

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND
COMPUTER ENGINEERING**

BINDER REPORT COVER PAGE

ELEG 4300 COMMUNICATION THEORY

SPRING 2022 SEMESTER

NAME OF INSTRUCTOR: Dr. Shumon Alam

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Above Average (Graded original work)

Average (Graded original work)

Below Average (Graded original work)

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Above Average (Graded original work)

Average (Graded original work)

Below Average (Graded original work)

II. Detailed Course Syllabus
(Distributed to Students at the beginning of the Semester)
ABET Outcomes measured using course should be
explicitly listed in the syllabus

Course Description in ABET Format

ELEG 4300 Communication Theory

1. **Course number and name:** ELEG 4300 COMMUNICATION THEORY
2. **Credits and contact hours:** 3 credit hours; 5 contact hours
* Subject Area: **Engineering Topics**
3. **Instructor's or course coordinator's name:** Dr. Shumon Alam
4. **Text book: Title:** MODERN DIGITAL AND ANALOG COMMUNICATION SYSTEMS
Author: B. P. Lathi and Zhi Ding
Publisher, Year & Edition: Oxford University Press, 2019, 5th edition
 - a. Other Supplemental material: Analog and Digital Communications, Hwei P. Hsu, Schaum's Outline Series, 2003
5. **Specific course information**
 - a. Brief description of the content of the course (catalog description): ELEG 4300 Communication Theory. (3-0) Credit 3 semester hours, Signals and spectra. Transmission and processing of signals. Continuous-wave modulation and pulse modulation. Baseband pulse transmission and passband digital transmission. Signal space analysis. Information measures.
 - b. Prerequisites or Co-requisites: ELEG 3302 Signals and Systems
MATH 3302 Probability and Statistics
 - c. ** Indicate whether a required, elective, or selected elective (as per definition provided) course in the program: Required

6. a. Specific goals for the course specific outcomes of instruction (e.g. The student will be able to explain the significance of current research about a particular topic.)	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.
<i>Students will be able to :</i>	<i>The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:</i>
1. Demonstrate a good understanding of the basic principles in design and analyses of analog and digital communication systems. 2. Distinguish and explain the theoretical and practical concepts of continuous-wave modulation and pulse modulation. 3. Provide specific examples of information measures and data compaction. 4. Demonstrate the application of communication theory methodologies to design communication systems. 5. Demonstrate the ability to apply probability and statistics in communications systems engineering.	Outcome 1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
7 Brief list of topics to be covered	Introduction to Communications Theory, Analog & Digital Communication Systems (1 hours) Review of Probability and Random Process (4 hours) Information Theory (4 hours) Review of Signals and Systems (3 hours) Continuous Wave Modulation (4 hours) Pulse Modulation (4 hours) Baseband Pulse Transmission (5 hours) Signal-Space Analysis (4 hours) Passband Digital Transmission (4 hours) Emerging Trends in Communications (2 hours)

* For all Engineering programs, indicate subject area from the following: **Math, Basic science, Engineering topic or Other**

** **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group

Additional Course Syllabus Information

ELEG 4300 COMMUNICATION THEORY SPRING 2022

Instructor: Dr. Shumon Alam, 114 Gilchrist Engineering Bldg.
(936) 261-1597, shalam@pvamu.edu

Office Hours: Tuesday and Thursday 1:00 pm – 4 pm

Course Location: New Electrical Engineering Bldg 219

Class Days & Times: Tuesdays & Thursdays, 11:00 AM – 12:20 PM

Major Course Requirements

The objective of this course is to provide students with a working knowledge required for the design and analysis of communication systems. Areas of study include signals and spectra, transmission and processing of signals, continuous-wave modulation and pulse modulation, baseband pulse transmission and passband digital transmission, signal space analysis, and information measures. Modern communication systems will also be introduced and used as examples. The use of computer is emphasized through homework assignments and course projects using MATLAB/SIMULINK and generation of graphical results. Students are expected to gain an understanding of communication theory methodologies employed to design communication systems.

