Engg. Services Exam, 2011

Serial No. 13401 D–RSR–L–RGA

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 = $-1{\cdot}6\times10^{-19}$ coulomb.

Free space permeability = $4\pi\times10^{-7}$ henry/m.

Free space permittivity = $\left(\frac{1}{36\pi}\right)\times10^{-9}$ farad/m.

Velocity of light in free space = 3×10^{8} m/sec.

Boltzmann constant = $1{\cdot}38\times10^{-23}$ joule/K.

Planck constant = $6{\cdot}626\times10^{-34}$ joule-sec.

1. (a) Distinguish between direct and indirect bandgap materials with suitable E-k diagrams.

How would you make an intrinsic GaAs sample n-type or p-type ? What happens when GaAs is doped with Si ? What is the nature of bonding in GaAs ? 10

(b) An n-type Ge sample is 2 mm wide and 0·2 mm thick. A current of 10 mA is passed through the sample (x-direction) and a magnetic field of 0·1 web/m^2 is directed perpendicular to the current flow (z-direction). The developed Hall voltage is 1·0 mV. Calculate the Hall coefficient and electron concentration. 10

(c) (i) How do you represent analog colour TV signal mathematically ? 1

(ii) How does discrete-time signal express in mathematics ? 1

(iii) Determine whether the following discrete time signal is time invariant or not :

$$y(n) = x(n) - x(n-2).$$ 1

(Contd.)

(iv) Represent recursive and non-recursive discrete-time system with the help of constant coefficient difference equation. 2

(v) What are the advantages of state-variable approach to analysis of a circuit (system) ? 2

(vi) The continuous-time system as in Figure 1 consists of two integrator and two scalar multipliers. Write a differential equation that relates the output y(t) and input x(t). 3

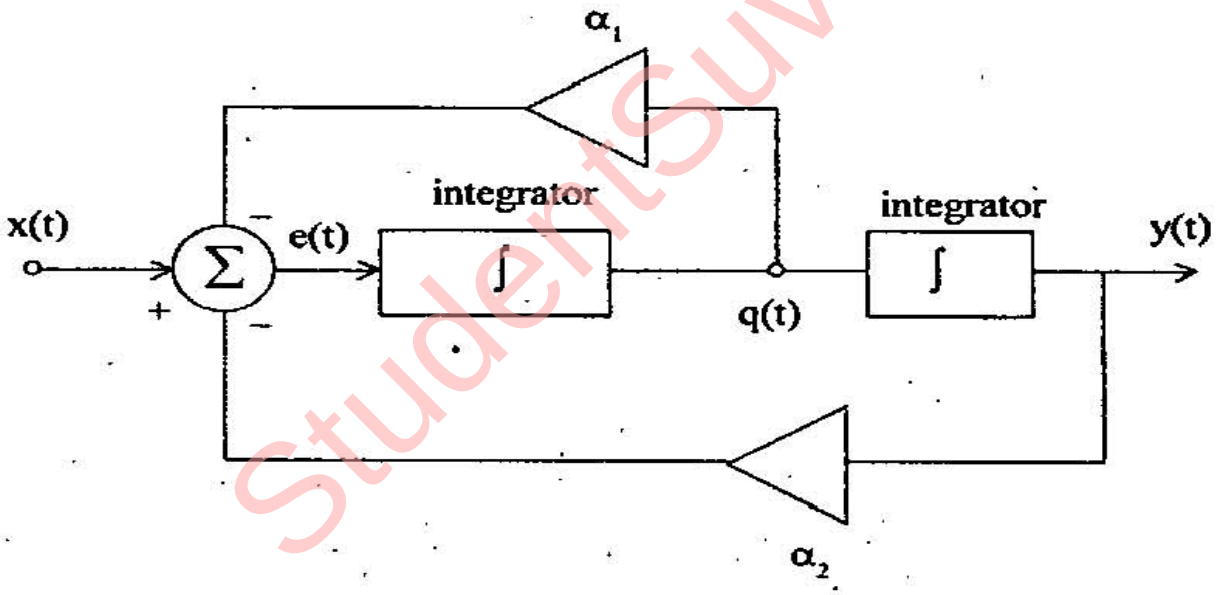
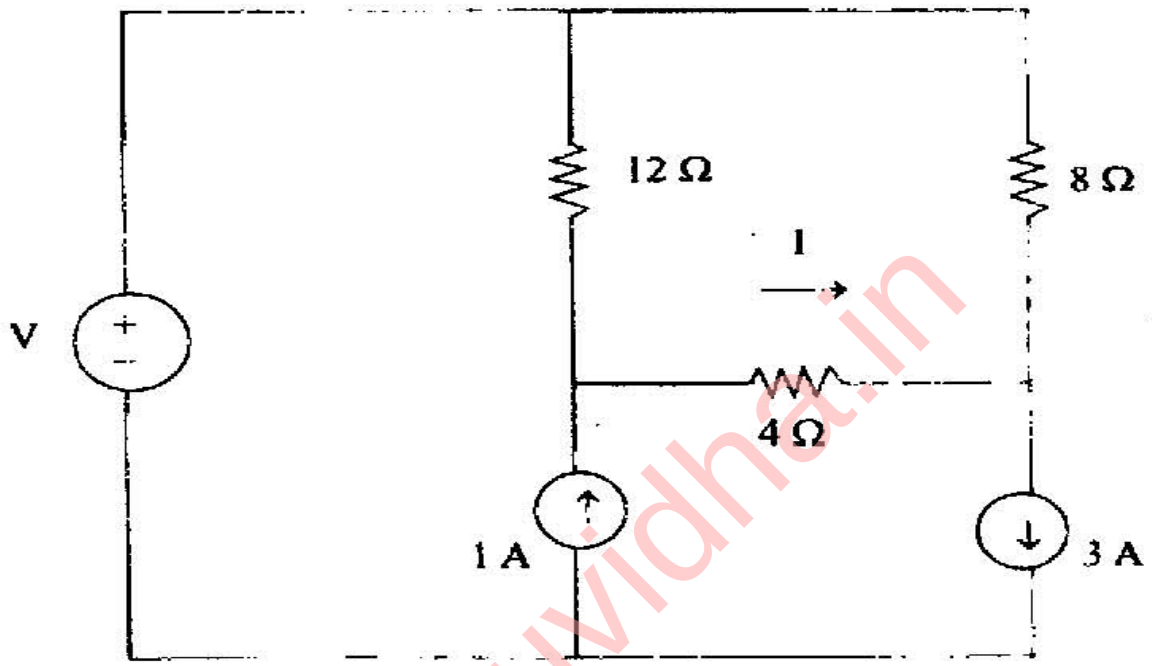


