INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

Date: 19 Sept., 2023 Time: 1 Hour Total Marks: 30 No. of Students: 35

Dept. of Avionics

Quiz-1

Sub. Name: **Advanced Sensors & Interface Electronics** (B. Tech VII Semester Elective)

Answer All Questions

Question 1 **(7 Marks)**

(a) A sine wave of 1 V amplitude is given as the input to a bipolar 12- bit ADC whose reference voltage ($\pm V_R$) is ± 10 V. Find the SNR of the ADC at the given input level.

(b) Derive the relation between INL and DNL of an ADC. Briefly discuss an application in which INL should be considered as an important specification.

Question 2 **(6 Marks)**

A 3-bit sigma-delta ADC (with reference voltages: -1 V, 1 V) is given an input of 1/3 V. Find the voltages at different nodes of the circuit (at different clock cycles) and the digital-output of the ADC for this input.

Question 3 **(8 Marks)**

Draw the circuit diagram of a LOW-pass-filter based on universal active filter topology. Design this circuit for a natural frequency = 1 kHz, damping ratio = 1, pass-band gain = 1.5.

Question 4 **(5 Marks)**

Derive the expression for output voltage (V_O), in terms of the inputs V_1 and V_2, of the circuit given in Fig. 1. Assume that the frequency (say, f_C) of the clock signal (v_C) is sufficiently high when compared to the frequency of V_1 and V_2. Switches will be at position A when v_C is high and at position B, otherwise.

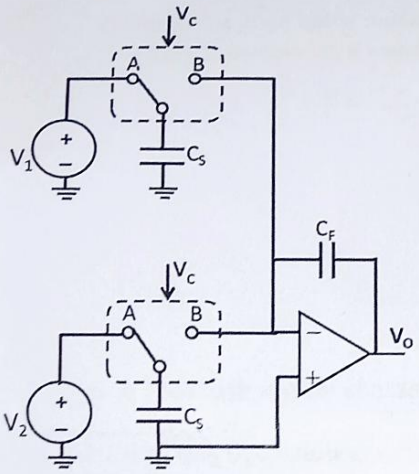

Fig. 1

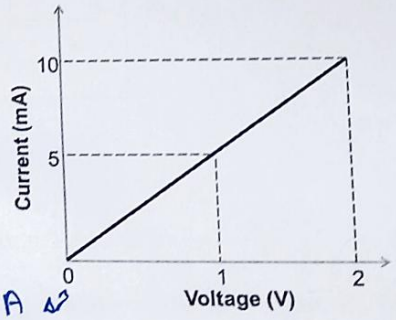

Fig. 2

Question 5 **(4 Marks)**

The approximate I-V characteristic of a diode is shown in Fig. 2. Draw its noise-equivalent model. Find the noise voltage across its terminals for a forward current of 5 mA and noise-bandwidth of 100 Hz.

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INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

Date: 31 Oct., 2023 Time: 1 Hour Total Marks: 30 No. of Students: 37

Dept. of Avionics

Quiz-2

Sub. Name: **Advanced Sensor & Interface Electronics,** Course code: **AV491**

Answer All Questions

Question 1 **(7 Marks)**

Consider a three-input summing amplifier realized using four 10 Ω resistors. The amplifier offers a gain of **-1** to each input. Find the total output-noise at the amplifier output above 0.1 Hz. Assume that OPAMP used has following specifications: (e_{nw} = 20 nV/√Hz, f_{CE} = 200 Hz, i_{nw} = 500 fA/√Hz, f_{CI} = 2 kHz, open-loop-gain = 10^6, gain-bandwidth-product = 1 MHz). Make valid approximations to simplify your solutions.

Question 2 **(7 Marks)**

Internal circuit of a Semiconductor-based Linear Temperature Sensor is shown in the figure. **Derive** and find the value of resistance R will give an overall-sensitivity of 1 μA/K for this sensor. Take Boltzmann constant k =1.4 × 10^{-23}J/K.

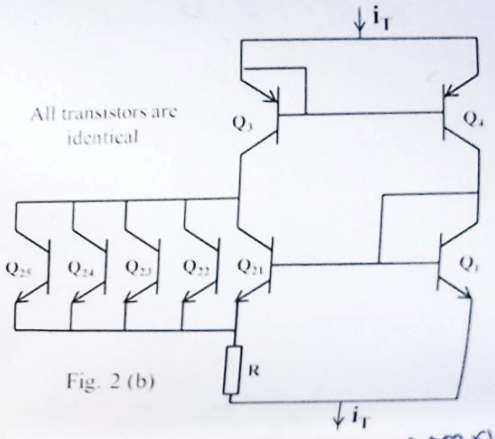

Fig. 2 (b)

Question 3 **(8 Marks)**

Justify any **TWO** *of the following statements. Use illustrative diagrams to aid your explanation.*

(a) *A GMR sensor unit cannot be used for through-shaft angle measurement.*

(b) *Special-shaped electrode structures are required for capacitive sensing of liquid level of a conductive liquid.*

(c) *Two-wire measurement technique can be used for interfacing remotely-located resistive sensor and provide lead-wire compensation.*

Question 4 **(8 Marks)**

(a) Briefly discuss how a phase-detector circuit (with 360° range) can be used for linearization of sine/cosine characteristics of a TMR angle sensor. Draw a neat circuit diagram of this phase detector.

(b) A piezoelectric crystal, acting as a force sensor, is connected using a cable to a voltmeter of purely resistive impedance of 10 MΩ. Crystal and Cable specifications are tabulated next:

Crystal specifications:	Cable specifications:
Charge sensitivity to force = 2 pC N^{-1}	Capacitance = 5 pF
Capacitance = 95 pF	Resistance = 1 GΩ

Obtain the transfer function of this force sensor system, and show that it follows a high-pass filter response.

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Indian Institute of Space Science And Technology

5^{TH} SEMESTER, 2023

Campus: Valiamala

AVIONICS

AV311 - Digital Signal Processing

(Time allowed: ONE hours)

Candidate's Name: _____ ID No: _____

1. Plot the following functions 1. $\phi_0(t) = 1, \quad 0 \le t \le 1/2$

$$\phi_1(t) = \begin{cases} 1 & 0 \le t < 0.5 \\ -1 & 0.5 < t \le 1 \end{cases}$$

$$\phi_2^1(t) = \begin{cases} 1 & 0 \le t < 0.25, \quad 0.75 < t \le 1 \\ -1 & 0.25 < t \le 0.75 \end{cases}$$

$$\phi_2^2(t) = \begin{cases} 1 & 0 \le t < 0.25, \quad 0.5 < t \le 0.75 \\ -1 & 0.25 < t < 0.5, \quad 0.75 < t \le 1 \end{cases}$$

Diagram these functions carefully and write whether they are orthogonal or not ? [2 Marks]

2. **Orthogonal Polynomial Basis :** Let V be a vector space of all polynomials $a_0 + a_1x + a_2x^2 + \cdots + a_nx^n$ with real coefficients. Starting with $\phi_1(x) = c$, obtain c such that $\int_{-1}^{1} \phi_1^2(x) = 1$. Next determine a, b of $\phi_2(x) = ax + b$ such that $\int_{-1}^{1} \phi_2^2(x)dx = 1$ and $\int_{-1}^{1} \phi_1(x)\phi_2(x)dx = 0$. Further determine α, β, γ of $\phi_3(x) = \alpha x^2 + \beta x + \gamma$ such that $\int_{-1}^{1} \phi_3^2(x)dx = 1$ and $\int_{-1}^{1} \phi_3(x)\phi_1(x)dx = 0$, $\int_{-1}^{1} \phi_3(x)\phi_2(x) = 0$. Substitute for the constants and write the final expressions for $\phi_1(x)$, $\phi_2(x)$ and $\phi_3(x)$.
Did you note that V is a vector space of polynomials over real coefficients with respect to addition of polynomials and multiplication by a constant. By solving the above steps, you have determined the first 3 orthogonal basis functions of such a vector space. [6 Marks]

3. **Signal Approximation :** Given the signal $x(t) = 2t, t \in (0, 2)$ as shown in Fig 1a and two basis functions in Fig 1b and Fig 1c,

   (a) Obtain the approximation to $x(t)$ ie., $\widehat{x}(t) = c\phi_1(t)$ by determining the constant c such that $\int_0^2 |x(t) - \widehat{x}(t)|^2 dt$ is minimized. Plot $x(t)$ and $\widehat{x}(t)$. Compute the energy of $\widehat{x}(t)$.

   (b) Obtain the approximation to $x(t)$ ie., $\widehat{x}(t) = c\phi_1(t) + d\phi_2(t)$ by determining the constants c, d such that $\int_0^2 |x(t) - \widehat{x}(t)|^2 dt$ is minimized. Plot $x(t)$ and $\widehat{x}(t)$. Compute the energy of $\widehat{x}(t)$.