Method of Determining Final Course Grade

This course will utilize the following instruments to determine student grades and proficiency of the learning outcomes for the course.

Class Attendance & Participation – regular class attendance is required.

Homework – Assignments will be assigned at the end of each unit of instruction to supplement and reinforce course material. Hence I will assume certain level of maturity and independence from you (i.e., I will not be "policing" you since those homework assignments are primarily intended as a self-assessment tool of individual students' grasp of the course material and practice sets that will help students prepare for tests/exams). Students may work in groups (discussions allowed) but must submit their completed assignments on time. Homework assignments will not be graded but solutions to the homework problems will be provided. Some of the homework assignments will be also used to assess specific ABET learning outcomes. Programming exercises may be assigned as part of homework problems (since it is essential that students practice writing and running programs on computers when learning a new programming language/software).

Course Projects – Students (may work collaboratively in a group consisting of no more than 3 students) will be asked to solve one or more open-ended problems during the semester focusing on the design, analysis, and optimization of communication systems (designed to measure the student's ability to apply knowledge gained from the covered course material). This assignment involves independent literature review to identify, formulate, and solve those engineering problems via

analysis, simulation and/or experimental approaches. A technical report is required and each team will give a 30 minutes technical presentation summarizing the salient features and key findings from their efforts. Additional information will be made available as the semester progresses.

Exam/Tests – There will be two tests and a comprehensive final examination that will contribute towards the final course grade. The tentative dates for the tests/exams are as follows (these dates are subject to change):

Test #1: March 4, 2022

Test #2: April 5, 2022

Final Exam: May 10, 2022

The final grade of each student will be determined by the following weights:

Items	Value (percentages)
Class Attendance, Homework & Quizzes**	15 %
Course Design Projects	25 %
Tests	40 %
Final Examination	20 %
Total:	100 %

** Pop quizzes may be given without prior announcement to ensure students are staying current with course materials and studying.

Grading Criteria and Conversion:

A = 86% - 100%

B = 76% - 85%

C = 66% - 75%

D = 56% - 65%

F = 0% - 55%

Course Procedures or Additional Instructor Policies

Taskstream

Taskstream is a tool that Prairie View A&M University uses for assessment purposes. One of your assignments may be required to be submitted as an "artifact," an item of coursework that serves as evidence that course objectives are met. If applicable, more information will be provided during the semester by your department, but for general information, you can visit Taskstream via the link in eCourses.

Conduct & Ethics

A strict code of ethics will be imposed in the class and in the examinations. It is a sign of impoliteness and disrespect to your professor and to your colleagues if you make a practice of coming to the class late. Absolutely no talking or cheating will be permitted during the examinations. You shall take a pledge that you will not copy, steal or plagiarize someone else's work nor will you tolerate anyone else doing the same. It shall be the policy in this course to discourage any such activity to the extent possible rather than punish. HOWEVER, IN FAIRNESS TO ALL CONCERNED, CHEATING AND PLAGIARISM WILL BE DEALT WITH SEVERELY WHEREVER THEY ARE FOUND. You are advised to read and abide by the rules and the regulations of the University as mentioned in the Catalog, in particular the topics Student

Life and Academic Regulations. Graduating means more than completing a certain number of hours and obtaining a reasonable GPA. You must strive to develop a code of strict conduct, acquire a sense of discipline, serve as a role model to your juniors and in particular experience the feeling of accomplishment. If you have any questions or have any problems that you think I may be able to help with, please do not hesitate to contact me. I am here to help.

