Engineering Services (Main)
Examination, 2024

SGSE–T–ETE

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER—II

Time Allowed : Three Hours	Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions

There are **EIGHT** questions divided in **TWO** Sections.

Candidate has to attempt **FIVE** questions in all.

Question Nos. **1** and **5** are compulsory and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each Section.

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

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.

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

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

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

SECTION—A

1. *(a)* An angle-modulated signal has the form

$$u(t) = 100\cos[2\pi f_c t + 4\sin 2000\pi t]$$

where $f_c = 10$ MHz.

(i) Determine the average transmitted power.

(ii) Determine the peak phase and frequency deviation.

(iii) Is this FM or PM signal? Explain. 4+4+2=10

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

$$G(s) = \frac{K}{s(Ts+1)}$$

The system is critically damped and the steady-state error is 0·5 when unit ramp input is applied. Find out the natural frequency of the system. 10

(c) With respect to cache memory organization, describe the importance of cache addressing models, considering physical address cache, virtual address cache and aliasing problem. Write a block schematic depicting memory hierarchy for a shared memory multiprocessor. 5+5=10

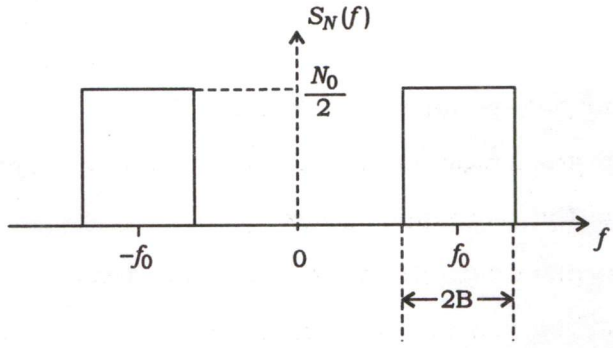
(d) For an air-filled coaxial transmission line, the outer radius of the inner conductor is 1 mm and the inner radius of the outer conductor is 4 mm. The outer conductor thickness is 0·6 mm and all conductors have conductivity $\sigma = 1\cdot6\times10^{7}$ S/m. Find the inductance L and capacitance C per unit length. What will be the resistance per unit length at an operating frequency of 2·5 GHz? The value of $\varepsilon_0 = 8\cdot854\times10^{-12}$ F/m and $\mu_0 = 4\pi\times10^{-7}$ H/m. 10

(e) Design 4-to-1 multiplexer using domino logic. 10

(f) A silicon *p-i-n* photodiode in an optical receiver receives a peak optical power at 1300 nm. The diode has a quantum efficiency of 50% and delivers electrical power to a load of 8 kΩ. If the diode receives a peak power of –30 dBm, calculate the thermal noise and shot noise if the bandwidth of operation is 8 MHz. The dark current value = 5 nA.

[$e = 1\cdot6\times10^{-19}$ C, $h = 6\cdot63\times10^{-34}$ J-s, $c = 3\times10^{8}$ m/s, $k_B = 1\cdot38\times10^{-23}$ J/K] 10

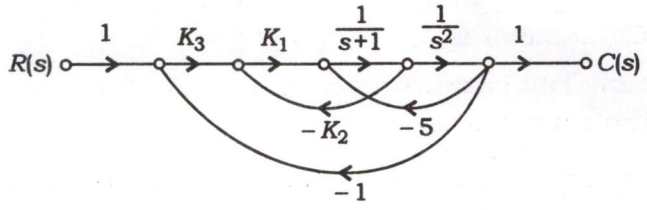
2. *(a)* A zero mean Gaussian noise $n(t)$ has power spectral density $S_N(f)$ as shown below :



(i) Plot the power spectral density of in-phase and quadrature components of $n(t)$.

(ii) Find the probability density function of the envelope of $n(t)$. 10+10=20

(b) A control system is represented by the signal flow graph shown below :



(i) Determine the overall system gain $\frac{C(s)}{R(s)}$, if $K_1 = 1$, $K_2 = 5$ and $K_3 = 5$.

(ii) Find the sensitivity of the system to changes in K_1 for $\omega = 0$. 10+10=20

(c) Explain the following terms associated with virtual memory : 5×4=20

(i) Address spaces

(ii) Address mapping

(iii) Private virtual memory

(iv) Shared virtual memory

3. *(a)* An AM signal has a form

$$u(t) = [20 + 2\cos 3000\pi t + 10\cos 6000\pi t]\cos 2\pi f_c t$$

where $f_c = 10^5$ Hz.

