Engineering Services (Main)
Examination, 2026

SNCS–T–ENTE

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)* A memoryless source has the alphabet $A = \{-5, -3, -1, 0, 1, 3, 5\}$ with corresponding probabilities (0·05, 0·1, 0·1, 0·15, 0·05, 0·25, 0·3).

(i) Find the entropy of the source.

(ii) Assume that the source is quantized according to the quantization rule

$$\begin{cases} q(-5) = q(-3) = -4 \\ q(-1) = q(0) = q(1) = 0 \\ q(3) = q(5) = 4 \end{cases}$$

Find the entropy of the quantized source. 10

(b) A system has a characteristic equation

$$q(s) = s^4 + 9s^3 + 45s^2 + 87s + 50 = 0$$

Determine whether the system is stable, using the Routh-Hurwitz criterion. Also, determine the roots of the characteristic equation. 10

(c) When multiple I/O devices generate service requests simultaneously, the system may select an incorrect device for servicing. Why does this happen in the I/O priority handling mechanism? Suggest a suitable priority encoding method to ensure that the correct device is always selected. 6+4=10

(d) A uniform plane wave of 300 MHz is propagating in a medium for which the conductivity $\sigma = 0$, relative permeability $\mu_r = 2$ and relative permittivity $\varepsilon_r = 4$. The average Poynting vector is 10 watts/m^2.

(i) Determine the phase velocity of the wave.

(ii) Determine the r.m.s. values of the electric and magnetic fields.

The value of the free space intrinsic impedance $\eta_0 = 377\ \Omega$. 4+6=10

(e) An nMOS device operating in the subthreshold region has a ξ of 1·5. What variation in V_{GS} results in a ten-fold change in I_D? If $I_D = 10\ \mu A$, what is g_m? 10

(f) Consider a 1000 m, 16 Mbps token ring network containing 20 stations. Every station has data to transmit with equal priority. The maximum data allowed to transmit is 5000 bytes before giving up the token. Once a station gives up a token, how long will it take for that station to get the token again? Assume that the frame processing time at each station is 4 bits duration and the speed of the signal in the medium is 2×10^8 m/s. The token is of 24 bits length. 10

2. *(a)* Consider an audio signal with spectral components limited to the frequency band of 300 Hz to 3300 Hz. A PCM signal is generated with a sampling rate of 8000 samples/second. The required output signal-to-quantizing-noise ratio is 30 dB.

(i) What is the minimum number of uniform quantizing levels needed, and what is the minimum number of bits per sample needed? 5

(ii) Calculate the minimum system bandwidth required. 5

(iii) Repeat parts *(i)* and *(ii)*, when a μ-law compander is used with $\mu = 255$. 10

(b) *(i)* Define signals and systems in control systems giving an example showing excitation and response. 5

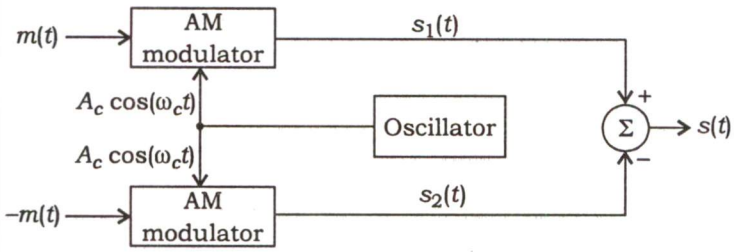
(ii) Briefly explain the fundamental classes of signals and the fundamental classes of systems. 10

(iii) Give the condition to determine if the system $y(t) = x(t^2)$ is linear, time-invariant and causal. 5

(c) *(i)* When a file system has millions of small files, maintaining a free space list becomes inefficient. Suggest a free space management method to handle the situation efficiently. 10

(ii) When two or more processes access the same file at the same time, they may overwrite each other's data. Give a file locking or concurrency control method to prevent such conflicts. 10

3. *(a)* *(i)* The figure below shows the circuit diagram of a balanced modulator. The input applied to the top AM modulator is $m(t)$, whereas that applied to the lower AM modulator is $-m(t)$; these two modulators have the same amplitude sensitivity. Show that the output $s(t)$ of the balanced modulator consists of a DSB-SC modulated signal.



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(ii) What is meant by orthogonal and antipodal signalling? Can the error performance of an FSK system ever be better than that given by the orthogonal case, and if so, how is the performance improved, and at what cost? 10

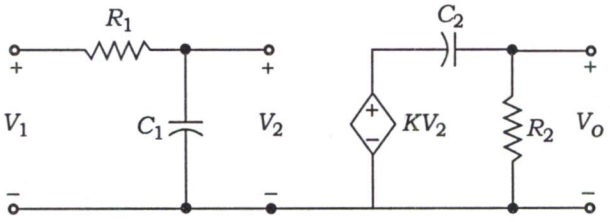
(b) A bandpass amplifier circuit is shown in the figure below. If $R_1 = R_2 = 1\ \text{k}\Omega$, $C_1 = 100\ \text{pF}$, $C_2 = 1\ \mu\text{F}$ and $K = 100$, show that

$$G(s) = \frac{10^9 s}{(s+1000)(s+10^7)}$$

(i) Sketch the Bode diagram of $G(j\omega)$.

