Engineering Services Examination-201 2

Sl. No. [ ]

C-FTF-M-UNA

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper I

(Conventional)

Time Allowed : Three Hours	*Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt Question No. 1 which is compulsory and any FOUR from the remaining questions.

The number of marks carried by each question is indicated at the end of the question.

Answers must be written only in ENGLISH.

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

Unless otherwise indicated, symbols and notations have their usual meanings.

Values of the following constants may be used wherever necessary.

Electronic charge $= -1{\cdot}6 \times 10^{-19}$ *coulomb.*

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

Free space permittivity $= \left(\frac{1}{36\pi}\right) \times 10^{-9}$ *farad/m.*

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

Boltzmann constant $= 1{\cdot}38 \times 10^{-23}$ *joule/K.*

Planck constant $= 6{\cdot}626 \times 10^{-34}$ *joule-sec.*

Important : *Candidates are to note that all parts and sub-parts of a question are to be attempted contiguously in the answer-book. That is, all parts and sub-parts of a question being attempted must be completed before attempting the next question.*

Any pages left blank in the answer-book must be clearly struck out. Answers that follow pages left blank may not be given credit.

1. (a) Avalanche breakdown can occur at large reverse voltage whereas Zener breakdown occurs at low voltage. Give reasons.

A 15 V Zener diode is connected in series with a forward-biased silicon diode for constructing a zero-temperature-coefficient voltage reference. The temperature coefficient of the silicon diode is –1·7 mV/°C. Find the required temperature coefficient of the Zener diode in per cent per degree. 10

(b) (i) Certain metal works as superconductor below the critical temperature T_C = 7·2°K. The critical magnetic field for the metal at 0°K is $7{\cdot}8 \times 10^5$ Amp/m. What is the critical magnetic field for the metal to be usable as superconductor at 5°K ? 5

(ii) A semiconductor has a bandgap of 0·62 eV. Find the maximum wavelength for resistance change in the material by photon absorption.

(Note : 1 eV = $1{\cdot}6 \times 10^{-19}$ Joules) 5

(c) Evaluate the following convolution :

$$y[n] = x_1[n] * x_2[n] * x_3[n]$$

where $x_1[n] = 0{\cdot}5^n u[n]$

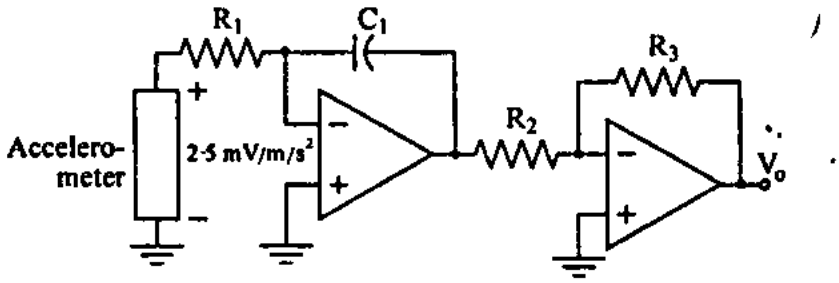
$$x_2[n] = u[n+3]$$

$$x_3[n] = \delta[n] - \delta[n-1]$$ 10

(d) Find the potentials at $\gamma_A = 4$m and at $\gamma_B = 16$ m due to a point charge $Q = 900$ PC at the origin and zero reference at infinity. Also find the potential at γ_A with respect to γ_B. 10

(e) Determine the time taken for the charge density ρ_0 introduced in the interior of a copper conductor to move to the surface and redistribute themselves under equilibrium conditions, if $\sigma = 5{\cdot}8 \times 10^7$ S/m, $\in \simeq 8{\cdot}85 \times 10^{-12}$ F/m for copper. Assume that the charge redistribution is complete in five time constants. What percentage of ρ_0 is remaining after one time constant. 10

(f)



A piezoelectric accelerometer is used with the signal conditioning circuit shown above. The accelerometer provides an output of 2·5 mV per m/s^2.

Determine the values of R_1, C_1, R_2 and R_3 such that the system translates this accelerometer output to a velocity output V_o of 0·25 volt per m/s. 10

2. (a) Explain the following statements :

(i) The temperature coefficient of metal resistors is positive.

(ii) The temperature coefficient of resistance in semiconductors is negative.

(iii) In the linear region operation of MOSFET drain current decreases as the temperature increases.

(iv) In the active region, as temperature increases the current in BJT increases.

