

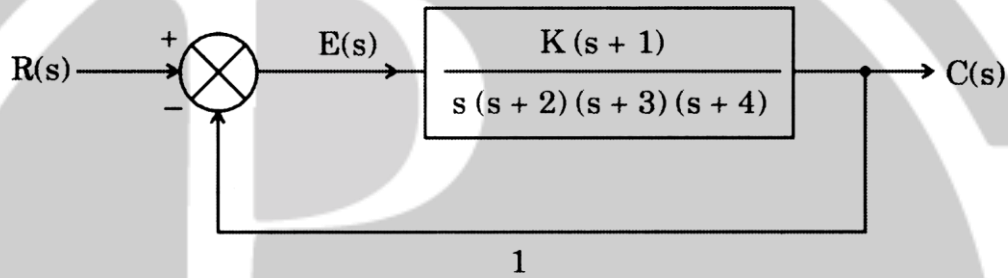
# ESE (Mains), 2022

## Electronics Paper-II

### SECTION 'A'

- Q1. (a)** An analog signal band limited to 3.3 kHz is sampled above Nyquist rate to have a guard band of 1.4kHz. The samples are quantized into 4 levels. The quantization levels Q1, Q2, Q3 and Q4 are assumed to be independent and occur with probabilities  $P_1 = \frac{1}{2}, P_2 = \frac{1}{4}, P_3 = P_4 = \frac{1}{8}$ . Determine the information rate of the source. 10

- (b)** A feedback control system is given by the following figure:



Find the value of 'K' so that there is 10% error in the steady state. 10

- (c)** By taking suitable examples, differentiate between concurrency and parallelism in the context of processes in operating systems. 10

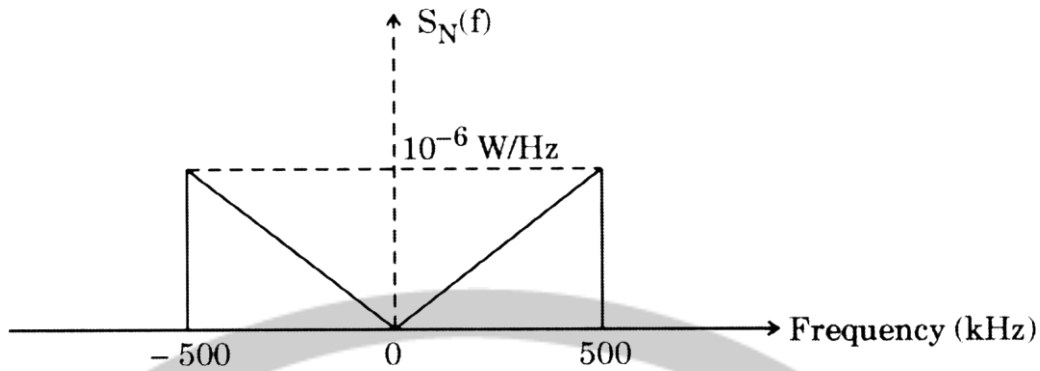
- (d)** Given magnetic field  $\vec{H} = \frac{x+2y}{z^2} \vec{a}_x + \frac{z}{2} \vec{a}_z$  A/m in free space, evaluate  $\oint_L \vec{H} \cdot d\vec{L}$ , where the

anticlockwise closed path for the integration is the boundary defining the closed surface  $2\text{m} < x < 3\text{m}$ ,  $3\text{m} < y < 6\text{m}$  and  $z = 3\text{m}$ . 10

- (e)** What is the importance of oxidation in VLSI technology? Which types of oxidation are used to grow gate oxide and field oxide in the fabrication of NMOS transistor? Justify your answer. 10

- (f)** Two stations have LOS communication link with half-wave antenna at 200 km distance. If the transmitter transmits 10 kW power at 300MHz, what is the maximum power received? The directivity gain of each antenna is 1.6. 10

- Q2. (a)** A double sideband-suppressed carrier (DSB-SC) modulated signal with message bandwidth of 5kHz and carrier frequency of 250kHz is transmitted over a noisy channel. The power spectral density (PSD) of the channel noise is as shown below:



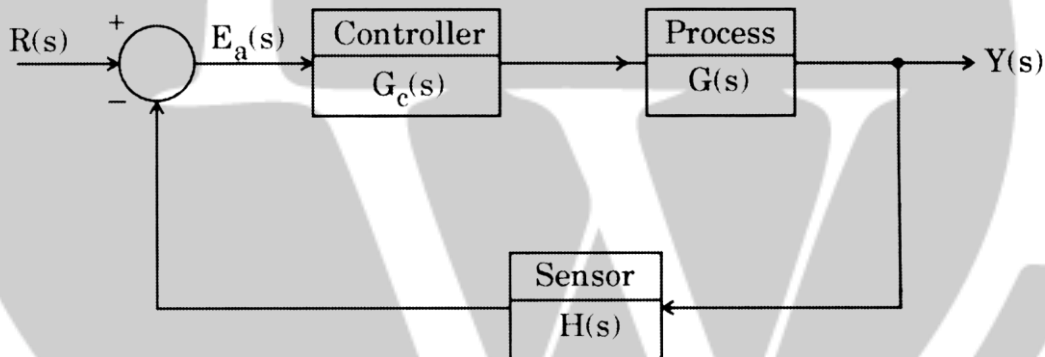
Coherent receiver is used for the demodulation.

- (i) Obtain and plot the PSD of the noise at the receiver output. 12
- (ii) Assuming that the average power of the modulated wave is 10 Watts, calculate the output signal-to-noise ratio of the receiver. 8

- (b) A feedback control system is shown in the following figure. The controller and process transfer functions are given as:

$$G_c(s) = K \text{ and } G(s) = \frac{s + 40}{s(s + 10)}$$

and the feedback transfer function is  $H(s) = \frac{1}{(s + 20)}$ .



- (i) Determine the limiting value of the gain 'K' for a stable system. 8
  - (ii) For the gain that results in marginal stability, determine the magnitude of the imaginary roots. 4
  - (iii) Reduce the gain to half the magnitude of the marginal value and determine the relative stability of the system by shifting the axis and using the Routh-Hurwitz criterion. 8
- (c) Consider a simple system running a single process. The size of physical frames and logical pages is 16 bytes. The RAM can hold 3 physical frames. The virtual addresses of the process are 6 bits in size. The program generates the following 20 virtual address references as it runs on the CPU: 0, 1, 20, 2, 20, 21, 32, 31, 0, 60, 0, 0, 16, 1, 17, 18, 32, 31, 0, 61. Note that the 6-bit addresses are shown in decimal here and assume that the physical frames in RAM are initially empty and do not map to any logical page.
- (i) Translate the virtual addresses above to logical page numbers referenced by the process. Assume pages are numbered starting from 0, 1, 2, .... 10

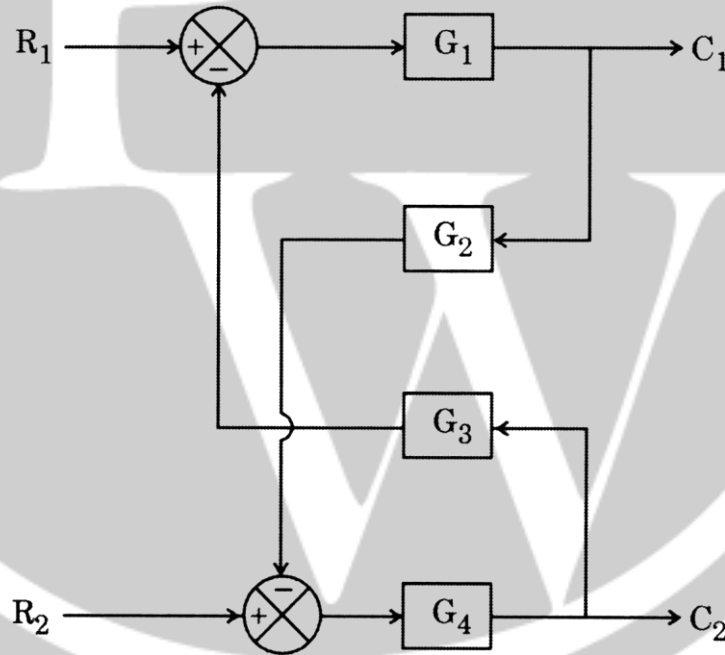
- (ii) Using First In First Out (FIFO) page replacement algorithm, calculate the number of page faults generated by the accesses above. 5
- (iii) Using Least Recently Used (LRU) page replacement algorithm, calculate the number of page faults generated by the accesses above. 5

**Q3. (a)** In digital audio system, the analog audio signal with peak-to-peak voltage ' $V_{pp}$ ' is sampled and uniformly quantized into L levels.