   (c) Obtain the approximation to $x(t)$ ie., $\widehat{x}(t) = e\phi_3(t) + f\phi_4(t)$ (as shown in Fig 2a and 2b)by determining the constants e, f such that $\int_0^2 |x(t) - \widehat{x}(t)|^2 dt$ is minimized. Plot $x(t)$ and $\widehat{x}(t)$. Compute the energy of $\widehat{x}(t)$.

   Do you observe any difference in the way the coefficients were computed. Are the enrgies of the approximations the same as that of the $x(t)$? [9 marks]

Fig 1a

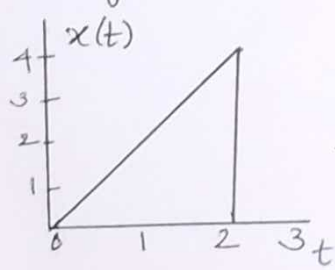


Fig 1b

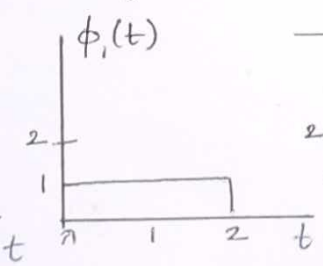


Fig 1c

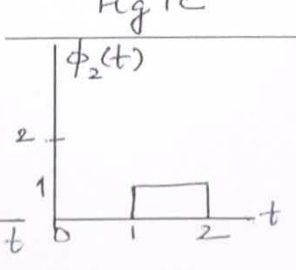


Fig 2a

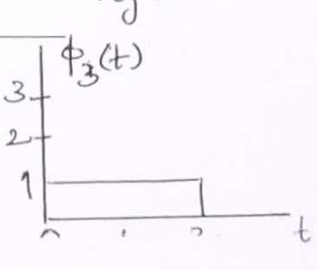
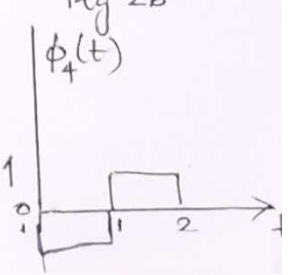


Fig 2b



Indian Institute of Space Science And Technology

5^{TH} SEMESTER, 2023

Campus: Valiamala

AVIONICS

AV311 - Digital Signal Processing

(Time allowed: ONE hours)

Candidate's Name: _____ ID No: _____

1. Determine which of the systems are stable, which are casual. [6 Marks]
   (a) $G(z) = H(z)H^*(z^*)$
   (b) $G(z) = H(z^{-1})$
   (c) $G(z) = H(-z)$

2. A signal $y(n)$ contains a primary signal plus two echos : [3 Marks]

$$y(n) = x(n) + 0.5x(n - n_d) + 0.25x(n - 2n_d) \quad (1$$

   Find a realizable filter tha can recover $x(n)$ from $y(n)$.

3. The relationship between the input and output of an FIR system is as follows : [6 Marks]

$$y(n) = \sum_{k=0}^{N} b(k)x(n - k) \quad ($$

   Find the coefficients $b(k)$ of the smallest order filter that satisfies the following conditions :
   (a) The filter has generalized linear phase.
   (b) It completely rejects a sinusoid of frequency $\omega_0 = \pi/3$
   (c) The magnitude of the frequency response is equal to 1 at $\omega = 0$ and at $\omega = \pi$.

Indian Institute of Space Science and Technology Trivandrum
End Semester Examination - AV311, Digital Signal Processing

Faculty : R. Lakshminarayanan

May 31, 2023

1 1. If $x_1(n)$ is even $x_2(n)$ is odd, then what is $x_1(n)x_2(n)$? (Even/odd) (1 Mark)

6 2. What is the impulse response of an ideal integrator (discrete time) circuit. (2 + 1 + 1 + 1 = 5 Marks)

(a) Plot the poles/zeros for system ?

(b) Is the system stable (based on the pole-zero plot)

(c) Is the system BIBO stable.

11 3. A discrete time signal $x(n)$ is delayed by Δ samples, where Δ can be an integer or a fraction. Obtain the impulse response of the system that effects both integer or fraction delay. (5 Marks)

14 4. A 90 degree phase shifter circuit has the system response

$$H(e^{j\omega}) = \begin{cases} -j & 0 < \omega < \pi \\ j & -\pi < \omega < 0 \end{cases}$$

Obtain the impulse response of the system. (3 Marks)

15 5. If the impulse response of a system is $h(n)$, what is the transfer function of the system $g(n) = (-1)^n h(n)$? (1 Mark)

17 6. What is fundamental period of the following signals (1+1 = 2 Marks)

(a) $x(n) = \cos(0.125\pi n)$

(b) $x(n) = \cos(0.2n)$

20 7. $x(n) = A\cos(2\pi 300/1000n) + A\cos(2\pi 301/1000n)$. How many samples N of $x(n)$ need to acquired to distinctly identify the presence of these components in the Fourier spectra ? (3 Marks)

23 8. Two discrete impulses occur spaced τ seconds apart. What is the minimum bandwidth required for the system that detects these impulses distinctly. (3 Marks)

27 9. Plot the Poles and zeros for the simplest Type I, II, III and IV systems. (4 Marks)

33 10. Obtain and plot the $N-$point DFT of (3 + 3 = 6 Marks)

(a) $x[n] = \delta(n)$ (b) $x[n] = \cos(2\pi rn/N), 0 \leq n \leq N-1$; r = integer

36 11. A sequence of ± 1 is interpolated using the pulse

$$\phi_T(t) = \frac{\sin(\pi/T(t-kT))}{(\pi/T(t-kT))}$$

what is the equation of the resulting analog signal $x(t)$? Hint : Plot it (3 Marks)

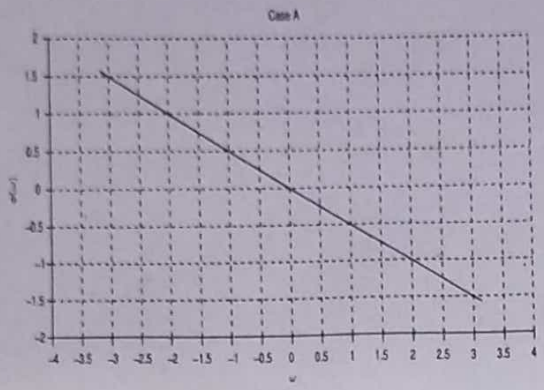
37 12. A radio broadcasting signal bandlimited to frequency of 12 kHz and time limited to 1 Min. How many samples are required to represent the analog signal without loss of information. (1 Mark)

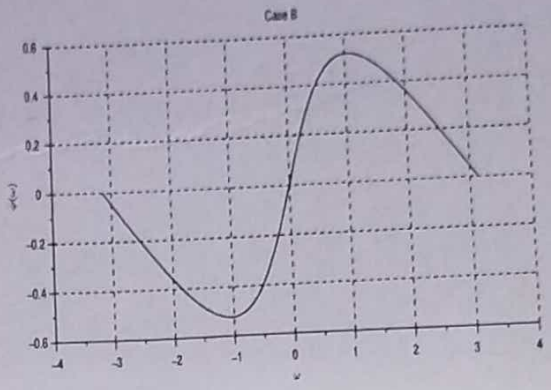
39 13. Which of the following is a valid auto-correlation function (2 Marks)

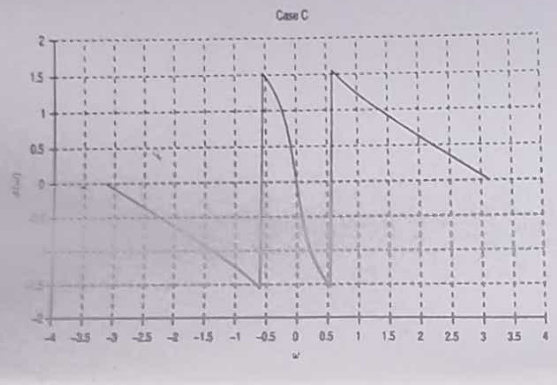
(a) $r_x(k) = \delta(k-1) + \delta(k+1)$

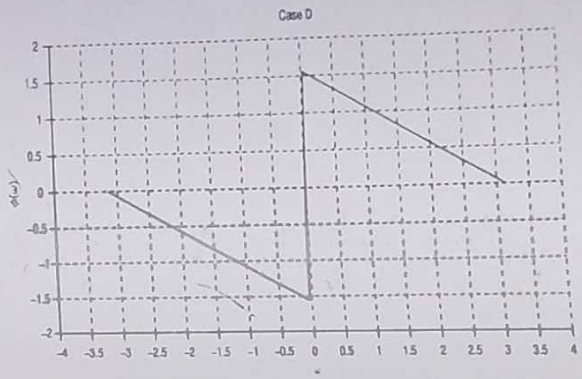
(b) $r_x(k) = 3\delta(k) + 2\delta(k-1) + 2\delta(k+1)$

for Ques 15









43 14. A length-6 sequence xn is defined for $0 \leq n \leq 5$ as[2+2 = 4 Marks]

$$\{x[n]\} = \{0, 1, 2, 3, 4, 5\} \quad (1)$$

The DTFT of $\{x[n]\}$ is obatined ~~at 8 equi-spaced point~~.

