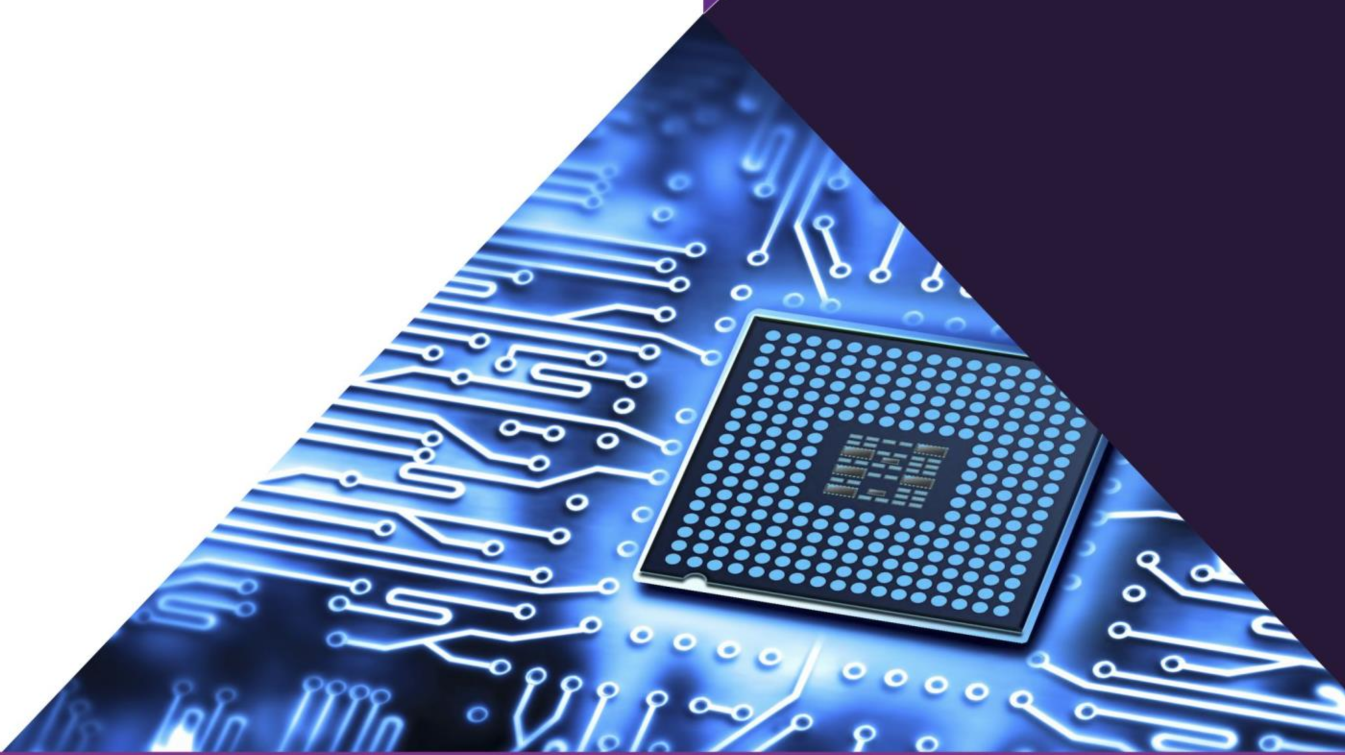
Electronics Engineering

DRDO Scientist B PYQ

2021 Paper 2



ELECTRONICS ENGINEERING

Paper-2

1.(a) Prove that the random process $x(t, \phi) = \frac{\sqrt{E}}{2T}\cos(\omega_0 t + \phi)$ is ergodic, where E, T and ω_0 are constants, and φ is random and UDF (0, 2π). **[10 Marks]**

1.(b) Explain the different masking steps required in the fabrication of a simple NMOS transistor starting from a p-type substrate. **[10 Marks]**

1.(c) A two-word instruction is stored in memory at an address designated by the symbol A. The address field of the instruction (stored at A + 1) is designated by the symbol B. The operand used during the execution of the instruction is stored at an address symbolized by 'C'. An index register contains the value X. State how 'C' is calculated from other addresses if the addressing mode of the instruction is **[10 Marks]**