Figure 1

(d) For the given circuit determine I by applying Superposition theorem. 10



(e) A material having $\sigma = 5{\cdot}0$ s/m and $\varepsilon_r - 1$ is subjected to an electric field intensity of $E = 250 \sin 10^{10} t$ (V/m). Find J_D and J_C. Determine the frequency at which J_D and J_C are equal in magnitude. 10

(f) (i) Explain CMOS as an optical sensor.

(ii) How is it superior to a CCD ? 10

2. (a) Derive one-dimensional continuity equation for holes in a semiconductor. Reduce this expression to the standard diffusion equation by assuming that drift is negligible and there is no generation in the region. 10

(b) Obtain expressions for short circuit current and open circuit voltage in an illuminated p-n junction. Explain how an illluminated p-n junction can be used as a photodetector or a photo-cell. 15

(c) Sketch the energy-band diagram of an ideal MOS capacitor at equilibrium. Explain with energy band diagram the following modes of operation of a MOS capacitor.

(i) accumulation

(ii) depletion

(iii) inversion. 10

3. (a) An abrupt Si p-n junction has

$N_A = 10^{23}/m^3$ on p-side and

$N_D = 10^{21}/m^3$ on n-side.

Calculate the value of the contact potential and the total width of the depletion region under unbiased condition at 300 K. Derive the relations used in the computation. The intrinsic carrier concentration of Si is $1 \cdot 5 \times 10^{16}/m^3$ and relative permittivity is 11·8. 15

(b) The bandgap of GaAs and AlAs are 1·43 ev and 2·16 ev respectively. Assuming the bandgap of $Al_xGa_{1-x}As$ to vary linearly with x between the two extreme values, find the value of x that would result in the emission of 680 nm from $Al_xGa_{1-x}As$. 10

(c) Obtain an expression for the drain current (I_D) as a function of drain voltage (V_D) for an n-channel MOSFET. Hence find the expression for the transconductance of the device in the saturation region. 10

4. (a) Given the following state-space description of a system :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -3 & 1 \\ -2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

and

$$y = [\, 1 \quad 0 \,] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

where x_1, x_2 are of the state-variable, u is the input and y is the output of the system :

(i) Find the state-transition matrix, 3

(ii) Transfer function of the system, 5

(iii) Complete solution of the system when input is the step function and having zero initial condition. 7

(b) (i) Draw the block diagram of the system represented by the following constant coefficient difference equation :

$$y(n) = b_0 x(n) + b_1 x(n-1) + a y(n-1)$$

where

x(n) is the input sequence

and

y(n) is the output sequence 2

(ii) Digital Filter is a discrete-time system which is operated on an input sequence to produce an output sequence according to some computational algorithm .

