American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 – Electronics
Midterm – October 30, 2014
Closed Book – No Programmable Calculators

90 minutes

There are 21 problems and 7 pages. All problems are equally graded.

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 $n = 1$ $n_i = 1.5\times10^{10}$ cm^{-3} $q = 1.6\times10^{-19}$ C

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

$$\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = V_T$$

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

$$I = J \times A$$

1. The current gain of an amplifier is 20 dB. Its power gain is 40 dB. What is its voltage gain (in dB)?

a) 60 b) 50 c) 70 d) 65 e) 55

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2. At the output of an amplifier, a resistive load R_L = 3 kΩ is connected to Ground. The current gain of the amplifier is 50 A/A. The input signal current is $i_i = 0.1\sin(\omega t)$ mA.
A 9 V battery feeds the amplifier with a DC current of 10 mA. What is the efficiency of the amplifier?

a) 69.4% b) 41.7% c) 55.6% d) 27.8% e) 13.9%

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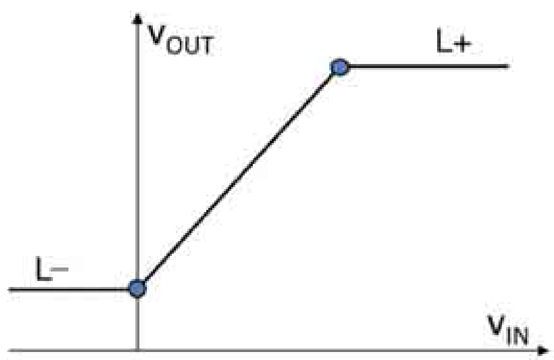
3. The voltage transfer characteristics for an amplifier are shown below. The output voltage saturation levels are L– = 1 V and L+ = 10 V.
What is the gain of the amplifier (in the non-zero gain region), if the largest sinusoidal input voltage that can be applied without causing distortion is 160 mV peak-to-peak? This sinusoidal input is applied with a proper bias value.



a) 90.0 b) 75.0 c) 64.3 d) 56.3 e) 50.0

4. Assume in the previous question that the amplifier has the same output voltage saturation levels, L– = 1 V and L+ = 10 V, but that the gain in the non-zero gain region is 160 V/V. Find the DC bias value at the input V_{IQ} (in mV) needed to obtain the largest undistorted sinusoidal output voltage.

a) 40.9 b) 37.5 c) 32.1 d) 28.1 e) 45.0

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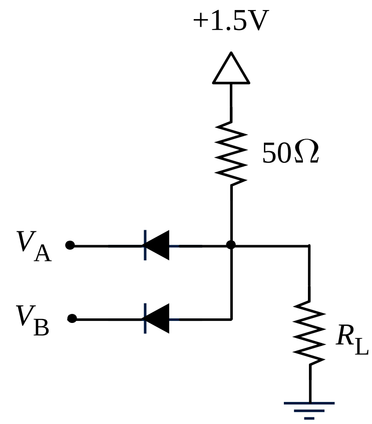
For the next two questions, refer to the circuit shown below.



Assume that R_L is 1 kΩ and that the diodes drop 0.7 V when conducting, and that they are open-circuits when OFF.

5. The combination of inputs (V_A, V_B) that leads to both diodes being OFF is:
a) (0V, 0V) b) (0V, 1V) c) (1.5V, 1.5V) d) (0V, 1.5V) e) (1.5V, 0V)

6. Assume that V_A = 1.5 V and V_B = 0 V. Find the power dissipated in the resistor R_L (in mW).
a) 0.56 b) 0.64 c) 0.36 d) 0.42 e) 0.49

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7. Two diodes D_1 and D_2 are connected in series and carry the same forward current. Diode D_1 has $n_1 = 1$ and $I_{s1} = 10^{-12}$ A, and diode D_2 has $n_2 = 1.3$ and $I_{s2} = I_{s1} = 10^{-12}$ A. The total forward voltage drop across both diodes is 1.3 V. Find the forward voltage drop across diode D_1 (v_{D1} in mV).
a) 541.7 b) 590.9 c) 577.8 d) 565.2 e) 553.2