(a) Write the sequence that will obtained by applying 8-point DFT inverse.

(b) Write the sequence that will obtained by applying 4-point DFT inverse.

48 15. Identify the property of (or type of) system impulse response for given phase response. (1+1+1+1+1 = 5 Marks)

(a) $< H(e^{j\omega}) = 0$

(b) Given a phase response as shown in Fig Case A, what can you tell about the nature of impulse reponse.

(c) Given that the system contains a pole at the origin, the phase plot shown in Fig Case B corresponds to what kind of zero placement ?

(d) Given that the system contains a pole at the origin, the phase plot shown in Fig Case C corresponds to what kind of zero placement ?

(e) Given that the system contains a pole at the origin, the phase plot shown in Fig Case D corresponds to what kind of zero placement ?

52 16. From the given Pole-Zero plots for the different cases, [4]

(a) Case A : Is the system real/Complex ?

(b) Case A : Is the system Stable and Causal ?

(c) Case B : Is the system Stable ?

(d) Case C : Is the system a valid All Pass system ?

(e) Case D : Is the system a valid All Pass system ?

54 17. From the given Pole-Zero plot of a mixed phase system, mark/draw the minimum phase-allpass factorization [2 Marks]

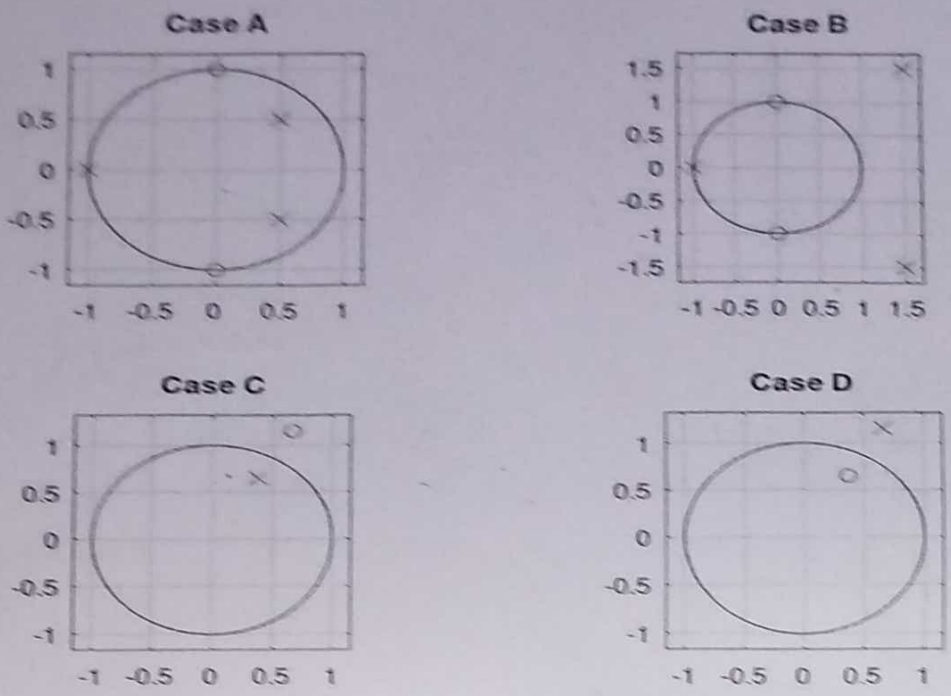


Figure 1: Problem 16

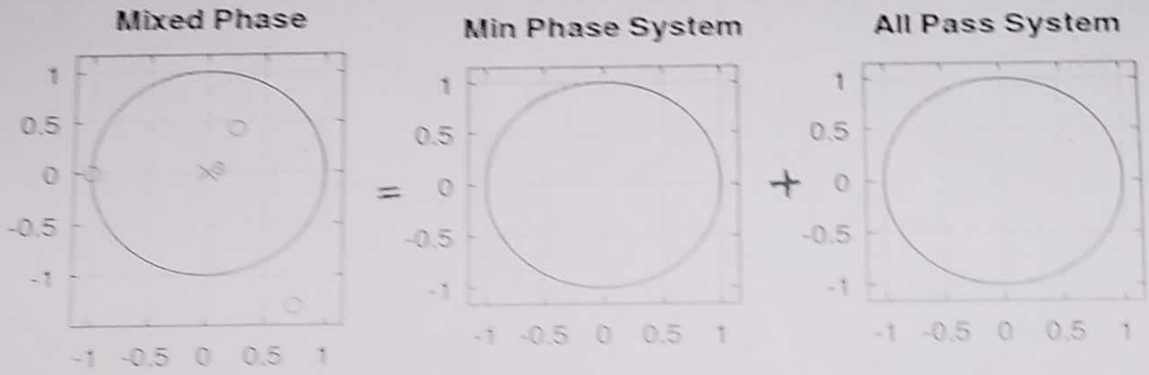


Figure 2: Problem 17

Indian Institute of Space Science and Technology
AV314 - Communication Systems I
Department of Avionics

Quiz 1 for Semester V on 15/09/2023

Note to the student

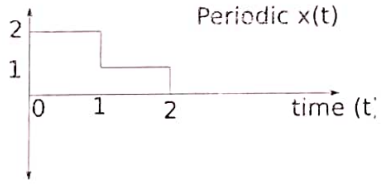
1. There are **5 questions** in this question paper on **2 pages**, for a total of **15 marks**.
2. Answer **all** questions.

Question 1 (2 marks): Suppose $x(t)$ is periodic with period T seconds. Suppose the Fourier series exists for $x(t)$ and $(x_k,\ k \in \mathbb{Z})$ are the Fourier series coefficients. How do we represent the Fourier series as a Fourier transform?

Question 2 (2 marks): Consider an LTI system with frequency response $H(f) = -jsgn(f)$ where $sgn(.)$ is the sign function. Let $x(t)$ be a real-valued signal which is the input to this system and $y(t)$ be the corresponding output from the above LTI system. Show that $x(t)$ and $y(t)$ are orthogonal.

Question 3 (6 marks):

1. Consider a periodic signal $x(t)$ which has a period of 2 seconds. The signal is defined over one period as shown below. Find out the Fourier series representation of $x(t)$. (2 marks)



2. Suppose $x(t)$ is the following aperiodic signal. Find out the Fourier transform of $x(t)$. (4 marks)

$$x(t) = \begin{cases} t, & \text{for } t \in [0,1], \\ 2-t, & \text{for } t \in [1,1.5], \\ 0, & \text{otherwise.} \end{cases}$$

Question 4 (2 marks): Using a signal flow diagram/block diagram, explain how you would **transmit and receive** a baseband voice signal, with a two-sided bandwidth of 10kHz over a passband channel of one-sided bandwidth 10 kHz, centered at 1 GHz. What modulation and demodulation scheme would you use? Clearly indicate these in your block diagram. Also draw the Fourier magnitude spectrum of the signal that you obtain at the output of the modulator.

Question 5 (3 marks): Let $m(t) = 2cos(2\pi 500t) + 5cos(2\pi 1000t)$ be a baseband audio signal. This message signal needs to be transmitted over a baseband channel with spectrum $H(f)$ (the following specification includes the phase) as follows

$$\begin{aligned} H(f) \;=\; & 1, \text{ for } |f| \in [0, 800], \\ & 0.7, \text{ for } |f| \in (800, 1200], \\ & 0.5, \text{ for } |f| \in (1200, 1500], \\ & 0, \text{ otherwise.} \end{aligned}$$

Describe what transmitter and receiver functions you would use (i.e. the $t(.)$ and $r(.)$ functions) so that you would be able to recover $m(t)$ at the destination. (All frequencies are in Hertz.)

Best of luck!

Indian Institute of Space Science and Technology
AV314 - Communication Systems I
Department of Avionics

Quiz 2 for Semester V on 27/10/2023

Note to the student

1. There are 4 questions in this question paper on 2 pages, for a total of 15 marks.
2. The first question has 5 sub-questions. Please write only the final answers for these 5 sub-questions. Rough work for these questions should be done separately.
3. Answer all questions.

