

[This question paper contains 8 printed pages.]

Your Roll No.

Sr. No. of Question Paper : 1397

Unique Paper Code : 32221403

Name of the Paper : Analog Systems and Applications

Name of the Course : B.Sc. (Hons) Physics

Semester : IV

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. 1 is compulsory.
3. Attempt any **four** questions from the remaining **five** questions.
4. Non-programmable calculators are allowed.

1. Attempt any **five** of the following : (3×5=15)

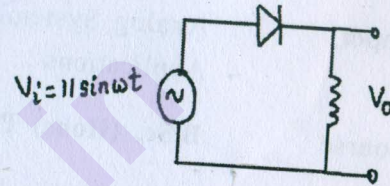
- (a) Find the conductivity of an intrinsic silicon at 300K. Mobility of electrons $\mu_n = 1350 \text{ cm}^2/\text{V-s}$ and that of holes $\mu_p = 480 \text{ cm}^2/\text{V-s}$. Intrinsic concentrations of electrons and holes $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$.

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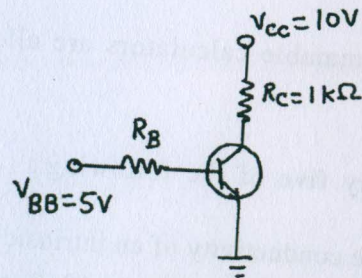
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- (b) The output of the circuit given below is connected to the dc voltmeter. What is the reading on it? (Assume ideal diode).



- (c) The transistor of the figure given below is specified to have β in the range 100 to 300. Find the value of R_B that results in saturation with an overdrive factor of at least 10. Assume $V_{CEsat} = 0.2V$ and $V_{BE} = 0.7V$.



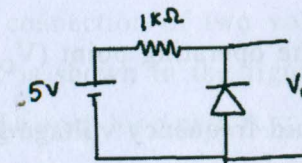
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- (d) Design a differentiator to differentiate an input signal that varies in frequency from 10Hz to 1KHz, using op-amp.
- (e) Draw a circuit diagram of a 4-bit R-2R ladder type DAC and calculate its percentage resolution.
- (f) Define slew rate and discuss why a high slew rate of an op-amp is desirable.
- (g) Draw I-V characteristics of a Tunnel diode.

2. (a) A and B are two semiconductor materials. They have a band gap of 1.1 eV and 1.9 eV respectively. Which of these can be used for LED production? Support your answer by evaluating the wavelength of radiations emitted on recombination of electrons and holes in the two cases. Planck's constant $h = 6.626 \times 10^{-34} \text{ J s}$.

- (b) For the circuit given below determine the voltage across the diode and the current flowing through it. Assume an ideal diode.

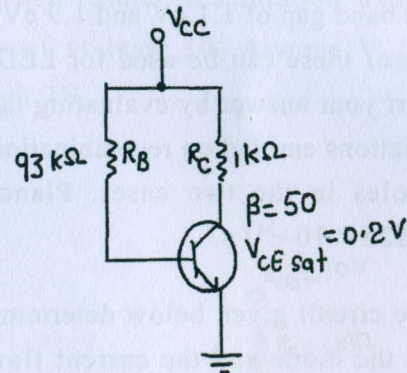


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(c) Photodiodes and solar cells are both photovoltaic. What is the difference between the two?

(d) Explain Zener breakdown and discuss the main applications of Zener diode. (5,2,3,5)

3. (a) For the circuit given below, draw the load line and determine whether the transistor in the figure is in the active region or saturation region. What significant change will happen if the transistor is replaced by the one with double the value of β . ($V_{CC}=10V$, $V_{BE}=0.7V$ and $V_{CEsat}=0.2V$).

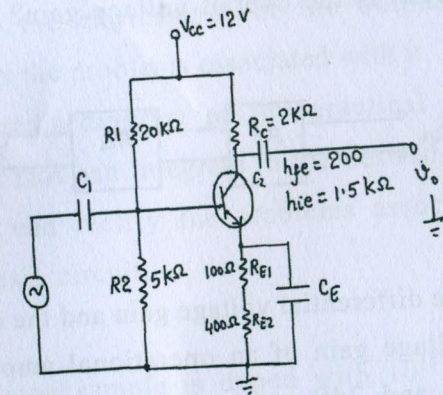


(b) In the circuit given below, evaluate :

- the operating point (V_{CE} , I_C)
- mid frequency voltage gain

(iii) mid frequency voltage gain when bypass capacitor C_E is removed

(iv) mid frequency voltage gain when C_E is connected parallel to R_{E2} .



(5,10)

4. (a) Derive an expression for the frequency of oscillations and the condition for sustained oscillations for phase shift oscillator constructed using BJT.
- (b) A cascade connection of two voltage amplifiers A1 and A2 is shown in the figure given below. $R_L=1k\Omega$. The open loop gain A_{V0} , input resistance

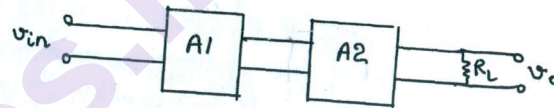
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R_{IN} and output resistance R_0 for A1 and A2 are as follows:

A1: $A_{V0}=10$; $R_{IN}=10\text{ k}\Omega$; $R_0=1\text{ k}\Omega$

A2: $A_{V0}=5$; $R_{IN}=5\text{ k}\Omega$; $R_0=200\Omega$.

What is the overall voltage gain?

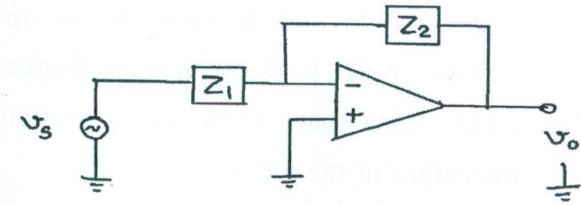


(10,5)

5. (a) The differential voltage gain and the common mode voltage gain of an operational amplifier are 100 dB and 2dB respectively. Calculate its CMRR. Why is it desirable to have high CMRR for an op-amp?

- (b) Draw the frequency response of the gain for the circuit given below when:

- Z_1 and Z_2 are both resistors.
- Z_1 is a resistor and Z_2 is a capacitor.
- Z_1 is a capacitor and Z_2 is a resistor.



- (c) Draw the circuit diagram of a basic integrator. Derive the expression for the output voltage. Discuss the problems associated with it. Also draw the circuit diagram of the practical integrator circuit that can integrate in the desired frequency range and rectify the problems associated with the basic circuit. (2,6,7)

6. (a) A silicon sample is doped with 10^{17} As atoms/ cm^3 . What is the equilibrium hole concentration p_0 at 300K? (The intrinsic electron and hole concentrations for silicon is $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$).

- (b) Calculate ripple factor and efficiency of a full wave rectifier. What is the PIV of a bridge rectifier?

- (c) An op-amp is used as a zero-crossing detector. The maximum output available from the op-amp is

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+12V & -12V and the slew rate of the op-amp is 12V/ps. What is the maximum frequency of the input signal that can be applied without causing distortion in the output?

- (d) What will be the output of a comparator circuit if the inverting input terminal of the op-amp is connected to the ground and a sinusoidal voltage is applied to the non-inverting input terminal.

(3,7,3,2)