(ii) Find the midband gain (in dB).

(iii) Find the high and low frequency –3 dB points.



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(c) (i) Compare and contrast cache memory and virtual memory with respect to a computer system. 5

(ii) Bring out the advantages and disadvantages of multilevel cache organization. 10

(iii) Find the average memory access time (AMAT) for a processor with a 2 ns clock time, a miss rate of 0·04 misses per instruction, a miss penalty of 25 clock cycles, and a cache access time of 1 clock cycle (including hit detection). Assume that the read and miss penalties are the same, and ignore other write stalls. 5

4. (a) The frame length of a pure TDMA system is 2·0 ms. If the QPSK symbol rate is 60·136 Mbaud and all traffic bursts are of equal length, determine—

(i) the maximum number of earth stations which the system can serve;

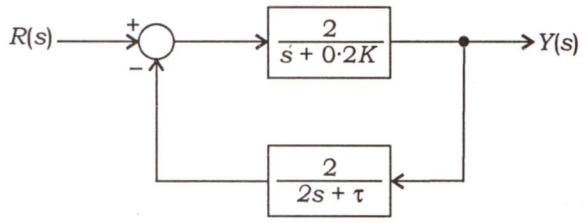
(ii) the frame efficiency. 20

(b) Consider the closed-loop system shown in the figure below where

$$G_c(s)\,G(s) = \frac{2}{s+0{\cdot}2K} \quad \text{and} \quad H(s) = \frac{2}{2s+\tau}$$

(i) If $\tau = 2{\cdot}43$, determine the value of K such that the steady-state error of the closed-loop system response to a unit step input $R(s) = \frac{1}{s}$ is zero.

(ii) Determine the percent overshoot (PO) and the time to peak T_p of the unit step response when K is as in part (i).



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(c) (i) Mention five important characteristics of database management systems that distinguish it from conventional file system. 5

(ii) What is transitive dependency in DBMS? How can it be eliminated? 5

(iii) Design a relational database schema for a library system to manage books, authors and loans. Identify the entities, relationships and necessary keys. Mention the ER diagram components and their respective shapes. Give a table which indicates mapping the schema. 10

SECTION—B

5. (a) An IIR digital low-pass filter is required to meet the following specifications :

Passband ripple (or peak-to-peak ripple) : ≤ 0·5 dB

Passband edge : 1·2 kHz

Stopband attenuation : ≥ 40 dB

Stopband edge : 2·0 kHz

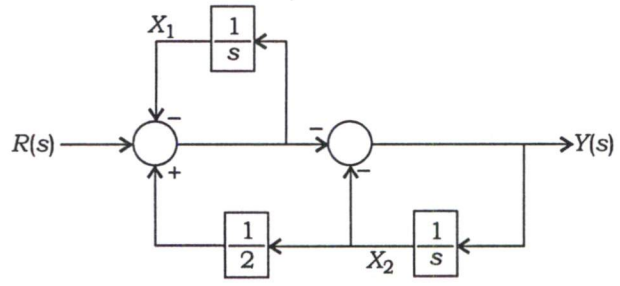
Sample rate : 8·0 kHz

Use the design formulas to determine the required filter order for—

(i) a digital Butterworth filter;

(ii) a digital Chebyshev filter. 10

(b) A multiloop block diagram is shown in the figure below. The state variables are denoted by x_1 and x_2. Determine a state variable representation of the closed-loop system where the output is denoted by $y(t)$ and the input is $r(t)$. Also, determine the characteristic equation.



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(c) (i) Briefly explain the necessary conditions for occurrence of deadlock in the context of computer operating system. 3

(ii) A system has 3 processes (P_1, P_2, P_3) that share 4 instances of a specific resource type. If each process can request a maximum of 2 instances, what is the maximum number of instances that can be requested (K) which will always avoid a deadlock? 3

(iii) How do semaphores help to prevent deadlock? 4

(d) An air-filled rectangular waveguide has inner dimensions of width $a = 2{\cdot}3$ cm and height $b = 1$ cm. Show that at an operating frequency of 9 GHz, the waveguide supports only one propagating mode. Determine the phase velocity and guide wavelength for the guided mode. 10

(e) Consider a vectored interrupt system in which multiple peripherals share a common interrupt line. How is the requesting device identified and what timing-related issue can lead to incorrect ISR execution? 10