(v) The temperature coefficient of resistance in Thermistors is negative. 10

(b) Discuss the difference in covalent bonding in carbon as

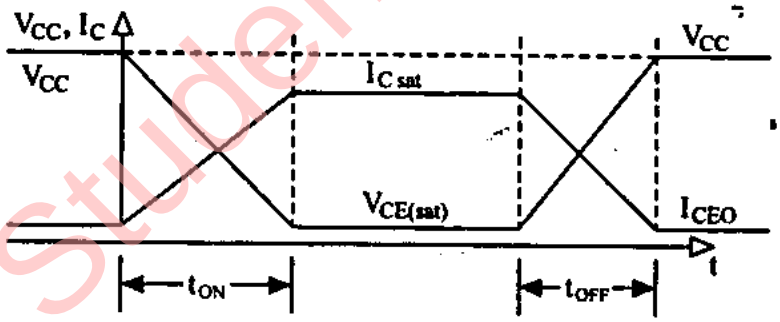
(i) diamond

(ii) graphite 10

(c) What is the basic building block of a CMOS integrated circuit ? Draw a neat sketch to illustrate the structure of the basic building block and explain the role of various regions in it. 15

3. (a) Draw E-K diagram of GaAs with two conduction band minima. Hence explain the negative resistance characteristics of Gunn diode. 10

(b)



The switching waveforms of collector current I_C and collector to emitter voltage V_{CE} of a power BJT operating at 10 kHz are shown in the above figure.

If V_{CC} = 200 V; I_{csat} = 10 A, turn-on time t_{ON} = 2 microsecond, turn-off time t_{OFF} = 5 microsecond. Determine,

(i) looking at the diagram, the point at which the peak power loss will occur.

(ii) average power loss during t_{ON} and t_{OFF}.

(iii) total average switching power loss of the device.

Neglect $V_{CE(sat)}$, collector to emitter leakage current I_{CEO} and power loss due to base current. 15

(c) Discuss the capacitance-voltage characteristics of varactor diodes with their applications. 10

4. (a) A continuous time LTI system whose input $x(t)$ and output $y(t)$ are related by the following differential equation :

$$\frac{d}{dt}y(t) + 4y(t) = x(t)$$

Find the Fourier series representation of the output $y(t)$ for the input

$$x(t) = \sin 4\pi t + \cos\left(6\pi t + \frac{\pi}{4}\right)$$ 15

(b) Develop a state-space description of a causal LTI system described by the difference equation :

$$y[n] + 0{\cdot}8\, y[n-1] + 0{\cdot}6\, y[n-2] + 0{\cdot}4\, y[n-3] = 0{\cdot}4\, x[n] + 0{\cdot}6\, x[n-1] + x[n-2] + 0{\cdot}8\, x[n-3].$$

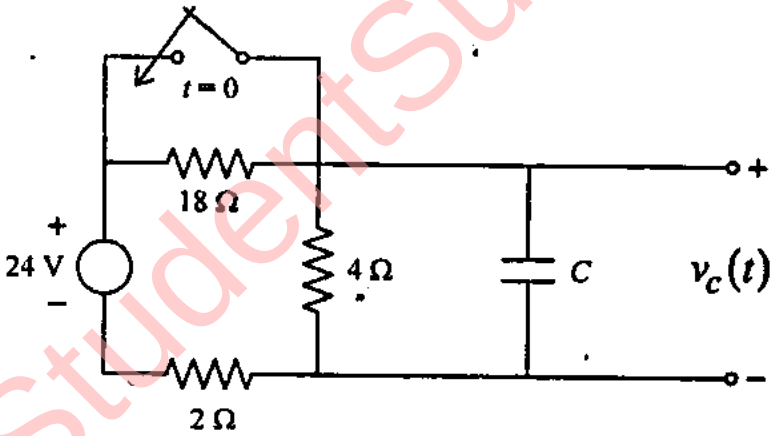
10

(c) The z transform of a causal sequence $h[n]$ is given by

$$H(z) = \frac{z(z+2{\cdot}0)}{(z-0{\cdot}2)(z+0{\cdot}6)}.$$

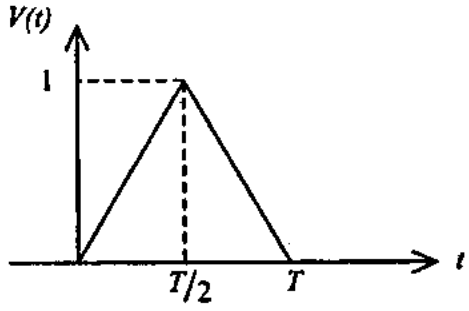
Find $h[n]$. 10

5. (a)