(i) Direct

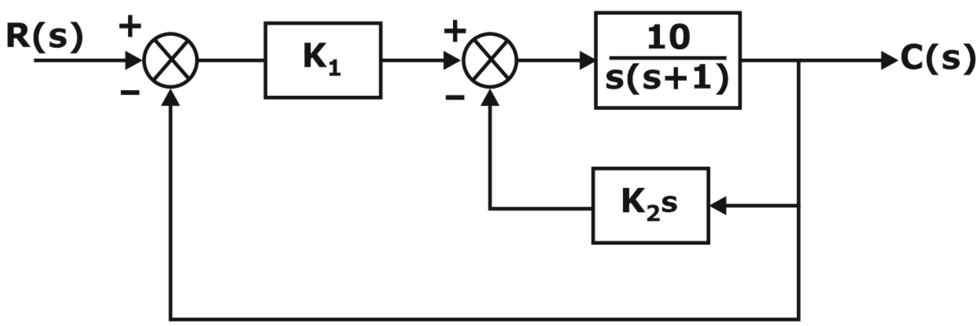
(ii) Indirect

(iii) Relative

(iv) Indexed

1.(d) A 75 Ω resistor is connected to a transmission line of the characteristic impedance of 50 Ω. Compute the VSWR at the termination. **[10 Marks]**

1.(e) Compute the values of K_1 and K_2 to obtain a peak time of 1.6 seconds and a settling time of 3.5 seconds for the closed-loop system shown below in response to a step input. **[10 Marks]**



1.(f) The autocorrelation sequence of a discrete-time stochastic process is $R(K) = \left(\frac{1}{2}\right)^{|K|}$.

Determine its Power Spectral Density. **[10 Marks]**

2.(a) Let s(t) be a digital NRZ signal (±A), which passes through the noisy channel. Channel introduces white Gaussian Noise (ω(t)) having PSD of $N_o/2$. The receiver was designed using Matched Filter, Sample & Hold Circuit. Decision-Making Circuit. Decision-Making circuit uses maximum likelihood algorithm/technique. Compute the following

(i) Output of the Sample & Hold circuit when '–A' is transmitted. **[5 Mark]**

(ii) Variance of the Noisy Signal at the output of S & H Circuit. **[5 Mark]**

(iii) Compute the probability of error when '–A' is received/detected as '+A', and '+A' is interpreted as '–A'. **[10 Marks]**

2.(b) The forward path transfer function of a control system with unity feedback is

$$G(s) = \frac{K}{s(s+a)(s+30)}$$

where 'a' and 'K' are real constants.

(i) Find the value of 'a' and 'K' so that the relative damping ratio of the complex roots of the characteristic equation is 0.5 and the rise time of the unit step response is approximately 1 sec. **[15 Marks]**

(ii) Find the steady-state errors of the system when the reference input is a unit ramp function. **[5 Mark]**

2.(c) Consider the flowing set of process, with the length of the CPU burst given in milliseconds:

Process	Burst Time
P_1	6
P_2	8
P_3	7
P_4	3

(i) Draw the Gantt chart for SJF scheduling **[5 Mark]**

(ii) What is the waiting time for Process P_1, Process P_2 and Process P_3? **[5 Mark]**

(iii) Calculate the average waiting time. **[5 Mark]**

(iv) Calculate the average waiting time for FCFS scheduling. **[5 Mark]**

3.(a) Let there be a transmitter source represented as $[x] = [x_1, x_2, \ldots x_N]$ having N symbols. Let there be a Receiver Having Destination Symbols Vector $[Y] = [y_1, y_2, \ldots y_M]$ having 'M' symbols. Transmitted symbols have to pass through the channel.

