I.E.S-(Conv.)-2005

# ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## PAPER - I

*Time Allowed: 3 hours* *Maximum Marks: 200*

*Candidates should attempt any FIVE questions.*

*Assume suitable data, if found necessary and Indicate them clearly.*

***Values of the following constants may be used wherever Necessary:***

Electronic charge = $-1.6 \times 10^{-19}$ Coulomb.

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

Free space permittivity = $(1/36\pi) \times 10^{-9}$ Farad/m;

Velocity of light in free space $3 \times 10^{8}$ m/sec.

Boltzmann constant $1.38 \times 10^{-23}$ Joule/K.

Planck's constant = $6.626 \times 10^{-34}$ Joule.sec.

1. (a) For a dielectric, establish an expression for the relationship between the polarizability and permittivity. How does this relation lead to Clausius-Mosotti equation ?

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(b) What are superconductors ? Explain the Meissner effect. Show that perfect diamagnetism and zero resistivity are two independent properties of the superconducting state.

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(c) A Si wafer is doped with $10^{15}$ phosphorus atoms $cm^{-3}$. Find the carrier concentration and Fermi level at room temperature ($300^{o}$ K), assume $N_c = 2.8 \times 10^{19}/cm^{3}$ at 300 K. Explain the concept of Fermi level.

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2. (a) A bipolar transistor has two junctions either one of which may be forward or reverse-biased. Therefore, we have four modes of operations – normal, cut-off, saturation and inverse region. With the help of Ebers-Moll equations model the transistor circuit with a single Set of equations describing these four regions.

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(b) When a current is passed through a semiconductor and a magnetic field is applied at right angles to the direction of the current flow, it is observed that an electric field is induced in a direction mutually perpendicular to the magnetic field and the flow of current. Name this phenomenon and calculate the voltage developed.

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(c) It is desired to operate the JFET shown in fig. below at $V_{GS} = -1.0$ V, $V_{DS} = 4.0$ V and $I_{DS} = 1$ mA. Determine the value $R_D$ and $R_S$.

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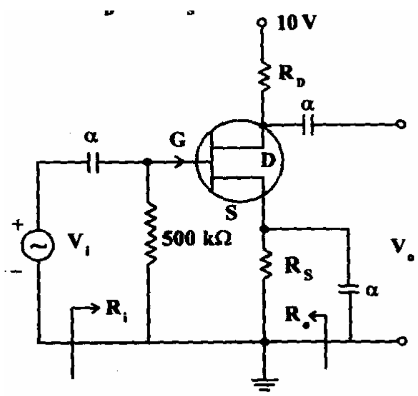


3. (a) Determine the Fourier transform of the signal shown in the following fig.

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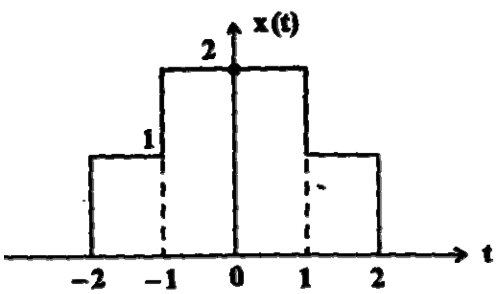


(b) Find the Fourier transform of the half-sinusoid given below:

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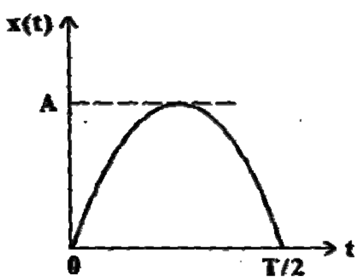


(c) Determine the Z transform of the signal:

$x(n) = \alpha^n u(n) = \alpha^n \qquad n \geq 0$

$= 0 \qquad n \leq 0$

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4. (a) In the circuit shown below, using the superposition theorem, determine the currents in the various resistors and the voltage source.

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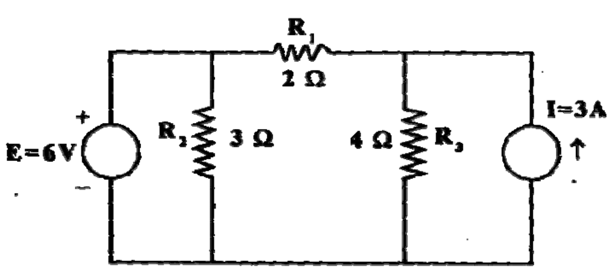
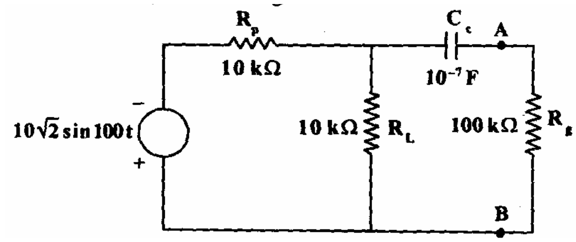



(b) Prove that Norton's theorem is dual of the Thevenin's theorem. Using Thevenin's theorem, in the network shown below, find the magnitude of the current in the resistor $R_g$.




