

Serial No. \_\_\_\_\_

A-FRF-M-DSA

**ELECTRONICS AND  
TELECOMMUNICATION ENGINEERING  
Paper—I  
(Conventional)**

*Time Allowed : Three Hours*

*Maximum Marks : 200*

**INSTRUCTIONS**

*Please read each of the following instructions carefully before attempting questions :*

*Candidates should attempt FIVE questions in all. Question No. 1 is compulsory. Out of the remaining SIX questions attempt any FOUR.*

*All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.*

*Answers must be written in ENGLISH only.*

*Assume suitable data, if necessary and indicate the same clearly.*

*Unless otherwise mentioned, symbols and notations have their usual standard meanings.*

*Values of the following constants may be used as indicated wherever necessary :*

*Electronic charge =  $-1.6 \times 10^{-19}$  coulomb*

*Free space permeability =  $4 \pi \times 10^{-7}$  Henry/m*

①

*Free space permittivity =  $(1/36\pi) \times 10^9$  Farad/m*

*Velocity of light in free space =  $3 \times 10^8$  m/s*

*Boltzmann constant =  $1.38 \times 10^{-23}$  J/K*

*Planck constant =  $6.626 \times 10^{-34}$  J-s*

*Neat sketches may be drawn, wherever required.*

*All parts and sub-parts of a question are to be attempted together in the answer book.*

*Any pages left blank in the answer book must be clearly struck out.*

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1. (a) (i) What are ferroelectric materials ? What advantages do they have over conventional dielectric materials ? 3
- (ii) Give one example each of a dielectric and a ferroelectric material having high relative permittivity ( $\epsilon_r$ ). 2
- (b) P-n junction transistors can be fabricated using the materials Germanium and Silicon. However silicon is preferred to Germanium. Explain. 5
- (c) Find the power spectral density if autocorrelation function is given as :
- $R_X(\tau) = e^{-\alpha |\tau|}$  for  $-\infty < \tau < \infty$ . 5

- (d) Find  $v_1$  and  $v_2$  by writing a single supernode equation for the given circuit. 5

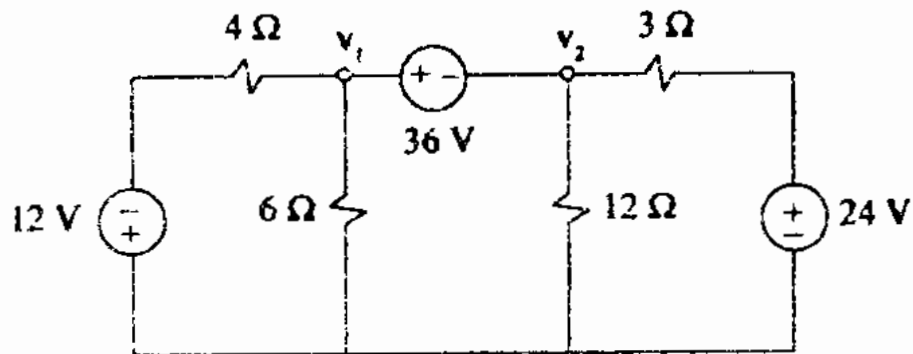


Fig. Q. 1(d)

- (e) Two concentric spherical shells ( $r_1 = 5$  cm and  $r_2 = 30$  cm) are applied with  $-10$  V and  $+120$  V respectively. The dielectric medium between the shells has  $\epsilon_r = 2.2$ . Find the charge densities. Determine the location where the  $V = 50$  V. 5
- (f) Three signals (0.1 GHz, 1 GHz and 10 GHz) are available for propagation. Will it be possible to send all of them through a parallel plate air filled waveguide with a separation of 12 cm between the plates? 5
- (g) In an oscilloscope X- and Y-signals both are saw-tooth waves of same amplitudes and time periods but different phase angles. If Y-input is leading the X-input by  $90^\circ$ , draw the pattern traced on the CRO screen. Take the saw-tooth signals with positive slopes. 5

(h) (a') Explain in brief the working of the circuit shown when :

