ECE 3455: Electronics

Section 12071
Spring 2011

Exam 2

Version A

April 23, 2011

Do *not* open the exam until instructed to do so. Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page. This is a closed-book/notes exam and you *may* use a calculator. You may use two crib-sheets as described in the syllabus and discussed in class. **You will have 1-¾ hours to finish the exam.**

Student's Name: _____

Question	Points	Score
1	25	
2	20	
3	30	
4	25	
Total:	100	

From Table 6.2:

$$i_C = I_S e^{v_{BE}/V_T}$$

$$i_B = \frac{i_C}{\beta} = \left(\frac{I_S}{\beta}\right) e^{v_{BE}/V_T}$$

$$i_E = \frac{i_C}{\alpha} = \left(\frac{I_S}{\alpha}\right) e^{v_{BE}/V_T}$$

Note: For the pnp transistor, replace v_{BE} with v_{EB}.

$$i_C = \alpha i_E$$

$$i_C = \beta i_B$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$i_B = (1-\alpha)\, i_E = \frac{i_E}{\beta+1}$$

$$i_E = (\beta+1)\, i_B$$

$$\alpha = \frac{\beta}{\beta+1}$$

$V_T =$ thermal voltage $= \dfrac{kT}{q} \simeq 25\,\text{mV}$ at room temperature

Summary of Table 6.4 (Small Signal Model Parameters)

Model Parameters in Terms of DC Bias Currents

$g_m = \dfrac{I_C}{V_T} \quad r_e = \dfrac{V_T}{I_E} = \alpha\dfrac{V_T}{I_C} \quad r_\pi = \dfrac{V_T}{I_B} = \beta\dfrac{V_T}{I_C} \quad r_o = \dfrac{|V_A|}{I_C}$

In Terms of g_m

$r_e = \dfrac{\alpha}{g_m} \qquad r_\pi = \dfrac{\beta}{g_m}$

In Terms of r_e

$g_m = \dfrac{\alpha}{r_e} \quad r_\pi = (\beta+1)\, r_e \qquad g_m + \dfrac{1}{r_\pi} = \dfrac{1}{r_e}$

1. (25 points) For the circuit below, plot v_A and v_B for

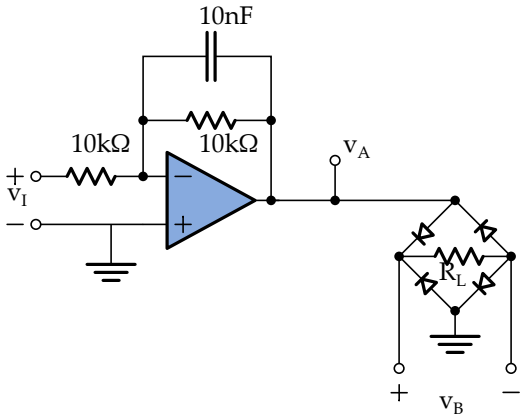
$$v_I = V_o \sin(\omega_o t),$$

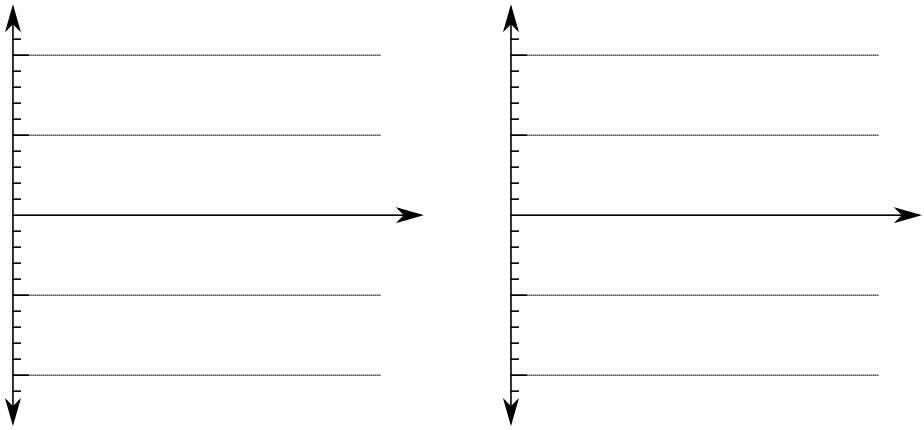
where $V_o = 5$ volts and

(a) $\omega_o = 100\,\text{rad/s}$.

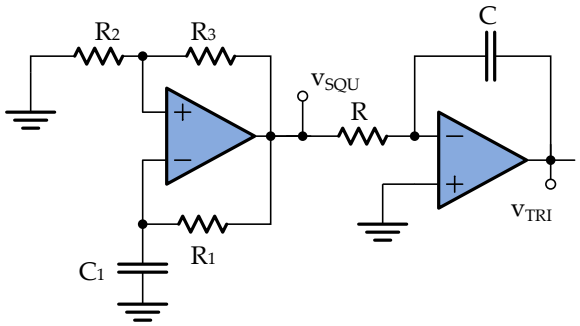
(b) $\omega_o = 10,000\,\text{rad/s}$.

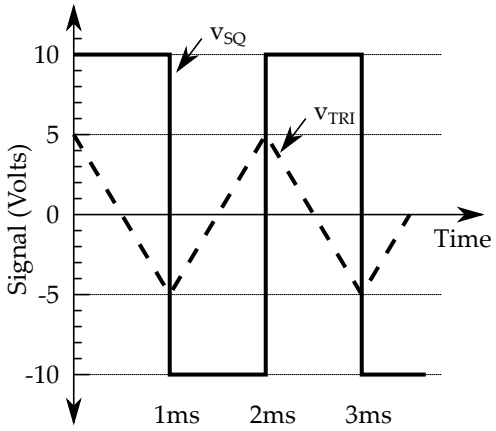
Assume a constant voltage drop model for the diodes with $V_D = 0.7$ volts and an ideal op-amp. Be sure to label your graph to receive credit.



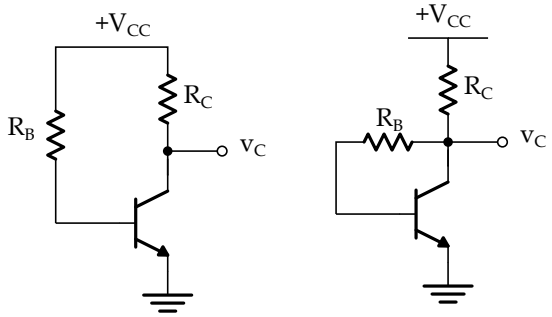


2. (20 points) For the following circuit, assume that R_1, R_2, R_3, and C_1 were chosen to give the output for v_{SQ} as shown in the graph. What value of RC will give the output v_{TRI} as also shown in the graph?





3. (30 points) For the following two circuits,
   (a) find expressions for v_C in terms of R_B, R_C, V_{CC}, V_{BE}, and β, and
   (b) determine for which circuit changes in β will result in a larger change in v_C. To get credit for this part, you must make an argument why this is true.



4. (25 points) For the following circuit,
   (a) Sketch the circuit for the small signal analysis using the hybrid-π model (do not do a DC analysis - leave everything in terms of the circuit resistors, β, and r_π.
   (b) Find an expression for the bandpass gain of the circuit.
   (c) Write expressions for the two 3-dB down corners of this circuit and make sketches of possible Bode magnitude *and* phase plots.