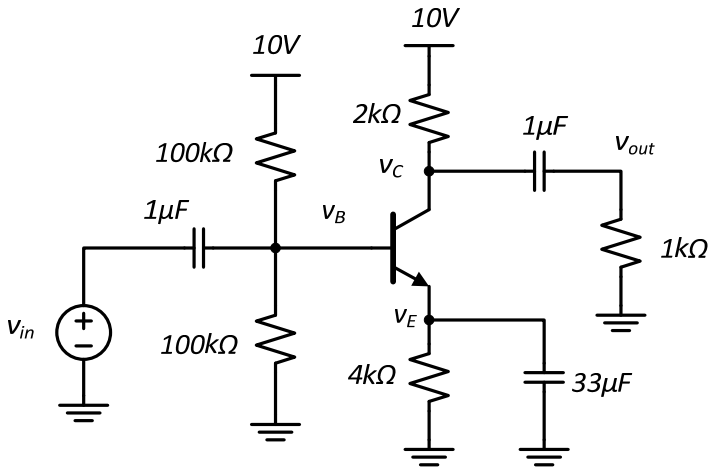
University of Michigan
EECS 311: Electronic Circuits
Fall 2009

PROBLEM SET 8

Issued 11/4/2009
Due in Lecture 11/11/2009

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

P8.1 Use the following circuit to complete this problem. For hand calculations assume $\beta_{F0} = 300, V_A = 74V, V_{BE,ON} = 0.6V$.



a) Show the DC equivalent circuit and calculate the values of I_C, V_B, V_E, and V_C at the DC operating point assuming $V_A = \infty$.

b) Now using Cadence, draw this circuit and simulate the DC operating point. Use the *AnalogLib > npn* component, and give it the model name *2n3904_typical*.

P8.2 In this problem, you will find the small-signal gain of the circuit from P8.1.

a) Calculate the values of β_F, r_π, g_m, and r_o at the DC operating point found in P8.1, now assuming $V_A = 74V$.

b) Draw the small-signal (ac) equivalent circuit and solve for the small-signal gain v_{out}/v_{in}. Evaluate the gain using the values from a).

c) Perform an *ac* analysis of the circuit in Cadence from the frequency range of 1Hz to 1MHz. Record the small-signal gain of the circuit in the mid-band.

d) Cadence will also compute the small-signal model parameters for the npn. From the Analog Environment, click on *Results > Print > DC Operating Points*. Then go to the schematic window and click on the npn transistor. In the Results Display Window, find

the parameters *betadc, gm*, *rpi*, and *ro*. Record these values, check to see if they match your calculations from part a).

P8.3 In this problem, you will analyze the AC coupling for the circuit from P8.1.

a) Re-draw the small-signal (ac) equivalent of the circuit from problem P8.1. Calculate the values of the small-signal gains from v_{in} to v_b, v_e, and v_c. That is, find v_b/v_{in}, v_e/v_{in}, and v_c/v_{in}.

b) Calculate the ac voltages v_b, v_e, and v_c when $v_{in} = (1mV) \cdot \cos(\omega t)$.

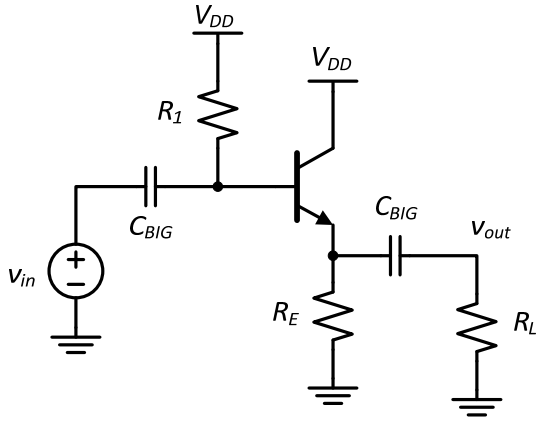
c) Sketch the total voltages v_B, v_E, and v_C, along with v_{in} on the same graph. Use the DC operating point values from problem P8.1.

d) Use Cadence to simulate the transient response of the circuit to an input sine wave with amplitude of 1mV and frequency 10kHz. Simulate the response for 1ms. Plot the transient voltages (total voltages) on nodes v_B, v_E, and v_C and turn in this plot.

e) Finally, plot the transient voltage across the bypass capacitor between nodes v_{in} and v_b using *Results > Direct Plot > Transient Difference*. What is the amplitude of the ac signal on this cap? Is our assumption of this capacitor being an 'ac short-circuit' a good one?

P8.4 J&B Problem 13.60.

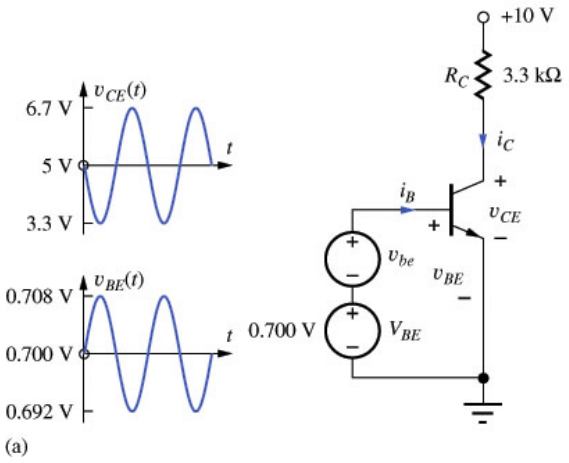
P8.5 Use the circuit below to complete the following parts of this problem.



a) Draw the small-signal equivalent circuit, replacing the npn with the small-signal model. Include r_o in your model.

b) Find an expression for the small-signal gain v_{out}/v_{in}.

P8.6 Approximate the small-signal gain v_{ce}/v_{be} of the amplifier below.



(a)