Electrical and Computer Engineering Department
University of Puerto Rico - Mayaguez, P.R.
Electronics II - INEL 4202 - Spring 2002 - Exam 1B - Prof. Manuel Toledo
THERE ARE THREE PROBLEMS - WORK CLEARLY OR LOOSE POINTS

1. An amplifier have a single low-frequency pole at $f_L = 10Hz$, and two high-frequency poles at $f_{h1} = 1MHz$ and $f_{h2} = 2MHz$. The amplifier's gain for intermediate frequencies is 60dB. The low-frequency zero is located at the origin.

   (a) Write an expression for the amplifier's gain has a function of the complex frequency s, valid for low-, mid- and high-frequencies. (15 points)

   (b) Find the high-frequency effective $3dB$ frequency. (10 points)

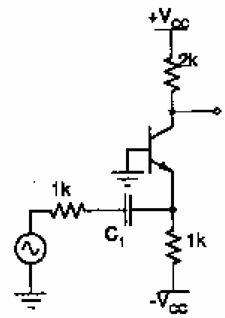
(a) $$A_v(s) = 1000 \frac{s}{s+20\pi} \frac{2\pi \times 10^6}{s+2\pi \times 10^6} \frac{4\pi \times 10^6}{s+4\pi \times 10^6}$$

(b) $$f_H = \frac{1}{\frac{1}{10^6 Hz} + \frac{1}{2 \times 10^6 Hz}} = 667 kHz$$

2. For the circuit shown below, assume that the operating point current is $i_{CQ} = 0.5mA$ and $\beta_0 = 100$.

   (a) select C_1 such that the amplifier's low-frequency pole is located at 100 radians per second. (20 points)

   (b) find the high-frequency pole due to $C_\pi = 10pF$ by replacing the transistor with its equivalent model and analyzing the resulting circuit. (25 points)



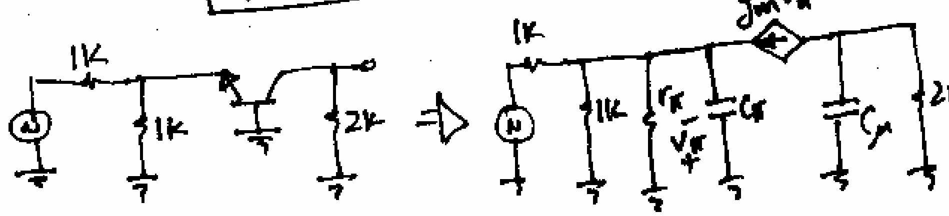
(a) C_1 sees $1K + 1K \| 1/g_m = 1K + 1K \| \frac{1/2\ mA}{25mV} = 1K + 1K \| 50\Omega$

$= 1047.2\,\Omega$

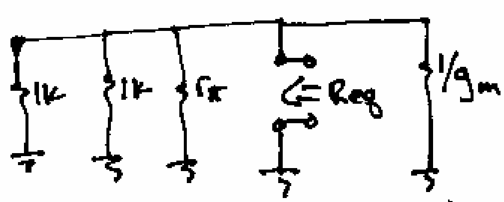
$\therefore\ 100\,(1047.2\,\Omega) = 1/C_1$

$C_1 = 9.6\mu F$

(b)



C_π sees =



$R_{eq} = \frac{1}{g_m} \| \frac{1k}{\beta} \| 1k \| r_\pi = 50\Omega \| 5k \| 500\Omega \approx 45\Omega$

$\omega_H = \frac{1}{10^{-11}F \times 45\Omega} = 2.22 \times 10^9$ rps.

3. For the power stage shown below, let $V_{CC} = 6V$ and $R_L = 4\Omega$. If the input is a sinusoid with $4.5V$ peak amplitude, find

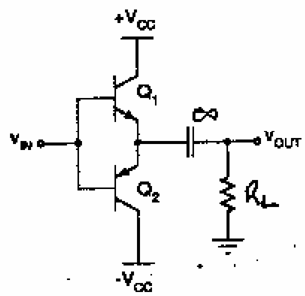
(a) the output power P_L; (5 points)

(b) the average power drawn from each supply; (5 points)

(c) the efficiency obtained at this output voltage; (5 points)

(d) the peak current supplied by v_{IN} assuming that $\beta_{NPN} = \beta_{PNP} = 50$; (5 points)

(e) the maximum power that each transistor must be capable of dissipating safely, assuming that the output level can assume any value. (10 points)



(a) $V_{Lpeak} \cong 4.5V - 0.7V = 3.8V$

$P_L = \frac{V_{Lpeak}^2}{2R_L} = \frac{3.8^2}{2(4\Omega)} = \boxed{1.805W}$

(b) $i_{CAVE} = \frac{V_{Lpeak}/R_L}{\pi} = \frac{3.8/4\Omega}{\pi} = 0.3A$

$P_{dc} = V_{CC}\, i_{CAVE} = 6V(0.3A) = \boxed{1.81W}$

(c) $\eta = \frac{P_L}{2P_{DC}} = \frac{1.805W}{2(1.81W)} \times 100\% = 50\%$

(d) $i_{Cpeak} = 3.8V/4\Omega = 0.95A$

$i_{INpeak} = \frac{i_{Cpeak}}{\beta} = \frac{0.95A}{50} = 19mA$

(e) max. power is dissipated when $V_{Lpeak} = \frac{2V_{CC}}{\pi} = 3.8V$

$\therefore$ that's above case $\Rightarrow \boxed{P_D = 0.9W}$

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Electronics II - INEL 4202 - SPRING 2002 - Exam 1A - Prof. Manuel Toledo
THERE ARE FOUR PROBLEMS - WORK CLEARLY OR LOOSE POINTS

