American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 – Electronics
Midterm – October 24, 2013
Closed Book – No Programmable Calculators

90 minutes

There are 21 problems and 6 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 $\quad n = 1 \quad n_i = 1.5\times10^{10}$ cm^{-3} $\quad q = 1.6\times10^{-19}$ C

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

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

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

$$I = J \times A$$

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The efficiency of an amplifier loaded by a 1 kΩ resistor is 43%. The amplifier is powered from a single 8 V DC supply. The supply current is 10 mA. The voltage gain of the amplifier is 45 dB. The input and output voltages are sine waves with zero average.

1. Find the power dissipated (lost) in the amplifier (in mW).
a) 65.6 b) 53.6 c) 61.6 d) 45.6 e) 69.6

2. Find the peak value of the input voltage in (in mV).
a) 34.11 b) 30.18 c) 25.65 d) 46.64 e) 40.86

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3. A large forward current is flowing in a Silicon diode. When the diode voltage increases by $\Delta = 27$ mV (from V_D to $V_D + \Delta$), this current doubles (from I_D to $2I_D$). Find the value of n for this diode.
a) 1.21 b) 1.33 c) 1.44 d) 1.56 e) 1.67

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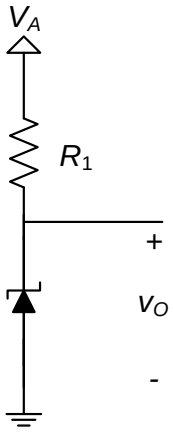
A Zener voltage regulator shown in the figure below uses a diode with $V_{Z0} = 5.6$ V, $r_Z = 25$ Ω, and $I_{ZK} = 2.5$ mA. The supply V_A is an unregulated 13.8 V voltage source. Assume $R_1 = 1$ kΩ.



4. If the supply voltage V_A changes by 0.9 V, what is the corresponding change in the output voltage v_O (in mV)?
a) 41.46 b) 26.83 c) 31.71 d) 36.59 e) 21.95

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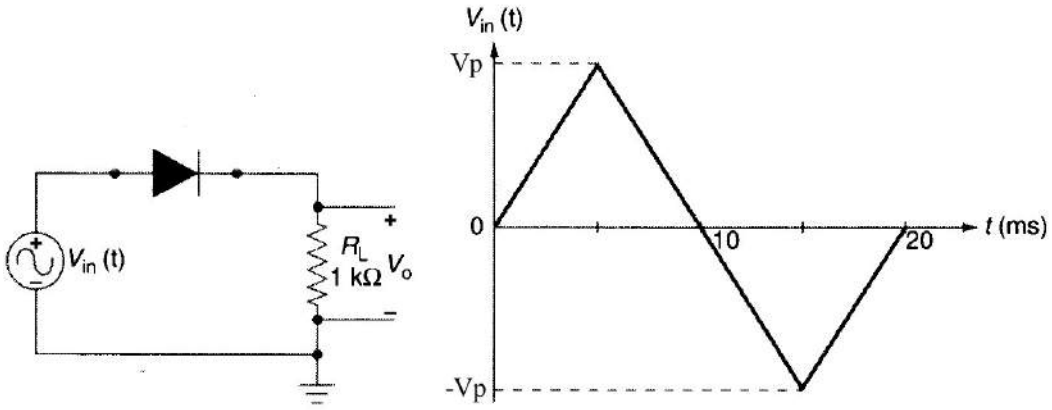
The rectifier in the figure shown below is fed with a voltage V_{in} having a periodic triangular waveform with a peak value Vp = 12 V, zero average, and a period of 20 ms. Assume that the diode is ideal.



5. Find the average (DC) value of the output voltage V_o (in V).
a) 3 b) 2.75 c) 2.25 d) 2.5 e) 2

6. An 800 µF capacitor is connected in parallel with R_L (= 1 kΩ). Find the output ripple voltage (in mV).
a) 300 b) 250 c) 275 d) 200 e) 225

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7. A full-wave bridge rectifier circuit with a purely resistive load operates from a sinusoidal supply through a step-down transformer having a single secondary winding. The **RMS** voltage at the transformer secondary is 14 V, and the bridge uses four diodes each of which can be modeled to have a 0.7 V drop for any forward current. Find the average voltage across the load (in V).
a) 16.6 b) 9.4 c) 11.2 d) 13.0 e) 14.8

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A diode with n = 1 is operating such that its voltage is v_D = 725 + 3 cos(100πt) mV, and its current is $i_D = I_D + 0.3\cos(100\pi t)$ mA.