TENTATIVE SCHEDULE OF LECTURE, READING ASSIGNMENTS AND TESTS

Week #	DATE	LECTURE	TEXTBOOK SECTIONS	TEST/E XAM
1 (1/17-1/21)	1/18 – 1/ 26 1/18-1/20	Attendance Reporting Period. Course Overview Introduction to Communications Theory, Analog & Digital Communication Systems	Chapters 1	
2 (1/24-1/28)	1/25, 1/27	Probability & Random Processes	Chapter 7, 8	
3 (1/31-2/4)	2/1 2/2 2/3	Probability & Random Processes 12th Class Day (Census Date) Final Day to Drop/Withdraw from Course(s) without Academic Record (A Financial Record will still exist) Information Theory and Source Coding	Chapter 7, 8 Chapters 12	
4 (2/7-2/11)	2/8, 2/10	Information Theory and Source Coding	Chapters 12	
5 (2/14-2/18)	2/14 2/15 2/15, 2/17	20th Class Day Project #1 Assigned Review of Signals and Systems	Chapter 2, 3	
6 (2/21-2/25)	2/22, 2/24	Continuous Wave Modulation	Chapter 4	
7 (2/28-3/4)	3/1 3/4	Continuous Wave Modulation Test	Chapter 4	Test #1
8 (3/7-3/11)	3/8, 3/10 3/8	Pulse Modulation Project1 Due	Chapter 5	
9 (3/14-3/18)	3/14-3/19 3/16	Spring Break (Student Break) Mid-Semester Grade Due		
10 (3/21-3/25)	3/22 3/22 3/24	Project #2 Assigned Pulse Modulation Baseband Pulse Transmission	Chapter 5 Chapter 6	
11 (3/28-4/1)	3/29, 3/31	Baseband Pulse Transmission	Chapter 6	
12 (4/4-4/8)	4/5 4/7	Test Signal-Space Analysis	Chapter 9	Test #2
13 (4/11-4/15)	4/12 4/14	Signal-Space Analysis Passband Digital Transmission	Chapter 9 Chapter 6	
14 (4/18-4/22)	4/19, 4/21 4/19	Passband Digital Transmission Final Date to Apply for Spring 2022 Graduation (ceremony participation)	Chapter 6	
15 (4/25-4/29)	4/26 4/29	Emerging Trends in Communications Project 2 Due Class Presentation		
16 (5/2-5/6)	5/3 5/4 5/5	Course Review Last Class Day Final Exam (final exam period 5/5-5/12)		Final Exam
17 (5/9-5/13)	5/12 5/17	Final Grades due for Graduation Candidates Final Grade due for all other students		

Student Support and Success

John B. Coleman Library

The John B. Coleman Library's mission is to enhance the scholarly pursuit of knowledge, to foster intellectual curiosity, and to promote life-long learning and research through our innovative services, resources, and cultural programs, which support the Prairie View A&M University's global mission of teaching, service, and research. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Website: <https://www.pvamu.edu/library/>; Phone: 936-261-1500

Academic Advising Services

Academic Advising Services offers students a variety of services that contributes to student success and leads towards graduation. We assist students with understanding university policies and procedures that affect academic progress. We support the early alert program to help students get connected to success early in the semester. We help refer students to the appropriate academic support services when they are unsure of the best resource for their needs. Faculty advisors support some students in their respective colleges. Your faculty advisor can be identified in PantherTracks. Advisors with Academic Advising Services are available to all students. We are located across campus. Find your advisor's location by academic major at www.pvamu.edu/advising. Phone: 936-261-5911

The University Tutoring Center

The University Tutoring Center (UTC) offers free tutoring and academic support to all registered PVAMU students. The mission of the UTC is to help provide a solid academic foundation that enables students to become confident, capable, independent learners. Competent and caring staff and peer tutors guide students in identifying, acquiring, and enhancing the knowledge, skills, and attitudes needed to reach their desired goals. Tutoring and academic support are offered face-to-face in the UTC, in virtual face-to-face sessions (<https://www.pvamu.edu/student-success/sass/university-tutoring-center/>), and through online sessions (<https://www.pvamu.edu/pvplace/>). Other support services available for students include Supplemental Instruction, Study Break, Academic Success Workshops, and Algebra Study Jam. Location: J. B. Coleman Library, Rm. 307; Phone: 936-261-1561; Email: pvtutoring@pvamu.edu; Website: <https://www.pvamu.edu/student-success/sass/university-tutoring-center/>

