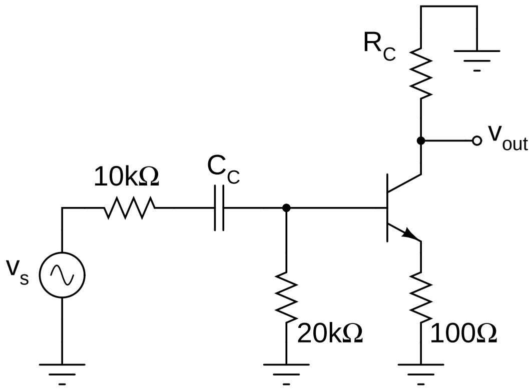
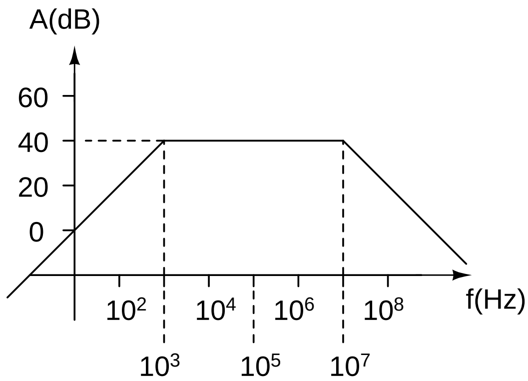
Electrical and Computer Engineering Department
University of Puerto Rico - Mayaguez, P.R.
Electronics II - INEL 4202 - Fall 2001 - Prof. Manuel Toledo
SOLUTIONS TO EXAM 1
FOUR PROBLEMS - 25 POINTS EACH





The amplifier shown in the above sketch has a single coupling capacitor C_C. The transistor is build such that the capacitance C_π is very small and can be neglected. Thus, the high frequency pole of the circuit is determined by the transistor's capacitance C_μ.

The drawing on the right displays the frequency response for the amplifier's gain, $A = v_{out}/v_s$.

You should neglect r_o and r_x in your work. You must apply the time-constant methods that we discussed in class, show all steps and justify your answers clearly.

Assuming that at the operating point $i_C = 0.5mA$ and $\beta = 75$, find

1. R_C.

   ANSWER: From the bode plot, the midband gain magnitude is $40dB = 100$. This must be equal to the common-emitter gain times the input loading factor. Using the formula sheet,

$$100 = \frac{\beta R_C}{r_\pi + (\beta+1)R_e} \times \frac{20k\Omega \,||\, [r_\pi + (\beta+1)R_e]}{20k\Omega \,||\, [r_\pi + (\beta+1)R_e] + 10k\Omega}$$

   Using $R_e = 100\Omega$, $r_\pi = \beta V_T/i_C = 75 \times 25mV/0.5mA = 3750\Omega$, and solving for R_C yields

$$R_C = 36k\Omega$$

2. C_C.

   ANSWER:

   From the bode plot, the low-frequency pole is at $1000Hz = 6280rps$. Since the coupling capacitor C_c "sees" a resistance

$$R_{eq} = 10k\Omega + 20k\Omega \,||\, [r_\pi + (\beta+1)R_e] = 10k\Omega + 7.24k\Omega = 17.24k\Omega$$

   Thus,

$$C_c = \frac{1}{R_{eq}\omega_L} = \frac{1}{6280 \times 17.24k\Omega} = 9pF$$

3. C_μ if Miller's Theorem can be applied and the output capacitor can be neglected. Use $R_C = 2k\Omega$, not the value you found in part (a).

   ANSWER:

   Miller's gain would be

$$K = v_c/v_b = \frac{\beta R_C}{r_\pi + (\beta+1)R_e} = \frac{-75 \times 2k\Omega}{3.75k\Omega + 76 \times 100\Omega} = -13.3V/V$$

   Thus applying Miller's theorem would yield a capacitor $C_{IN} = 14.3 \times C_\mu$ from base to ground. Such capacitor would "see" an equivalent resistance

$$R_{eq} = 10k\Omega \mid\mid 20k\Omega \mid\mid [r_\pi + (\beta+1)R_e] = 4.2k\Omega$$

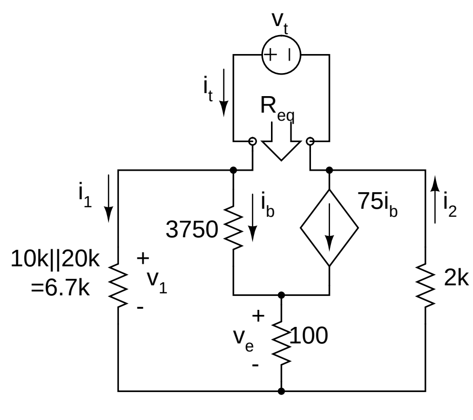
   Since this capacitor will cause the high-frequency pole at $10^7 Hz = 62.8Mrps$,

$$C_{mu} = \frac{1}{(1-K)R_{eq}\omega_H} = 0.27pF$$

4. C_μ without applying Miller's Theorem, and by replacing the transistor with its model and analyzing the resulting circuit to find out the resistance seen by C_μ. Use $R_C = 2k\Omega$, not the value you found in part (a).