8. Find the small-signal resistance r_d of this diode (in Ohms).
a) 15 b) 12 c) 10 d) 20 e) 30

9. Estimate the value of the reverse saturation current I_S for this diode ($\times 10^{-16}$ A).
a) 5.3 b) 6.4 c) 4.2 d) 2.1 e) 3.2

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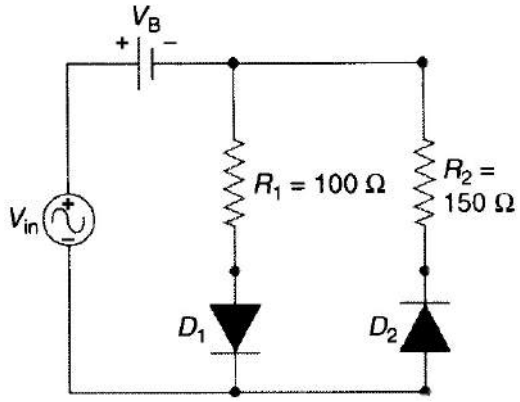
The diodes in the circuit shown below are ideal. The voltage V_{in} is sine wave with a 10 V peak value and zero DC component, and V_B = 6 V.



10. Find the maximum forward current in diode D_2 (in mA).
a) 106.7 b) 100 c) 93.3 d) 80 e) 86.7

11. Find the Peak Inverse Voltage (PIV) of diode D_2 (in V).
a) 4 b) 5 c) 8 d) 7 e) 6

12. Find the fraction of each cycle during which diode D_1 conducts.
a) 0.436 b) 0.403 c) 0.369 d) 0.333 e) 0.295

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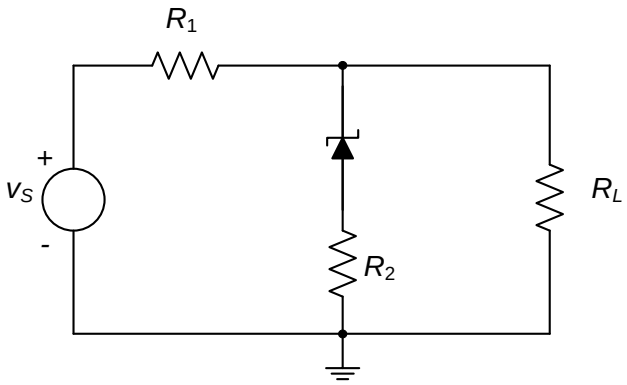
In the circuit shown below, the Zener diode has V_Z = 6 V at I_Z = 5 mA, with r_Z = 20 Ω and I_{ZK} = 2 mA. Assume R_1 = 1 kΩ, R_2 = 50 Ω, and R_L = 3.2 kΩ. The source voltage is $v_S(t) = 13 + \boldsymbol{A}\sin(\omega t)$ V.



13. Find the voltage across R_L at time t = 0 (in V).
a) 5.32 b) 5.78 c) 6.24 d) 6.69 e) 7.15

14. Find the maximum value of ***A*** (in V) to keep the Zener diode operating in the breakdown region.
a) 3.07 b) 2.42 c) 1.76 d) 3.73 e) 4.39

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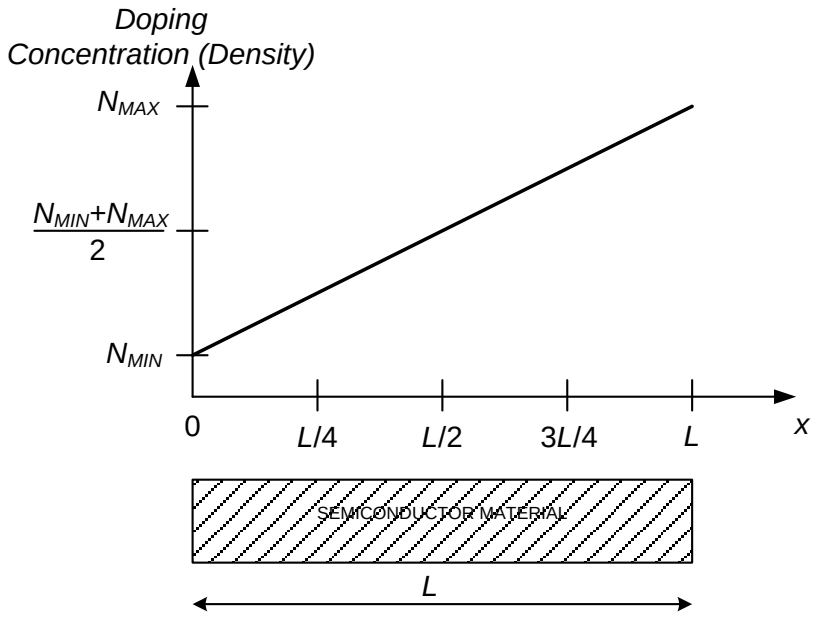
The doping concentration (density) profile of acceptor atoms in a piece of semiconductor material of length L = 1 mm, is shown in the figure below.
N_{MIN} is *much* larger than n_i, and N_{MAX} = $7N_{MIN}$.