Question 1 (5 marks):

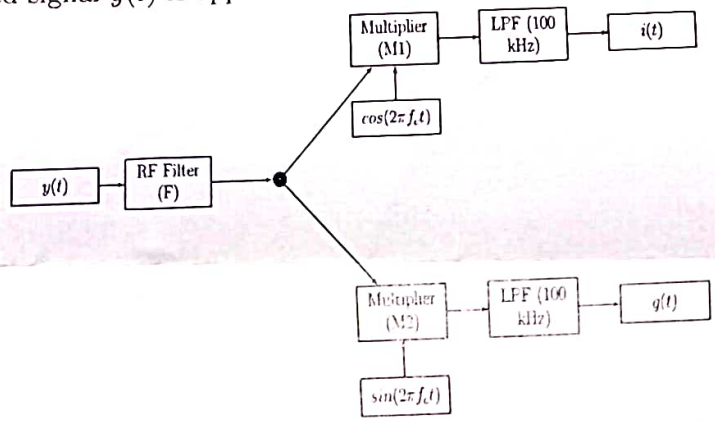
1. Suppose $J_n(\beta)$ denotes the n^{th} order Bessel function of the first kind with argument β. For small values of β, what are the approximate values for $J_n(\beta)$ for $n \in \{0, 1, 2, 3 \dots\}$?
2. Consider a plain-AM system with a carrier frequency of $500kHz$ that is modulated by a baseband signal with one sided bandwidth of $10kHz$. The modulated signal is demodulated by an envelope detector containing an ideal diode with zero on-resistance. If the load resistance used in the envelope detector circuit has a value of $1k\Omega$, what is an appropriate value of the capacitance so that the baseband signal can be recovered by the envelope detector?
3. A signal $m(t)$ with a power of $1W$ and one-sided bandwidth of $1kHz$ is wideband FM modulated using a carrier $0.5cos(2\pi f_c t)$ and a maximum frequency deviation Δf. What is the the power of the transmitted signal?
4. A baseband signal with one sided bandwidth of $10kHz$ is FM modulated with a frequency deviation of 20 kHz. What is the one-sided bandwidth of the generated FM signal.
5. Suppose the baseband signal $m(t) = 2cos(2\pi 10t)$ is modulated using plain-AM with a modulation sensitivity of 0.1. The modulation is done using the carrier $5cos(2\pi 500t)$. What is the power efficiency of this scheme?

Question 2 (3 marks): Consider a FM modulator which uses a VCO with a free running frequency of $200kHz$. The sensitivity of the VCO is such that when modulating a baseband signal the modulated signal has a maximum frequency deviation of $25Hz$. Draw a block diagram of a system (which may involve frequency multiplications and/or mixing) that can generate an FM signal at a center frequency of $96MHz$ with a maximum frequency deviation of approximately $76kHz$. Assume that a local oscillator with an output frequency of $10.8MHz$ is available.

Question 3 (3 marks): Weaver's method for SSB modulation:

1. Draw a block diagram to show the different steps in Weaver's method for SSB modulation (1 mark).
2. Consider a general baseband signal $m(t)$ which has to be SSB modulated using Weaver's method. Suppose $u(t)$ and $l(t)$ are complex signals that correspond to the lower and upper sidebands of $m(t)$. Explain how Weaver's method can be used to generate an upper side band SSB signal; the explanation should be done using the Fourier transforms $U(f)$ and $L(f)$ of $u(t)$ and $l(t)$ respectively (2 marks).

Question 4 (4 marks): Suppose $m(t)$ is $cos(2\pi 100t)$. A signal $x(t)$ is obtained by narrowband frequency modulation of $m(t)$ with a frequency modulation index $\beta \ll 1$ using a carrier $cos(2\pi f_f t)$, with $f_f = 1$ MHz.
The signal $x(t)$ is sent through an ideal channel such that the received signal $y(t)$ is $x(t)$ itself. The received signal $y(t)$ is applied to a demodulator shown in the following figure:



The RF filter (F) is an ideal bandpass filter with passband from $1MHz$ to $1.2MHz$ (the passband includes these two frequencies). The output $f(t)$ from the RF filter is applied to two multipliers M1 and M2 as shown. The multipliers multiply the signal $f(t)$ with the locally generated signals $cos(2\pi f_c t)$ and $sin(2\pi f_c t)$ leading to the signals $i(t)$ and $q(t)$. The low pass filters (LPF) are assumed ideal with bandwidth of $100kHz$. The frequency f_c for the locally generated signals is 1.1 MHz.

1. Write down an approximate expression for the passband signal $x(t)$, as well as its approximate bandwidth. Justify your approximation.
2. Write down the complex baseband equivalent $f_b(t)$ of the passband signal $f(t)$ centered at 1.1 MHz
3. Describe mathematically the signals $i(t)$ and $q(t)$

Best of luck!

Indian Institute of Space Science and Technology
AV314 - Communication Systems I
Department of Avionics

Final Exam for 5th Semester, B.Tech (ECE) on 06/12/2023

Note to the student

1. There are **10 questions** in this question paper on **3 pages**, for a total of **50 marks**.
2. Answer all questions. You have three hours.
3. Credit will be given only for answers which are written legibly, clearly, and with complete steps. Clearly state any assumptions that you are making.
4. **Your answer to a single question should be on contiguous pages of your answer sheet and should not be interleaved with other answers.**
5. **The question number corresponding to your answer should be clearly written.**
6. The notation $\mathbb{I}_A(x)$ is used for the indicator function (or boxcar function).

Question 1 (3 marks): Consider a FM receiver system which uses a limiter-discriminator for demodulation of a baseband signal $m(t)$.

1. What is pre-emphasis and de-emphasis filtering? Using a block diagram show where pre-emphasis and de-emphasis filtering is used within a FM system.
2. Why do you need pre-emphasis and de-emphasis filtering? Explain using a discussion of the noise signal and its power spectrum for a limiter-discriminator based FM receiver. You should use a block diagram for this explanation, clearly label the signals and corresponding power spectra for this discussion.

Question 2 (5 marks): Suppose $(X(t), t \in (-\infty, \infty))$ is a real valued continuous time random process which is wide sense stationary. Let the autocorrelation function of the random process be $R_{XX}(\tau) = e^{-a|\tau|}$, where τ is the time lead/lag variable and a is a finite positive real number. Find out the output power when $X(t)$ is passed through a ideal bandpass filter with unit gain and one-sided bandwidth of $2W$ centered at f_c.

Question 3 (6 marks): A real valued deterministic signal $s(t)$ in a communication system has a Fourier spectrum (or transform) $S(f)$ which is defined as

$$S(f) = \begin{cases} 1 - |f|, \text{ for } f \in [-1, 1], \\ 0, \text{ otherwise.} \end{cases}$$

The receiver in this system, receives a signal $y(t) = s(t)+N(t)$, where $N(t)$ is a random noise signal. The random noise signal $N(t)$ has a power spectral density 0.01 for all frequencies, i.e., it is white. The received signal $y(t)$ is passed through an ideal low pass filter with frequency response $H(f)$ defined as:

$$H(f) = \begin{cases} 1, & \text{for } f \in [-B, B], \\ 0, & \text{otherwise.} \end{cases}$$

Derive the signal to noise ratio (SNR) at the filter output for the cases $B = 1$ and $B = 1/2$. For what B is the SNR better? Comment on whether the better SNR obtained at the cost of signal distortion.

Question 4 (6 marks):

1. For a real baseband signal $m(t)$ (with one-sided bandwidth B_m) write down the modulated signal obtained using: (a) DSBSC, and (b) upper side band SSB. Both modulated passband signals should have the same power (Note that this is transmit power.) Assume that the carrier frequency for DSBSC is f_c while the SSB signal lies in the band f_c to $f_c + B_m$.

2. Consider DSBSC and SSB receivers which are modelled to have an additive white Gaussian noise source of zero mean and power spectral density of $N_0/2$. Obtain the SNR for both DSBSC and SSB after demodulation and recovery of $m(t)$.

3. Compare the SNR of DSBSC and SSB.

Question 5 (8 marks):

1. Using a block diagram explain superheterodyne receiver architecture for FM signal reception.

2. Explain what is image frequency interference. How will you mitigate image frequency interference?

3. Consider a radio receiver that needs to receive a FM channel that has a one-sided bandwidth of 1MHz at 1800.5 MHz. In order to hear this channel satisfactorily, any nearby channels need to be attenuated by a factor of at least 60 dB. We want to design a superheterodyne receiver with a intermediate frequency (IF) of 300 MHz. The intermediate frequency is generated by a local oscillator that is tunable from 1900 to 2250 MHz, with any frequency divider circuits if needed. Design a superheterodyne receiver (use a block diagram in order to present your design) to receive the channel at 1800.5 MHz. For the superheterodyne receiver that you have designed, what is the image frequency corresponding to the channel above? Assume that any interfering image signal should be attenuated by a factor of at least 100 dB. Specify the requirements on the response of the RF and IF filters and show how the IF signal required for mixing is generated.

Question 6 (3 marks): A continuous time random process $X(t), t \in (-\infty, \infty)$ is defined as $X(t) = Acos(2\pi f_c t + \Theta)$ where A, f_c are positive real constants and Θ is a random variable, uniformly distributed in the interval $[0, 2\pi]$. Is $X(t)$ wide sense stationary? Justify mathematically.

Question 7 (5 marks):

1. A stationary Gaussian process $(X(t))$ has zero mean and power spectral density $S_{xx}(f)$. Determine the probability density function of the random variable $X(t_k)$ where t_k is an arbitrary time instant.

2. A stationary Gaussian process $(X(t))$ has zero mean and power spectral density $S_{xx}(f) = \mathbb{I}_{[-B,B]}$ where $\mathbb{I}$ is the boxcar function. Determine the joint probability density function of the random variables $X(t_1)$ and $X(t_2)$ where $t_1 < t_2$ are two arbitrary time instants.

