UNIVERSITY OF TORONTO
Faculty of Applied Science and Engineering
FINAL EXAM

MIE346S Analog and Digital Electronics for Mechateronics

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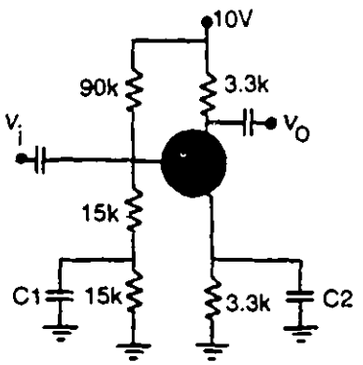
Test time: 2 hours and 30 minutes

Test Type: D

This test has 5 pages including the cover page.

April 17th, 2001

Problem 1 (25 marks): A Silicon NPN transistor with $\beta = h_{fe} = 50$ is used to build an amplifier as shown in the circuit below.



(a) Find the DC voltages at the base, collector and emitter.

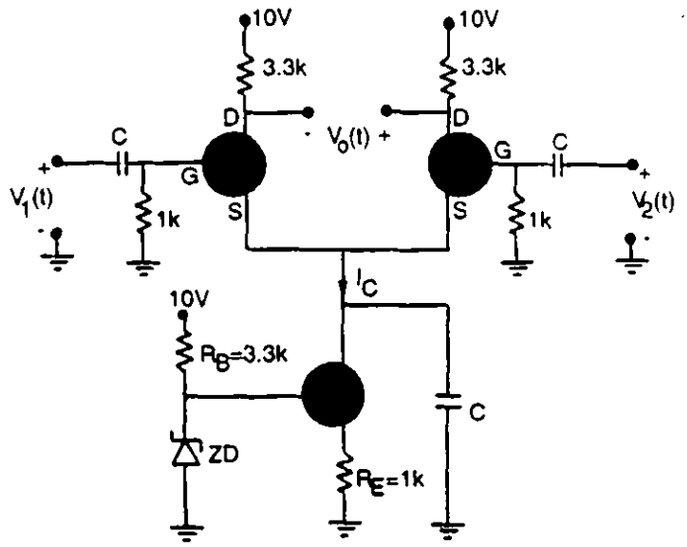
(b) Calculate the output voltage $v_o(t)$ if $v_i(t) = 0.01\sin(2\pi \times 10^6 t)$ volts. (All the capacitors can be assumed short-circuit at input signal's frequency.)

(c) Explain in words how $v_o(t)$ might change if

i. the capacitor C_1 is removed,

ii. the capacitor C_2 is removed.

Problem 2 (30 marks): The circuit below shows a differential amplifier designed using two identical FETs and a BJT. The FETs used have $I_{DSS} = 9mA$ and $V_P = -6V$. The BJT is made of Silicon and has $\beta = 50$. The Zener diode ZD operates at a break-down voltage of 2.7 V.



(a) The BJT serves as a current source. Calculate the current I_C provided by it.

(b) Now, let $V_1(t) = 0.01\cos(2\pi \times 10^3 t)$ and $V_2(t) = -V_1(t)$ be the input signals. Calculate $V_o(t)$ using an appropriate small-signal model. (All the capacitors might be assumed short-circuit at the input signals' frequency.)

(c) Explain in words how $v_o(t)$ might change if

i. R_B is decreased,

ii. R_E is decreased.

Problem 3 (25 marks): A small-signal amplifier (shown below) is used by a student to measure the common-base hybrid-h parameters of an unknown transistor. She assembles the circuit in the lab and chooses R_1 and R_2 to make sure that the transistor is biased in its active region.

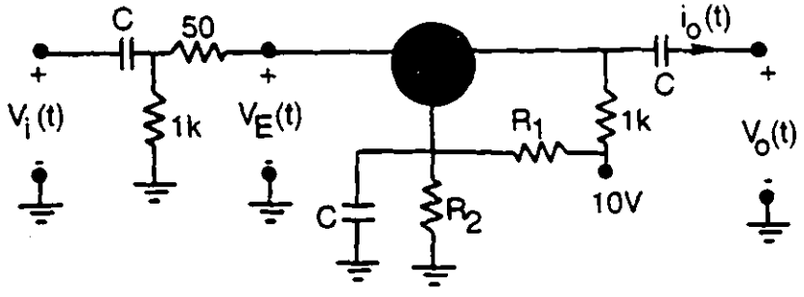
She also sets a signal generator to generate a $10KHz$ sinusoidal signal and connects it to the circuit's input. She then makes the following AC (small-signal) measurements:

(1.) $v_i = 100mV$ peak-to-peak,

(2.) $v_e = 50mV$ peak-to-peak,

(3.) $v_o = 1V$ peak-to-peak when output is open-circuit,

(4.) $i_o = 2mA$ peak-to-peak when output is short-circuit.



(a) Draw the small-signal equivalent circuit for this amplifier. Assume that all the capacitors are short-circuit at input signal's frequency.

(b) Use the measurements made by this student to calculate the numerical values of h_{ib}, h_{fb} and h_{ob}. Assume that $h_{rb} = 0$ for simplicity.

Problem 4 (20 marks): Consider the circuit shown below. The BJTs are made of Silicon and have $\beta = 5$. The MOSFET is an "enhancement" type. It is known that $V_o = 1V$ when point X is connected to point C and that $V_o = 9V$ when point X is connected to point B. Find V_o when point X is connected to point A.