(i) Show that the ratio of peak signal power to peak quantization noise power  $\left(\frac{S}{N_q}\right)_{\text{peak}} = L^2$ .

(ii) If the samples are encoded with PCM, determine the bit rate in bits per second for  $\left(\frac{S}{N_q}\right)_{\text{peak}} = 84 \text{ dB}$ . The sampling frequency is 44.1 kilo samples per second.

- (b) The system shown in the following figure is a two input-two output system. Derive the expressions for  $\frac{C_j(s)}{R_i(s)}$ , where i and j represent the number of inputs and number of outputs respectively in the system. 20



- (c) (i) Let 'f' be the clock rate of a digital computer, 'N' be the number of machine instructions to be executed in a program on the digital computer, 'p' be the number of processor cycles needed for the instruction decode and execution, 'm' be the number of memory references needed and 'K' be the ratio between memory cycle and processor cycle. Derive the expression for CPU time needed to execute the program assuming single instruction type in the program. 15
- (ii) A given application written in the same programming language runs 12 seconds on a processor. After release of a new compiler for the same language, it requires only 0.5 as many instructions

as the old compiler, but it increases the Cycles Per Instruction (CPI) by 1.2. How fast can we expect the application to run using this compiler?

- Q4. (a)** Binary data at a bit rate of 104 bits/second is to be transmitted using binary FSK. 5
- (i) If the FSK signal is transmitted over binary symmetrical channel with noise spectral density  $N_0 = 2 \times 10^{-5}$  Watts Hz, determine the channel capacity required for error free transmission. The average power of the FSK modulated signal is 1 Watt and assume that binary 1 and binary 0 are equiprobable. 8
- (ii) Draw the block diagram and show the non-coherent demodulation of FSK. What should be the minimum separation between the two carrier frequencies representing binary 1 and binary 0? Determine the bandwidth of the bandpass filters used in the receiver system. 12
- (b)** A system is represented in state variable form as
- $$\frac{dx}{dt} = Ax + Bu$$
- $$y = Cx + Du,$$
- where
- $$A = \begin{bmatrix} 0 & 1 \\ -4 & -K \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix},$$
- $$C = [1 \ 0] \text{ and } D = [0].$$
- (i) Determine the characteristic equation. 5
- (ii) Sketch the root locus of the system. 10
- (iii) Test the stability of the system. 5
- (c)** Write a code or pseudocode (in any standard programming language) to check whether or not there exist two elements in a given array  $X[ ]$  whose sum is exactly 'S'. Consider that array  $X[ ]$  has 'X' numbers and 'S' is another number. Also write the comments for the lines in your code or pseudocode. 20

### SECTION 'B'

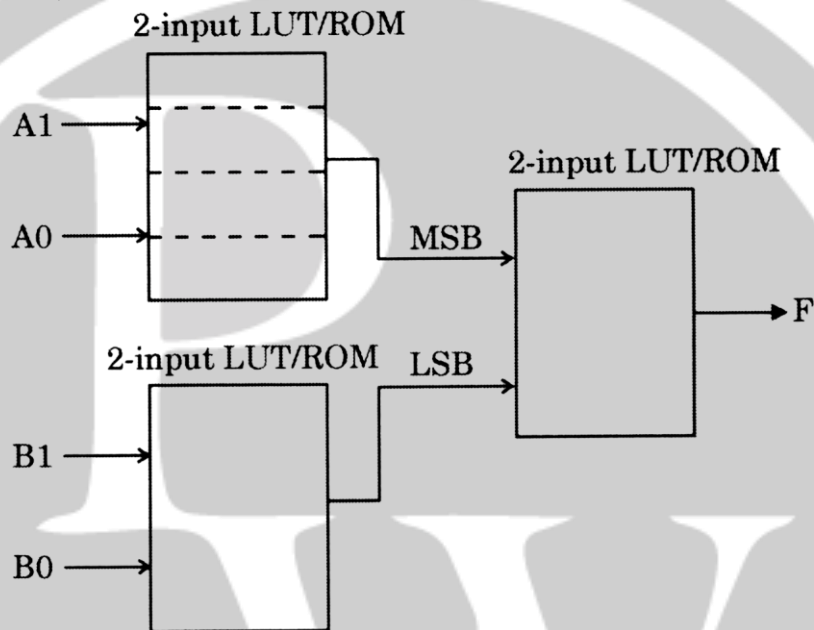
- Q5. (a)** The carrier signal  $c(t) = 8\cos(2\pi \times 10^6 t)$  is frequency modulated by a modulating signal  $m(t) = 5\cos(2000\pi t) + 6\cos(3000\pi t)$ . The frequency sensitivity of the modulator is 103 Hz/volt. Obtain the time domain expression for the FM wave and calculate the maximum frequency deviation, modulation index, transmission bandwidth (using Carson's rule) and average power in the FM wave. 10
- (b)** Prove that the Z-transform of a sampled unit ramp signal is given by  $F(z) = \frac{Tz}{(z-1)^2}$ . 10
- (c)** Consider the following code segment in a function of a process:
- ```
int *y = (int *) malloc (20* size of (int));
```
- When this function is invoked and executed:
- (i) Where is the memory for the variable 'y' allocated within the memory image (heap/stack) of the process and why? 5
- (ii) Where is the memory for the 20 integer variables allocated within the memory image (heap/stack)