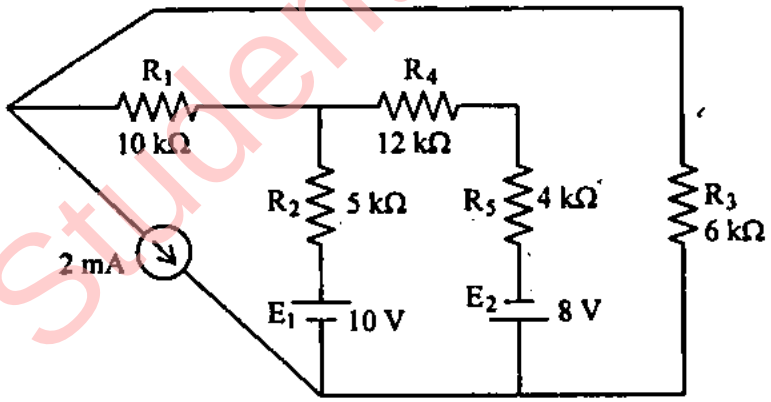
Find the value of capacitor C in the circuit shown above, if the voltage across the capacitor is $v_c(t) = 16 - 12\, e^{-0{\cdot}6t}$ for $t > 0$ and the switch which was initially open is closed at $t = 0$. The circuit had attained steady state before closing of the switch. 15

(b)



An initially relaxed series R-L circuit is fed from a voltage pulse source of triangular shape as shown in the above figure. Find the current in the circuit, $i(t)$, if $R = 1\Omega$ and $L = 1H$ and $T = 2s$. 10

(c)



Solve for the current through R_2 and R_3 in the circuit shown above. 10

6. (a) A travelling $\vec{E}$ field in free space of amplitude 100 V/m and frequency of 200 MHz is normally incident on a sheet of silver of thickness 5 μm (micrometers). If conductivity of silver is 61·7 MS/m find the amplitude of $\vec{E}$ field emanating from the opposite surface of the sheet. 10

(b) Two parallel conducting planes in free space are at $y = 0$ and $y = 0{\cdot}04$ m, and zero voltage reference is at $y = 0{\cdot}02$ m. If $D = 126\, a_y\, nC/m^2$ between the conductors, determine the conductor voltages. 10

(c) Derive the expression for radiation efficiency of an isolated Hertzian dipole made of copper wire in free space. Calculate its radiation efficiency if the radius of the wire is 1·8 mm, $dl = 2$ m, $f = 1{\cdot}5$ MHz, and $\sigma = 5{\cdot}8 \times 10^7$ S/m. 15

7. (a) What is the basis for classifying transducers into either 'Active' or 'Passive' ? Separate the following list of transducers into 'Active' or 'Passive' categories :

Resistive Strain Gauge	Photodiode
LVDT	Thermocouple
Piezoelectric material	Photoconductive materials
Thermistor	Tachogenerator

10

(b) Explain how the transfer characteristic of a capacitive displacement transducer may be linearized using

(i) a charge amplifier

(ii) Differential three plate capacitor arrangement with the middle plate sensing displacement. 15

(c) The resistors in the four arms of a strain gauge bridge $ABCD$ with a d.c. supply across A and C are : $R_{AB} = 350\ \Omega = R_{BC} = R_{CD} = R_{DA}$. R_{BC} constitutes the active gauge (unstrained resistance being $350\ \Omega$). R_{CD} is a dummy gauge of the same resistance value. The detector is connected across B and D. The supply voltage is 10 V d.c. The active gauge has $GF = 2{\cdot}03$. If the gauge in the arm BC is subjected to a strain of 1450 μm/m, find the bridge offset voltage. 10

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Engineering Services Examination-201

Serial No. [ ]

C–FTF–M–UNB

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper—II

(Conventional)

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

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

*Question No. **1** carries **60** marks and each of the other questions carry **35** marks.*

The number of marks carried by each part of a question is indicated against each.

*Answers must be written only in **ENGLISH**.*

Assume any data, if required, and indicate the same clearly.

Unless otherwise indicated, symbols and notations have their usual meanings.

