American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 – Electronics
Midterm – July 15, 2011
Closed Book – No Programmable Calculators

120 minutes

Profs. Chehab and Kayssi

Penalty is 5 to 1

(1 to 4 wrong answers do not result in a penalty; 5 to 9 wrong answers cancel one correct answer; 10 to 14 wrong answers cancel two correct answers; and so on)

Name: _____ID number: _____

Unless otherwise specified, assume that:

V_T = 25 mV **n = 1** **n_i = 1.5×10^{10} cm^{-3}** **q = 1.6×10^{-19} C**

$$J_p = -qD_p \frac{dp}{dx} \qquad J_n = qD_n \frac{dn}{dx}$$

$$J_d = \left(qp\mu_p + qn\mu_n\right)E$$

$$I = J \times A$$

$$V_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

1. The saturation levels at the output of an amplifier are +/– 12 V. To avoid saturation and obtain the *maximum* undistorted output, a sinusoidal voltage with zero average and an RMS value of 0.4 V is used at the input. Find the voltage gain (in V/V) of this amplifier.

a) 42.4 b) 33.9 c) 28.3 d) 24.2 e) 21.2

2. An amplifier produces a 1.1 V peak-to-peak output voltage across a 30 Ω load resistor. Find the power gain of the amplifier (in dB) if the input power is 1 mW.

a) 11.8 b) 9.7 c) 7.0 d) 10.8 e) 8.5

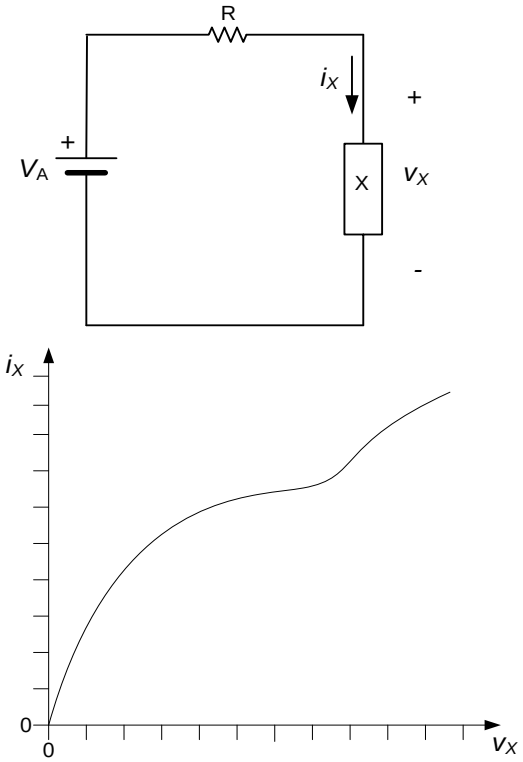
3. The efficiency of an amplifier powered from a 9 V battery is 35%. The power delivered at the output is 0.2 W. Find the average current (in mA) drawn from the battery.

a) 49.4 b) 88.9 c) 63.5 d) 74.1 e) 55.6

4. A circuit consists of a series connection of a 9 V battery, a 15 kΩ resistor, and a forward-biased diode. The diode has $I_S = 10^{-16}$ A and n = 1. Starting with an initial guess for the diode current equal to the current that flows if the diode were ideal, find the value of the diode current (in mA) using iterations.

a) 0.307 b) 0.251 c) 0.459 d) 0.376 e) 0.551

5. The current-voltage characteristics of device X are shown on the i_x–v_x plot in the figure below. The *x*-axis division is 0.2 V, and the *y*-axis division is 30 μA. Using the load line graphical method, the operating point is found to be at $V_X = 0.6$ V when V_A is 1.4 V. Find the value of R (in kΩ).



a) 0.5 b) 5 c) 3 d) 2 e) 1

6. A diode is modeled by $V_{D0} = X$ Volts and $r_D = Y$ Ohms when conducting, and an open-circuit when OFF. The diode voltage increases from 0.72 V to 0.8 V when the diode current increases from 1 mA to 10 mA. Find X (in V).