(i) the switch  $S_1$  is ON

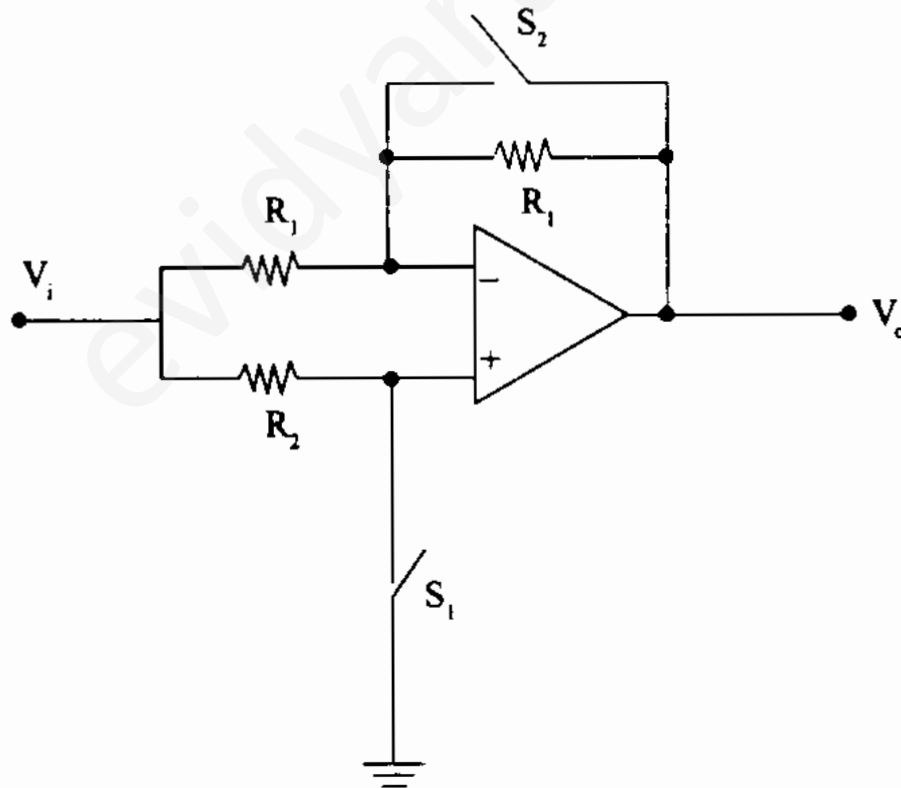
(ii)  $S_1$  is OFF.

(b') What will be the output  $V_o$  when  $V_i$  is  $5 \sin 100 \pi t$  and :

(i)  $S_1$  is OFF  $\begin{cases} S_2 \text{ ON} \\ S_2 \text{ OFF} \end{cases}$

(ii)  $S_1$  is ON  $\begin{cases} S_2 \text{ ON} \\ S_2 \text{ OFF} \end{cases}$

5



**Fig. Q. 1(h)**

④

(Contd.)

2. (a) What are the expressions for series and parallel resonances of the equivalent circuit of a quartz crystal oscillator ? 5
- (b) A quartz crystal oscillator has an equivalent inductance of  $L = 10 \text{ mH}$  and series and parallel capacitances of  $C_s = 10 \text{ } \mu\text{F}$  and  $C_p = 10 \text{ } \mu\text{F}$ . Find the series and parallel resonant frequencies of this oscillator. 5
- (c) Show schematically the static characteristics of a thyristor identifying clearly various regions. 5
- (d) What is a direct band gap and an indirect band gap semiconductor ? 5
- (e) Explain why a silicon diode can not be used as a LED but it is useful as a photodiode ? 5
- (f) If Si diode is used as a photodiode find the maximum value of responsivity and maximum wavelength upto which it can be used. 10
- (g) A magnetically levitated train travels between the city centre and the airport in Shanghai, China. Which peculiar property of superconductivity is taken advantage of in this application ? 5

3. (a) A zener diode regulates at 50 V over a range of diode currents from 5 mA to 40 mA. Supply voltage  $V = 200$  V.

(i) Calculate the value of R to allow voltage regulation from a load current  $I_L = 0$  upto  $I_{\max}$ , the maximum possible value of  $I_L$ . 5

(ii) What is  $I_{\max}$ ? 5

(b) A half wave rectifier having a diode with an internal resistance of  $20 \Omega$  is to supply power to a  $1 \text{ k}\Omega$  load from a 110 V (rms) source of supply.

**Do the following :**

(a) Draw a schematic that represents the above description of the circuit.