(i) Derive the expression for I(X, Y). **[15 Marks]**

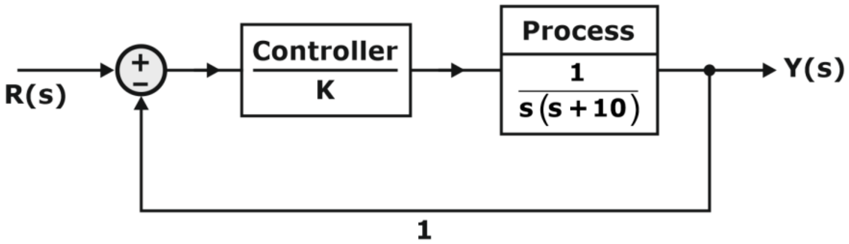
(ii) From the derived expression, compute Max [I(X, Y)] expression.
Explain the meaning of terms. **[5 Mark]**

3.(b) A feedback control system is shown in the following figure. The specification for the closed loop system required that the overshoot in a step input be less than 15%

(i) Determine the corresponding specification M_P in the frequency domain for the closed loop transfer function $\frac{Y(j\omega)}{R(j\omega)} = T(j\omega)$. **[10 Marks]**

(ii) Determine the resonant frequency ω_r. **[5 Mark]**

(iii) Determine the bandwidth of the closed loop system. **[5 Mark]**



3.(c) A digital computer has a memory unit with 28 bits per word. The instruction set consists of 235 different operations. All instructions have an operation code part (op code) and an address part. Each instruction is stored in one word memory.

(i) How many bits are reserved for operation code? **[5 Mark]**

(ii) How many bits are left for the address part of the instruction? **[5 Mark]**

(iii) What is the maximum size for the memory? **[5 Mark]**

(iv) Draw the instruction format and indicate the number of bits in each part. **[5 Mark]**

4.(a) Consider the Narrow Band FM wave.

(i) Determine the envelope of this modulated wave. What is the ratio of maximum to minimum amplitudes? **[5 Mark]**

(ii) Determine the average power of NBFM. **[5 Mark]**

(iii) by expanding the angular argument θ(t) = $2\pi f_c t + \phi t$ of NBFM, wave s(t) in the form of a power series and restricting the modulation index β to a maximum value of 0.3 rad, show that

$$\theta(t) = 2\pi f_c t + \beta \sin(2\pi f_m t) - \frac{\beta^3}{3}\sin^3(2\pi f_m t)$$

Computer the value of Harmonic distortion for β = 0.3 rad. **[10 Marks]**

4.(b) A unity feedback system has a loop transfer function

$$L(s) = \frac{4(s+a)}{s(s+1)(s+3)}$$

(i) Draw the root locus as 'a' varies from '0' to 100. **[10 Marks]**

(ii) Using the root locus, estimate the percentage overshoot and settling time (with a 2% criterion) of the system at a = 2 and a = 4. **[5 Mark]**

(iii) Determine the actual overshoot and settling time at a = 2 and a = 4. **[5 Mark]**

4.(c) **(i)** Explain programming paradigms with examples. **[10 Marks]**

(ii) Write a pseudocode/program to sort given number. **[10 Marks]**

5.(a) **(i)** Let X be a random variable and let Y = (X − μ_X)/σ_X. What is the mean and variance of the random variable Y? **[5 Mark]**

(ii) Compute the mean of $e^{j\omega t}$ where ω is a random variable. **[5 Mark]**

5.(b) Describe the importance of photolithography in the fabrication of Integrated Circuits. How is the junction depth determined after the diffusion of n-bypte dopants in a p-type substrate with a background concentration of $10^{15}/cm^3$? **[10 Marks]**

5.(c) Explain the following terms with example: **[10 Marks]**

(i) Attribute

(ii) Domain

(iii) Entity

(iv) Relationship

5.(d) A reflector antenna used for a cellular base station backhaul ratio link operates at 38 GHz with a gain of 39 dB, a radiation efficiency of 90%, and a diameter of 30 cm. Find the aperture efficiency of this antenna. **[10 Marks]**

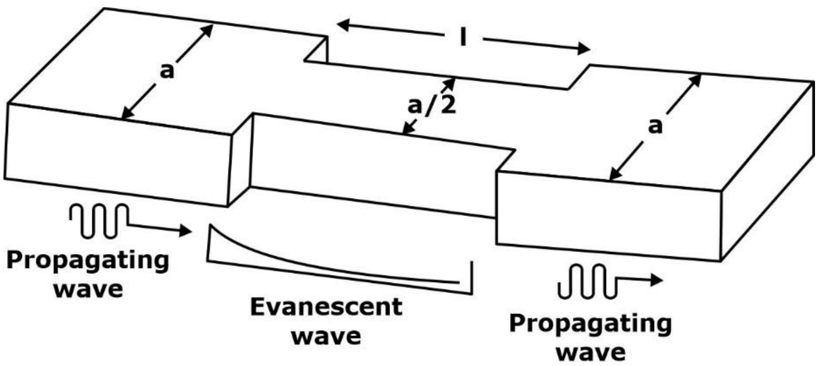
5.(e) Design a pipeline architecture to compute the value of the following summation by using 8-bit adders and 8-bit registers:

Sum = A + B + C + D + E + F + G + H

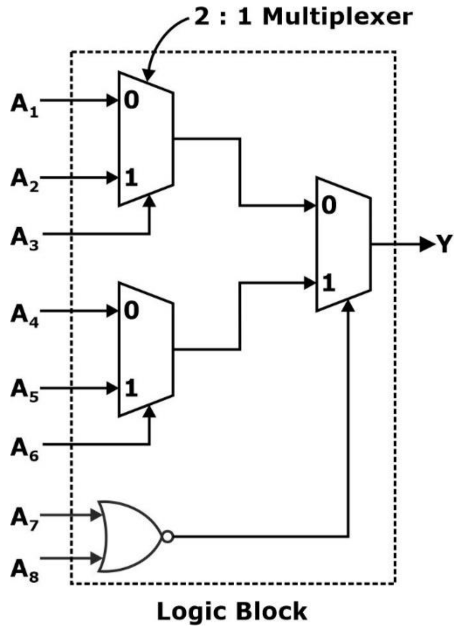
Assume that all the inputs are of 8-bits and the output 'Sum' is also restricted to 8-bits. Moreover, all the inputs and outputs are registered. Also compute its latency. **[10 Marks]**

5.(f) Write down the procedure to compute orthogonal basis function for two given signals ($x_1(t)$ and $x_2(t)$). **[10 Marks]**

6.(a) An attenuator can be made using a section of waveguide operating below cutoff as shown in the following figure. If a = 2.286 cm and operating frequency is 12 GHz, determine the required length of the below-cutoff section of a waveguide to achieve an attenuation of 100 dB between the input and output guides. The effect of reflections at the step discontinuities can be neglected. **[20 Marks]**



6.(b) Realize a full adder Sum = A ⊕ B ⊕ C in output by using only minimum number of multiplexer-based logic blocks as shown below. The 'Sum' output is obtained by appropriately setting all the inputs of these logic blocks. **[20 Marks]**



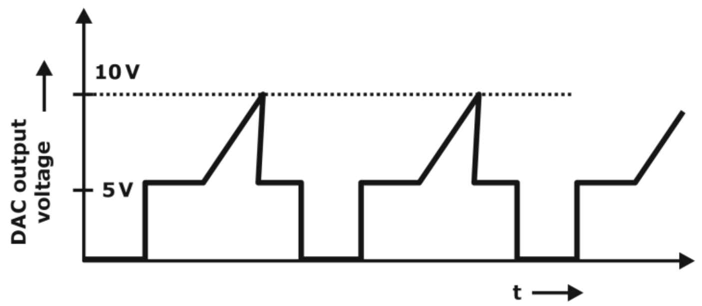
6.(c) Two multimode step index fibers have Numerical Aperture of 0.2 and 0.4 respectively. Both fibers have 1.48 as their refractive index of core. Calculate the insertion loss at a joint in each fiber caused due to 5° angular misalignment of axes of fiber core. Medium between fibers is air. **[20 Marks]**

7.(a) The radial component of the radiated power density of an antenna is given by

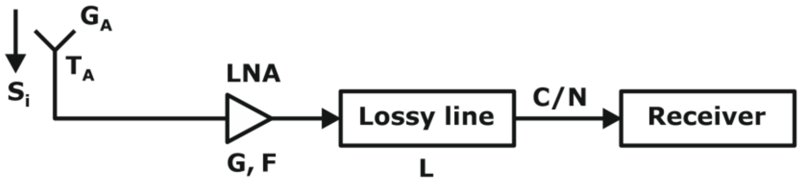
$$W_{rad} = \hat{a}_r w_r = \hat{a}_r A_0 \frac{\sin\theta}{r^2} \, w/m^2$$

