6} \times 7000} = 142.8\ rad/s$

$\omega_2 = \frac{1}{1 \times 10^{-6} \times 26800} = 37.3\ rad/s$

$\omega_{CE} = \frac{1}{47 \times 10^{-6} \times 23.6} = 901\ Rad/s$

ω_1 → recalc. w/ C_E open →

$R_{th1} = 1 + 180 \| 4515 \cong 181\ k\Omega$

$\omega_1 = 5.52\ rad/s$

ELECTRONICS-II • Exam 1 • April 5, 2001
60 Minutes • Dr. Erkaya

This is a closed-book, closed-notes exam. Write your answer to the space provided below each question. If you need more space, use the back of the sheet and indicate the question number. Read the questions carefully. Do not use any time on any question more than what you allocate in the beginning of the exam. Good Luck!

I have neither given nor received unauthorized help with this work; nor do I have reason to believe that anybody else has.

Student ID: __________ *Name:* ERKAYA *Signature:* SOLUTIONS *Grade:* ______

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1. *(50 pts)* Find the input resistance, output resistance and the voltage gain v_{out}/v_s for the amplifier given in Figure 1. (g_m = 33 mA/V, R_D = 5 kΩ, R_F = 250 kΩ, R_G = 1 MΩ, R_S = 5 kΩ)

v_{out}/v_s = -38.22

R_{in} = 1.5k

R_{out} = ______

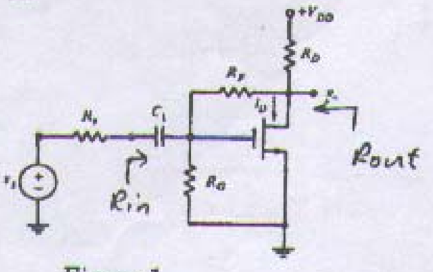
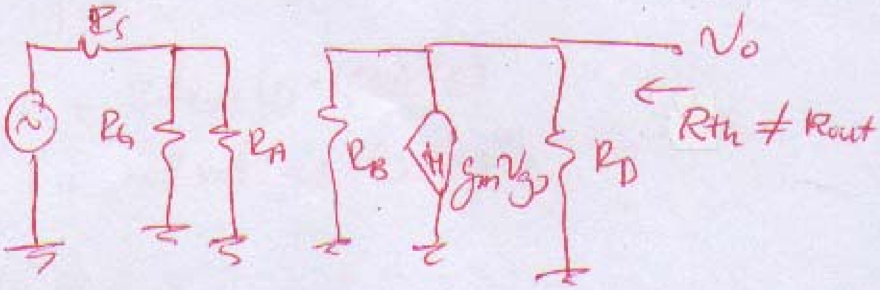


Figure 1



$R_B \simeq R_f$ because $|-g_m R_D| \gg 1$

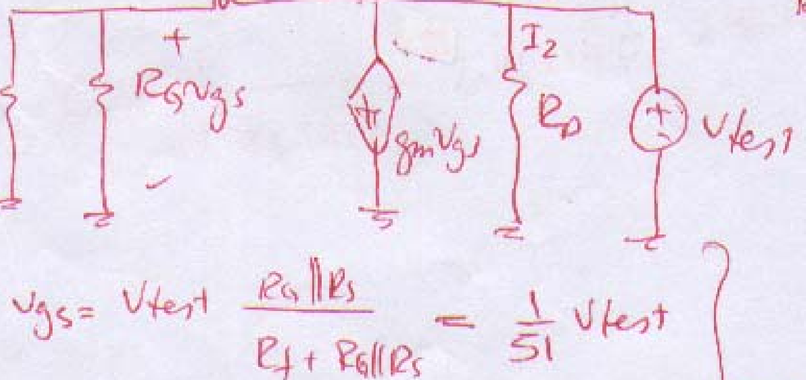
$165 \gg 1$

$R_B \| R_D \cong R_D = 5 k\Omega$ $\qquad R_A = \dfrac{R_f}{1+165} = 1.5 k\Omega$

$R_{in} = R_G \| R_A \cong R_A = 1.5 k\Omega$

$$\frac{v_o}{v_s} = -165 \frac{R_{in}}{R_s + R_{in}} = -165 \frac{1.5}{5+1.5} = -38.22$$

Rout must be calculated from the ckt below:



$$R_{out} = \frac{V_{test}}{I_{test}}$$

$$v_{gs} = V_{test} \frac{R_G \| R_S}{R_f + R_G \| R_S} = \frac{1}{51} V_{test}$$

$$I_{test} = I_1 + I_2 + g_m v_{gs}$$

$$I_1 = \frac{V_{test}}{R_f + R_S \| R_G}, \quad I_2 = \frac{V_{test}}{R_D}$$

$$R_{out} = \frac{V_{test}}{\dfrac{V_{test}}{R_f + R_G \| R_S} + \dfrac{V_{test}}{R_D} + \dfrac{g_m V_{test}}{51}}$$

$$R_{out} = (R_f + R_G \| R_S) \| R_D \| \frac{51}{g_m} = 1.175 \text{ k}\Omega$$

(50 pts) For the BJT in Figure 2, I_C = 1.5 mA, h_{FE} = 350, f_T = 500 MHz, C_μ = 1.5 pF. Find the values of the capacitors C_1, C_2 and C_E so that the low 3-dB cutoff frequency is no larger than 20 Hz.

C_1 = ________

C_2 = ________

C_E = ________

$I_C = 1.5\,mA$, $g_m = \frac{1.5}{0.025} = 60\,mA/V$ $\quad r_\pi = \frac{350}{60} = 5.8\,k\Omega$

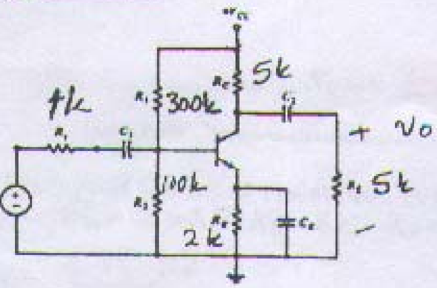


Figure 2

consider pole frequencies only

$f_1 + f_2 + f_E \le 20$ Hz

No unique solution!

C_E = dominant capacitor

Let $f_E = 18$ Hz, $f_1 = f_2 = 1$ Hz

$C_1 = \frac{1}{2\pi f_1 R_{th1}}$, $R_{th1} = R_s + R_1 \| R_2 \| [r_\pi + (\beta_o+1)R_E]$

$= 1 + 100 \| 300 \| [5.8 + (351 \times 2)] \simeq 68.7\,k\Omega$

$C_1 = \frac{1}{2\pi \times 1 \times 68700} = 2.3 \times 10^{-6}\,F$

$C_2 = \frac{1}{2\pi f_2 R_{th2}}$, $R_{th2} = R_C + R_L = 10\,k\Omega$

$= \frac{1}{2\pi \times 1 \times 10000} = 15.9 \times 10^{-6}\,F$

$C_E = \frac{1}{2\pi f_E R_{thE}}$, $R_{thE} = \frac{(1 \| 100 \| 300)^k + 5.8^k}{351} \| 2k = 0.0192\,k\Omega$

$C_E = \frac{1}{2\pi\, 18 \times 19.2} = 2.96 \times 10^{-4}\,F = 296 \times 10^{-6}\,F$