$$y(n) = \sum_{K=0}^{\infty} a_K\, x(n-K) - \sum_{K=1}^{\infty} b_K\, y(n-K).$$

Find its transfer function. 3

(iii) Solve the difference equation using the one-sided z-transform

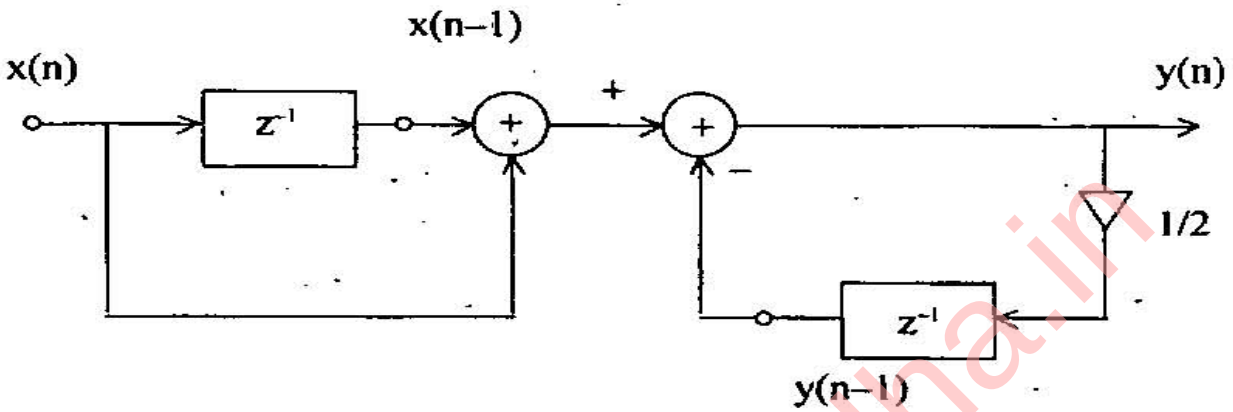
y (n) x (n) + by (n 1)

with initial condition

y (1) P

Let the input be x (n) e^{jwn} u (n). 5

(c) (i) Consider the system shown in the Figure below. Determine its impulse response of the system. 3



(ii) (a) Obtain the frequency response of the first-order recursive system represented by the difference equation

$$y(n) = ay(n-1) + x(n)$$

considering the system is initially relaxed.

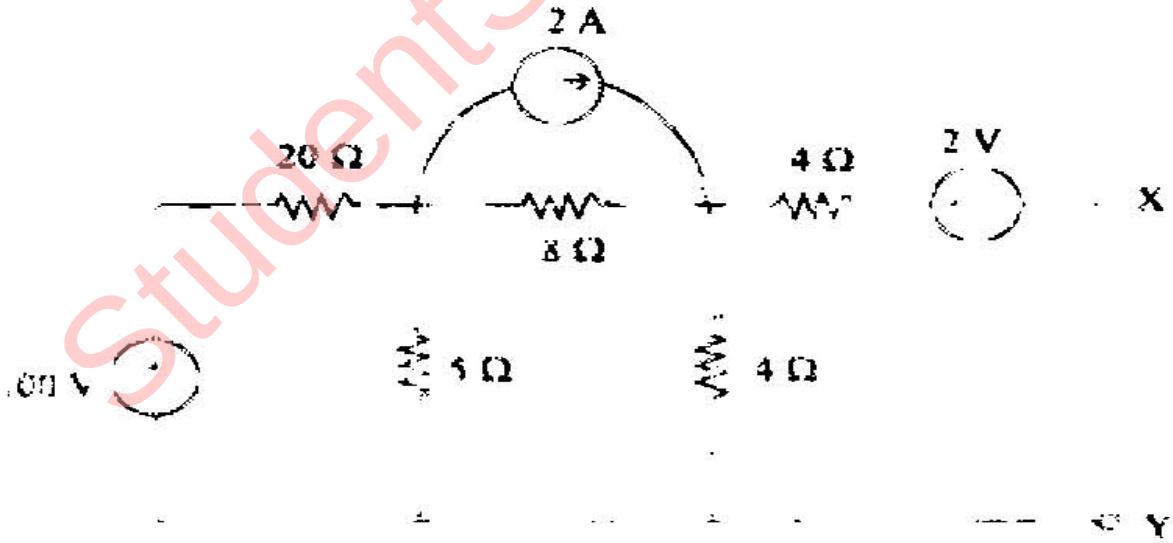
(b) also plot magnitude and phase response 5