Neat sketches to be drawn, wherever required.

Some useful constants are given below :

Electron charge	:	$e = 1{\cdot}6\times10^{-19}$ coulomb
Electron mass	:	$m = 9{\cdot}1\times10^{-31}$ kg
Planck's constant	:	$h = 6{\cdot}625\times10^{-34}$ J-s
Velocity of light	:	$c = 3\times10^{8}$ m/s
Universal constant of gravitation	:	$G = 6{\cdot}668\times10^{-11}$ $m^3/kg\text{-}s^2$
Mass of the earth	:	$M = 5{\cdot}997\times10^{24}$ kg
Radius of the earth	:	R = 6378 km
Permeability of vacuum	:	$\mu_o = 4\pi\times10^{-7}$ H/m
Permittivity of vacuum	:	$\varepsilon_o = \frac{10^{-9}}{36\pi}$ F/m

Important note :—

All parts and sub-parts of a question being attempted are to be answered contiguously on the answer-book. That is, all the parts and sub-parts of one question must be completed before attempting the next question.

Pages left blank in the answer-book, if any, are to be struck out. Answers that follow blank pages may not be given credit.

1. (a) (i) A particular diode circuit produces the output shown in Fig. 1 a (i), when the input $V_i = 5 \sin wt$. Design the circuit. Draw and explain the transfer characteristic of the circuit. Neglect the diode voltage drop. Assume the forward resistance of diode to be 100 Ω and the reverse resistance to be 1 MΩ. 5

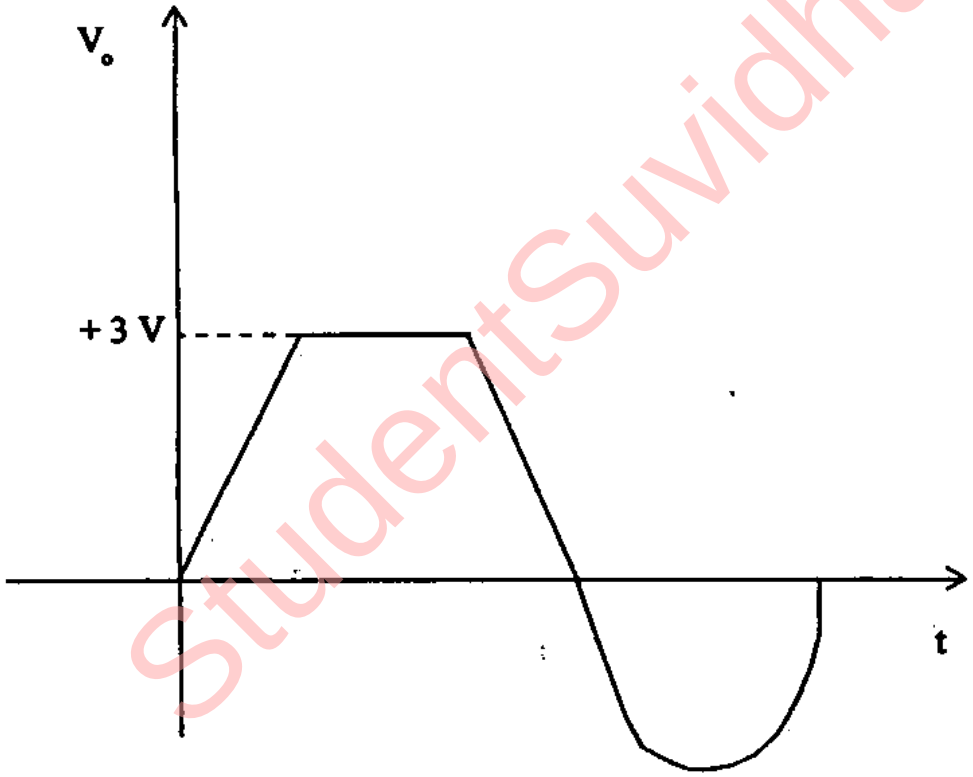

Fig. 1 a (i)

(ii) Calculate the output $-V_o$ of the circuit shown in Fig. 1 a (ii). Calculate the value of R for which the output of the circuit becomes 0 V. 5

