NK-121 (43)

DEPARTMENT OF ELECTRONICS AND ELECTRICAL COMMUNICATION ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Date: 20 Feb 2019, FN/AN, Time: 2Hrs., Full Marks: 60, No. of Students: 698 (Non-ECE branches); Mid Spring Semester-2019, Sub. No.: EC21101, Sub. Name: Basic Electronics

Instructions

- **All waveform sketches / diagrams must be neatly drawn and clearly labeled. Answers must be brief and to the point.**
- **The final answers (numerical values with unit) should be underlined or enclosed within box with unit.**
- **For every Question No., start your answer from a new page.**
- **Avoid writing answers of the various parts of a single question at different locations in your answer-script.**
- **For any value related to any device parameter or circuit parameter, which you may find not given with a problem, assume suitable value for such parameter. V_γ stands for cut-in voltage for Silicon diode which should be taken as 0.7 V.**

1. Multiple choice questions (only one correct answer) (10×1=10 marks)

I. Built-in potential in a p-n junction depends on
(a) temperature (b) doping concentration
(c) intrinsic concentration (d) all of these

II. Breakdown mechanism in a normal diode under reverse bias is
(a) Zener breakdown (b) Avalanche breakdown
(c) both (a) & (b) (d) none of the above

III. The current in a forward biased pn junction mainly consists of
(a) the diffusion current (b) the drift current
(c) both diffusion and drift current (d) none of the above

IV. With increase in temperature, the resistance of a semiconductor
(a) increases (b) decreases
(c) remains constant (d) varies non-monotonically

V. A capacitor is placed across a half/full-wave rectifier to
(a) short high frequency component (b) block the dc component
(c) provide an almost constant output (d) none of the above

VI. A pn junction diode with a 100 Ω resistor is forward biased so that a current of 100 mA flows. If the voltage across this combination is instantaneously reversed to 10 V time t=0, the reverse current that flows through the diode at $t=0^+$ is approximately given by,
(a) 0 mA (b) 100 mA
(c) 200 mA (d) 50 mA

VII. A pn junction has a donor atom concentration of $10^{15}/cm^3$ and acceptor atom concentration of $10^{16}/cm^3$. If the intrinsic carrier concentration is $10^{10}/cm^3$, then at room temperature (300K) the built in potential (in volts) of the junction will be approximately
(a) 0.66 (b) 1.26
(c) 0.29 (d) 0.7

VIII. A high-pass filter for a square input pulse waveform acts as
(a) Integrator (b) Differentiator
(c) Both (a) & (b) (d) None

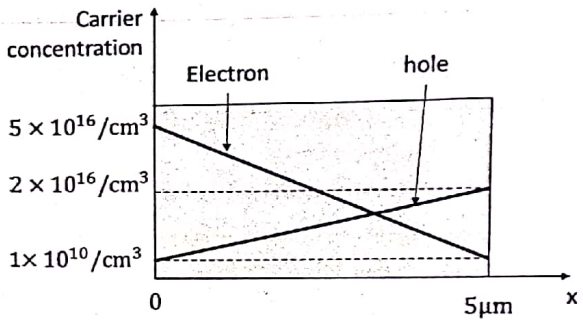
IX. A clamper circuit consists of an ideal diode, capacitor and a load resistor. When an input square wave signal (with peak voltage of V_m) is applied to the circuit and the output is measured across the load/diode such that the diode conducts in the negative half cycle, then the output waveform will have the maximum amplitude of

(a) V_m (b) $2V_m$
(c) $-2V_m$ (d) $-V_m$

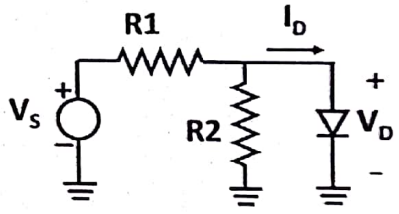
X. When a 50 Hz sinusoid signal with a peak voltage of 10 V is applied to a full-wave rectifier consist of an ideal diode and load resistance of 10 kΩ, the capacitance required to achieve the ripple voltage of 0.25 V will be

(a) 40 μF (b) 4 μF
(c) 80 μF (d) 8 μF

2(a). Carrier concentration in a silicon substrate, as shown in figure, varies linearly where electron injection is from left and the hole injection is from right. Determine the current density and total current flowing through the device if the cross sectional area is equal to $1\mu m^2$. Also indicate the direction of the current flow. Silicon parameters: $\mu_n = 1400\,cm^2/V.s$, $\mu_p = 470\,cm^2/V.s$, $D_n = 34\,cm^2/s$, $D_p = 12\,cm^2/s$, electron charge $= 1.602 \times 10^{-19}C$. [4 marks]

