American University of Beirut

Faculty of Engineering and Architecture
Department of Electrical and Computer Engineering

EECE 311 - Electronics
Instructors: A. Kayssi and Z. Othman

Final Exam
June 14, 2003

Closed Book
No Programmable Calculators

Time: 180 minutes

NAME:
ID NUMBER:

► Return the computer card attached to the question sheet.

► Provide your answers on the computer card:
Only the computer card will be considered in grading.
Use a pencil for marking your answers and ID number on the computer card.
When using an eraser, make sure you erased well.

► On this sheet, write with a pen your name followed by your ID number.
Sign the honor pledge.

► All questions are equally graded (5 points per question)
<u>PENALTY is FOUR to ONE</u>
Penalty is calculated as follows: One to three wrong answers result in no penalty; four to seven wrong answers result in canceling one correct answer; eight to eleven wrong answers result in canceling two correct answers; and so on.

Questions 1 to 30 are equally graded.

1. Refer to **Figure 2**. What should the value of R be in order to have class AB operation? Assume $V_{BE(on)}$ = 0.6V and neglect base current. Note that the bias circuit of Q_1 has negligible effect and is not shown.

a) 12K b) 60K c) 0.6K d) 6K e) none of the above

2. Refer to **Figure 2**. Neglect the base current of the output transistors and assume β = 50 for Q_1. Find the value of C that would give a lower 3-dB frequency of 100 Hz. Assume V_T = 25 mV. Note that the bias circuit of Q_1 has negligible effect and is not shown.

a) 97.9 nF b) 17.4 nF c) 8.43 nF d) 0.723 nF e) none of the above

3. Refer to **Figure 2**. The average DC current drawn from both power supplies is 15 mA. What is the efficiency of the amplifier if the peak-to-peak output voltage is 8V?

a) 29.4% b) 17.8% c) 13.2% d) 56.3% e) none of the above

4. Which output stage has the smallest quiescent current?

a) Class A
b) Class B
c) Class AB
d) Class A and Class AB

5. For the modified Wien bridge oscillator shown in **Figure 1**, find the frequency of oscillation when R = R_1 = 100K and C = 1 nF.
a) 3.18 KHz b) 62.8 KHz c) 10 KHz d) 1.59 KHz e) none of the above

6. A BJT biased at I_C = 1mA has f_T = 300 MHz. Find C_π assuming that when I_C=1mA, C_π=10C_μ.

a) 22.6 pF b) 13.3pF c) 19.3pF d) 10.5pF e) none of the above

7. For the two-stage amplifier shown in **Figure 3**, assume that for the BJTs, V_{BE} = 0.7 V, V_T = 26 mV, and β = 100. Find the DC collector currents for Q_1 and Q_2. Neglect base current.
a) I_{C1} = 0.118 mA, I_{C2} = 0.55 mA
b) I_{C1} = 0.253 mA, I_{C2} = 0.65 mA
c) I_{C1} = 0.174 mA, I_{C2} = 0.82 mA
d) I_{C1} = 0.266 mA, I_{C2} = 0.97 mA
e) none of the above

8. For the circuit of Problem 7, find the input resistance of stage 2, R_{i2} (at midband)
a) 22K b) 13.9K c) 16K d) 105.7K e) none of the above

9. For the circuit of Problem 7, find the AC midband gain of the first stage (V_x/V_s) taking into account the loading effect of the input resistance of stage 2 on stage 1.
a) -12.6 b) -3.02 c) -18.2 d) -8.08 e) none of the above

10. For the circuit of Problem 7, find the overall gain of the amplifier at midband V_o/V_s.
a) 30.6 b) 21.5 c) 11.4 d) 6.8 e) none of the above

11. For the circuit of Problem 7, find the lower 3 dB frequency. Neglect the effect of C_{E1} and C_{E2} and assume that the low frequency response is due to C_{B1} and C_{B2} only. Use the method of short-circuit time contants. Assume the presence of a dominant pole.
a) 4.65 Hz b) 39.6 Hz c) 0.948 Hz d) 19.4 Hz e) none of the above

12. For the circuit of Problem 7, find the upper 3 dB frequency. Assume that the high frequency response of the circuit is determined *by the input circuit of stage 1 only*. Use Miller's theorem.

a) 98 KHz b) 47 KHz c) 69 KHz d) 191 KHz e) none of the above

13. For the amplifier circuit shown in **Figure 4**, find the voltage V_S when $V_1 = V_2 = 0$. Assume $V_D = 0.7V$ and $V_{BE} = 0.7V$. The BJTs are identical and have negligible base current. The FETs are identical with $k'_n W/L = 2.5\ mA/V^2$ and $V_t = -2\ V$.

a) -0.7V b) 1.368V c) 2.437 V d) -4.672V e) none of the above

14. For the circuit of Problem 13, find V_{out} when $V_1 = V_2 = 0$.

a) 5 V b) 3 V c) 1 V d) 0 V e) none of the above

15. Find the gain Vo/Vs in the circuit shown in **Figure 5**. The BJTs have $\beta = 260$, $V_A = 90V$ and $V_{BE} = 0.7V$. Assume $V_T = 26$ mV and neglect the Early Effect in the DC analysis.