**Also calculate :**

(b) Peak load current

(c) DC load current

(d) AC load current

(e) DC diode voltage. 10

(c) For the circuit shown, neglecting base currents  
find  $I_0$  and  $I_1, I_2, I_3$ . 10

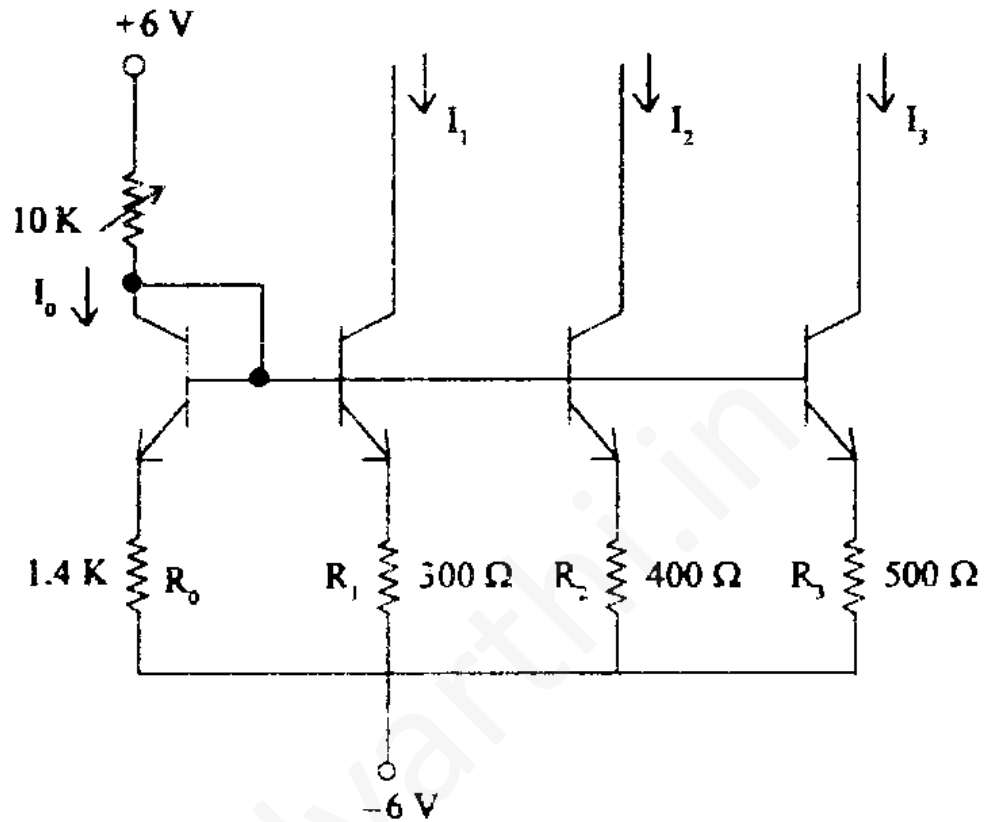


Fig. Q. 3(c)

(d) In the following circuit :

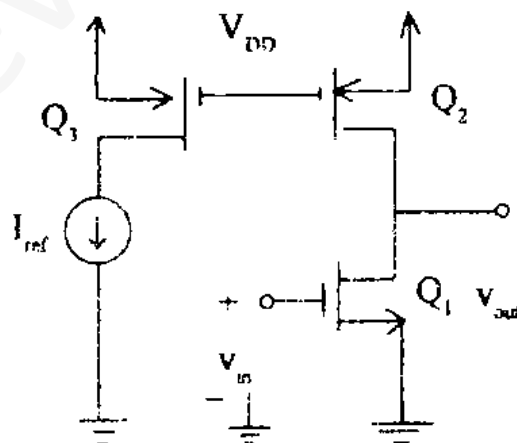


Fig. Q. 3(d)

if  $V_{DD} = 10 \text{ V}$ ,  $V_{tn} = |V_{tp}| = 1 \text{ V}$ ,  $\mu_n C_{ox} = 2 \mu_p C_{ox} = 20 \mu\text{A}/\text{V}^2$ ,  $W = 100 \mu\text{m}$ ,  $L = 10 \mu\text{m}$  and  $|V_A| = \text{Early voltage} = 100 \text{ V}$  both for n and p devices,  $I_{ref} = 100 \mu\text{A}$ , find the small signal voltage gain. 10