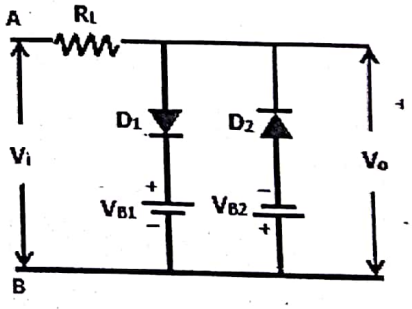


2(b). In the circuit as shown in right, the supply voltage is kept between 5V and 10V ($10V \geq V_s \geq 5V$) in order to keep the diode 'on'. The minimum diode current (I_D) is to be 2mA and the power dissipation in the diode should not cross 10mW. Using the piecewise linear model with $V_\gamma = 0.7V$ and $r_f = 10\Omega$, determine the appropriate values of R_1 and R_2. [6 marks]



3 (a). Consider the circuit shown in the right. Assume a sinusoidal voltage is applied to the input with amplitude $V_{i,max} > |V_{B1}|, |V_{B2}|$. (i) Draw the variation of the output voltage with time as the input varies sinusoidally. Put appropriate labels wherever required. [3 marks]

3(b) Draw the input-output characteristics when the input varies from $-2(V_{B2} + V_{B1})$ to $2(V_{B2} + V_{B1})$. Put appropriate labels wherever required [3 marks]



4. A Zener diode regulator has a specified rating of $V_Z = 10V$ at $I_Z^{min} = 25mA$. The incremental Zener resistance is given to be $r_z = 5\Omega$.

(a) Write down the linearized equation for the voltage across the Zener diode as a function of current for $V_Z > 10V$. [2 marks]

(b) If the maximum power rating of the Zener diode is $1W$, from the equation derived in part (a), determine the maximum current that can flow through the Zener diode without damaging it. [4 marks]

(c) Determine the voltage at the maximum current that the Zener diode can withstand. [2 marks]

5(a). Explain the mechanism to convert AC into desired DC with the help of different blocks. Sketch the waveform at every stage of the block. [4 marks]

5(b). What type of rectifier circuit one should use and why? Explain the rectification mechanism and obtain the average dc output and ripple factor. [8 marks]

5(c). Depending on your answer in (b), estimate the PIV of a diode used in that particular rectifier circuit. [2 marks]

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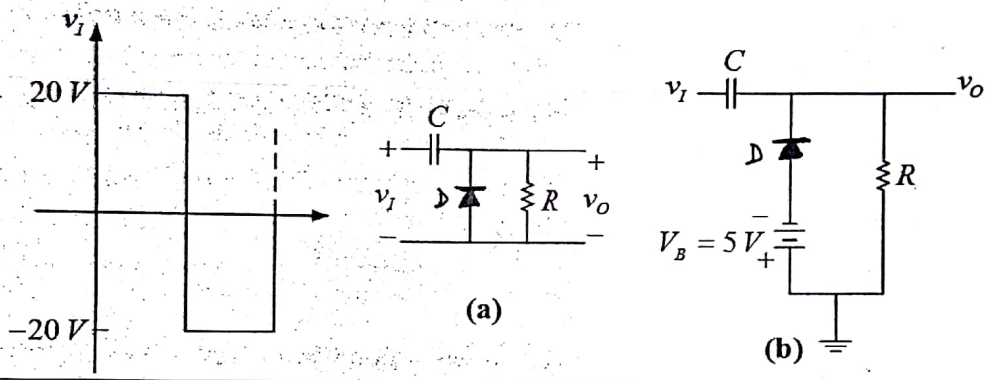
6. Sketch the steady-state output voltage v_o versus time for each circuit in (a) and (b) with the input voltage shown in the figure below. Assume $V_\gamma = 0.7V$ and the *RC* time constant to be large with respect to half-time period. [3+3 marks]



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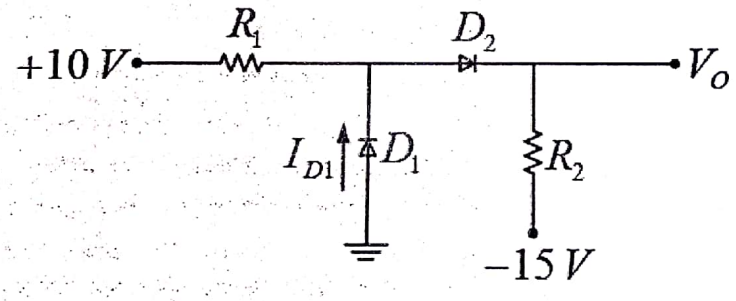
7. For the circuit shown in the figure below, let $V_\gamma = 0.7V$ for each diode. Calculate I_{D1} and V_O for (a) $R_1 = 10\,k\Omega, R_2 = 5\,k\Omega$ and for (b) $R_1 = 5\,k\Omega, R_2 = 10\,k\Omega$. [3+3 marks]



End of Question Paper