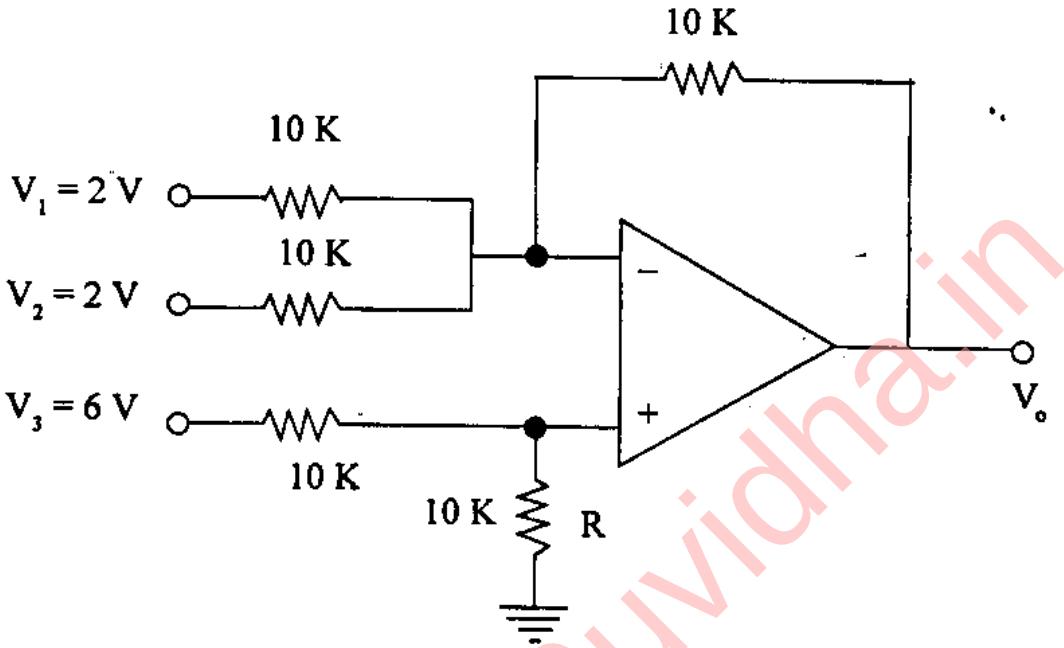

Fig. 1 a (ii)

(b) (i) Find the decimal equivalent of hex number 1A53. 2

(ii) Find the hex sum of $(93)_{16} + (DE)_{16}$. 3

(iii) Find the decimal equivalent of Binary number 11010. 2

(iv) Draw a logic circuit to convert binary code y_1, y_2, y_3 to Gray code. 3

(c) The open-loop transfer function of a unity feedback system is given by :

$$G(s) = \frac{5}{s(s+1)}.$$

Find the rise time, percentage overshoot, time of peak overshoot and settling time for a step input of 10 units. Also determine the value of peak overshoot. 10

(d) Interface an 8-bit microprocessor with a 2K×8 ROM chip and two 1K×8 chips such that the following address map is realized :

Device	Size	Address Assignment
ROM chip	2K × 8	0000 — 07FF
RAM chip 1	1K × 8	0800 — 013FF
RAM chip 2	1K × 8	1000 — 13FF

10

(e) A lossless parallel strip line has a conducting strip width 'w'. The substrate dielectric separating the two conducting strips has a relative dielectric constant ϵ_r of 6 and a thickness d of 4 mm. Evaluate the following :—

(i) The required width 'w' of the conducting strip in order to have a characteristic impedance of 50 Ω. 4

(ii) The phase velocity of the wave in the parallel strip line. 4

(Contd.)

(f) Sketch the electric and magnetic field configuration for TE_{10} mode and TE_{20} mode in a rectangular waveguide. 2

(g) Explain T1 PCM system for telephone voice service. Show that T1 system has data rate of 1·544 M bits/s. 10

SECTION—A

2. (a) (i) Using the 7805 voltage regulator IC, design a current source that will deliver a current of 0·25 A to the 76 Ω, 10 W load. Drop voltage for the IC is 2V. Neglect quiescent current. 5

(ii) Design an FSK generator using 555 IC to produce 'mark' frequency f_M = 1070 Hz when the input digital data is logical '1' and to produce 'space' frequency f_s = 1270 Hz when the input digital data is logical '0'. Show the nature of output. 10

(b) (i) Derive the truth table for a combinational circuit which has 3 binary inputs and the output is input + 3. Express each output using Boolean expression. 4