4. (a) Find the energy  $E_x$  of the signal  $x(t) = e^{-at} u(t)$ . Determine the frequency  $W$  (rad/sec) so that the energy contributed by the spectral components of all frequencies below  $W$  is 95% of the signal energy. 10

- (b) Given that  $X(w)$  is the Fourier transform of  $x(t)$ . Find the Fourier transform of following in terms of  $X(w)$  :

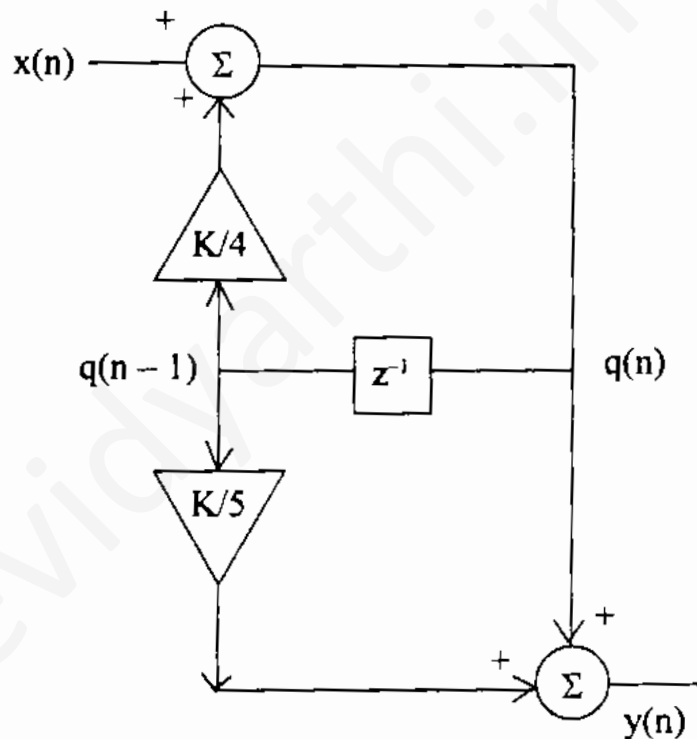
(i)  $x_1(t) = x(1 - t) + x(-1 - t)$

(ii)  $x_2(t) = x(4t - 5)$

(iii)  $x_3(t) = \frac{d^2 x}{dt^2}(t - 1)$  10



- (c) The output  $y(t)$  of a continuous time LTI system is found to be  $3e^{-4t} u(t)$  when the input  $x(t)$  is  $u(t)$ .
- Find the impulse response  $h(t)$  of the system.
  - Find the output  $y(t)$  when the input  $x(t)$  is  $e^{-t} u(t)$ . 10
- (d) Consider the discrete time system as shown in the figure below.



**Fig. Q. 4(d)**

For what value of  $K$  is the system BIBO stable ?

10

9

(Contd.)

5. (a) State and prove maximum power transfer theorem for a circuit with source  $V_S$  and source resistance  $R_S$  and a variable load resistance  $R_L$ . 10
- (b) If  $R_L$  is fixed and  $R_S$  is varied will the formula be valid ? Prove. 10
- (c) For the circuit shown determine  $Z_L$  that will draw maximum power from the source. 10

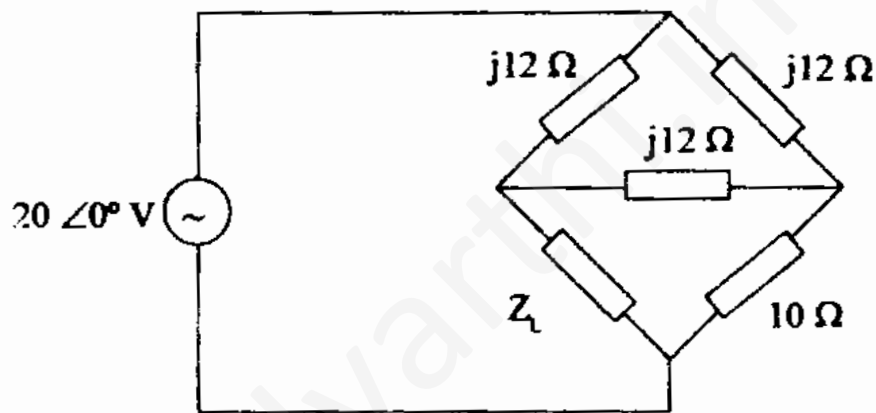


Fig. Q. 5(c)