15. The hole concentration (density) is largest at $x = x_1$, and the free electron concentration (density) is largest at $x = x_2$. Find x_1 and x_2.
a) $x_1 = L$, $x_2 = 0$ b) $x_1 = 0$, $x_2 = L$ c) $x_1 = L/2$, $x_2 = L/2$ d) $x_1 = L$, $x_2 = L$

16. What is the direction of flow of the hole diffusion current?
a) Negative y (down) b) Positive y (up) c) Unknown d) Positive x e) Negative x

17. Under equilibrium conditions, the total current should be zero. Find the magnitude of the electric field E (in V/m) at $x = L/2$ that must exist to maintain the zero-current condition. *Consider majority carriers only*.
a) 40.0 b) 38.9 c) 37.5 d) 33.3 e) 35.7

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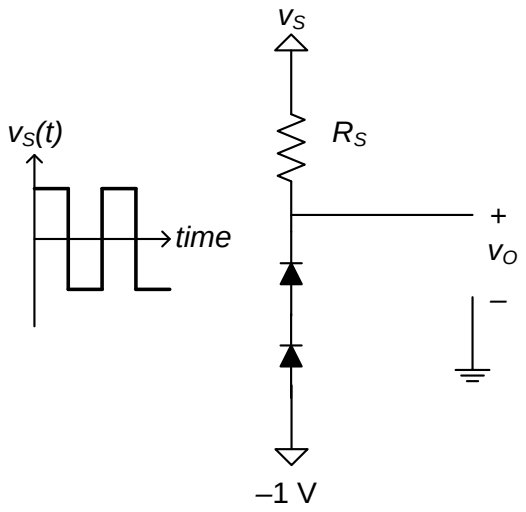
In the circuit shown below, the diodes are modeled by a fixed 0.75 V drop when conducting, and by an open circuit when OFF. The voltage v_S is a square wave with zero average, and symmetrical levels at ±8 V. Assume R_S = 5 kΩ.



18. Find the diode current (in mA), when the diodes are conducting.
a) 1.7 b) 1.9 c) 1.1 d) 1.3 e) 1.5

19. Find the average (DC) value of the output voltage v_O (in V).
a) 4.75 b) 4.25 c) 3.75 d) 3.25 e) 2.75

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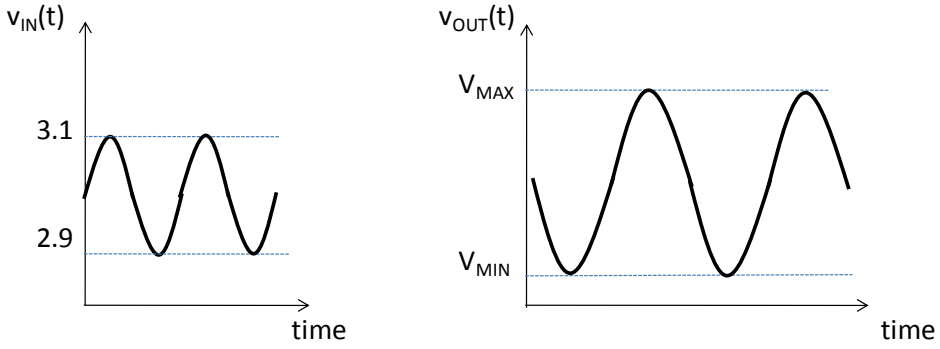
A nonlinear amplifier is characterized by the equation $v_{OUT} = a + b \times v_{IN}^3$, where v_{IN} is the input voltage, and v_{OUT} is the output voltage. $v_{IN}(t)$ and $v_{OUT}(t)$ vary as shown in the figure below, where $v_{IN}(t)$ is a sine wave that varies between 2.9 V and 3.1 V, $V_{MIN} = 1$ V, and $V_{MAX} = 4.5$ V.



20. Find the value of b (in V^{-2}).
a) –0.741 b) –0.648 c) –0.370 d) –0.463 e) –0.556

21. Find the value of a (in V).
a) 23.00 b) 12.00 c) 14.75 d) 17.50 e) 20.25

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