(c) Design a delay line using T-sections with characteristic impedance $R_0$ = 600 Ω, total delay time of 1..5 μs and rise time of 0.4 μs.

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5. (a) Discuss the theory of electromagnetic wave propagation along a rectangular wave guide and obtain the conditions for the propagation of wave.

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(b) Explain Poynting's vector and establish the relation

$$\vec{P} = \vec{E} \times \vec{H}$$

where the quantities have their usual meanings.

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(c) A transmission line has a series inductance of 0.56 mH and a capacitance of 0.1 μF per km. If the losses due to conductor resistance and insulation leakage are negligible, calculate the characteristic impedance and phase velocity.

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6. (a) Describe Anderson's bridge for measuring low resistance. What are its advantage over Maxwell's bridge used for the same purpose ?

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(b) A copper-constantan thermocouple was found to have linear caliberation between 0 to 400°C, with emf at maximum temperature (reference junction at 0°C) equal to 20.68 mV. Determine:

(i) The correction which must be made to the indicated emf if the cold junction temperature is 25°C.

(ii) If the indicated emf is 8.92 mV in the thermocouple circuit, determine the temperature of the hot junction.

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(c) A freshman student of electrical engineering wanted to calibrate a power meter. He recorded the current flowing through a resistor (value marked as 0.0105 Ω), as 30.4A. Lateron, a second year student discovered that the ammeter reading taken by the freshman was lower by 1.2% and the value marked on the resistor was 0.3% lower. Find the true value of the power as a percentage of the power calculated by the freshman.

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7. (a) Establish the condition of population inversion in LASERS. How would you justify the presence of negative exponent in the expression ?

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(b) What is a thermistor ? Describe its working and its important characteristics.

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(c) The intrinsic resistivity of Germanium at room temperature is 0.47 Ω-cm. The electron and hole mobilities at room temperature are 0.39 and 0.19 $m^2$/V-s respectively. Calculate the density of electrons in the intrinsic semiconductor. Also calculate the drift velocities of these charge carriers for a field of 10 kV/m.

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I.E.S-(Conv.)-2005

# ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## PAPER - II

*Time Allowed: 3 hours* *Maximum Marks : 200*

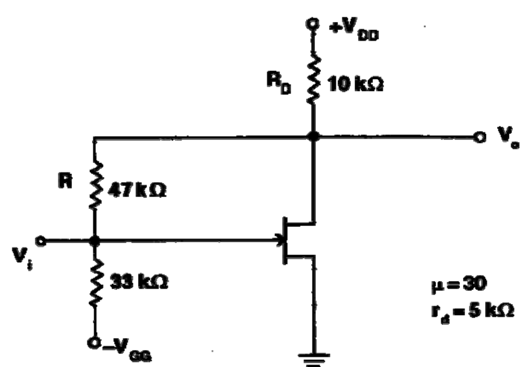
*Candidates should attempt Question No. 1 which is compulsory and FOUR more questions taking TWO each from Section 'A' and Section 'B'.*

*Assume suitable data, if required.*

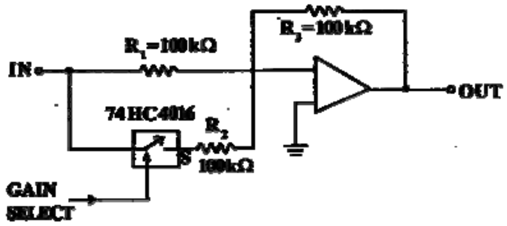
**Some useful constants are given below :**

| | |
|---|---|
| Electron charge | : $e = 1.6 \times 10^{-19}$ Coulomb |
| Electron mass | : $M = 9.1 \times 10^{-31}$ kg |
| Planck's constant | : $h = 6.625 \times 10^{-34}$ J-s |
| Velocity of light | : $c = 3 \times 10^{8}$ m/s |
| Universal constant of gravitation | : $G = 6.668 \times 10^{-11}$ $m^3/kg\text{-}s^2$ |
| Mass of earth | : $M = 5.997 \times 10^{24}$ kg |
| Radius of earth | : R = 6,378 km |
| Permeability of vaccum | : $\mu_0 = 4\pi \times 10^{-7}$ H/m |
| Permittivity of vaccum | : $\varepsilon_0 = 10^{-9}/36\pi$ F/m. |

1. (a) Determine the voltage gain $A_v = \dfrac{V_0}{V_i}$ for the amplifier circuit shown below. $V_i$ is the input voltage between the gate terminal and ground. Neglect all capacitances. 8




(b) Find the gains of the OP-AMP circuit for the two states of the 'gain-select' input. The bilateral switch in the ON state has negligible resistance. 8




(c) The impulse response of a linear time-invariant (LTI) system is g(t). Determine the condition on bounded-output (BIBO) stable with zero initial conditions.

