University of Michigan
EECS 311: Electronic Circuits
Fall 2009

Quiz 2

11/18/2009

NAME: ____

Honor Code:
I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code.

Signature ___________________________________

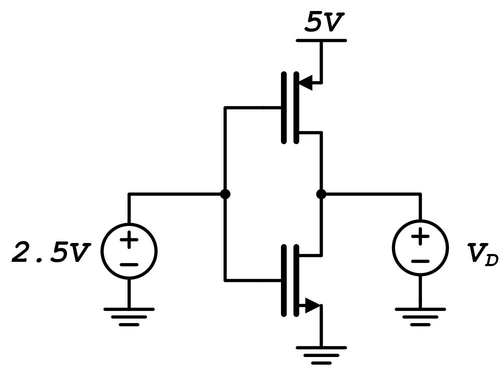
Problem	Points	Score	Initials
1	20		
2	25		
3	30		
4	25		
	Total		

Problem 1 (20 Points): Potpourri.

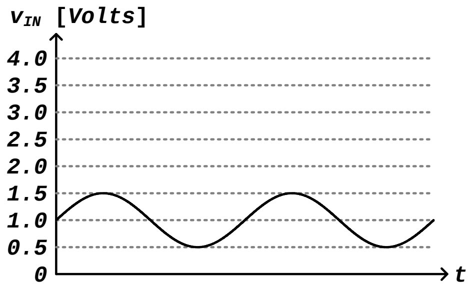
a) For the circuit below, find the range of V_D that will simultaneously bias the NMOS and PMOS in the Saturation region.

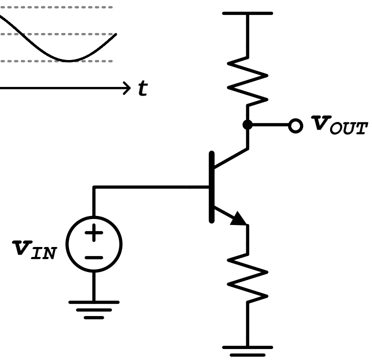
$V_{tn} = 1V$

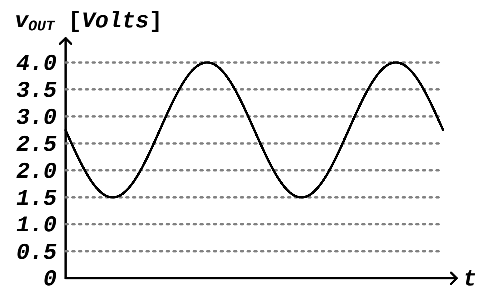
$V_{tp} = -1V$



b) Determine the values of the DC and ac components of the waveforms shown below, assuming the signal are sinusoidal with frequency $\omega = \omega_0$. Additionally, evaluate the ac gain $a_v = v_{out}/v_{in}$ of the circuit.







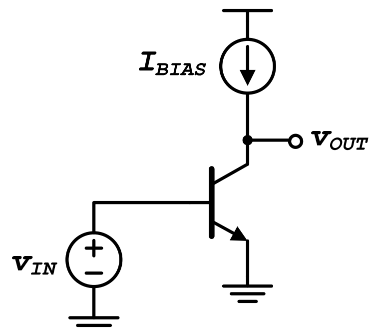
Total = DC Component + ac Component

v_{IN} = ____________________ + ____________________

v_{OUT} = ____________________ + ____________________

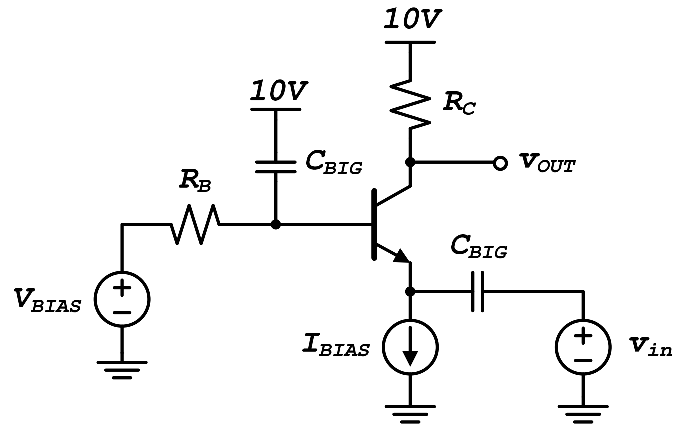
ac Gain $a_v = v_{out}/v_{in} =$ ____________________

c) Assume the BJT is biased in the FAR region, and that I_{BIAS} is a DC bias source. Substitute the small-signal model for the BJT and find an expression for the small-signal gain $a_v = v_{out}/v_{in}$. Assume the BJT has finite V_A (include base-width modulation).