Question 8 (5 marks):

1. Write down an example of an IID random process. What is the finite dimensional distribution for this process?

2. Suppose X is a Binomial random variable with parameters $n = 10$ and $p = 0.3$. Let a random process $Y(t)$ be defined as $X + t$. Prove whether $Y(t)$ is wide sense stationary or not.

Question 9 (5 marks): Let $m(t)$ be the signal $cos(2\pi f_m t)$. Assume that $x_1(t)$ is obtained by the SSB-modulation of $m(t)$ using the carrier $cos(2\pi f_c t)$. Also assume that f_m is very small compared to f_c. In order to try and de-modulate the SSB signal using envelope detection, we transmit the signal $x(t) = x_1(t) + acos(2\pi f_c t)$. Suppose we assume that $x(t)$ is received as it is without any distortion or noise addition. Obtain the output of an ideal envelope detector (which acts like an ideal rectifier followed by an ideal filter) when $x(t)$ is applied to it. Is it possible to recover $m(t)$ back from $x(t)$ using this ideal envelope detector? Are there any conditions that a needs to satisfy for this to happen?

Question 10 (4 marks): Suppose $m(t)$ is a baseband real valued signal bandlimited to $[-f_m, f_m]$ Hz. Let $x(t) = A + m(t)$, where A is a positive real valued constant. Let $x_s(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\delta(t - nT_s)$, where $T_s = \frac{1}{10f_m}$. Assume that $x_s(t)$ is transmitted over an ideal bandpass channel with lower and upper cutoff frequencies $8f_m$ and $12f_m$ (only the positive frequencies are stated here). Let $y(t)$ be the output of the above bandpass channel. Assume that $\hat{m}(t)$ is obtained by applying $y(t)$ to an ideal envelope detector (which acts like an ideal rectifier followed by an ideal filter). What is the relationship between $\hat{m}(t)$ and $m(t)$? Make and state appropriate assumptions on A.

Best of luck! (Maximum marks: 50)

Indian Institute of Space Science and Technology (IIST)
B. Tech, Avionics 3rd Year
Quiz 1 Question Paper
RF and Microwave Communication (AV 313), V Semester

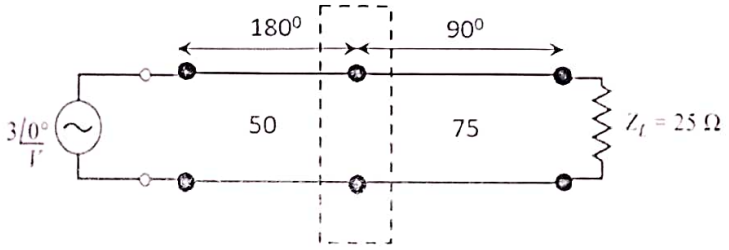
Marks: 15 Date of Exam: September 18 '2023 Time: 1 Hr

Note: Make suitable assumptions if necessary and mention them clearly. Smith chart problem should be done in pencil in case you want to erase it you can. In the smith chart problem write your name and roll no also mention the question number.

It is a closed book exam; No Formula Sheet is allowed. Answer should be brief and to the point and the same questions answer should be at the same place.

1. (a) For a general two port microwave network prove the condition for being lossless.[2]

(b) For the circuit given below, determine the S matrix of the portion shown in the rectangular dotted portion. If a voltage of 3V (shown below) is applied at its input determine analytically the voltage developed across the load of 25 ohm. Also draw the SFG (Signal Flow Graph) of the over-all circuit. [Note: Two transmission Lines connected are ideal here and their electrical length and characteristic impedances are specified in the figure.] [2] + [3] + [1]



(c) A two-port network is known to have the following scattering matrix. Assume that the measurement is taken at 1.8 GHz and both the ports are having 50-ohm characteristic impedance

$$[S] = \begin{bmatrix} 0.15\angle 0^\circ & 0.85\angle -45^\circ \\ 0.85\angle 45^\circ & 0.2\angle 0^\circ \end{bmatrix}$$

i) Determine the input reflection coefficient in dB if the output port is terminated with a 75-ohm load using SFG. [2]

ii) Using SFG determine the input reflection coefficient in dB if the port 1 is terminated with a source of 3V with 0^0 phase and with an internal resistance of 75 ohm and if the load connected at the output is remained same of 75 ohm like previous [1]

2. (a) Design an 'L' section lumped matching circuit to transform a load Z_{LOAD} = 50 ohm to a source impedance of Z_{source} =20+j20 ohm at 1.8 GHz. Use the given ZY smith chart to solve the problem. [2]
[No need to consider the Complex conjugate of the load. Navigate from Z_{LOAD} to Z_{source} in the smith chart. Designed matching circuit should attenuate all very high frequency signal.]

(b) Solve the above problem theoretically with considering the Q of the network and verify your result with your finding in problem (a) above [2]

END

Indian Institute of Space Science and Technology (IIST)
B. Tech, Avionics 3rd Year
Quiz 2 Question Paper
RF and Microwave Communication (AV 313), V Semester

Marks: 15 Date of Exam: October 30 ' 2023 Time: 1 Hr

Note: Make suitable assumptions if necessary and mention them clearly. Smith chart problem should be done in pencil in case you want to erase it you can. In the smith chart problem write your name and roll no also mention the question number.

If it is not mentioned, the symbols and variables usually have their own meaning. It is a closed book exam; No Formula Sheet is allowed. Answer should be brief and to the point and the same questions answer should be at the same place.

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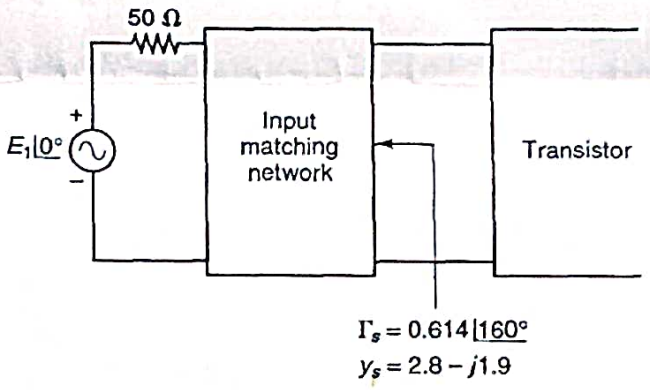
1. (a) Design the distributed Microstrip based Matching Network for the following circuit. Mention the length of the line in terms of the free space operating wavelength. Use the given Z smith chart for solving the problem. [2]



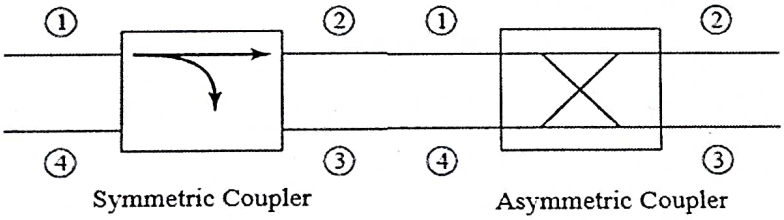
(b) Design a three-section binomial multi-section transformer to match a 100-ohm load to a 50-ohm line. Calculate the best return loss that can be obtained between 2 and 3 GHz (considering 2.5 GHz as resonating frequency) to attain a fractional bandwidth (FBW) of 70 percent. Also draw the signal flow graph of the above multi-section transformer considering the theory of small reflection. [2] + [1] = [3]

(c) What is Bode Fano criteria. Consider any fixed type of load to define the same. [1]

2. (a) Obtain the scattering parameters of the 3 dB Wilkinson Equal split power divider using Even and Odd Mode analysis. [3]
(b) Find the coupling factor (C) and the directivity (D), return loss (RL) and isolation (I) of the directional coupler whose scattering matrix is given below [4]

$$[S] = \begin{bmatrix} 0.1\angle 40^\circ & 0.944\angle 90^\circ & 0.178\angle 180^\circ & 0.0056\angle 90^\circ \\ 0.944\angle 90^\circ & 0.1\angle 40^\circ & 0.0056\angle 90^\circ & 0.178\angle 180^\circ \\ 0.178\angle 180^\circ & 0.0056\angle 90^\circ & 0.1\angle 40^\circ & 0.944\angle 90^\circ \\ 0.0056\angle 90^\circ & 0.178\angle 180^\circ & 0.944\angle 90^\circ & 0.1\angle 40^\circ \end{bmatrix}$$

(c) Two ideal 3 dB symmetric and asymmetric couplers are connected as shown below. Find the resulting phase and amplitudes at port 2 and 3 (at final output stage of the second coupler) relative to port 1 of the first coupler. (Assume the incoming signal at port 1 is of magnitude 1 milli Watt and phase of -90^0 as shown below in figure, port 4 of the first stage is terminated with 50 ohm) [2]



END

Indian Institute of Space Science and Technology (IIST)
B. Tech, Avionics 3rd Year
End-Sem Question Paper
RF and Microwave Communication (AV 313), V Semester

Marks: 50 | Date of Exam: December 8' 2023 | Time: 3 Hr

Note: Make suitable assumptions if necessary and mention them clearly. Smith chart problem should be done in pencil in case you want to erase it you can. In the smith chart problem write your name and roll no also mention the question number.