(iii) $X(e^{j\omega}) = \frac{1}{(1 - be^{j\omega})(1 - ae^{-j\omega})}$

Find the inverse Fourier Transform of above expression 2

5 (a) (i) Determine the Thevenin and Norton equivalent of the circuit at the terminals X-Y 15

(ii) What load resistance connecting X and Y will draw maximum power ? What is that power ? 5



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(b) A current source drives a parallel R-L-C network. If $R = 6\ \Omega$ and $L = 3H$ and $C = \frac{1}{12}$ F, determine its network function $H(s) = \frac{V_c(s)}{I_s(s)}$, where i_s is the current source. 10

(c) (i) Consider the circuit of Fig. 2. Find the value of R_L and the power delivered to each load resistor i.e. R_L, $R_L/2$ and $R_L/3$ for maximum power transfer to the three resistor load.

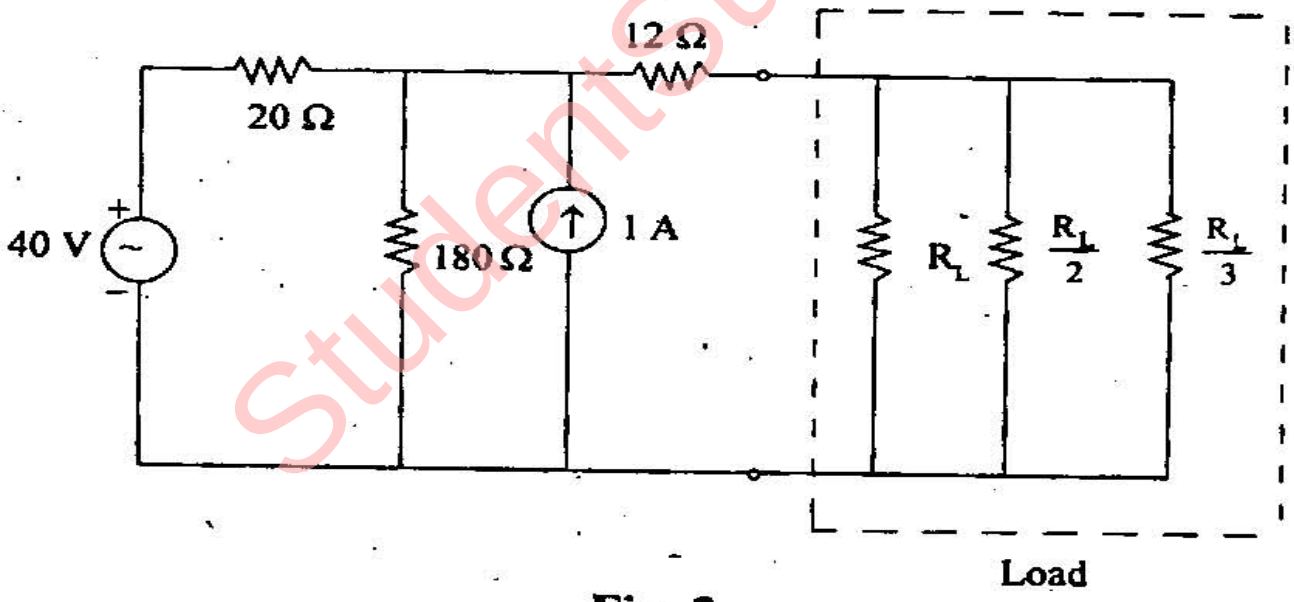

Fig. 2

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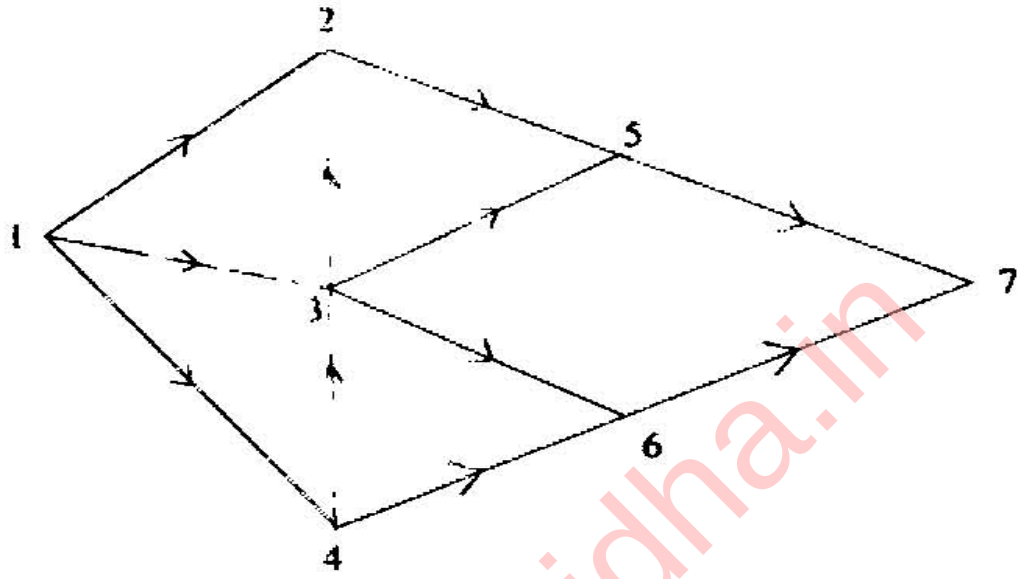
(ii) Write the incidence matrix A for the graph of Fig. 3.