Where 'A_0' is the peak value of the power density, 'θ' is the usual spherical coordinate, and '$\hat{a}_r$' is the radial unit vector. Find the maximum directivity of the antenna. Write an expression for the directivity as a function of directional angles 'θ' and 'ϕ'. **[10 +10 Marks]**

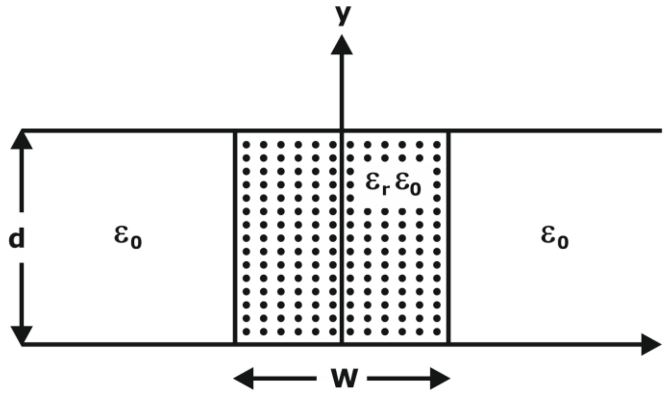
7.(b) Write an 8085 program to generate the following waveform with the help of 8085 microprocessor kit and an 8-bit DAC connected to an output port 'A' of 8255. The output voltage range of DAC is 0V to 10V. the addresses of port 'A' and Control register of 8255 are 00H and 03H respectively. **[20 Marks]**



7.(c) Consider the GPS receiver system given below. the guaranteed minimum L1 (1575 MHz) carrier power received by an antenna on Earth having a gain of 0 dBi is S_i= – 160dBW. A GPS receiver is usually specific as requiring a minimum carrier to noise ratio, relative to a 1 Hz BW, of C/N (Hz). If the receiver antenna actually has a gain G_A, and a noise temperature T_A, derive an expression for the maximum allowable amplifier noise figure, F, assuming an amplifier gain, G and a connecting line loss, L. Evaluate this expression for C/N = 32 dB-Hz, G_A = 5 dB, T_A = 300 K, G = 10 dB and L = 25 dB. **[20 Marks]**



8.(a) Consider the partially filled parallel plate waveguide as shown below. Derive the solution (field and cutoff frequency) of the lowest order TE mode of this structure. Assume the metal plates are infinitely wide. **[20 Marks]**

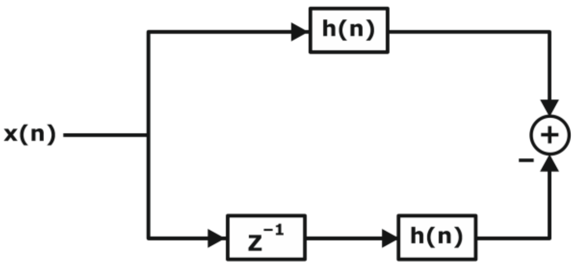


8.(b) **(i)** Find the response y(n) of the system shown below to the input

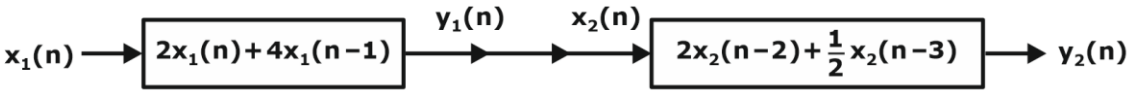
x(n) = u(n + 4) – u(n – 9)

where

$h(n) = b^n u(n)$, – 1 < b < 1. **[10 Marks]**



(ii)



Determine input – output relationship between $x_1(n)$ and $y_2(n)$. Comment, when the sequence is reversed. **[10 Marks]**

8.(c) A 10 kW transmitter amplitude modulates a carrier with a tone m(t) = sin (2000πt), using 50% modulation. Propagation losses between the transmitter and the receiver attenuate the signal by 90 dB. The receiver has a front-end noise No = – 113 dBW/Hz and includes a BPF B_T = 2ω = 10 kHz. What is the post-detection SNR, assuming the receiver uses an envelope detector? **[20 Marks]**

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