If it is not mentioned, the symbols and variables usually have their own meaning. It is a closed book exam; No Formula Sheet is allowed. Answer should be brief and to the point.

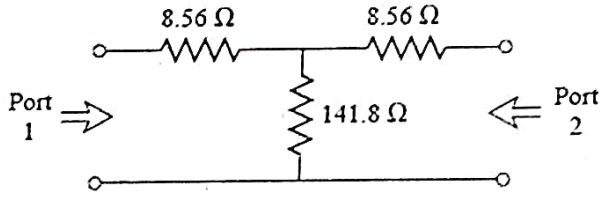
(10) 1. (a) A four-port network has the scattering matrix shown as follows. [1] + [2] = [3]

$$[s]=\begin{bmatrix} 0.1\angle 90^0 & 0.6\angle -45^0 & 0.3\angle -45^0 & 0 \\ 0.6\angle -45^0 & 0 & 0 & 0.4\angle 45^0 \\ 0.3\angle -45^0 & 0 & 0 & 0.3\angle -45^0 \\ 0 & 0.4\angle 45^0 & 0.3\angle -45^0 & 0 \end{bmatrix}.$$

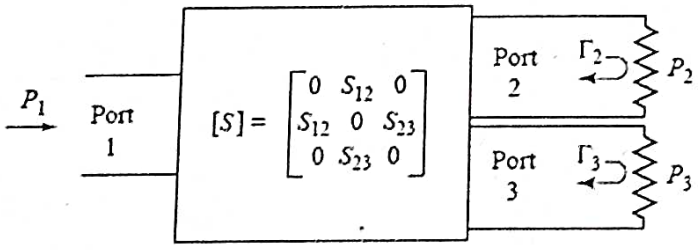
(i) Is this network lossless?
(ii) What is the reflection coefficient seen at port 2 if port 1 is made open and all other ports are terminated with matched loads?

(b) Draw the signal Flow graph of a reciprocal and lossless 3 port microwave network whose two ports are not matched. [2]

(c) Find the scattering parameters of the 3 dB attenuator circuit shown. [2]



(d) Use signal flow graphs to find the power ratios P2/P1 for the mismatched three-port network shown in the accompanying figure. [3]



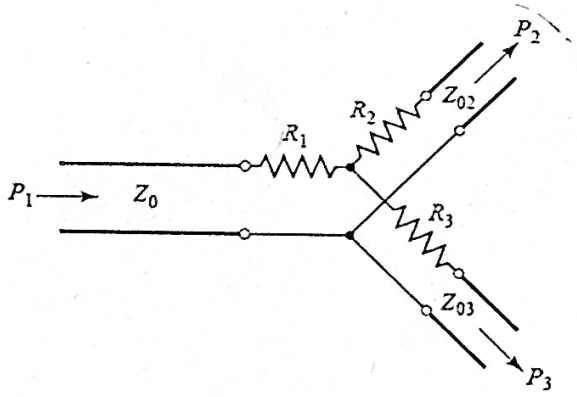
(17) 2. (a) Design a low pass lumped matching network to transform a 200-ohm load to a 20-ohm source impedance at 2.5 GHz in the given smith chart. Take 200 ohm as your characteristic impedance. Navigate from Load to source in the smith chart. [3]

(b) If the above impedance matching (in Question 2 (a)) is to be such that it uses a 3 section multi-section binomial quarter wave transformer for minimum reflection coefficient value of 0.05. Demonstrate the scheme and design the over-all circuit to achieve that operation at 2.5 GHz. Implement and draw the over-all circuit lay-out of this matching. [4]

(c) An ultra-wideband (UWB) radio transmitter, operating from 3.1 to 10.6 GHz, drives a parallel RC load with R = 75 ohm and C = 0.6 pF. What is the best return loss that can be obtained with an optimum matching network? [3]

(d) Using signal Flow Graph approach explain how quarter wave transformer shows zero reflection even if the discontinuity exists at the junction. [2]

(18) 3. (a) Consider the general resistive divider shown below. For an arbitrary power division ratio α = P2/P3, derive expressions for the resistors R1, R2, and R3, and the output characteristic impedances Zo2 and Zo3 so that all ports are matched, assuming the source impedance is Z0.[4]



(b) Draw the circuit diagram of a 180^0 Hybrid Coupler and Determine which port is acting as a differential Port. Why that particular port is acting as differential port? Explain the reason qualitatively and quantitatively using odd and even mode analysis. [1] + [3] = [4]

(c) which capacitance (even and odd mode) is more for coupled lines and why so? [3]

(d) For a lossless power divider which divides power in 1:3 ratio in its output port 2 and 3 respectively, obtain its input reflection coefficient looking into port 2 and 3. Also Determine the transmission magnitude and phase between input port and port 2? [4]

(e) Draw the SFG of the cascaded 2-section coupled line coupler each having 20 dB coupling coefficient at 3 GHz. Determine the total coupling at the coupled port of the first coupler. [3]

4. (a) Design a maximally flat low-pass filter (draw the lumped circuit) with a cut-off frequency of 2 GHz, impedance of 50 and filter order of 5. This is having at least 15 dB insertion loss at 3 GHz. Draw the circuit diagram and calculate the lumped inductor and capacitor values. [g_1 = 0.618, g_2 = 1.618, g_3 = 2, g_4 = 1.618, g_5 = 0.618, g_6 = 1] [3]

(10)

(b) Design a low pass fourth order maximally flat filter using only shunt stubs. The cut-off frequency is 8 GHz and the impedance is 50 ohms. [Draw the circuit diagram/ layout] [4]
Assume the values [g_1 = 0.7654, g_2 = 1.8478, g_3 = 1.8478, g_4 = 0.7654, g_5 = 1.00]

(c) Design a stepped-impedance low-pass filter (draw the circuit diagram/layout) with cut off frequency of = 2.0 GHz and R_0 = 50 ohm, assume a maximally flat N = 5 response, and solve for the necessary electrical line lengths and physical line length considering the circuit printed in a microstrip substrate having thickness 1.6 mm, permittivity of 4.2 and loss tangent of 0.02. Assume the stepped section impedances to be Z_l = 10 ohm (Low) and Z_h = 150 ohm (High) [g_1 = 0.618, g_2 = 1.618, g_3 = 2, g_4 = 1.618, g_5 = 0.618, g_6 = 1] [3]

no width req.

END

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM 695 547

Quiz I - September 2023

B.Tech - V Semester

MA311 - Probability, Statistics and Numerical Methods

Date: 11/09/2023 **Time: 09.00 am - 10.00 am** **Max. Marks: 15**

Answer all questions.

1. A bin contains 3 different types of disposable flashlights. The probability that a type-1 flashlight will give over 100 hours of use is 0.7, with the corresponding probabilities for type-2 and type-3 flashlights being 0.4 and 0.3, respectively. Suppose that 20 percent of the flashlights in the bin are type-1, 30 percent are type-2, and 50 percent are type-3. What is the probability that a randomly chosen flashlight will give more than 100 hours of use? Given that a flashlight lasted over 100 hours, what is the conditional probability that it was a type-3? [3]

2. Let $f : \mathbb{R} \longrightarrow \mathbb{R}$ be a function defined by $f(x) = a(x - b)$ for all $x \in (1,\ 2)$ and $f(x) = 0$ otherwise where $a, b \in \mathbb{R}$. Find the values of a and b so that f becomes a density function of a random variable with mean $5/3$. [3]

3. Let $X \sim b(n, p)$. Find the mean and variance of X. [3]

4. Two coins are flipped. The first coin will land on heads with probability 0.6, the second with probability 0.7. Assume that the results of the flips are independent, and let X count the total number of heads. Find the probability mass function of X. [3]

5. Let X be a random variable with density function given by $f(x) = \dfrac{1+x}{2}$ for all $x \in (-1, 1)$ and $f(x) = 0$ otherwise. Find the density function of $Y = X^2$. [3]

END

Indian Institute of Space Science and Technology

Quiz II - October 2023

B.Tech 5th Semester

MA 311 - Probability, Statistics and Numerical Analysis

Date : 19th Oct 2023 **Time: 9.00 am to 10.00 am** **Max. Marks: 15**

May attempt all the questions.

1. Let (X, Y) has the following joint density function.

$$f(x,y) = \begin{cases} 8xy & 0 \leq y \leq x \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

Are X and Y independent? Find $P(X > 0.25 \,|Y = 0.5)$. [3 marks]

2. 4% of LED bulbs manufactured by a company are defective. The company's Quality Control manager is quite concerned and therefore randomly samples 100 bulbs coming off of the assembly line. Let X denote the number in the sample that is defective. Find the probability that the sample contains at most three defective bulbs? [3 marks]

3. In an exam, the mean score of the students is 70 and the variance is 16. With proper explanation find the probability that a student's score will lie within 3 standard deviations on either side of the mean score? [3 marks]

4. Let X, Y and Z are three independent random variables whose mgfs are given by $M_X(t) = e^{3e^t-3}$, $M_Y(t) = (\frac{3}{5}e^t + \frac{2}{5})^8$ and $M_Z(t) = (\frac{3}{5}e^t + \frac{2}{5})^2$. Find $P(X + Y + Z = 2)$. [3 marks]

5. While attempting to hit a target in a three-dimensional space, suppose that the coordinate errors are independent normal random variables with mean 0 and standard deviation 2 unit. Find the probability that the distance between the point of hit and the target is maximum 5 unit.