5+5

Fig. 3

6. (a) Two voltages of equal frequencies and amplitudes travel in opposite directions on a lossless transmission line. Find the expression of the total voltage pattern as a function of time and position on the line. Draw a neat sketch of the voltage wave pattern varying along z-direction. Give the positions of voltage nulls. (10+2+3=15)

(b) The electric field $\overline{E}$ and the magnetic field $\overline{H}$ in a source-free, homogeneous, isotropic region are given as

$$\overline{E} = 100\,(j\hat{x} + 2\hat{y} - j\hat{z})\,e^{jwt}$$
$$\overline{H} = (-\hat{x} + j\hat{y} + \hat{z})\,e^{jwt}$$

Estimate the average power flow density and its direction in the region. 5+5=10

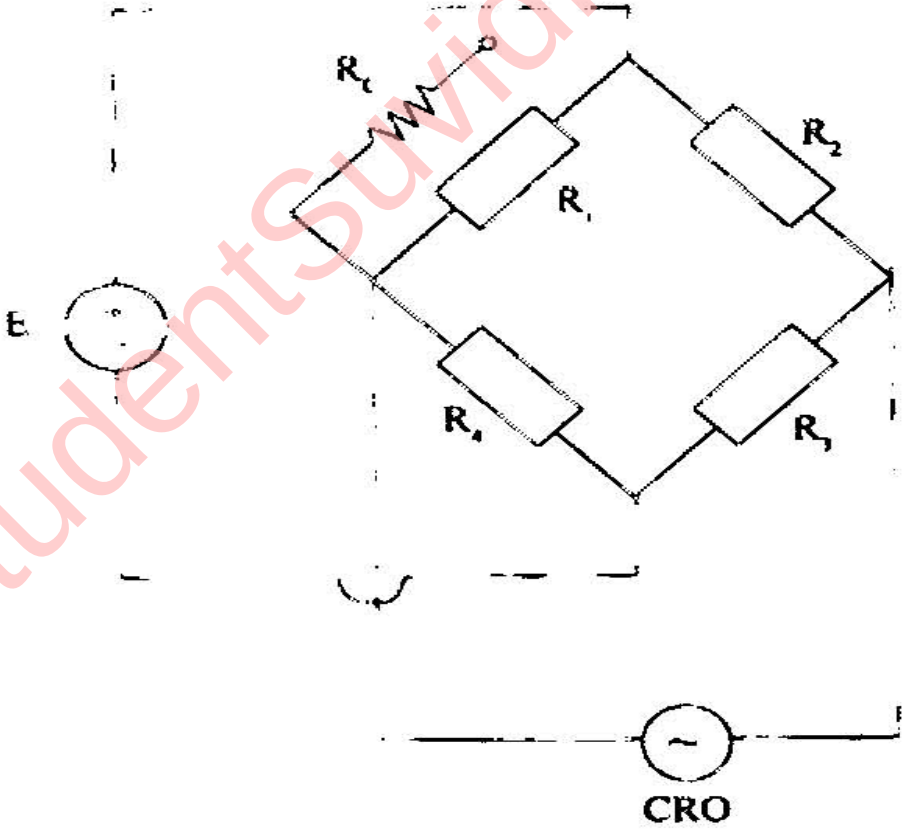
(c) A vertical Hertz dipole radiates 1 KW power. Find the electric field and the Poynting vector at a distance 10 km from the dipole in a horizontal plane passing through the dipole. What is the direction of electric field at the point ? 10

7. (a) (i) Define gage factor for a strain gage and derive an expression for it. 5

(ii) Explain the significance of piezo-resistivity in the expression. 5

(iii) A strain gage is used as a force measuring device as shown in the figure. All elements are strain gages with resistance 120 Ω. Only R_1 is active. If the maximum gage current

is 25 mA, determine the battery voltage E. A calibrating resistance of 1·2 MΩ is connected in parallel to R_1 and the trace shift in the CRO is 5 cm. Find the trace shift when the applied force causes 10 microstrain. If the temperature coefficient of the gage is 10^{-5} Ω/Ω°C what will be the output when the temperature compensation is not used ? 10



(b) With a block diagram, explain the function of a dual slope DVM.