- (d) Determine the h-parameters of the network shown. 10

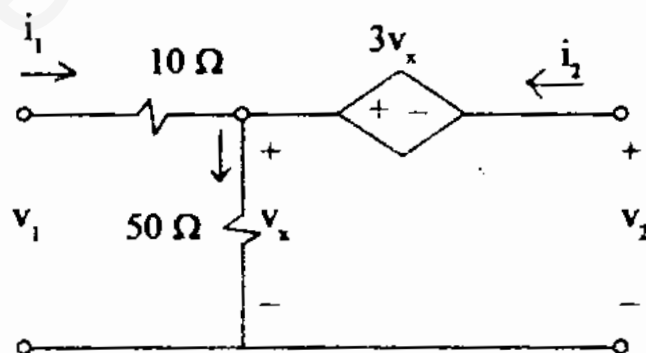


Fig. Q. 5(d)

6. (a) A pair of isolated parallel power lines of 1 cm radius with a separation of 90 cm have a voltage difference of 440 V. These power lines are 60 cm above a pair of telephone lines. Find the voltage difference between the telephone lines due to induction from power lines. The telephone lines are separated by 20 cm. 10
- (b) Two coils kept on a common axis are separated by 12 cm. Coil A has 10 turns of radius 4 cm with a current of 1 A. Coil B has 5 turns of wire with a radius of 6 cm. The current in Coil B is to be determined such that the induced magnetic field due to this current cancels the magnetic field at the center of Coil A generated by Coil A. 10

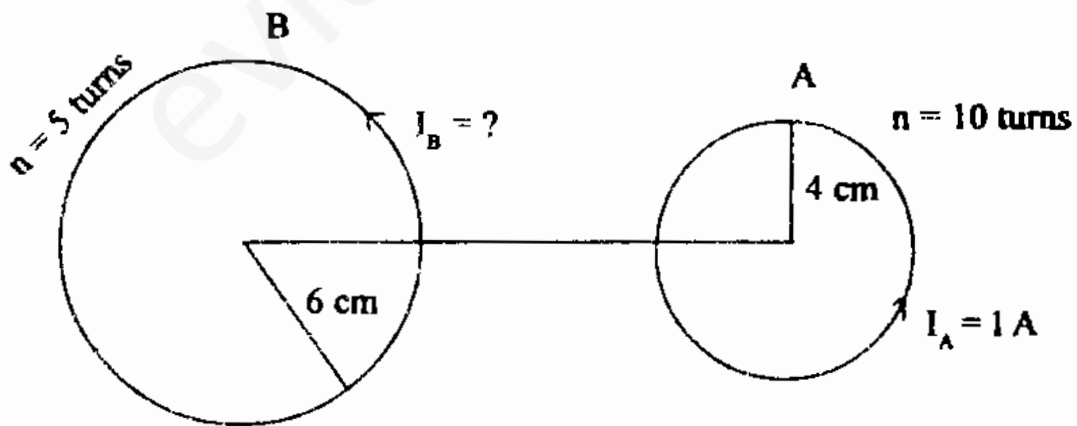
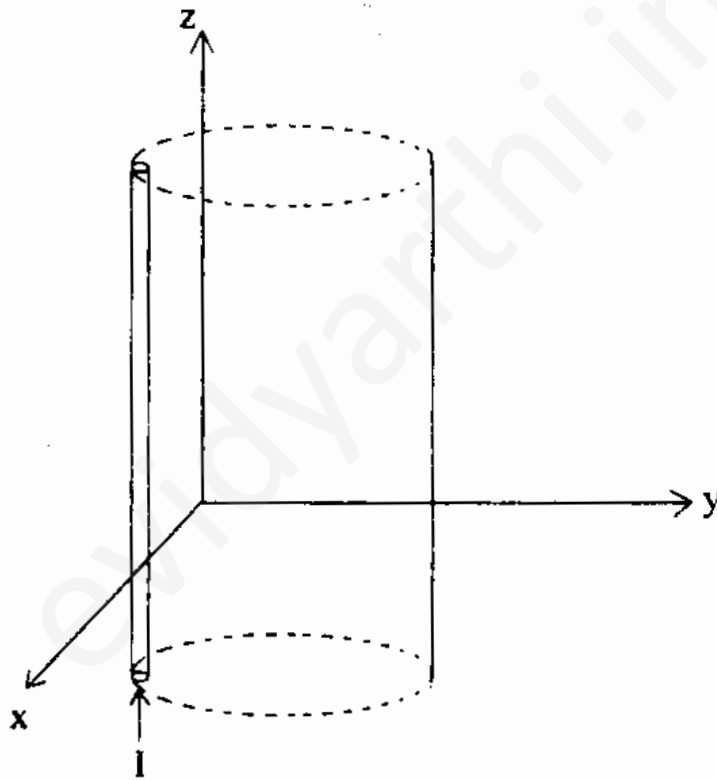