[3 marks]

6. From past experience it is known that the weights of salmon grown at a commercial hatchery are normal with a mean that varies from season to season but with a standard deviation that remains fixed at 0.3 pounds. A sample observation of size 16 from hatchery shows that the weights of salmon are $9.5, 11.5, 10, 12.25, 8.75, 13, 10.5, 9.75, 14.25, 11, 12.5, 13.75, 7.75, 14.5, 8, 12$. Find a 90% confidence interval for mean weight of the salmons. If we want to be 95% certain that our estimate of the present season's mean weight of a salmon is correct to within ± 0.01 pounds, how large a sample is needed? [3 marks]

PTO for Statistical Tables

Indian Institute of Space Science and Technology

End Semester Examination - November 2023

B.Tech 5th Semester

MA 311 - Probability, Statistics and Numerical Methods

Date : 29th Oct 2023 **Time: 9.30 am to 12.30 pm** **Max. Marks: 50**

Section - A

Answer any 8 questions. 2.5 marks × 8 = 20.

1. Let $X \sim p(\lambda)$. Show that $E[X^n] = \lambda E[(X+1)^{n-1}]$. Use this result to compute $E[X^3]$.
2. Let $X \sim N(0,1)$. Find the density of X^2.
3. Let X and Y independent random variables such that $M_{X^2}(t) = (1-2t)^{-1/2}$ and $M_Y(t) = e^{2t^2}$. Assume that the density of X takes both positive and negative values and is an even function. Find $P(X+Y \geq 0)$. [Hint: What is X? Look at Question 2]
4. Let $X, Y, Z, W \sim N(\mu, \sigma^2)$ such that X, Y, Z and W are independent. Show that

$$\frac{\sqrt{2}(X-Y)}{\sqrt{Z^2+W^2+2\mu^2-2\mu(Z+W)}} \sim t(2).$$

5. Let $X_i \sim N(0, \sigma_i^2)$ where $\sigma_i = 2^i$ for all $i = 1, 2, 3$. Assume that X_i's are independent. Find the mean and variance of $X_1^2 + X_2^2 + X_3^2$. [3 marks]
6. We call an estimator $\hat{\Theta}_n$ of an parameter θ to be consistent for θ, if for any $\varepsilon > 0$, we have $\lim_{n \longrightarrow 0} P(|\hat{\Theta}_n - \theta| \geq \varepsilon) = 0$. With explanation give example of an estimator which is not unbiased but that is consistent.
7. Give an example of a positive sequence $\{\epsilon_n\}$ converging to zero in such a way that $\lim_{n\to\infty} \frac{\epsilon_{n+1}}{\epsilon_n^p} = 0$ for some $p > 1$, but not converging with any order $p' > p$.
8. Derive the following numerical schemes used for solving the first order ODE, $x' = f(t,x)$ with $x(t_0) = x_0$.

   (a) $x_{k+1} = x_k + h\ f\left(t_k + \frac{h}{2}, x_k + \frac{h}{2} f(t_k, x_k)\right)$

   (b) $x_{k+1} = x_k + \frac{h}{2}\left[f(t_k, x_k) + f(t_k + h, x_k + h\ f(t_k, x_k))\right]$

   Check whether the proposed schemes are consistent? Find the order of the truncation error.
9. Consider the integral $I = \int_{-1}^{1} |x|\, dx$, whose exact value is evidently 1. Suppose I is approximated by the composite trapezoidal rule $T(h)$ with $h = \frac{2}{n},\ n = 1, 2, 3, \cdots$.

   (a) Show that $T\left(\frac{2}{n}\right) = 1$ if n is even.

(b) Determine $T\left(\frac{2}{n}\right)$ for n odd and comment on the speed of convergence.

Section - B

There are 6 questions in this section. Each question carries 6 marks. One may attempt all the questions. However, one can score maximum 30 marks.

10. (a) Police plan to enforce speed limits by using radar traps at four different locations within the city limits. The radar traps at each of the locations L1, L2, L3, and L4 will be operated 40%, 30%, 20%, and 30% of the time. A person who is speeding on her way to work has probabilities of 0.2, 0.1, 0.5, and 0.2, respectively, of passing through these locations.
    i. What is the probability that she will receive a speeding ticket?
    ii. Given that she has received a speeding ticket, which is the most probable location from which she got the ticket.

    [3 marks]

    (b) Let the joint density function of the random variables X and Y is given by

$$f(x,y) = \begin{cases} \dfrac{e^{-x/y}e^{-y}}{y} & if\ x,y \in \mathbb{R}^+ \\ 0 & otherwise \end{cases}$$

    Are X and Y independent? Find $P(X > 0 \,|Y = 1)$. [3 marks]

11. (a) i. State and prove Markov's inequality.
    ii. Error in an experiment follows a distribution with mean .001 and variance .04. What can you say about the probability that the error will not exceed 50% of the standard deviations from the mean?

    [3 marks]

    (b) Each computer chip made in a certain plant will, independently, be defective with probability 0.025. If a sample of 100 chips is tested, what is the approximate probability that more than 5 chips will be defective? [3 marks]

12. (a) It is know from the previous experiences that in an exam, roughly 40% of the students get grade-B. In a year a batch of 2500 studnets are apprearing the exam. Find the probability that more than 120 students will get grade-B. [3 marks]

    (b) Let X and Y independent random variables such that $M_X(t) = (1-2t)^{-1/2}$ and $M_Y(t) = (1-2t)^{-3/2}$ $\times e^{2t^2}$. Assume that the density of X takes both positive and negative values and is an even function. Find $P(X + Y \geq 0)$. [Hint: What is X?] [3 marks]

13. (a) The following data resulted from 24 independent measurements of the melting point of lead in celsius.

330	322	345	328.6	331	342	342.4	340.4
329.7	334	326.5	325.8	337.5	327.3	322.6	341
340	333	343.3	331	341	329.5	332.3	340

    Assume that the measurements can be regarded as constituting a normal sample whose mean is the true melting point of lead. Find an ML estimate of the mean of the concerned population. [3 marks]

(b) The following measurements were recorded for the drying time, in hours, of a certain brand of latex paint: 3.4, 2.5, 4.8, 2.9, 3.6, 2.8, 3.3, 5.6, 3.7, 2.8, 4.4, 4.0, 5.2, 3.0, 4.8, 3.2. Assume that the measurements represent a random sample from a normal population. With explanation, find a 90% confidence interval for the mean drying time for the next trial of the paint. Find the maximum error involved in this estimation with 95% confidence. [3 marks]

14. (a) Suppose $|f''(k)| \leq K$ for $a \leq x \leq b$. If E_T and E_M are the errors in the trapezoidal and Midpoint Rules, then prove that

$$|E_T| \leq \frac{k(b-a)^3}{12n^2} \quad \text{and} \quad |E_M| \leq \frac{k(b-a)^3}{24n^2}$$

(b) Let $f \in C^4[a,b]$. Derive the Simpson's Rule for integration.

$$\int_a^b f(x)\, dx = \frac{b-a}{6}\left(f(a) + 4\, f((a+b)/2) + f(b)\right)$$

15. (a) Derive the Newton's Method for solving the nonlinear equation $f(x) = 0$. Under what conditions on $f(x)$ the method converges? If it converges what will be the order of convergence considering the repeated roots.

(b) Let $f \in C^2(I)$ be given, for some interval $I \subset \mathbb{R}$, with $f(\alpha) = 0$, for some $\alpha \in I$. For a given $x_n \in I$, consider the Newton's iteration

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Show that there exists a point ξ_n between α and x_n such that

$$\alpha - x_{n+1} = -\frac{1}{2}(\alpha - x_n)^2 \frac{f''(\xi_n)}{f'(\xi_n)}$$

PTO for Statistical Tables

Indian Institute of Space Science and Technology (IIST)
Department of Avionics [www.iist.ac.in]

5th Semester B.Tech ECE Quiz-1
AV 312: Computer Architecture and Organization, Aug-Dec 2023

Name:
Student ID:
Date: 13/09/2023 **Duration: 1 hour** **Max Score: 15**

Make suitable assumptions, if necessary, and clearly state them. Answers should be marked with question/branch question numbers properly. Clear and legible steps are important for answers. COx stands for Course Objective x which can be ignored by students as these notations are used by the instructor for Outcome Based Education with Multi-track Modular Teaching in order to enhance the teaching-learning process at IIST.

1. **[CO1, CO2] (1 points)** What are interrupts? How do they work?

2. **[CO1, CO2] (2 points)** What are the main design issues in Bus interconnects?