A dual slope integrating type of A/D converter has an integrating capacitor 0·1 μF and a resistance of 100 kΩ. The reference voltage is 2 V and the output of the integrator is not to exceed 10 V. What is the maximum time required for the output voltage to be integrated ? 15

Engg. Services Exam, 2011

Sl. No. 7801 D–RSR–L–RGB

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.

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

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.

Some useful constants are given below :

Electron charge	:	$e = 1 \cdot 6 \times 10^{-19}$ coulomb
Electron mass	:	$m = 9 \cdot 1 \times 10^{-31}$ kg
Planck's constant	:	$h = 6 \cdot 625 \times 10^{-34}$ J-s
Velocity of light	:	$c = 3 \times 10^{8}$ m/s
Universal constant of gravitation	:	$G = 6 \cdot 668 \times 10^{-11}$ $m^3/kg\text{-}s^2$

Mass of the earth : $M = 5 \cdot 997 \times 10^{24}$ kg

Radius of the earth : $R = 6378$ km

Permeability of vacuum : $\mu_0 = 4\pi \times 10^{-7}$ H/m

Permittivity of vacuum : $\varepsilon_0 = \frac{10^{-9}}{36\pi}$ F/m

1. *(a)* The ideal transfer characteristic of a particular circuit is given in Fig. 1. Design the circuit. Draw the output waveform with proper explanation, if $V_i = 10 \sin \omega t$. 8

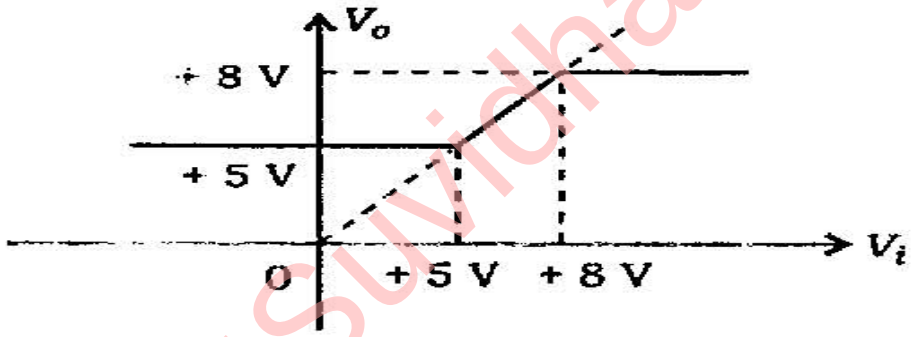


Fig. 1

(b) Implement the function

$$f(A, B, C, D) = \Sigma(0, 1, 5, 7, 10, 14, 15)$$

using an appropriate multiplexer. 8

(c) Without drawing the Nyquist plot, find the number of encirclements, N of the $-1 + j0$ point, in the $G(s)H(s)$-plane, for the system having its open-loop transfer function

$$G(s)H(s) = \frac{10}{s(s+3)(s^2+s+1)}$$

Comment on the stability of the closed-loop system. 8

(d) A system employing a proportional and an error-rate control is shown in Fig. 2. Determine *(i)* the error-rate factor K_e, so that the damping ratio is 0·5 and *(ii)* the steady-state error for unit ramp input. 8

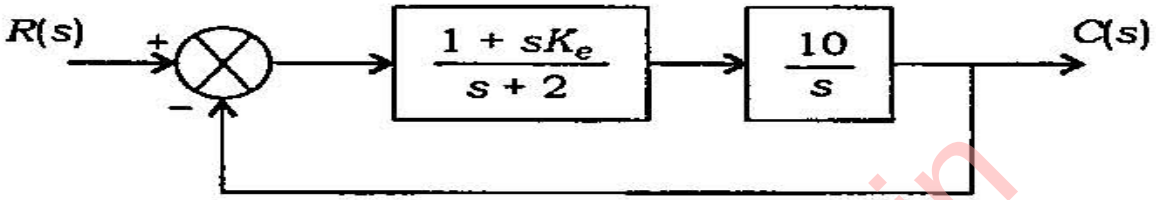


Fig. 2

(e) Four source messages are probable to appear as

$$m_1 = \frac{1}{2},\ m_2 = \frac{1}{4},\ m_3 = \frac{1}{8},\ m_4 = \frac{1}{8}$$