Writing Center

The Writing Center provides well-trained peer tutors to assist students with writing assignments at any stage of the writing process. Tutors help students with various writing tasks from understanding assignments, brainstorming, drafting, revising, editing, researching, and integrating sources. Students have free access to Grammarly online writing assistance. Grammarly is an automated proofreading and plagiarism detection tool. Students must register for Grammarly by using their student email address. In addition, students have access to face-to-face and virtual tutoring services either asynchronously via email or synchronously via Zoom. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: <https://www.pvamu.edu/student-success/writing-center/>; Grammarly Registration: <https://www.grammarly.com/enterprise/signup>

Academic Early Alert

Academic Early Alert is a proactive system of communication and collaboration between faculty, academic advisors, and PVAMU students that is designed to support student success by promptly identifying issues and allowing for intervention. Academic Early Alerts help students by providing a central location to schedule advising appointments, view advisor contact information, and request assistance. Students who recognize that they have a problem that is negatively affecting their academic performance or ability to continue school may self-refer an Academic Early Alert. To do so, students will log in to PV Place and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: <https://www.pvamu.edu/student-success/early-alert/>

Student Counseling Services

The Student Counseling Services unit offers a range of services and programs to assist students in maximizing their potential for success: short-term individual, couples, and group counseling, as well as crisis intervention, outreach, consultation, and referral services. The staff is licensed by the State of Texas and assists students who are dealing

with academic skills concerns, situational crises, adjustment problems, and emotional difficulties. Information shared

with the staff is treated confidentially and in accordance with Texas State Law. Location: Hobart Taylor, 2nd floor; Phone: 936-261-3564; Website: <https://www.pvamu.edu/healthservices/student-counseling-services/>

Office of Testing Services

Testing Services serves to create opportunities by offering a suite of exams that aid in the students' academic and professional success. Currently, we administer entrance (HESI A2), college readiness (TSI assessment), Prior Learning (CLEP, DSST), and proctored exams. Location: Wilhelmina Delco, 3rd Floor, Rm. 305; Phone: 936-261-3627; Email: aetesting@pvamu.edu; Website: www.pvamu.edu/testing

Office of Diagnostic Testing and Disability Services

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil

rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, contact the Office of Disability Services. As a federally mandated

educational support unit, the Office of Disability Services serves as the repository for confidential disability files for faculty, staff, and students. For persons with a disability, the Office develops individualized ADA letters of request for accommodations. Other services include learning style inventories, awareness workshops, accessibility pathways, webinars, computer laboratory with adapted hard and software, adapted furniture, proctoring nonstandardized

test administrations, ASL interpreters, ALDs, digital recorders, Livescribe, and a comprehensive referral network across campus and the broader community. Location: Hobart Taylor, Rm. 1D128; Phone: 936-261-3583; Website: <https://www.pvamu.edu/disabilityservices/>

Center for Instructional Innovation and Technology Services (CIITS)

Distance Learning, also referred to as Distance Education, is the employment of alternative instructional delivery methods to extend programs and services to persons unable to attend college in the traditional manner. The Center for Instructional Innovation and Technology Services (CIITS) supports student learning through online, hybrid, webassist,

and 2-way video course delivery. For more details and contact information, visit:

<https://www.pvamu.edu/dlearning/distance-learning-2-2/students-2/>; Phone: 936-261-3283

Veteran Affairs

Veterans Services works with student veterans, current military and military dependents to support their transition to the college environment and continued persistence to graduation. The Office coordinates and certifies benefits for both the G.I. Bill and the Texas Hazlewood Act. Location: Evans Hall, Rm. 102; Phone: 936-261-3563; Website: <https://www.pvamu.edu/sa/departments/veteranaffairs/>