(i) Sketch the voltage spectrum of $u(t)$.

(ii) Determine the power in each of the frequency components.

(iii) Determine the modulation index.

(iv) Determine the sideband power and total power.

(v) Determine the transmission efficiency. 4×5=20

(b) Sketch the Nyquist plot and conclude on closed-loop stability of the following open-loop transfer function of unity feedback control system : 20

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

(c) *(i)* Define and differentiate between the following types of databases :

(1) Relational databases

(2) Object-oriented databases

(3) NoSQL databases

Discuss the key characteristics of each database type, highlighting their strength and weaknesses. 5+5=10

(ii) Over the years, several protocol standards for I/O have emerged, with USB becoming most popular. Give at least five reasons to justify this statement.

With the help of a block schematic, explain the working of a DMA controller. 4+6=10

4. *(a)* *(i)* Analog voice frequency signal band-limited to 4 kHz is sampled at 1·25 times the Nyquist rate. The samples are quantized and encoded using N-bit PCM. Find the minimum N to have an average signal to quantization noise ratio of at least 40 dB. What is the minimum storage capacity needed to accommodate the digitized signal if the total duration of the voice frequency signal is 10 seconds? Also find the information rate of the source if all the quantization levels are equally likely and statistically independent. 10

(ii) Obtain and draw the PSK signal constellations for the value of $M = 2$, 4 and 8, if all have same transmitted signal energy E_s. Determine the minimum distance between the adjacent signal points. For $M = 8$, determine by how many dB the transmitted signal energy E_s must be increased to achieve the same d_{min} as $M = 4$. 10

(b) Design a proportional plus integral (PI) controller so that the system having transfer function

$$G(s)H(s) = \frac{1}{s-1}$$

will have closed-loop poles at $s = -0 \cdot 5$ and -1. 20

(c) (i) Explain the following terms associated with computer security : 10

Breach of confidentiality, breach of integrity, breach of availability, theft of service and denial of service

(ii) If an instruction set architecture is to prevail, it must be designed to survive rapid changes in computer technology. An architect must plan for technology changes that can increase the lifetime of successful computer. With respect to this, discuss and analyze the following trends : 4+3+3=10

(1) Implementation technologies

(2) Performance trends, bandwidth and latency

(3) Power and energy in integrated circuits

SECTION—B

5. (a) A parabolic index profile graded index fiber has a core diameter of 62·5 μm, numerical aperture of 0·275. Determine its normalized frequency at a wavelength of 850 nm and calculate the number of guided modes that can propagate through this optical fiber. 10

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

$$s^6 + s^5 + 3s^4 + 3s^3 + 3s^2 + 2s + 1 = 0$$

Determine the number of right-half *s*-plane roots, left-half *s*-plane roots and roots on the imaginary axis. 10

(c) (i) Calculate the number of memory chips needed to design 8K-byte memory if the memory chip size is 1024×1.

(ii) The memory address of the last location of an 8K-byte memory chip is FFFF in hexadecimal system. Find the starting address. 5+5=10

(d) A dipole antenna of length $0 \cdot 02\lambda$ has a linear current distribution with peak current I_0 occurring at the center of the dipole. Determine I_0 required to provide a radiation field amplitude of 100 microvolts per meter at a distance of 500 m at $\theta = \frac{\pi}{2}$. What will be the total average power radiated at this current? 10

(e) An analog filter is characterized as

$$H(s) = \frac{4}{(s+2)^2}$$

Design the corresponding IIR filter if the sampling frequency is 10 Hz, using impulse invariance method. 10

(f) (i) What is the purpose of using directional couplers in microwave communication systems? With the help of a schematic diagram, explain the working of a two-hole waveguide directional coupler.

(ii) For a pyramidal horn antenna, define gain and beamwidth. If the operating frequency is 10 GHz and a horn antenna has a height of 10 cm and a width of 12 cm, calculate the beamwidth and gain, taking the value of $k = 0 \cdot 5$. 6+4=10

6. (a) 60 MHz uniform plane wave is propagating in a lossless medium with $\varepsilon_r = 9$ and $\mu_r = 4$.

(i) Determine the phase constant β, wavelength λ and phase velocity v_p for the wave.

