University of Michigan
EECS 311: Electronic Circuits
Fall 2009

PROBLEM SET 9

Issued 11/18/2008
Due in Lecture 11/25/2008

J&B refers to the course text: "Microelectronic Circuit Design (3rd Edition)," by Richard Jaeger and Travis Blalock.

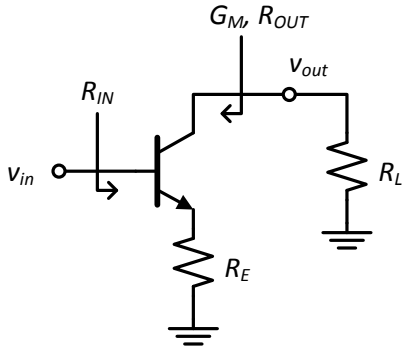
P7.1 J&B Problem 16.22.

P7.2 J&B Problem 16.28.

P7.3 J&B Problem 16.50. In this problem a resistor is "Miller Multiplied", but the result is <u>not</u> $R_{IN} = R\big(1 + A(s)\big)$. Rederive the expressions for the Miller effect to find what factor multiplies the resistor.

P7.4 J&B Problem 16.58. Note that $f_T = g_m/(C_\pi + C_\mu)$. First find the DC operating point of the circuit. Then use I_C to find the component values in the small signal model. Find gain, f_L, and f_H as usual. Simplify by ignoring r_o, and approximating $\beta_F + 1 \approx \beta_F$.

P7.5 Use the amplifier shown on the right to answer the following parts. Include r_o in your small signal model unless otherwise specified.

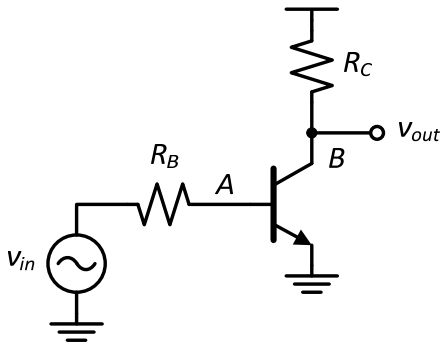


a) Find the exact expressions for small signal R_{IN} (keep R_L in the circuit), G_M when v_{out} is ac grounded, and R_{OUT} when $v_{in} = 0$. Include r_o and make no simplifications in your expression.

b) Simplify R_{IN} and G_M assuming $r_o = \infty$. Derive all conditions that must be met in order for this assumption to hold. i.e. $r_o \gg ?$.

c) Simplify R_{OUT} assuming $r_\pi = \infty$. What conditions must be put on r_π in order for this assumption to hold.

P7.6 Use the circuit shown below for this problem. Ignore r_o for all parts. Include C_π and C_μ in your high-frequency small-signal model.



a) Find an expression for the *midband* gain of the amplifier v_{out}/v_{in}.

b) Draw the high-frequency small signal model. Use the Miller effect to find expressions for the total capacitances from node *A* to ground, and node *B* to ground. Do not forget to include C_π at node *A*.

c) Use OCTC to find an expression for f_H.

d) Evaluate your expression for A_v and f_H using the values from the table on the right. Plot the response of the amplifier in Matlab using:

$$\frac{v_{out}}{v_{in}} = \frac{A_v}{1 + \frac{s}{2\pi f_H}}$$

R_B	1kΩ
R_C	50kΩ
β_F	100
C_μ	2pF
C_{jE}	0
I_C	1mA
τ_F	500ps

e) Find the exact transfer function v_{out}/v_{in} of the original high-frequency small signal model by replacing capacitors with $Z_C = 1/sC$. Do <u>not</u> use the circuit simplified with Miller effect.

f) Using the values given in part d), evaluate your expression from part e) and plot this on the same graph as your simplified result found using Miller and OCTC. Over what frequency range to the two plots match?