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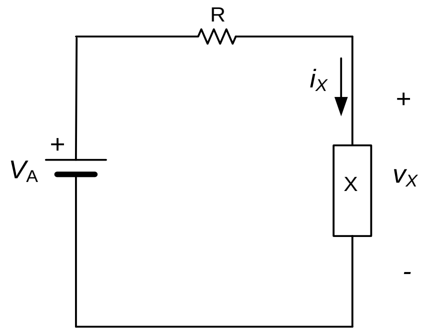
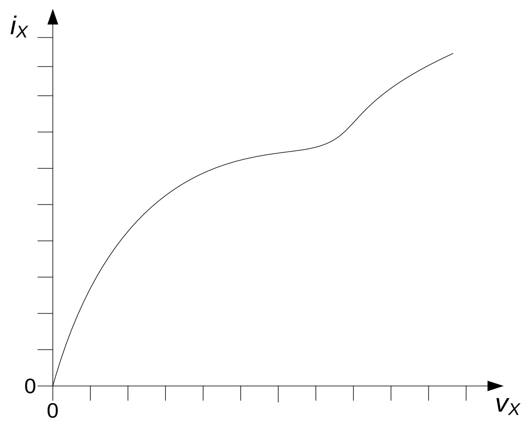
8. The current-voltage characteristics of device X are shown on the $i_X - v_X$ plot in the figure below. The x-axis division is 0.6 V, and the y-axis division is 50 μA. When device X is replaced with an open circuit, the voltage v_X is 6 V. When device X is replaced with a short circuit, the current i_X is 0.35 mA. Find the value of v_X (in V) when the actual device X is connected in the circuit.





a) 1.96 b) 1.40 c) 1.12 d) 0.84 e) 1.68

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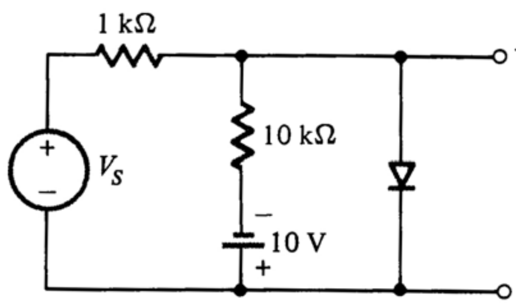
The diode in the circuit shown below is ideal, and $V_S = V_p \sin(\omega t)$. Refer to this circuit for the next two questions.



9. Find the value of V_p (in V) if the diode PIV is 15 V.

a) 16.6 b) 12.2 c) 13.3 d) 14.4 e) 15.5

10. Find the value of V_p (in V) if the maximum forward diode current is 5 mA.

a) 8 b) 9 c) 5 d) 6 e) 7

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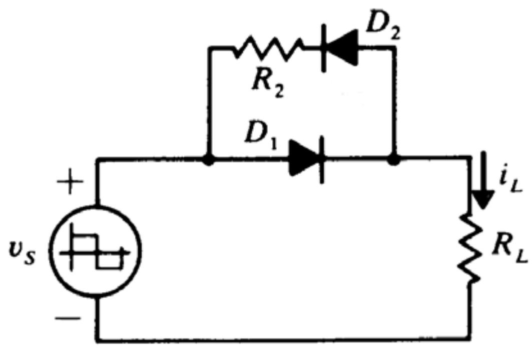
Each of the two diodes in the circuit shown below is modeled by a fixed 0.8 V drop when conducting, and by an open circuit when OFF. Assume $R_2 = R_L = 1\ \text{k}\Omega$. The square-wave input voltage v_s is –12 V for 50% of the time, and +12 V for 50% of the time.



11. Find the power dissipated in R_L (in mW) when v_s is positive.
a) 174.2 b) 27.0 c) 51.8 d) 84.6 e) 125.4

12. Find the average (DC) value of the load current i_L (in mA).
a) 2.8 b) 2.3 c) 1.3 d) 1.8 e) 3.3
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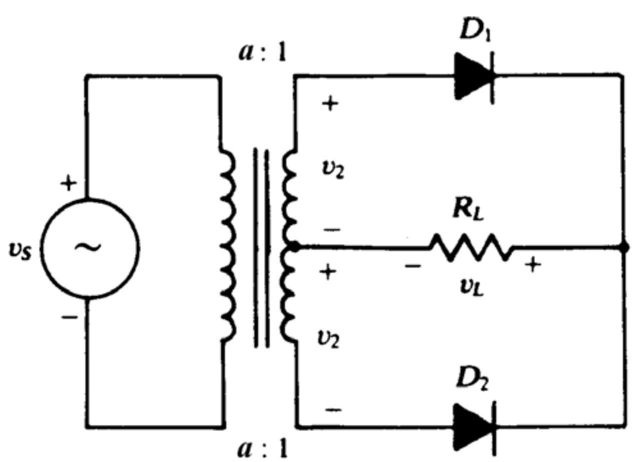
13. The rectifier circuit shown below uses a center-tapped transformer with turns-ratio a, i.e. $v_2 = v_s / a$. The voltage source v_s is sinusoidal with zero average and an RMS value of 48 V. The average (DC) value of the load voltage v_L is 21.61 V. Assuming that the diodes are ideal, find the maximum value of load current (in mA) flowing in R_L when $R_L = 1\ \text{k}\Omega$.
a) 19.4 b) 33.9 c) 27.2 d) 22.6 e) 45.2