8

(d) An HF transmitter used in binary communication system has a peak power limited to 1 kW. The power loss in the channel is 60 dB and the noise power at the receiver input is $10^{-4}$ watts. Find $P_e$ for non-coherent ASK and coherent PSK signalling schemes. Assume maximum signalling rate and equiprobable message bits.

8

(e) A single mode step index fibre with a core refractive index of 1.49 has a critical bending radius of 10.4 mm when illuminated with light at a wavelength of 1.3 microns. If the cutoff wavelength of the fibre is 1.15 microns, calculate its relative refractive index difference.

8

(f) The carrier frequency of an uplink is 6 GHz. The transmitting earth station EIRP is 80 dBW. The satellite receiver is –8 dB/K and the transmission losses are 0.6 dB. Determine the CNR at the satellite receiver input for an earth station-to-satellite distance of 35,860 km.

8

(g) What is the measured frequency on a wave-guide slotted line if the distance between adjacent minima is 1.27 cm and the width dimension of the wave-guide is 2.286 cm?

8

(h) Specify the register contents and the flag status as the following instructions are executed. Also indicate the output at PORT O.

8

| A | B | S | Z | CY |
|---|---|---|---|---|
| OO | FF | 0 | 1 | 0 |

Initial Contents

MVI A, F2H

MVI B, 7AH

ADD B

OUT PORT O

HLT

(i) Two identical silicon transistors with

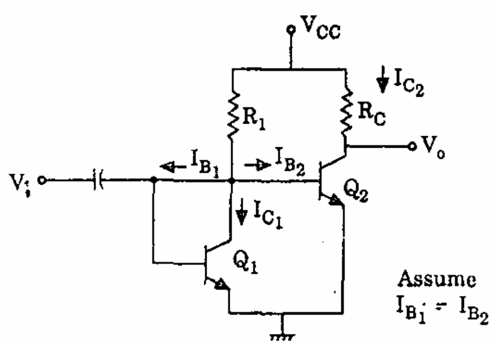
$\beta = 50$, $V_{BE} = 0.7$ V at T = 25°C

$V_{CC} = 20.7$ V, $R_1 = 10$ kΩ and $R_C = 5$ kΩ are used in the circuit shown.

(1) Find the currents $I_{B_1}, I_{B_2}, I_{C_1}, I_{C_2}$ at T = 25°C

(2) Find $I_{C_2}$ at T = 175° C when β = 98 and $V_{BE}$ = 0.22 V.

4+4




(j) Draw the simplest possible logic diagram that implements the output of the logic diagram shown below :

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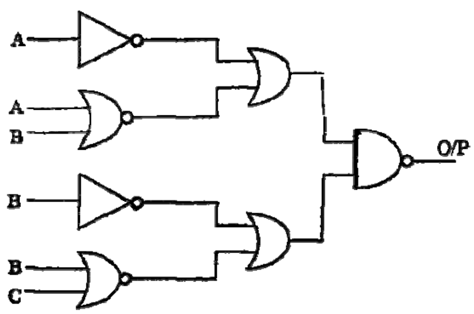


## SECTION A

2. (a) Explain the operation of the Circuit shown below What type of signal does it produce ? Determine the frequency of the output signal. How can we change the frequency of the signal to 10 kHZ ?

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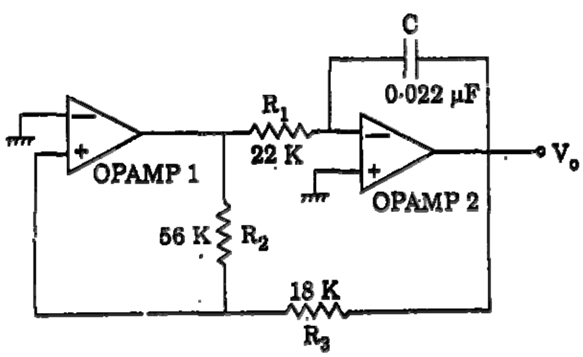


(b) The base width of a germanium pnp transistor is 5 microns. At room temperature and for a dc emitter current of 2 mA, determine

(i) emitter resistance (ii) alpha cutoff frequency

(iii) emitter diffusion capacitance, and

(iv) the base transit time.