(ii) Simplify the following expression into sum of products using Karnaugh map

$F(A, B, C, D) = \Sigma(1, 3, 4, 5, 6, 7, 9, 12, 13)$. 6

(c) Any system will oscillate with a frequency w if it has no poles in the right-half of the s-plane and has poles at $s = \pm jw$. Find the values of K and a of the system shown in Fig. 2 (c), that makes the system to oscillate at a frequency of 2 rad/s. 10

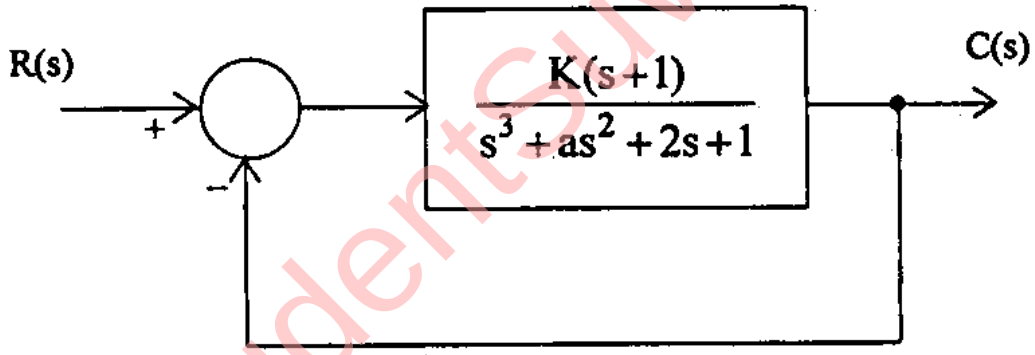

Fig. 2 (c)

3. (a) (i) Implement a 4 bit serial-in serial-out shift register using D flip flops and draw the output waveform for an input 1010. 10

(ii) A binary ripple counter is required to count up to 16383_{10}. How many flip flops are required ? If the clock frequency is 10·5 MHz, what is the frequency at the output of MSB ? 5

(b) Design a second-order active Band-pass filter with a midband gain of 33.98 dB, a center frequency of 200 Hz and a 3-dB bandwidth of 20 Hz. Use capacitors of 0·1 μF value. Draw the response of the filter. 10

(c) A plant has open-loop transfer function as $G(s) = 1/S^2$. The plant is controlled by a forward proportional controller with gain of K_P, and a rate controller in its feedback path. The overall feedback system is shown in Fig. 3 c (i). It is desired to obtain a response to a step input as shown in Fig. 3 c (ii). Design the values of the gain K_P and K_D to get the desired response. Obtain the corresponding rise time and settling time of the overall system. 10

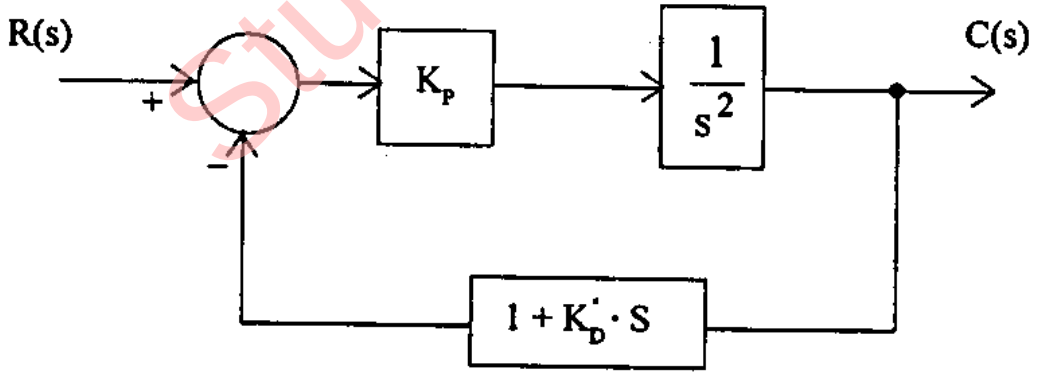

Fig. 3 (c) (i)