Obtain its Huffman coding and determine the coding efficiency. 8

(f) Explain what is meant by geostationary orbit of satellite. How do the geostationary and geosynchronous orbit differ? 8

(g) In order to sample incident and reflected power in a waveguide, two identical 30-dB directional couplers are used. If VSWR = 2 and output of the directional coupler sampling incident power = 4·5 mW, determine the value of the reflected power. 8

(h) An earth station uses a 30 metre dish with circular aperture for receiving satellite signals at 4 GHz downlink frequency. If $\frac{G}{T}$ ratio of the earth station is 20 dB, compute the system noise temperature. 8

(i) Explain the sequence of operations during a double-handshake data transfer in a microprocessor-based system, with the help of timing waveforms of the associated signals. Mention the device that automatically manages handshake operation. What are the two 'control words' in this device? 8

(j) (i) Explain the purpose of the following expressions in C language :

(1) (a % 5) == 0

(2) fabs (x + y)

(ii) Distinguish between a 'pointer' and an 'identifier' with example.

(iii) Write a C program to convert a temperature reading in degree Fahrenheit to degree Celsius, using the formula $C = (5/9) \times (F - 32)$. 8

Section—A

2. *(a)* Design a combinational circuit that accepts a 3-bit number as input and generates an output binary number equal to square of the input number. 10

(b) A non-inverting op-amp amplifier has got a gain of 10. The open-loop gain of the op-amp is 2×10^5. Its output resistance is 75 Ω. Calculate the output resistance of the non-inverting amplifier. 10

(c) The state transition diagram of a synchronous counter is given in Fig. 3. Design the counter circuit using *J-K* flip-flops. Use the state table for the design. 10

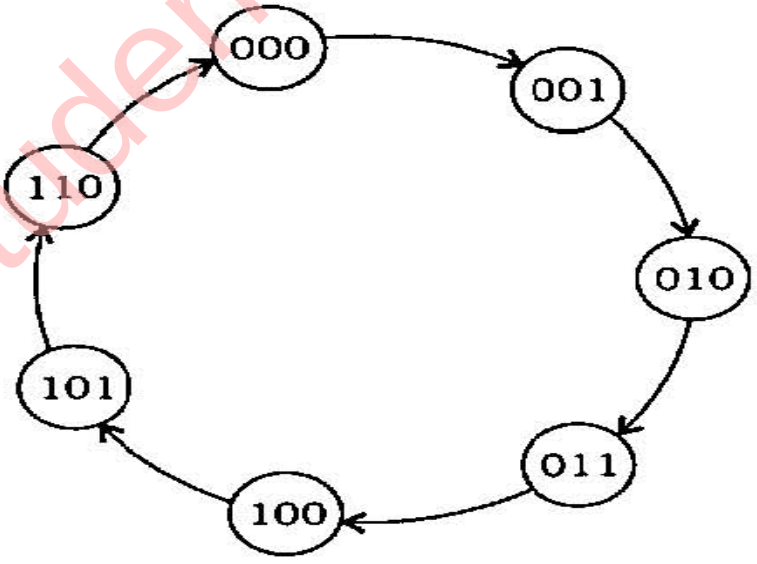


Fig. 3

3. *(a)* Define and deduce an expression for the slew rate of an op-amp. A particular op-amp has a slew rate of 0·5 V/μs. It is used as a non-inverting amplifier with a gain of 25. The voltage gain against frequency curve is flat up to 50 kHz. Calculate the maximum peak-to-peak input signal that can be applied to get the undistorted output. 10

(b) For the given circuit in Fig. 4, the decimal inputs are given from a mod 16 counter. Calculate the equivalent analog voltages when the counter outputs are 0011, 0111, 1011 and 1110. Also calculate the counter outputs when the equivalent analog voltages are 1·25 V, 2·5 V, 3·75 V and 4·06 V. Assume that binary '1' = 5 V and '0' = 0 V. 10