Office for Student Engagement

The Office for Student Engagement delivers comprehensive programs and services designed to meet the cocurricular

needs of students. The Office implements inclusive and accessible programs and services that enhance student development through exposure to and participation in diverse and relevant social, cultural, intellectual, recreational, community service, leadership development, and campus governance. Location: Memorial Student Center, Rm. 221; Phone: 936-261-1340; Website: <https://www.pvamu.edu/studentengagement/>

Career Services

Career Services supports students through professional development, career readiness, and placement and employment assistance. The Office provides one-on-one career coaching, interview preparation, resume and letter writing, and career exploration workshops and seminars. Services are provided for students at the Northwest Houston

Center and College of Nursing in the Medical Center twice a month or on a requested basis. Distance Learning students are encouraged to visit the Career Services website for information regarding services provided. Location: Anderson Hall, 2nd floor; Phone: 936-261-3570; Website: <https://www.pvamu.edu/careerservices/>

III. ASSESMENT RESULTS FOR CURRENT AND PAST PERIODS

Program Outcomes Assessed in this course

Outcome 1:

An ability to identify, formulate, and solve complex engineering problems (CEP) by applying principles of engineering, science, and mathematics.

**Assessment Summary of Class Semester Average for Outcomes
(Should be provided for Fall 2019 through Spring 2022 Assessment Period)**

Outcomes	1
Semester	Semester Class Average (%)
Spring 2022	80.25 (ELEG)
Fall 2021	Data Not Available
Spring 2021	Data Not Available
Fall 2020	Data Not Available
Comments on Trend of Data (Improving or deteriorating)	Data for previous periods was not available. Expectations were met by the ELEG program for current semester. There were no CPE students for the current semester and hence CPE program was not assessed.

***Expected Semester Class Average = 70% (or as defined by the program)**

End of Semester Course Assessment Report

This summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance **(stated as %)** in each course outcome assessed in this class and the **two previous times course was assessed.**
- The acceptable class average for the class in each outcome area as set by your Department. **You cannot use any number of your choice**
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

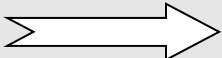
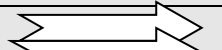
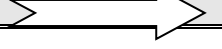
5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO.**

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 4300 COMMUNICATION THEORY (ELECTRICAL ENGINEERING MAJOR)
SPRING 2022 SEMESTER

Report Prepared by: Shumon Alam

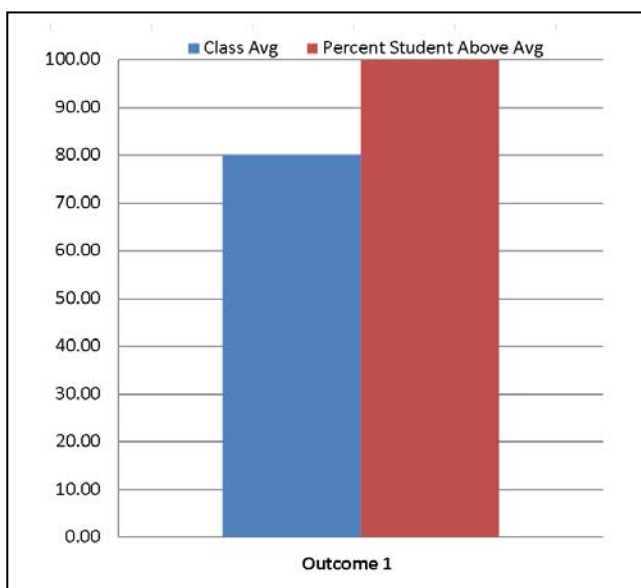
Report Date: May 20, 2022

Semester	Analysis Type	Number of Students	Outcome 1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.			
			Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Spring 2022	Direct	8	70	100	80.25	100
Fall 2021	Direct	Not Available	NA	NA		
Spring 2021	Direct	Not Available	NA	NA		
Implementation Summary	Items implemented from previous report or after meeting previous instructor		Signal and systems, probability problems and Fourier transformation were reviewed to minimize the deficiency in applying those in communication theory.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		The students had problems applying concepts/theories in communication system design and in establishing major milestones for tracking progress and define performance metrics to measure success.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		The following is recommended for implementation: 1. Signal and System and Fourier transformation should be reviewed thoroughly 2. Use Simulink or other simulation tools to engage students for concept development 3. A Communication Theory Lab is desirable to understand various communication theories 4. Instead of two projects, one technical/design project should be given so that students complete the project throughout the semester with full attention.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters		No data was available from previous semesters. Students did average performance in this semester.			
Were Expectations Met?	 		YES			