(ii) This wave is normally incident onto another medium having conductivity $\sigma = 4\ S/m$, $\varepsilon_r = 80$ and $\mu_r = 1$. The second medium is assumed to be good conductor at 60 MHz. Determine the fractions of the incident power that are reflected and transmitted. 6+14=20

(b) Write an 8085A program to exchange the higher and lower nibble of ten 8-bit numbers stored from location 2200H. Make use of subroutine and explain parameter passing using pointer and stack techniques. 20

(c) (i) Receiving antenna and input RF amplifier are the most crucial areas of a ground receiver in a satellite communication system. Write a typical block diagram considering the receive-only TV (ROTV) converter and indicate the various aspects with typical numerical values of frequencies. 10

(ii) Highlight the importance of power budget and rise-time budget in the design of optical communication systems. What are the three factors that limit the transmission distance, when the link lengths are long or data transmission rates are high?

Show how maximum link length is determined for RZ coding and NRZ coding, considering material dispersion. 3+2+5=10

7. *(a)* A lossless transmission line of length $0 \cdot 8\lambda$ and characteristic impedance $Z_0 = 75\ \Omega$ operating at 60 MHz has velocity on the line 3×10^8 m/s.

(i) If the line is short circuited at the load end, find the input impedance Z_{in}. At what distance closest to the short-circuited end is the impedance seen zero?

(ii) If the short circuit is replaced by a load $Z_L = 60 - j40\ \Omega$, determine the input impedance Z_{in}, reflection coefficient Γ and standing wave ratio (SWR). Determine the power delivered to the load if a source of 10 volts r.m.s. with series impedance $Z_g = 75\ \Omega$ is connected at the input.

10+10=20

(b) What is essential hazard? Find the hazard-free realization circuit for the following function :

$$f(a, b, c, d) = \Sigma m(1, 5, 7, 14, 15)$$ 5+5=10

(c) *(i)* Suppose that a 1 MHz channel can support a 1 Mbps transmission rate. The channel is to be shared by 10 stations. Each station receives frames with an exponential interarrival rate of $\lambda = 500$ frames/s and frames are of constant length $L = 1000$ bits. Compare the total frame delay of a system that uses FDMA to a system that uses TDMA.

Compare IS-54 and GSM in terms of their ability to handle speech and the effect on spectrum efficiency. 10+6+4=20

(ii) What are the salient features of 802.11 wireless LAN standard? Write the architecture and protocol stack of 802.11 and highlight the major issues. Comment on the physical layer aspects of 802.11. 3+5+2=10

8. *(a)* An air-filled rectangular waveguide has dimensions $a = 2 \cdot 4$ cm and $b = 1 \cdot 2$ cm.

(i) Over what range of frequencies will this guide operate single mode?

(ii) This air-filled waveguide is joined end-to-end with another waveguide of identical dimension. The second waveguide is filled with a lossless dielectric of relative permittivity ε_r. Find the maximum allowable value of ε_r such that single-mode operation can be simultaneously ensured in both waveguides. What will be the range of frequencies for single-mode operation if ε_r is chosen to be equal to half of the maximum allowable value? 8+12=20

(b) *(i)* In a CMOS logic circuit, assume that $V_{DD} = 1 \cdot 8$ V, load capacitance $C_L = 0 \cdot 1$ pF, $L_n = L_p = 2\lambda$, $W_n = 18\lambda$ and $W_p = 42\lambda$. Using $0 \cdot 18\ \mu$m parameters, $K'_n = 96\ \mu A/V^2$, $K'_p = 48\ \mu A/V^2$ and $V_{T_{on}} = |V_{T_{op}}| = 0 \cdot 4$ V, find the propagation delays t_{PHL} and t_{PLH}. 14

(ii) Find the z-transform of the following composite signal and determine the region of convergence : 6

$$x[n] = \left(\frac{1}{2}\right)^n u[n] + 4\left(-\frac{1}{3}\right)^{2n} u[n]$$

(c) (i) The main ingredients of a good routing algorithm depend on the objective function that one is trying to optimize. In this background, list and explain the goals that a routing algorithm should seek in general.

How are routing algorithms classified? Distinguish between link state routing and distance vector routing. 6+4=10

(ii) What are application protocols with respect to TCP? Show schematically how file transfer occurs using FTP.

What are the three default specifications which must be supported in every FTP implementation? 2+5+3=10

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