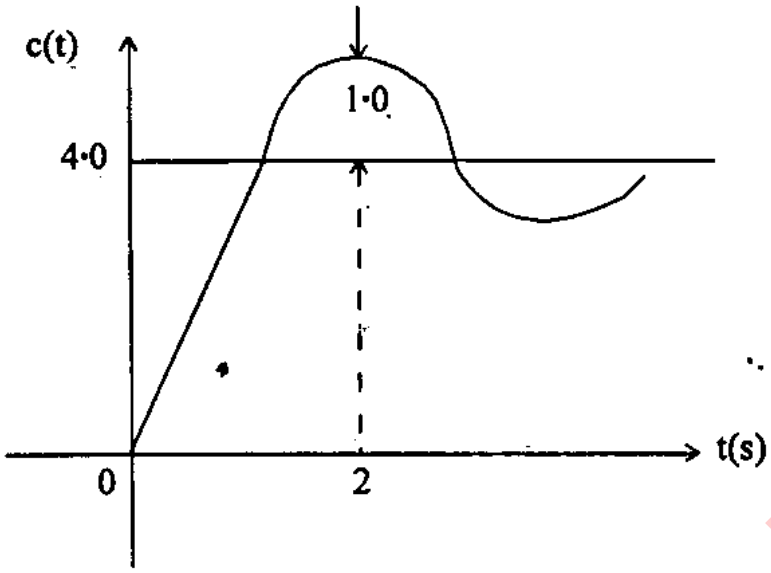

Fig. 3 (c) (ii)

4. (a) (i) Consider the feedback control system shown in Fig. 4 (a) (i) where inner loop corresponds to internal feedback of the plant. The controller is an integrator with a gain of K and plant has an inertia. 10

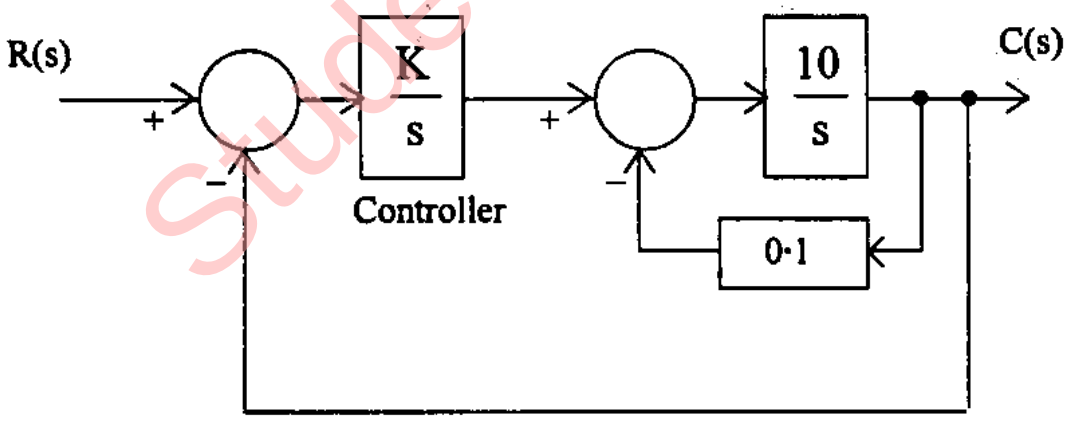

Fig. 4 (a) (i)

(Contd.)

(A) Determine the value of K for which steady-state error to unit ramp input is less than 0·01.

(B) For the value of K calculated in part (A) find the sensitivity $\left(S_K^T\right)$ of T with respect to variation in K, where $T(s)=\frac{C(s)}{R(s)}$. What will be the limiting value of S_K^T at low frequencies ?

(ii) A process has an open-loop transfer function given by $G(s)=\frac{1}{s(s+\alpha)}$, where α is an unknown parameter. A controller for unity feedback system has to be designed such that the closed-loop transfer function becomes $\frac{1}{s(s+\alpha)}$.

The transfer function of the controller has to be found for :

(A) controller being put in the forward path.

(B) controller being put in the feedback path.

Out of these possibilities which one should be preferred ? 5

(b) For the circuit shown in Fig. 4 (b), $V_{BE} = 0{\cdot}7$ V, $\beta = 50$ and $V_{CEQ} = 4$ V. Determine R_E and the stability factor S. 10