1. A common-source amplifier is constructed with a $10\mu F$ bypass capacitor in parallel with a $1k\Omega$ resistor, both connected to the FET's source terminal. The equivalent resistance "seen" by the bypass capacitor is 100Ω. At high frequencies there is a single pole located at $1MHz$. If the amplifier's mid-band gain is $80dB$, find an expression for the amplifer's gain as a function of the complex frequency s, valid for low-, mid- and high-frequencies. (25 points)

$$\omega_Z = \frac{1}{1k \times 10\mu F} = 10^2 \text{ rps}$$

$$\omega_{P_L} = \frac{1}{100 \times 10\mu F} = 10^3 \text{ rps}$$

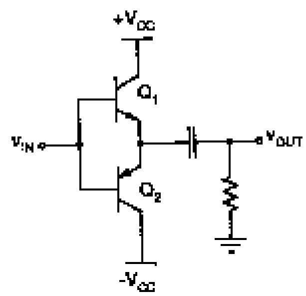
$$\omega_H = 2\pi \times 10^6 \text{ rps}$$

$$A_{mid} = 80\,dB = 10^4\ V/V$$

$$A_v(s) = -10^4 \frac{s+10^2}{s+10^3} \frac{2\pi \times 10^6}{s + 2\pi \times 10^6}$$

2. The transistors in the class-B power amplifier shown below dissipate an average power of $10W$ each, when their peak collector current is $1A$. Assuming sinusoidal output and $R_L = 10\Omega$, find

(a) the output power P_L; (5 points)
(b) the average power drawn from each supply; (5 points)
(c) the efficiency obtained at this peak current; (5 points)
(d) the value of V_{CC} being used; (5 points)
(e) the maximum power that each transistor must be capable of dissipating safely, assuming that the output level can assume any value. (10 points)



(a) $P_L = I_{rms}^2 R_L = \left(\frac{1}{\sqrt{2}}\right)^2 (10\Omega) = 5W$

(b) $i_{AVE_{DC}} = \frac{1A}{\pi}$; $P_{DC} = 2V_{CC}\, i_{AVE_{DC}} = P_L + 2P_D = 25W$

(c) $\eta = \frac{5W}{25W} \times 100\% = 20\%$

(d) $P_{DC} = 2V_{CC}\, i_{AVE_{DC}} = 25W$

$V_{CC} = \frac{25W}{2(1A/\pi)} = 39V$

(e) P_{Dmax} occur when $V_{out} = \frac{2V_{cc}}{\pi} = 25V$

for this voltage $P_L = \frac{25V^2}{2(10\Omega)} = 31.25W$

$$P_{DC} = 2(39V)\frac{25V}{10\Omega \times \pi} = 62W$$

$$P_{D_{max}} = \frac{1}{2}(62 - 31.25W) = 15.4W$$

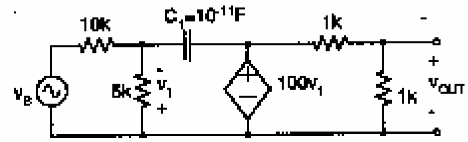
or use the formula from class $P_{Dmax} = \frac{V_{cc}^2}{\pi^2 R_L}$

3. For the circuit shown below, find

(a) the pole frequency applying Miller's theorem; (10 points)

(b) the pole frequency by analyzing the circuit directly (this is, not using Miller's theorem) (25 points)

(c) an expression for the voltage gain $A_v(s) = \frac{v_{OUT}}{v_S}$ as a function of complex frequency s, valid for mid- and high-frequencies. (10 points)

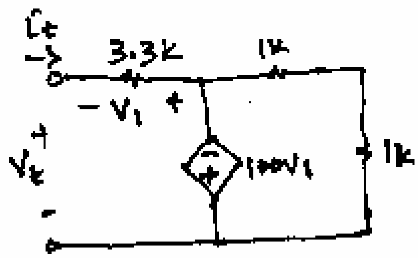


(a) $K = -100\ \text{V/V}$; $C_{in} = 101 \times 10^{-11}\,\text{F} = 1.01\,\text{nF}$

C_{in} "sees" $5k \| 10k = 3.3\text{k}\Omega$

$$\therefore\ \omega_H = \frac{1}{3.3k \times 101 \times 10^{-9}\,\text{F}} = \boxed{297\ \text{krps}}$$

(b)



$-V_1 = (3.3k)\,i_t$

$$i_t = \frac{V_t + 100V_1}{3.3k}$$

$i_t(3.3k) = V_t - 100(3.3k\ i_t)$

$$R_{eq} = \frac{V_t}{i_t} = 101\,(3.3k) = 337\text{k}\Omega$$

$$\omega_H = \frac{1}{337\text{k}\Omega \times 10^{-11}\,\text{F}} = \boxed{297\,\text{krps}}$$

(c) $A_{mid} = V_{out}/V_s$; $V_{out} = \frac{1}{2}(100V_1)$

$$= \frac{1}{2}(100)\left(\frac{-5}{15}V_s\right)$$

$$\therefore\ A_{mid} = -16.7\ \text{V/V}$$

$$A_v(s) = -16.7\ \text{V/V}\ \frac{297\,\text{krps}}{s + 297\,\text{krps}}$$