a) 0.756 b) 0.733 c) 0.689 d) 0.711 e) 0.667

7. In the previous problem, find Y (in Ω).

a) 6.67 b) 4.44 c) 13.3 d) 11.1 e) 8.89

8. A piece of semiconductor material is doped with acceptor atoms with a density $N_A = 10^{17}$ cm^{-3}. Estimate the conductivity (in S/cm) of the material if an applied electric field with intensity 5 V/cm results in a drift current density of 20 A/cm^2.

a) 7.2 b) 6.4 c) 5.0 d) 4.0 e) 8.0

9. Estimate the hole mobility (in cm^2/V.s) in the previous problem. The electron mobility is double that of holes.

a) 250 b) 500 c) 450 d) 400 e) 313

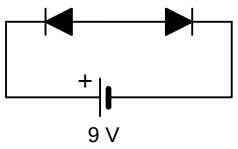
10. The diffusion current density for holes in a piece of semiconductor is J_1 at x = 1 cm but becomes $0.5 \times J_1$ at x = 2 cm. The hole density function is $p(x) = a_0 + x - a_2 x^2$. Find the value of a_2 (in cm^{-1}).

a) 0.188 b) 0.167 c) 0.143 d) 0.115 e) 0.206

11. A diode conducts a current 1 mA; its current increases to 1.9 mA when its voltage increases by 30 mV (i.e. the new value is equal to the old value plus 30 mV). Find the value of n for this diode.

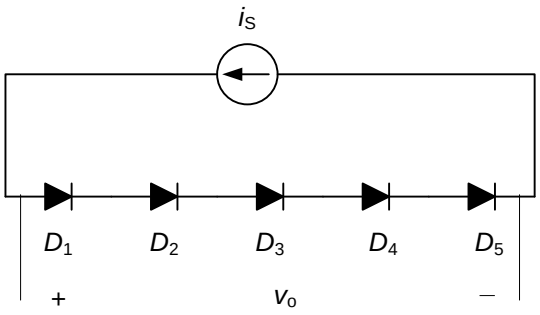
a) 1.21 b) 1.87 c) 1.62 d) 1.44 e) 1.31

12. Two identical diodes with n = 1.3 are connected back-to-back (their two anodes are connected) across the terminals of a 9 V battery. Find the voltage across the forward-biased diode (in mV).



a) 32.9 b) 29.4 c) 19.1 d) 22.5 e) 26.0

13. Five forward-biased diodes are connected across the terminals of a current source with a current given by $i_S = 1 + 0.1 \sin(\omega t)$ mA. The diodes D_1, D_2, D_3, D_4, and D_5 have n = 1.1, 1.2, 1.3, 1.4, 1.5, respectively. Find the small-signal resistance r_{d3} (in Ω) of diode D_3.

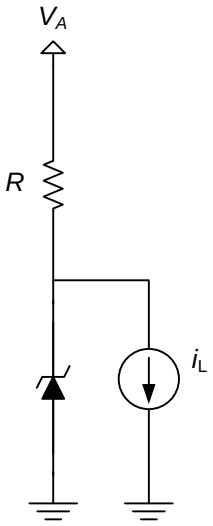


a) 32.5 b) 21.7 c) 16.3 d) 13.0 e) 10.8

14. Find the *peak-to-peak* variation in the total voltage v_o across the five forward-biased diodes in the previous problem.

a) 16.3 b) 13.0 c) 10.8 d) 32.5 e) 21.7

15. A Zener diode regulator shown in the circuit below uses a Zener diodes that has $V_Z = 9$ V at $I_{ZT} = 20$ mA, with $r_Z = 10\ \Omega$ and $I_{ZK} = 5$ mA. The source V_A is 15 V, but varies between 13 V and 17 V. The load draws a current that varies from 0 to 10 mA. Find the value of V_{Z0} (in V) for the Zener diode.



a) 6.8 b) 7.8 c) 8.8 d) 9.8 e) 10.8

16. In Problem 15, if the maximum variation in the Zener voltage due to the total variation in the load current is 92 mV, what should be the value of R (in Ω)? Assume that the source voltage is fixed at 15 V.

a) 80.9 b) 61.4 c) 48.8 d) 190 e) 115

17. In Problem 15, and in order to maintain regulation under all conditions of v_S and i_L, what is the maximum value of R (in Ω)?