of the process and why?

5

- (d) A half-wave dipole situated with its center at the origin in free space radiates a time averaged power of 600 Watts at a frequency of 300MHz. A receiving half-wave dipole antenna is placed at (300 m, 90°, 40°). It is oriented so that its axis is parallel to that of the transmitting antenna. Determine the available power at the receiving antenna. The directivity of half-wave dipole is 2.15 dB. (e) What is the advantage of using a PLA over ROM in the realization of a combinational function? Realize the following Boolean function 'F' of three variables by storing appropriate values and setting proper inputs to a cascade of 2 -input look-up tables (ROM) with only one bit output as shown below:

$$F(A, B, C) = \Sigma(0, 1, 3, 5, 6, 7)$$



- (f) A TCP segment consisting of 1500 bits of data and 160 bits of header is sent to the IP layer, which appends another 160 bits of header. This is then transmitted through two networks, each of which uses a 24-bit packet header. The destination network has a maximum packet size of 800 bits. How many bits, including headers, are delivered to the network layer protocol at the destination? 10

**Q6. (a)** A 100 MHz uniform plane wave is propagating in a lossless medium in positive z-direction. The medium has  $\epsilon_r = 9$  and  $\mu_r = 4$ .

- (i) Determine the propagation constant, wavelength and phase velocity of the wave. 8
- (ii) Assuming electric field in x-direction and magnetic field in y-direction, obtain expressions for Poynting vector and average power of the wave. What will be the average power if  $E_{x0} = 400$  V/m? 12

- (b) Write an 8085 program to generate an approximate digital clock by utilizing the delays associated with different instructions. Assume that the 8085 microprocessor is operating at a clock frequency of 3MHz and a display routine is available to display the binary contents of memory locations 2700H, 2701H and 2702H corresponding to hours, minutes and seconds of a digital clock respectively. 20