(f) Consider a 6 km long optical fiber link using step-index fiber which has core radius of 25 micrometre, core refractive index of 1·49 and index difference of 1%. The overall fiber link loss is 1·5 dB/km. A light-emitting diode that has circular emitting area of radius 35 micrometre and a Lambertian emission pattern with 100 W/(cm^2-sr) axial radiance at 100 mA drive current is used to couple optical power to the fiber at the transmitting end. Determine the optical power available at the receiving end of the fiber link. 10

6. *(a)* Time-varying electric and magnetic fields exist in a homogeneous medium for which conductivity $\sigma = 0$, permittivity $\varepsilon = 8 \cdot 854 \times 10^{-12}$ F/m and permeability is unknown. If the magnetic field intensity $\vec{H} = 2 \sin(10^8 t - 0 \cdot 5z)\vec{a}_y$ A/m, find—

(i) the electric field intensity $\vec{E}$;

(ii) the relative permeability μ_r for the medium.

Assume that the medium has only time-varying fields. 10+10=20

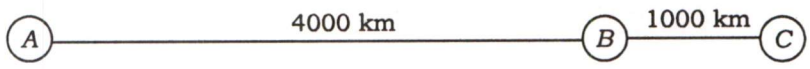
(b) Calculate the threshold voltage V_{th} of a two-input NAND gate under the following conditions :

(i) If all nMOS and pMOS transistors have the same size

(ii) If all pMOS transistors have twice the size of nMOS transistors and all nMOS transistors have the same size

Assume that V_{DD} is 3·3 V and $V_{T0_n} = |V_{T0_p}| = 0 \cdot 5$ V. The electron and hole mobilities are 540 cm^2/(V-s) and 180 cm^2/(V-s) respectively. 10+10=20

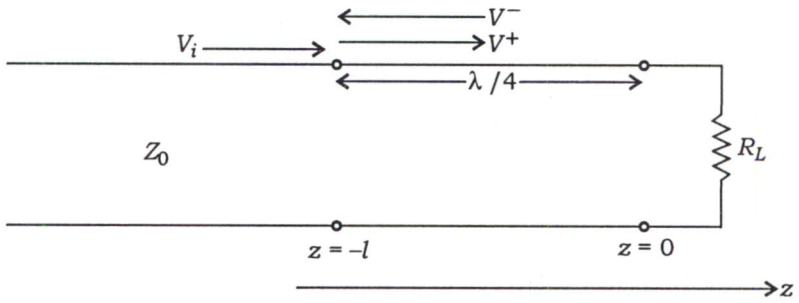
(c) *(i)* Three stations *A*, *B* and *C* are connected as shown :



Station *A* generates frames of 1000 bits each and sends to *C* through station *B*. The link between *A* and *B* uses sliding window protocol with window size of 3. The link between *B* and *C* uses stop-and-wait protocol with error-free transmission. Both links are full duplex and the propagation delay is 5 micro- seconds per kilometre for both the links. The acknowledgement frames are separate frames of negligible length. If the data rate between *A* and *B* is 100 kbps, what should be the data rate between *B* and *C* to avoid buffer overflow at station *B*? 10

(ii) A cellular base station is connected to telephone switching office 2·5 km away through radio link operating at 15 GHz with transmitting and receiving antenna gains $G_t = G_r = 30$ dB. Determine the transmitter power required to get receiver power level of 1 milliwatt. How much transmitter power is required to keep the same receiver power level if the radio link is replaced by wired link using coaxial cable with four 20 dB repeater amplifiers along the link? The coaxial cable has an attenuation of 0·05 dB/m. 10

7. *(a)* *(i)* Consider the RF quarter-wave matching transformer circuit shown below :