a) 143 b) 210 c) 410 d) 343 e) 277

18. A half-wave rectifier circuit using an ideal diode operates from a 24 V RMS, 50 Hz sinusoidal source and delivers rectified current to a 1.6 kΩ resistive load. What is the average value of the load current (in mA)?

a) 6.75 b) 6.00 c) 7.72 d) 10.8 e) 9.00

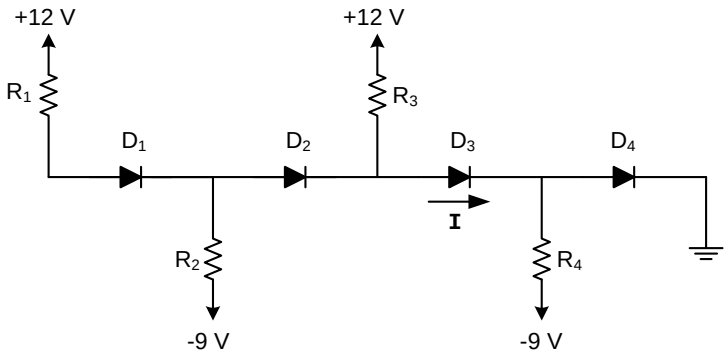
19. Assume in the previous problem that a capacitor is connected in parallel with the load resistor. What should the value of this capacitance be (in mF) in order to limit the ripple voltage to 0.5 V?

a) 0.97 b) 0.85 c) 1.36 d) 0.75 e) 1.13

20. A 4-diode bridge rectifier circuit with a resistive load operates from a 220 V RMS sinusoidal supply through a step-down transformer having a turns ratio of 11-to-1. Each diode is modeled by a 0.7 V drop for any forward current, and an open-circuit when the diode is OFF. What is the peak inverse voltage (PIV, in V) for the diodes in the circuit?

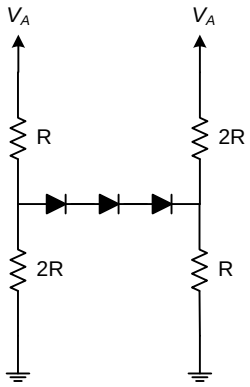
a) 21.5 b) 23.2 c) 25.2 d) 27.6 e) 30.4

21. Assume that the diodes in the circuit are ideal. Furthermore, assume that they are all conducting. Find the current I (in mA). The resistors are all equal to 3 kΩ.



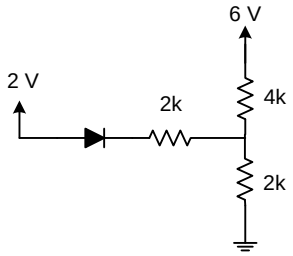
a) 2.5 b) 3.75 c) 5 d) 7.5 e) 3

22. Each diode in the circuit is modeled by a constant voltage drop of 0.7 V when conducting. Find the current in the three diodes (in mA). Assume V_A = 10 V and R = 1 kΩ.



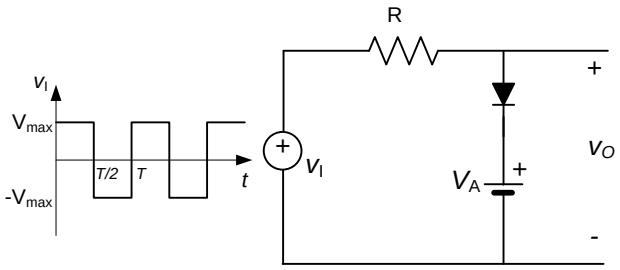
a) 1.175 b) 1.425 c) 0.425 d) 0.675 e) 0.925

23. Find the current flowing out of the 6 V supply (in mA). The diode drops 0.7 V when conducting, and is an open circuit when it is OFF.



a) 1 b) 1.2 c) 1.5 d) 1.8 e) 2

24. Find the average value of the output voltage. Assume that the diode is ideal and $V_{max} = 2\ V_A$.



a) $-0.5V_A$ b) V_A c) 0 d) $-2V_{max}$ e) $1.5V_A$