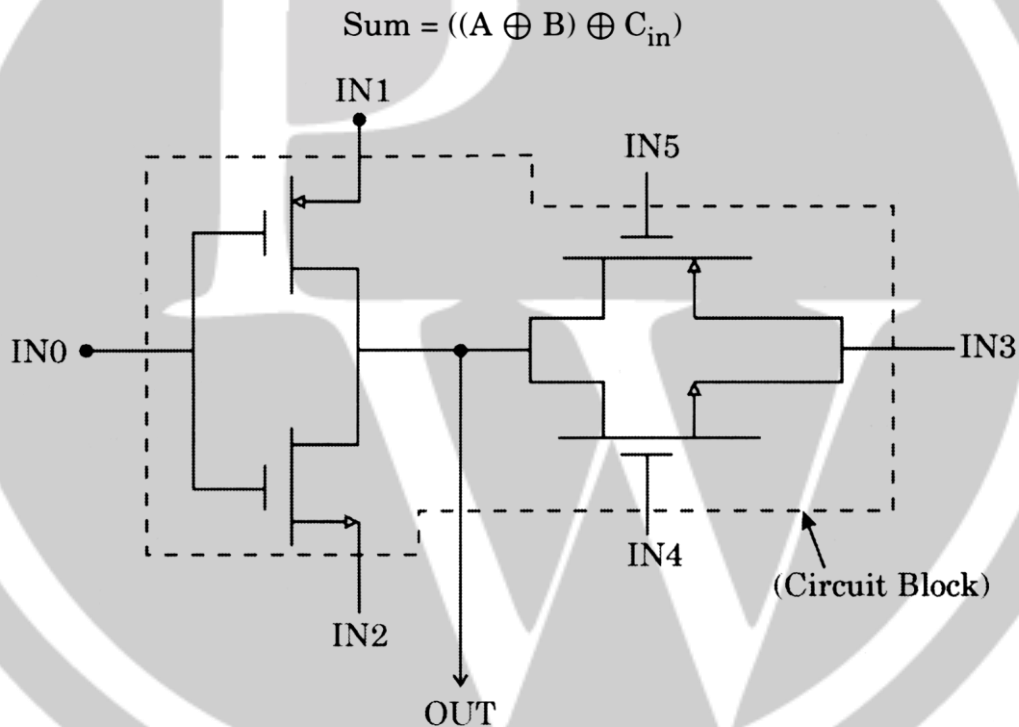
- (c) A continuous 12 km long optical fiber link has a loss of 1.5 dB/km.

- (i) What is the minimum optical power level that must be launched into the fiber to maintain an optical power level of  $0.3\mu\text{W}$  at the receiving end? 10
- (ii) What will be the input power required, if the fiber link is increased by 100% and fiber loss is reduced to 1 dB/km? 10

**Q7. (a)** A certain lossless transmission line is 1.6 m long and has characteristic resistance  $R_0 = 500\Omega$ . The line is operating in air and frequency of operation is 500MHz.

- (i) The line is terminated with a short circuit. It is observed that the maximum voltage at any point on the line is 11.56 volts. What will be the magnitude of input voltage? Determine the current through the short circuit. 10
- (ii) The short circuit is replaced by a resistance load of  $200\Omega$ . The input voltage is varied so that 100 Watts of power is delivered to the load. Find the reflection coefficient, voltage standing wave ratio and power in the incident wave.

**(b)** Realize a 'sum' output of a full adder by using appropriate number of circuit blocks shown below and inverters. 20



The circuit block has six inputs IN0, IN1, ... IN5 and one output 'OUT'.

- (c) (i) A telephone network consists of two end offices and one intermediate switch with a 1MHz full duplex trunk between each end office and the intermediate switch. The average telephone is used to make four calls per 8 hour work day, with a mean call duration of six minutes. Ten percent of the calls are long distance. What is the maximum number of telephones an end office can support? 10
- (ii) In a pure ALOHA system, the channel bit rate is 2400bits/second. Each terminal transmits a 100 bits message every minute. Determine the maximum number of terminals that can use the channel. 10

8. (a) An air-filled rectangular waveguide is to be constructed for single mode operation at 15GHz. The design condition is that the frequency is 20 percent higher than the cut-off frequency for the fundamental mode, while being 20 percent lower than the cut-off frequency for the next higher order mode.
- (i) Determine the guide dimensions a and b. 10
  - (ii) Find the propagation constant, wavelength and phase velocity for the guided mode. 10
- (b) (i) Design a block level architecture of a seven coefficient FIR filter by using appropriate number of multipliers, adders and registers. Assume that all the input operands are available in 8 bit, 2's complement fixed point representation. The architecture should give one output per clock cycle. 12
- (ii) Identify the different blocks required, if the FIR filter is to be realized by using a single multiplier and an adder. Justify your answer. 8
- (c) A QPSK signal is transmitted by satellite. Raised-cosine filtering is used, for which the roll-off factor is 0.2 and a BER of  $10^{-5}$  is required. For the satellite downlink, the losses amount to 200 dB, the receiving earth station G/T ratio is 32dBK(-1), and the transponder bandwidth is 36MHz. Calculate
- (i) the maximum bit rate that can be accommodated. 10
  - (ii) the required equivalent isotropic radiated power. 10

Assume that  $\left(\frac{E_b}{N_o}\right)$  ratio for  $10^{-5}$  BER is 10 dB.