**Grade Sheet Showing
Student and Class Performance in Outcomes
The computed semester average in each outcome
as stated in the Assessment report are
highlighted in boldface**

Grade Sheet Showing Student and Class Performance in Course Outcomes
ELEG 4300 Communication Theory, SPRING 2022 Semester (Electrical Engineering Program)

	OUTCOME 1				
	Test1	Test2	Final Project	TOT	PCENT
	100	100	100	300	100
	80	75	90	245	81.67
	70	65	85	220	73.33
	80	70	95	245	81.67
	70	89	80	239	79.67
	80	82	90	252	84.00
	80	70	80	230	76.67
	70	80	95	245	81.67
	70	90	90	250	83.33
AVERAGE	75	77.63	88.13	240.75	80.25
SDEV	4.71	9.18	5.94	10.79	3.60
EXPECTED AVERAGE					70
% STUDENTS ABOVE EXPECTED AVG					100



Outcome 1:

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

IV. EXAM

OUTCOME SPECIFIC ASSIGNMENTS USED TO ASSESS OUTCOMES

(Provide at least two assignments used to specifically measure each outcome and justify the suitability of the assignments for the outcome being measured)

ASSIGNMENTS FOR OUTCOME 1

**An ability to identify, formulate, and solve complex engineering problems
by applying principles of engineering, science, and mathematics**

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
COMMUNICATION THEORY
SPRING 2022
Instructor: Dr. Shumon Alam**

Title of Assignment

TEST 1

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Check the complex engineering problem characteristics related to this assignment

Test 1 Covered the following topics:

1. Probability & Random Processes
2. Information Theory and Source Coding
3. Continuous Wave Modulation

Brief justification of why this assignment is suitable for this outcome

The questions on this section of Test 1 tests the students ability to identify relevant laws and equations, formulate the solution methodology, and solve the resulting engineering equations in Communication Theory.

**OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Solution/ Sample of graded student's solution**

Solution

ELEG 4300 COMMUNICATION THEORY

Test# 1, 3/3/2022, Total: 100

Duration: 90 Mins

1. Let X and Y be Gaussian random variable with $E[X]=E[Y]=0$ and $\text{Var}[X]=1$ and $\text{Var}[Y]=4$.

a. Sketch the PDFs $f_X(x)$ and $f_Y(y)$ on the same axes.

[10]

b. What is $P[-1 < X \leq 1]$ =?

[5]

c. What is $P[Y > 3.5]$ =?

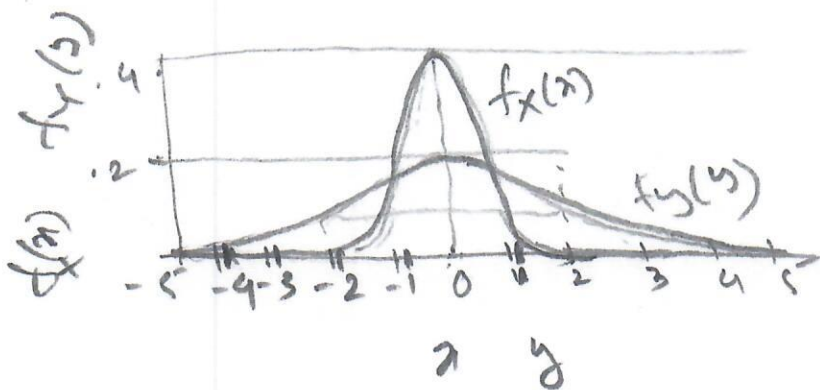
[5]