14. In the previous problem, find the value of a.
a) 3.5 b) 3 c) 2.5 d) 1.5 e) 2
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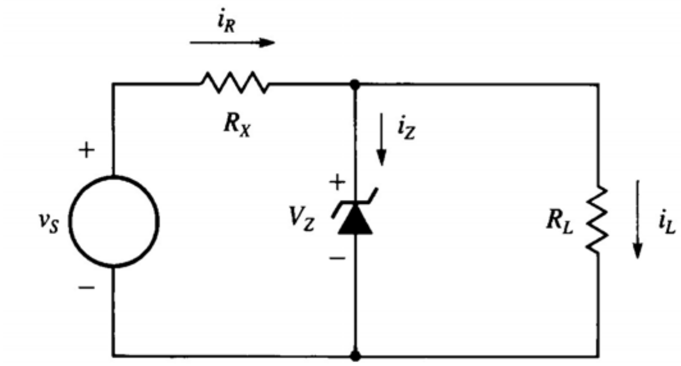
The Zener diode in the circuit shown below has V_{Z0} = 20 V, r_Z = 0 Ω, and I_{ZK} = 0.3 mA. Refer to this circuit for the following two questions.



15. The source voltage is v_S = 25 V and R_X = 50 Ω. What value of R_L (in Ω) makes the Zener diode dissipate 1.2 W?

a) 666.7 b) 285.7 c) 333.3 d) 400.0 e) 500.0

16. The source voltage is $v_S = 25 + 2\sin(\omega t)$ V and R_L = 5 kΩ. What is the maximum value of R_X (in Ω) for which the Zener diode remains in the breakdown region?

a) 666.7 b) 638.3 c) 612.2 d) 588.2 e) 697.7

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17. A circuit consists of a 4 V DC source, a 2 kΩ resistor, and a forward-biased diode. The diode has n = 1. Starting with an initial guess for the diode current of 2 mA, the value of the diode current after completing one iteration is found to be 1.7784 mA. If $I_S = K\times10^{-11}$ A, find the value of the constant K. Hint: Use high precision in your calculations.

a) 2 b) 3 c) 4 d) 5 e) 6

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18. Small-signal sinusoidal variations in a diode voltage are measured to be $v_d = 3.6\sin(\omega t)$ mV. The *total* diode current is measured to be $i_D = I_D + 0.1\times I_D \sin(\omega t)$. Find the value of n for this diode.

a) 1.92 b) 1.12 c) 1.28 d) 1.44 e) 1.68

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The doping concentration (density) profile of donor atoms in a piece of semiconductor material of length L is given by $N_D(x) = N_0 + N_1(x/L)^3$ for $0 \leq x \leq L$ with $N_0 = 10^{16}$ cm^{-3}, $N_1 = 3\times10^{16}$ cm^{-3}, and $L = 0.1$ cm. The mobility of free electrons is 1000 cm^2/V.s, and the mobility of holes is 500 cm^2/V.s.

19. The free electron concentration (density) is largest at $x = x_1$, and the hole concentration (density) is largest at $x = x_2$. Find x_1 and x_2.

a) $x_1 = L, x_2 = 0$

b) $x_1 = L/2, x_2 = L/2$

c) $x_1 = 0, x_2 = 0$

d) $x_1 = 0, x_2 = L$

e) $x_1 = L, x_2 = L$

20. What is free electron diffusion current density (in A/cm^2) at $x = L/2$?

a) 0.6 b) 0.9 c) 1.2 d) 1.5 e) 1.8

21. Assume in this question that the total diffusion current density at $x = L$ is 8 A/cm^2. Under equilibrium conditions, the *total current* density should be zero. Find the magnitude of the electric field E (in V/cm) at $x = L$ that must exist to maintain the equilibrium.

a) 1.00 b) 0.83 c) 1.25 d) 1.67 e) 0.71

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