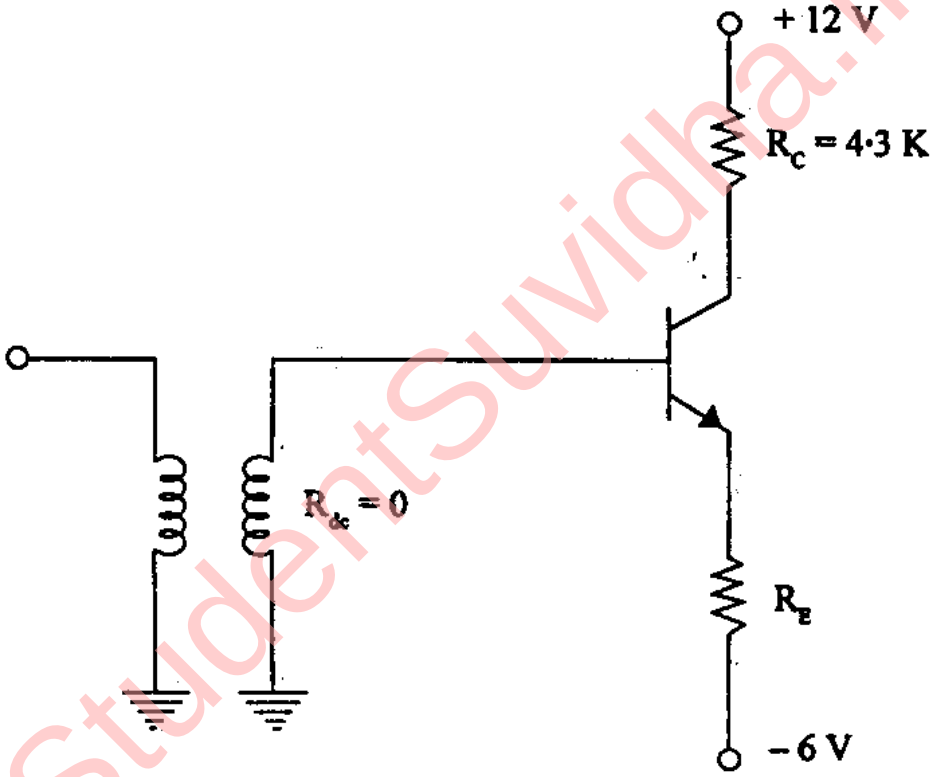

Fig. 4 (b)

(c) Implement a four variable function

$F(A, B, C, D) = \Sigma(0, 1, 3, 4, 8, 9, 15)$

using an 8×1 multiplexer. 10

SECTION—B

5. (a) (i) If $I(x_1)$ is the information carried by message x_1 and $I(x_2)$ is the information carried by message x_2, then prove that the amount of information carried compositely due to x_1 and x_2 is

$$I(x_1, x_2) = I(x_1) + I(x_2).$$ 7

(ii) At 2 km in free space from a point source, the power density is 200 $\mu w/m^2$. What is the power density 25 kms away from this source ? 3

(iii) A graded index fiber has a core with a parabolic refractive index profile which has a diameter of 50 μm. The fiber has a numerical aperture of 0.2. Estimate the total number of guided modes propagating in the fiber when it is operating at a wavelength of 1 μm. 5

(b) With the help of a diagram, show how a magic Tee can be used to behave as a mixer producing IF frequency. 10

(c) Describe scope, visibility and lifetime of variables for storage class none, extern, auto, register and static. 10

6. (a) (i) Give block diagram for a set-up for measuring VSWR using reflectometer technique and explain the same. 8

(ii) Evaluate the VSWR of a transmission system which is operating at 10 GHz. Inside dimensions of waveguide are a = 4 cm and b = 2·5 cm. Distance between twice minimum power points is 1 mm on a slotted line.
(Use double minimum method) 7

(b) (i) Write an 8086 assembly program to compute

$$\sum_{i=1}^{n} X_i Y_i$$

where X_i and Y_i are signed 8-bit numbers and n = 100. Assume DS is already initialized and X_is and Y_is are already stored in memory. Also assume no overflow. 7

(ii) Perform the operation $(12_{10} - 35_{10})$ using 2's complement method. 3

(c) In an AM Transmitter, antenna current is 8 amperes, when only the carrier is sent. But it increased to 8·93 amperes when carrier is modulated by a single sine wave. Determine the percentage of Modulation. Also evaluate the antenna current when the percentage of Modulation is changed to 80%. 10

7. (a) (i) Explain break and continue statement in 'C' language with illustration. 8

(ii) Write and explain an algorithm to evaluate

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \ldots\ldots$$

for first 10 terms. 7

(b) Explain Hamming codes.

How many Hamming bits are required for a block length of 20 message bits to correct 1 bit error ? 10

(c) Draw the schematic diagram of a 4 port circulator. How will you convert it into (A) a switch and (B) a coupler ?

For a perfectly matched, lossless, non-reciprocal four port circulator, write down the S-matrix. 10