$$\begin{aligned} \text{PDF of } f_X(x) &= \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \\ &= \frac{1}{\sqrt{2\pi}} e^{-x^2/2} \approx 0.4 e^{-x^2/2} \end{aligned}$$

$$\text{PDF of } f_Y(y) = \frac{1}{\sqrt{8\pi}} e^{-y^2/4} = 0.2 e^{-y^2/4}$$

a). $\text{Var}[X]=1$, $\sigma_X=1$, $\text{Var}[Y]=4$, $\sigma_Y=2$

Height of the peak = 0.4 ; height of the peak = 0.2



$$1(b) \quad P[-1 < X \leq 1] = F_X(1) - F_X(-1) = \Phi(1) - \Phi(-1)$$

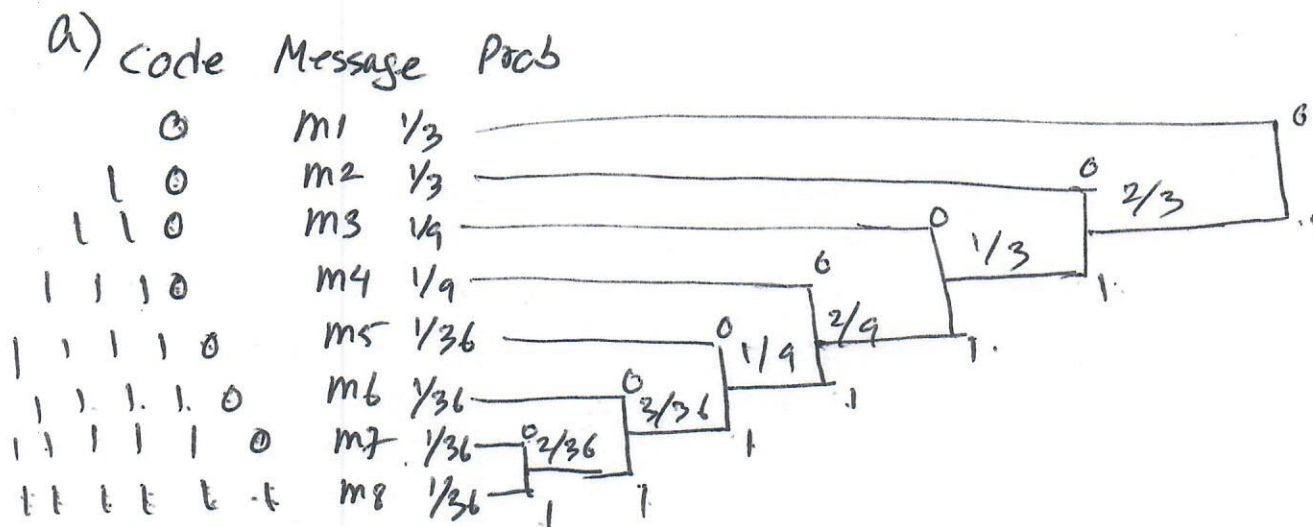
$$= 2\Phi(1) - 1$$

$$= 0.6826$$

Since, Y is $N[0, 4]$

$$1(c) \quad P[Y > 3.5] = Q\left(\frac{3.5}{2}\right) = Q(1.75) = 1 - \Phi(1.75) \\ = 0.0401$$

2. A source emits eight messages with probabilities $1/3, 1/3, 1/9, 1/9, 1/36, 1/36, 1/36,$ and $1/36$ respectively.
- Obtain the compact binary code and find the average length of the codeword. [10]
 - Find the entropy of the source. [5]
 - Find the efficiency of the binary code. [5]



$$\text{length } L = \sum_{i=1}^8 P_i L_i$$

$$= \frac{1}{3}(1) + \frac{1}{3}(2) + \frac{1}{9}(3) + \frac{1}{9}(4) + \frac{1}{36}(5) + \frac{1}{36}(6) + \frac{1}{36}(7) + \frac{1}{36}(8)$$

$$= 2.4722 \text{ bits}$$

b) entropy, $H(m) = - \sum_{i=1}^8 P_i \log_2 P_i = 2.3355 \text{ bits}$

c) efficiency; $\eta = \frac{H(m)}{L} = 94.47\%$

3. Consider a baseband message signal $m(t) = \cos 150\pi t$

a. Sketch the spectrum $m(t)$

[5]