   ANSWER:

   The high-frequency pole at $\omega_H = 62.8Mrps$ is associated with C_μ and thus $C_\mu = \frac{1}{R_{eq}\omega_H}$. After replacing the transistor with it's model and placing a test source in place of C_μ to find R_{eq}, the following diagram results



   A KVL in the left loop yields

$$v_1 = i_b(3750 + 76 \times 100) = 11350\Omega \times i_b$$

   Thus

$$i_1 = \frac{v_1}{6.7k\Omega} = 1.69 i_b$$

A KCL on the top-left node gives

$$i_t = i_1 + i_b = 2.69 i_b$$

A KCL on the bottom node yields,

$$i_2 = i_e + i_1 = 76 i_b + 1.69 i_b = 77.69 i_b = 28.9 i_t$$

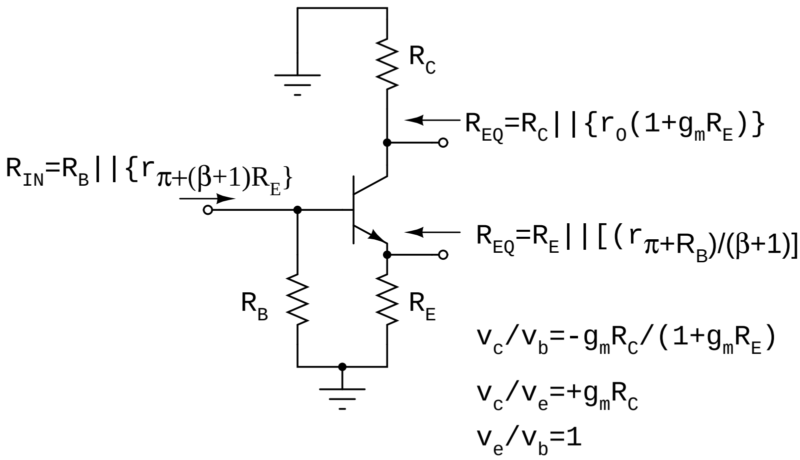
Finally, a KCL in the outer loop give

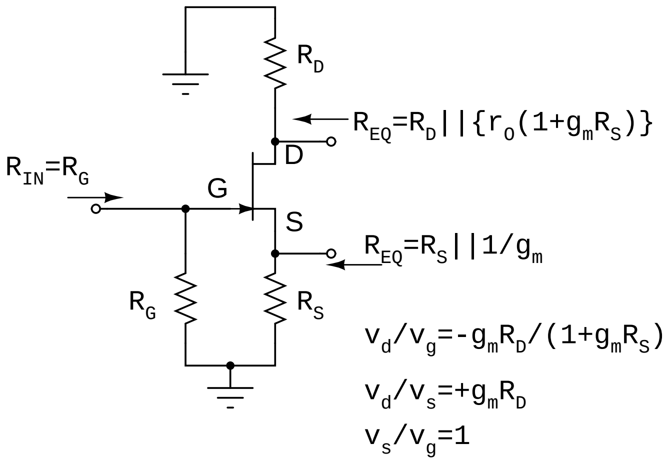
$$v_t = v_1 + 2k \times i_2 = \left(\frac{11350\Omega}{2.69} + 2000\Omega \times 28.9\right) i_t$$

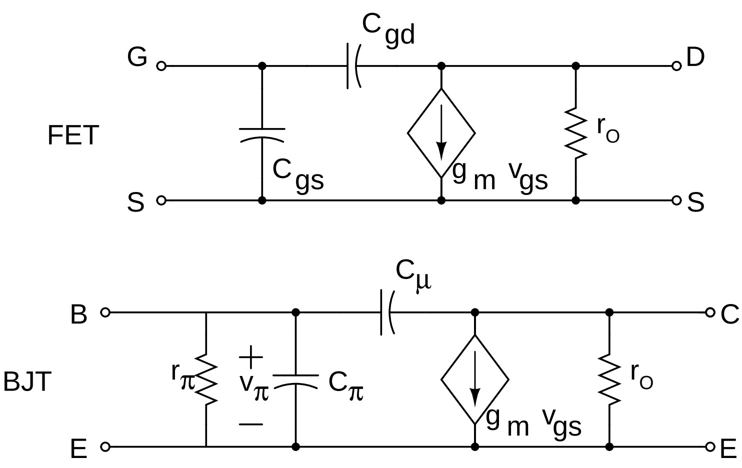
and

$$R_{eq} = \frac{v_t}{i_t} = 62k\Omega$$

$$C_\mu = \frac{1}{62 \times 10^3 \Omega \times 6.28 \times 10^7} = 0.26pF$$







small-signal incremental model