Fig. Q. 6(b)

- (c) Derive the expression for the power required to move a current carrying conductor at a rotational frequency of  $N$  rev/min if it is placed in a magnetic field of flux density  $B_0 \hat{a}_r$ . Find the value with the given data :  $B_0 = 0.6$  T;  $I = 10$  A;  $L = 1.2$  m;  $N = 25$  rev/min,  $r = 2$  cm. From this determine the magnetic flux density to be applied if the power is to be 1.5 W. 10



**Fig. Q. 6(c)**

- (d) A plane wave travelling in the  $+z$  direction in free space ( $z < 0$ ) is normally incident at  $z = 0$  on a conductor ( $z > 0$ ) for which  $\sigma = 61.7$  MS/m,

$\mu_r = 1$ . The free space wave has a frequency of 2.5 MHz. The  $\vec{E}$  field amplitude is 1.5 V/m at the interface. Find the expression for  $\vec{H}$  in the conductor. 10

7. (a) In the circuit shown, R is a resistive transducer. The bridge is balanced and the output,  $V_o = 0$  when  $R_3 = R$ . Now R is changing in response to a physical variable. Show that the output voltage

$$V_o = V_R \left( 1 + \frac{R_2}{R_1} \right) \frac{\Delta R}{2R + \Delta R}$$

where  $\Delta R$  is the change in the value of R. 20

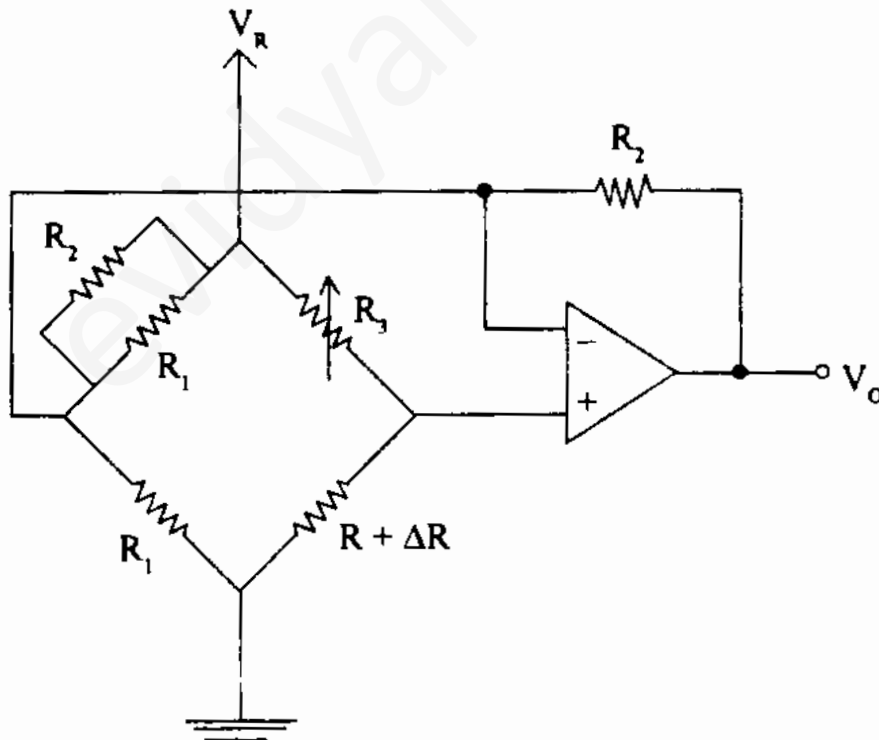


Fig. Q. 7(a)

- (b) In the circuit shown, the output voltage is found to be 25 mV. If the optical power input is at a wavelength,  $\lambda = 1.32 \mu\text{m}$  calculate the optical power in  $\mu\text{W}$ . Take the quantum efficiency of the photo-diode to be 65%.