3. **[CO1, CO2] (3 points)** Consider a processor similar to 8085 which needs to interface with a memory of size 64KB. Due to the lower price of the 16K memory chips which have four-bit words in each cell, you preferred to use that chip. Design the interface circuitry necessary to achieve and operate the 64KB memory with the processor.

4. **[CO1, CO2] (3 points)** In a processor with clock speed of 100MHz, the bus width is 16 lines. Addressing memory takes about 3 cycles and one cycle is essential for a word transfer. What will be the time taken to transfer 320 byte data between the memory and CPU using the following two cases: (i) normal data transfer and (ii) bulk data transfer. Make suitable assumptions. Also estimate the maximum data transfer rate in bits per second in both the cases.

5. **[CO1, CO2] (3 points)** In a computer system, there are three levels of memory, L1, L2 and L3. The L1 is of size 1KB, L2 is of size 1MB, and L3 is of size 20MB and each of these levels, respectively, has access time of 0.001uS, 0.01uS, and 0.1uS. Assuming that the same hit rate applies to every level, compare and contrast the average access performance for the system when the hit rate is (i) 30% and (ii) 90%. How good the multi-level memory compared to a single level memory with access time of 0.01uS.

6. **[CO5] (3 points)** Describe your Track-4 Innovative R&D project including the design details.

----------All the best----------

Indian Institute of Space Science and Technology (IIST)
Department of Avionics [www.iist.ac.in]

5th Semester B.Tech ECE Quiz-2
AV 312: Computer Architecture and Organization, Aug-Dec 2023

Name:
Student ID:
Date: 26/10/2023 **Duration: 1 hour** **Max Score: 15**

Make suitable assumptions, if necessary, and clearly state them. Answers should be marked with question/branch question numbers properly. Clear and legible steps are important for answers. Course instructor will not be available during the examination. COx stands for Course Objective x which can be ignored by students as these notations are used by the instructor for Outcome Based Education with Multi-track Modular Teaching in order to enhance the teaching-learning process at IIST.

1. **[CO1] (1 point)** What are Vega, Aries, and Thejas in the context of Indian CPUs?

2. **[CO1, CO2, and CO5] (5 points)** You are required to design a computer peripheral I/O system to communicate between two CPUs similar to 8085 or other Intel family CPUs. Provide the logic circuit diagram, addressing mechanism, control signals, and associated details for the Master CPU to Slave CPU interface. Also provide the program in assembly language for the Sender (Master) CPU to the Receiver (Slave) CPU. The sender side program must first send the number of bytes to be transferred before actually transferring the bytes. The receiver should receive the number of bytes to be received from the sender before start receiving the data bytes. Provide detailed logic/interface diagrams and program. Sufficient comments/remarks are required to easily understand the program. **[Hint: You can consider using 8255 programmable peripheral interface].**

3. **[CO1 and CO2] (3 points)** What are the different types of I/O? Compare and Contrast Memory mapped I/O and I/O mapped I/O.

4. **[CO1 and CO2] (3 points)** What are cache write policies? Describe some of the major write policies and explain in detail.

5. **[CO5] (3 points)** Explain your Track-4 R&D project in detail with Design details, technical drawings, and the roles played by each member of the group in the form of a table.

----------All the best----------

Indian Institute of Space Science and Technology (IIST)
Department of Avionics [www.iist.ac.in]
5th Semester B.Tech ECE Finals
AV 312: Computer Architecture and Organization, Aug-Dec 2023

Name:
Student ID:
Date: 04/12/2023 **Duration: 3 hours** **Max Score: 50**

Answers should be marked with question/branch question numbers properly. Clear and legible question numbers and answer steps are important for answers. Course instructor may not be available during the examination. COx stands for Course Objective x which can be ignored by students as these notations are used by the instructor for Outcome Based Education with Multi-track Modular Teaching (MT2) in order to enhance the teaching-learning process at IIST. Further, as per the MT2 method, questions belonging to various tracks are included.

Make suitable assumptions, if necessary, and clearly state them.

1. **[CO1, CO2, and CO5] (20 points) A billionaire friend of yours, Malone Esk, contacted you for a highly advanced computer system design.** He contracted a deal with you for designing his new Moon colony housing modules. Despite your initial busy schedule, finally, you gave in to his friendly push to take this responsibility. His only reason for signing you for this design mission was **your passion and deep interest for computer architecture and organization.**

   A sample unit of his Moon colony consists of two housing modules, one Mother housing module and another Daughter housing module. Each of these modules consists of an enclosure with access control and ambience control. A Mother module controls the ambience of multiple Daughter modules. Each of these modules has a separate CPU. The key ambience control decisions and optimizations are taken at the Mother module and passed on to the Daughter module to take action. Local switch controls within a Daughter module are handled locally by the Daughter module CPU. Sensors are controlled by the Daughter module, however, decisions are sent by the Mother module. The Mother module CPU is acting as master where the daughter module CPU will follow as a slave. Mother module will communicate with the Daughter module for all the ambience control decisions made. Mother module CPU will take and pass the decisions such as actuators turning ON or OFF etc. based on the sensor readings.

   You are required to do a computer-controlled ambience maintenance for a sample housing unit and the Daughter housing module. Appropriate programmable peripheral interface design between Mother module and Daughter module is needed.

   The ambience requirements for the Daughter modules are listed as follows.

   a. Temperature to be maintained between 20-25 degree Celsius. If temperature exceeds, AC needs to be turned ON to reduce the temperature. If temperature is lower than the acceptable range, then a heater is to be turned ON. Decisions for the ambience maintenance was taken by Mother CPU and implemented by the Daughter CPU.
   b. Humidity to be maintained at a healthy level of 30-50%. If humidity is lower than the acceptable range, then a small water spray device needs to be turned ON to improve the humidity. If humidity is higher than the range, then a device called Esk-Humidity-Remover needs to be turned on to bring the humidity from ambience. Esk-Humidity-Remover is a magical device invented and patented by Esk himself to create water out of thin air. A side-benefit of his device is to reduce humidity in the ambience.
   c. The lights are to be controlled using switches connected to the Daughter module CPU. Three LED lights are to be controlled using three switches. Another two switches are used for intensity levels. There are four intensity levels possible for the LED lighting system. Switch controls are done by Daughter CPU only.
   d. Access to the module is controlled through a switch system where switch pad that generates a binary single digit code is used for access. Code number 9 is used for the default access. The door is actuated by a liver mechanism which is controlled by an electrical relay. Access switch control is handled by the Daughter CPU.

Detailed design diagram, Mother-Daughter CPU-CPU interfaces, interface logic circuitry, interface chips, address, data, and control lines, and program to control and manage for both the Mother module and daughter module of the colony are essential for him. Detailed, logical circuit diagram, address, data, and control lines, as well as interface designs are mandatory.

Malone, in fact, is a very tough person! So, you agreed to do it in the best possible way.

2. **[CO1, CO2] (6 points)** A computer consists of a processor and an I/O device D connected to main memory M via a shared bus with a data bus width of one word. The processor can execute a maximum of 10^6 instructions per second. An average instruction requires six machine cycles, three of which use the memory bus. A memory read or write operation uses one machine cycle. Suppose that the processor is continuously executing "background" programs that require 90% of its instruction execution rate but not any I/O instructions. Assume that one processor cycle equals one bus cycle. Now suppose the I/O device is to be used to transfer very large blocks of data between M and D.
   a. If programmed I/O is used and each one-word I/O transfer requires the processor to execute three instructions, estimate the maximum I/O data-transfer rate, in words per second, possible through D.
   b. Estimate the same rate if DMA is used.

3. **[CO1, CO2] (6 points)** Consider a magnetic disk drive of a computer with 8 surfaces, 512 tracks per surface, and 64 sectors per track. Sector size is 1 KB. The average seek time is 8 ms, the track-to-track access time is 1.5 ms, and the drive rotates at 5000 rpm. Successive tracks in a cylinder can be read without head movement.
   a. What is the disk capacity?
   b. What is the average access time? Assume this file is stored in successive sectors and tracks of successive cylinders, starting at sector 0, track 0, of cylinder i.
   c. What is the burst transfer rate?
   d. Estimate the time required to boot the Operating System of the computer if the essential OS files constitute a size of 10MB.

4. **[CO1, CO2, CO3] (6 points)** What are pipelining Hazards? Define and explain speedup factor. What is the impact of such hazards. How to handle such hazards? Explain in detail.

5. **[CO1, CO2, CO3] (6 points)** A nonpipelined processor has a clock rate of 2.5 GHz and an average CPI (cycles per instruction) of 4. An upgrade to the processor introduces a five-stage pipeline. However, due to internal pipeline delays, such as latch delay, the clock rate of the new processor has to be reduced to 2 GHz.
   a. What is the speedup achieved for a typical program?
   b. What is the MIPS rate for each processor?
   c. What is the speedup achieved if there is a structural hazard for instruction fetch and storage of results?

6. **[CO5] (6 points)** Explain the final design including the system architecture, design parameters, design optimizations, of your Track-4 R&D project. Also explain the roles played by the members of the project.-

----------All the best----------