Given for germanium :

$D_p = 47\ cm^2/s$

$D_n = 99\ cm^2/s$

$\mu_n = 3800\ cm^2/V\text{-}s$

$\mu_p = 1800\ cm^2/V\text{-}s$

3. (a) (i) Consider a D flip-flop that triggers only on positive going transitions. Write its truth table and draw the output at Q for given D-input and clock waveforms as shown.

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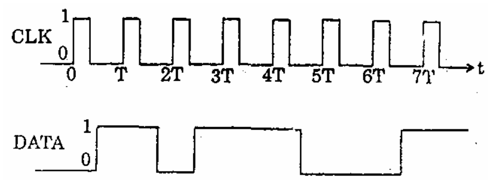


(ii) How can a D flip-flop be implemented using a JK flip-flop?

(b) Consider the circuit shown. Initially all the flip-flop outputs X, Y and Z are in the 0 state before the clock pulses are applied. Determine and sketch the waveforms at Z, Y, X and W for eight cycles of the clock input.

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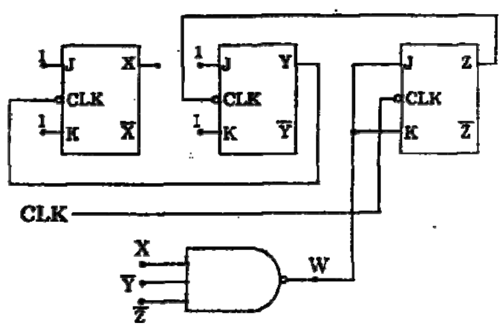


4. (a) Construct a signal flow graph for the following equations and evaluate $y_5/y_1$ :

$y_2 = a_{12}y_1 + a_{32}y_3$

$y_3 = a_{23}y_2 + a_{43}y_4$

$y_4 = a_{24}y_2 + a_{34}y_3 + a_{44}y_4$

$y_5 = a_{25}y_2 + a_{45}y_4$

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(b) The characteristic equation of a closed loop control system is

$$s^3 + 3Ks^2 + (K+2)s + 4 = 0$$

Find the range of K for which the system is stable. Show all steps clearly.

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5. (a) Construct a 4-input multiplexer using four 3-input AND gates, an OR-gate and three inverters. Show the input, output, select lines, and write a table showing the outputs for various select inputs.

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(b) Consider a mechanical system as shown. Write the force equations and draw a fully labelled state diagram.

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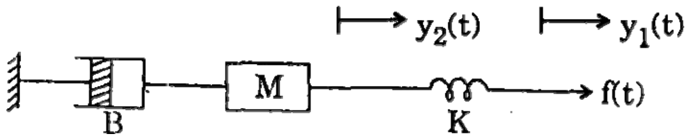


(c) An amplifier with an open loop voltage gain of 500 delivers 10 W of output power at 5% second harmonic distortion when the input signal is 5 mV. If 20dB negative voltage is to remain 10 W, determine

(i) the required input signal strength, and

(ii) the percent second harmonic distortion.

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## SECTION B

6. (a) The transmitting antenna beam width of a geosynchronous satellite (35860 km from the surface of the earth) is $0.1^o$. Assuming a circular spot coverage, determine the area of the spot illuminated by the antenna on the earth's surface.

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(b) Define Fresnel Zone and derive an expression for the first Fresnel Zone radius. A microwave radio-link operating at 8 GHz covers a distance of 80 km. Determine the mid path clearance needed to coincide with the first Fresnel Zone.

15

7. (a) A TWT operates on a beam current = 50mA, beam voltage = 2.89 kV, characteristic impedance of the helix = 6.0 Ω, Circuit length 40, frequency 9 GHz. Determine :

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(i) the gain parameter,

(ii) the output power gain in dB,

(iii) the four propagation constants, and

(iv) the wave equations for all modes in exponential form

(b) The impedance matrix of a certain lumped element network is $\left[Z_{ij}\right] = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$. Determine its scattering matrix. State the properties of the scattering matrix both in word statement and in mathematical form.

15

8. (a) Write a program to count from 0 to 20H with a delay of 100 ms between each count. After the count 20H, the counter should reset itself and repeat the sequence. Use register pair DE as a delay register. Show your calculations to set up 100 ms delay. The clock period is 3255 ns.

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(b) Write instructions to clear the CY flag, to load a number FFH in register C and to add 01 to (C). If otherwise display the contents of register C.

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9. (a) Compare TDM and FDM techniques (at least 8 points, in the form of a table).

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(b) Calculate the gain of an X-band open ended rectangular wave-guide radiator at a frequency of 9 GHz. The wave-guide dimensions are 0.9” × 0.4”.

(c) (i) What is the difference between cycle stealing DMA and interleaved DMA ? What is meant by block transfer DMA ? 5

(ii) A transmitter is sending ASCII-Coded data to a receiver with an Odd-Parity bit. Show the actual codes when the transmitter is sending the message ‘HELLO’. 5