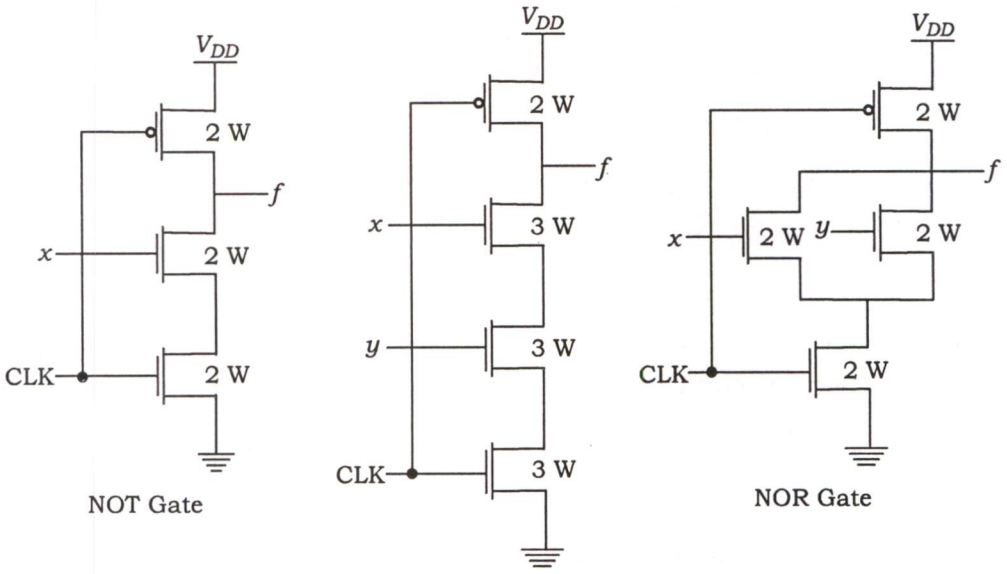


V_i is the incident voltage amplitude, V^+ and V^- are respective amplitudes of forward and reverse travelling waves on the quarter-wave line section. Derive the expressions for V^+ and V^- in terms of V_i. Assume propagation constant $\gamma = j\beta$ with usual notations. 8

(ii) A 50 Ω transmission line operating at 300 MHz is matched to a 10 V source and feeds a load $Z_L = 100$ Ω. The line is 2·3 m long and has an attenuation constant $\alpha = 0{\cdot}5$ dB/m. Find the powers that are delivered by the source, lost in the transmission line and delivered to the load. 12

(b) *(i)* What do you understand by logical effort? Explain why dynamic logic has generally less logical effort than static logic. 10

(ii) Calculate the logical effort of the three basic dynamic gates shown in the figure below; assuming that all transistors use the minimum channel length. 10



The three dynamic gates

(c) A communication satellite system operating in C-band has the following parameters :

Uplink frequency = 6 GHz

Downlink frequency = 4 GHz

Modulation scheme : QPSK with efficiency 1·7 b/s/Hz

Earth station antenna : Parabolic reflector with diameter 30 m and efficiency parameter $k = 0{\cdot}55$

Satellite onboard antenna : Parabolic reflector with diameter 1 m and efficiency parameter $k = 0{\cdot}55$

Earth station transmitter power = 1 kW

Transponder bandwidth = 36 MHz

Uplink path loss = 200 dB

Branch and feed losses are negligible

(i) Determine the earth station antenna gain in dB. 5

(ii) Determine the power received at the satellite LNA input. 10

(iii) If the transponder is used to carry voice channels with T_1 digital carrier system, how many such T_1 groups can be accommodated? One T_1 group occupies a bandwidth of 1·544 Mb/s. 5

8. (a) (i) Define radiation intensity and directivity of an antenna. Show that

$$D = \frac{4\pi U(\theta, \phi)}{P_{rad}}$$

where D = directivity, $U(\theta, \phi)$ = radiation intensity and P_{rad} = radiated power. θ and ϕ are usual spherical coordinates. The radiation intensity of certain antenna is given by

$$U(\theta, \phi) = A \sin\theta, \quad 0 \le \theta \le \pi$$
$$0 \le \phi \le 2\pi$$

Determine the maximum directivity for this antenna. 12

(ii) A 0·5 m long dipole antenna with ohmic resistance of 0·3 Ω is driven by 300 MHz source having an internal resistance of 50 Ω and a voltage of 10 V. Determine the power radiated and power dissipated by the antenna. Also, determine the radiation efficiency of the antenna. The input impedance for a half-wavelength dipole is $(73 + j42{\cdot}5)$ Ω. 8

(b) (i) Present a scenario where arithmetic instructions unintentionally modify condition flags and lead to incorrect branch decision. How can instruction reordering prevent such logical errors without changing program output? 10

(ii) A DMA transfer sometimes fails when CPU is busy in executing high priority tasks. How can conflicts in bus arbitration between CPU and the DMA controller cause this problem? Suggest a simple DMA control method that allows smooth data transfer without blocking CPU for longer time. 10

(c) A 1550 nm single-mode point-to-point digital optical fiber link over 100 km without amplifier is designed. A laser diode with 1 nm spectral width that emits 0 dBm optical power from an attached fiber fly lead is used as the source and an APD with sensitivity –39 dBm is used at the receiver. The optical fiber has 0·25 dB/km attenuation loss and there is a splice with 0·1 dB loss every kilometre. The connectors used at each end have 1 dB loss per connector.

(i) Draw the optical power loss model for the link. 6

(ii) Set up the optical power budget and determine the system margin for the link. 8

(iii) If the total dispersion in the fiber is 2 picosecond/(nm-km) and the transmitter and receiver rise times are 0·025 ns and 0·14 ns respectively, determine the maximum bit rate for an NRZ signal. Assume that the NRZ bit rate B_{NRZ} is related to system rise time t_r by $t_r = \frac{0 \cdot 7}{B_{NRZ}}$. 6

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