a) -284 b) -498 c) -331 d) -102 e) none of the above

16. For the amplifier shown in **Figure 6**, find the midband gain V_o/V_s. For the FET, $g_m = 10$ mA/V, and $C_{gs} = C_{gd} = 1$ pF. For the BJT, $\beta = 100$, $g_m = 100$ mA/V, $C_\pi = 10$ pF and $C_\mu = 1$ pF.

a) -99 b) -110 c) -11 d) -76.3 e) none of the above

17. For the circuit of Problem 16, find the upper 3-dB frequency using Miller's theorem and the open circuit time constants method. Assume the presence of a dominant pole.

a) 26 MHz b) 3.8 MHz c) 5.1 MHz d) 56 MHz e) none of the above

18. Find the value of R that gives a current $I_{C2} = 0.01$ mA in the circuit of **Figure 7**. The transistors are matched. Assume $I_{C1} = 0.1$ mA and $V_T = 26$ mV. Neglect base current.

a) 29.3K b) 13.8K c) 5.99K d) 10K e) none of the above

19. Find the transfer function A(s) whose Bode plot is shown in **Figure 8**.

a) $100s / ((s+100)(s+10^6)(s+10^8))$
b) $100s(s+100) / ((s+10^6)(s+10^8))$
c) $10^{16}s / ((s+100)(s+10^6)(s+10^8))$
d) $10^{16}s(s+100) / ((s+10^6)(s+10^8))$
e) none of the above

20. For the amplifier of Problem 19, what is the approximate value of the gain at 10^7 rad/sec?

a) 10 dB b) 0 dB c) 40 dB d) 30 dB e) none of the above

21. Two amplifiers with upper 3-dB frequencies of 10 MHz and 15 MHz, respectively, are cascaded together. What is the upper 3-dB frequency of the resulting system?

a) 10 MHz b) 15 MHz c) 25 MHz d) 12.5 MHz e) none of the above

22. Refer to **Figure 10**. The MOSFET has $g_m = 3$ mA/V, $C_{gs} = 4$pF, and $C_{gd} = 10$pF. Find the lower 3-dB frequency using the method of short-circuit time constants.

a) 20.6 Hz b) 9.02 Hz c) 14.7 Hz d) 6.82 Hz e) none of the above

23. The gain of an amplifier at 10 MHz should be 90% its midband gain. What should be the upper 3 dB frequency of this amplifier? Assume the presence of a high-frequency dominant pole.

a) 10 MHz b) 15.8 MHz c) 17.3 MHz d) 20.6 MHz e) none of the above

24. When the inputs to a differential amplifier are $v_1 = \sin(\omega t)$ mV and $v_2 = 3\sin(\omega t)$ mV, the output is $-204\sin(\omega t)$ mV. When v_1 increases to $5\sin(\omega t)$ mV, while v_2 is kept the same, the output becomes $+192\sin(\omega t)$ mV. What is the common-mode rejection ratio of this differential amplifier?

a) 81.45 dB b) 33.98 dB c) 48.33 dB d) 78.92 dB e) none of the above

25. A class A amplifier should provide a 4V peak-to-peak signal to an 8 Ω load. What is the average current drawn from a 12V power supply at maximum efficiency?

a) 133.33 mA b) 100 mA c) 500 mA d) 83.33 mA e) none of the above

26. For the circuit shown in **Figure 9**, find the input resistance R_{i1}. Assume that $\beta = 100$ and $r_{\pi1} = 1$ KΩ, $r_{\pi2} = 0.5$ KΩ, and $r_{\pi3} = 0.5$ KΩ.
a) 101 KΩ b) 10 KΩ c) 11.1 KΩ d) 1 KΩ e) none of the above

27. For the circuit shown in **Figure 9**, find the output resistance R_o. Assume that $\beta = 100$ and $r_{\pi1} = 1$ KΩ, $r_{\pi2} = 0.5$ KΩ, and $r_{\pi3} = 0.5$ KΩ.
a) 24.6 Ω b) 19.7 Ω c) 38.2 Ω d) 31.7 Ω e) none of the above

28. For the circuit shown in **Figure 9**, find the voltage gain v_{o1}/v_s. Assume that $\beta = 100$ and $r_{\pi1} = 1$ KΩ, $r_{\pi2} = 0.5$ KΩ, and $r_{\pi3} = 0.5$ KΩ.
a) –3.03 b) –4.61 c) –2.54 d) –6.33 e) none of the above

29. For the circuit shown in **Figure 9**, find the voltage gain v_o/v_{b3} where v_{b3} is the voltage at the base of transistor Q_3. Assume that $\beta = 100$ and $r_{\pi1} = 1$ KΩ, $r_{\pi2} = 0.5$ KΩ, and $r_{\pi3} = 0.5$ KΩ.
a) 0.895 b) 0.999 c) 0.911 d) 0.944 e) none of the above

30. For the circuit shown in **Figure 9**, find the upper 3 dB frequency. Assume that $\beta = 100$, $C_\pi = 10$ pF, $C_\mu = 1$ pF for the three BJTs, and that $r_{\pi1} = 1$ KΩ, $r_{\pi2} = 0.5$ KΩ, and $r_{\pi3} = 0.5$ KΩ. Use the method of open-circuit time constants.
a) 5.2 MHz b) 12.8 MHz c) 7.3 MHz d) 2.6 MHz e) none of the above