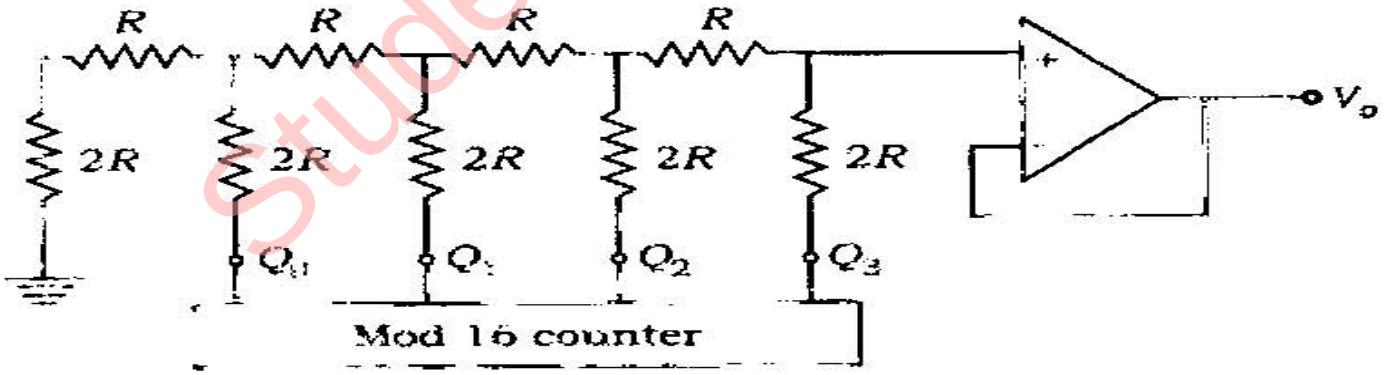


Fig. 4

(c) Implement the following functions using static CMOS circuit : 10

(i) $Y = A \cdot B$

(ii) $Y = A + B$

(iii) $Y = A \oplus B$

(iv) $Y = A \odot B$

4. (a) The response of a second-order control system has an overshoot of 30% for a step input and the overshoot takes place 0·05 second after the application of the input. Find the transfer function of the system. 10

(b) A unity feedback control system has its open-loop transfer function

$$G(s) = \frac{20(s+1)}{s^2(s+2)(s+4)}$$

Calculate its steady-state error when the applied input is

$$r(t) = 40 + 20t + 5t^2$$ 10

(c) Determine the transfer function of a compensator that will provide a phase lead of 45° and gain of 10 dB at ω = 8 rad/sec, without using graphical approach. 10

Section—B

5. *(a)* Consider a modulating signal

$$m(t) = 10 \sin (2\pi \times 10^4 t)$$

that is used to modulate a carrier frequency of 25 MHz.

(i) Find the bandwidth for 98% power transmission for phase modulation and frequency modulation using $\beta_p = 10$ and $\beta_f = 10$.

(ii) Repeat *(i)* when modulating frequency is doubled.

(iii) Repeat *(ii)* when amplitude of the modulating signal is halved. 10

(b) *(i)* The discrete sample of an analog signal is to be uniformly quantized for PCM system. If the maximum value of the analog sample is to be represented within 0·05% accuracy, find the minimum number of binary digits required.

(ii) What is companding? Why is it used? Why is it preferable to quantizing with tapered steps? 10

(c) Determine the optical power received in dBm and watt for a 20-km optical fibre link with the following parameters : 10

LED output power of 30 mW
Four 5-km sections of optical cable each with a loss of 0·5 dB/km
Three cable-to-cable connectors with a loss of 2 dB each
No cable splices
Light source-to-fibre interface loss of 1·9 dB
Fibre-to-light detector loss of 2·1 dB
No losses due to cable bends

6. (a) (i) What are the three significant differences between Microwave Transistors and Transferred Electron Devices (TED)? Sketch the two-valley model of band structure of GaAs (Gallium Arsenide).

(ii) On the basis of RWH theory, give the important criteria a semi-conductor must satisfy, in order to exhibit negative resistance. 10

(b) (i) Sketch the different Gunn domain modes exhibited by GaAs. Which mode will give a frequency much higher than the intrinsic frequency of the Gunn diode?

(ii) A negative resistance parametric amplifier has a signal frequency of 2 GHz, pump frequency of 12 GHz and output resistance of signal generator is 16 ohms. If input resistance of the signal generator is 1 kΩ, calculate the power gain in dB. What will be the power gain, if it is working as a USB converter? 10

(c) What is the magic in a 'Magic Tee'? With the help of a schematic, show how a magic tee can be used in microwave receiver for constructing a balanced mixer.

If drift length of a Read diode is 20 μm, calculate the drift time of carrier and operating frequency of the diode (carrier drift velocity = 10^5 cm/sec). 10

7. (a) (i) Perform the following operations on the given binary numbers as specified :

(1) 110·01 + 1·011

(2) Convert 11101·01 to decimal

(3) 11100·101 − 101·01 using 2's complement

(4) Convert 111000 to octal

(ii) State whether the following statement is True or False :

"All decimal fractions have exact binary equivalents." 10

(b) (i) Mention the two independent functional units in the 8086 microprocessor and explain their basic function.

(ii) Which are the registers that form part of these two units? Explain instruction pipelining. 10

(c) (i) Distinguish between Hardwired control and Microprogrammed control.

(ii) Compare and contrast RISC instruction and VLIW. 10

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