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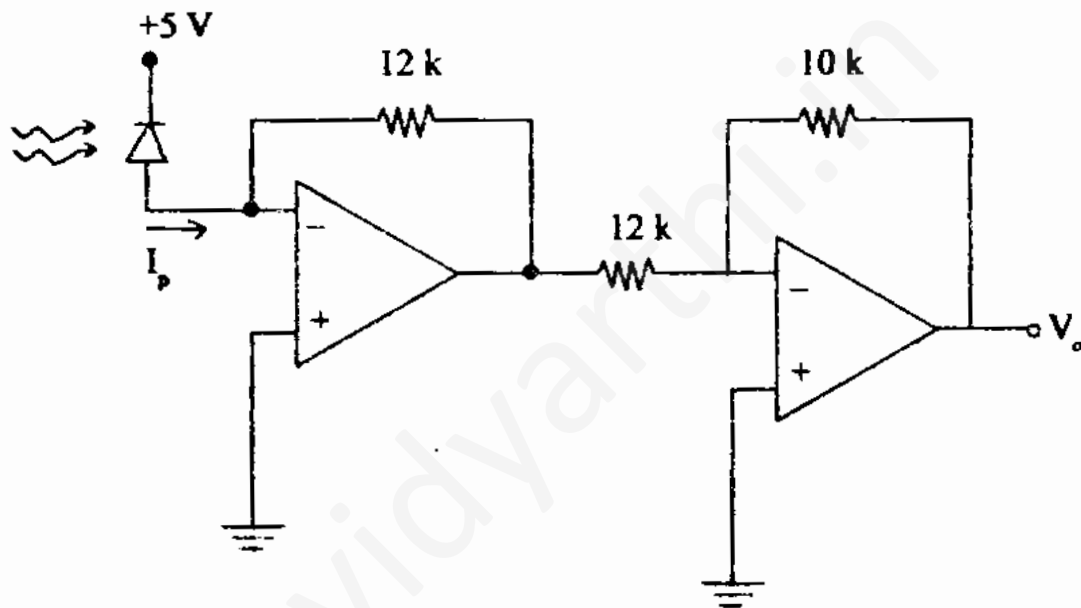


Fig. Q. 7(b)

- (c) Overall quantum efficiency of GaAs light emitting diode shown in the circuit is 70%. ON state diode voltage is 1.8 V.  $V_i$  is a binary signal with  $V(1) = 5 \text{ V}$  and  $V(0) = 0 \text{ V}$ . Find the logic levels

(14)

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of the optical binary output. Take band-gap energy  
for GaAs = 1.43 eV. 10

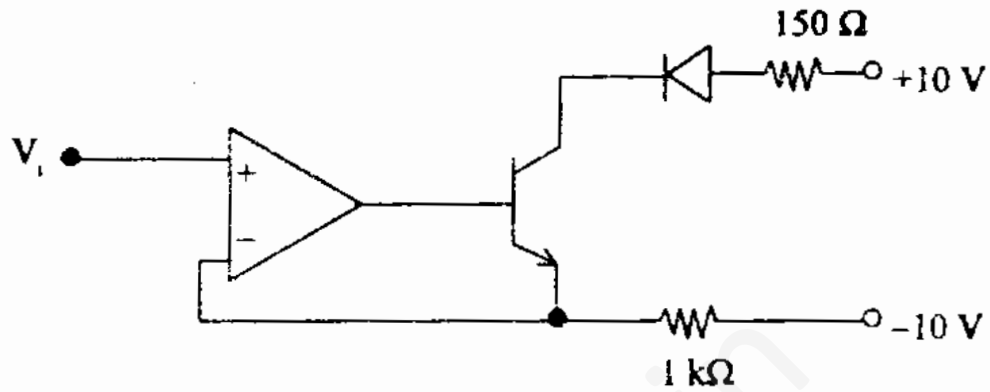


Fig. Q. 7(c)



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