Problem 2 (25 Points): Use the circuit below and the values given in the table for all parts of this problem. The C_{BIG} capacitors should be treated as bypass capacitors.

$\beta_F = 100$
$V_A = \infty$
$V_{BE,ON} = 0.6V$
$V_{BIAS} = 5V$
$R_B = 10k\Omega$
$R_C = 1k\Omega$

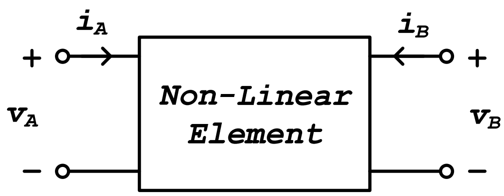


a) Draw the DC equivalent circuit. Calculate the value of I_{BIAS} that will bias the BJT in the FAR region, at the boundary between FAR and Saturation.

b) For this part only, assume the bias current $I_C = 2.5mA$. Draw the small-signal (ac) circuit and evaluate the values of the elements in the BJT small-signal model assuming "room temperature". Assume $V_A = \infty$.

c) For this part, do NOT use the evaluated values of small signal elements found in part b). Derive an expression for the midband small-signal gain $a_v = v_{out}/v_{in}$. Leave this expression in terms of variable names (r_π, g_m, etc.). Assume $V_A = \infty$.

Problem 3 (30 Points): In this problem you will derive the small-signal (ac) model for a non-linear, 2-port element. For each part of this problem, use the device below with the given expressions for large-signal I-V relationships. Show all your work.



for $v_A > 0$, $i_A > 0$, $i_B > 0$

$$i_A = Kv_A$$

$$v_B = \beta i_A^3(1 + \rho i_B)$$

a) Derive an expression to model the small-signal resistance at Port A, $r_a = v_a/i_a$, for the DC operating point: V_A, I_A, V_B, and I_B. Show all your work.

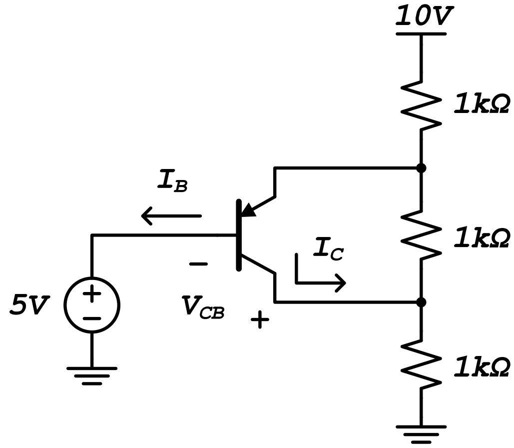
b) Derive an expression to model the small-signal resistance at Port B, $r_b = v_b/i_b$, for the DC operating point: V_A, I_A, V_B, and I_B. Show all your work.

c) Derive an expression to model the small-signal trans-resistance from Port A to Port B, $r_m = v_b/i_a$, for the DC operating point: V_A, I_A, V_B, and I_B. Show all your work.

d) Draw an equivalent circuit to model the small-signal response of the 2-port element.

Problem 4 (25 Points): Use the circuit below and parameters given in the table for each part of this problem.

$\beta_F = 50$
$V_{EB,ON} = 0.6V$
$V_{EC,SAT} = 0.4V$
$V_A = \infty$



a) For this part, assume the BJT is in the Saturation region. Use the simplified model for the BJT in saturation, using the constant-voltage-drop model for the E-B junction and $V_{EC,SAT}$. Solve for the values of I_B, I_C, and V_{CB} and enter them in the space below.

$I_B =$ ________________________________

$I_C =$ ________________________________

$V_{CB} =$ ________________________________

b) For this part, assume the BJT is in the FAR region. Use the simplified model for the BJT in FAR, using the constant-voltage-drop model for the E-B junction. Solve for the values of I_B, I_C, and V_{CB} and enter them in the space below.

$I_B =$ ______________________________

$I_C =$ ______________________________

$V_{CB} =$ ____________________________

c) Based on your answers from parts a) and b), specify the correct region of operation of the BJT. Justify your answer.

(Space for additional work)