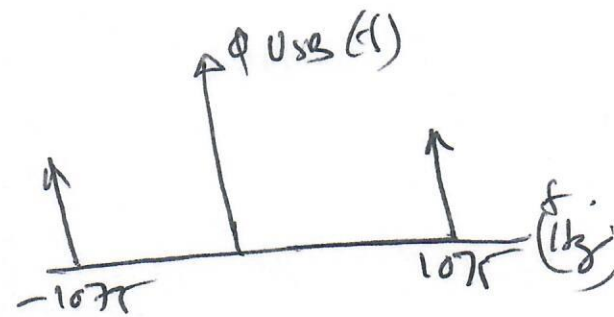
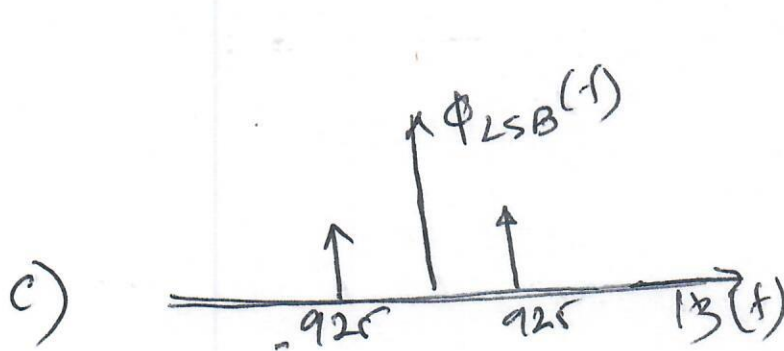
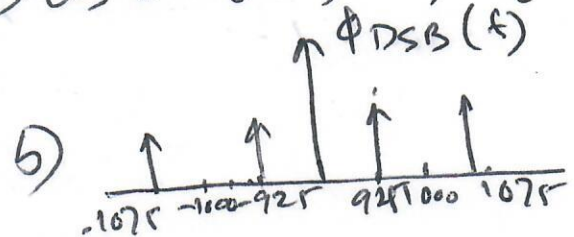
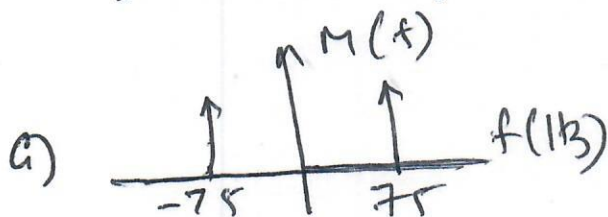
b. Sketch the spectrum of the DSB-SC signal $2m(t) \cos 2000\pi t$

[10]

c. Identify the USB and LSB spectra

[5]

~~a)~~ $m(t) = \cos 2\pi (75) t$; ~~m~~ $f_m = 75 \text{ Hz}$.
 DSB-SC signal $2m(t) \cos 2\pi (1000) t$; $f_c = 1000 \text{ Hz}$



ABOVE AVERAGE

93

ELEG 4300 COMMUNICATION THEORY

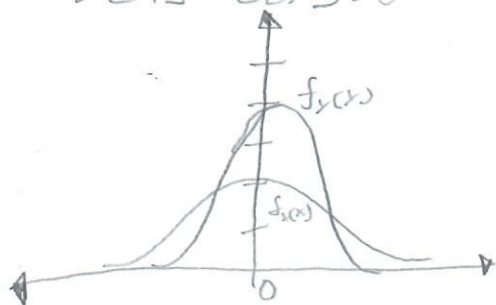
Test# 1, 3/3/2022, Total: 100

Duration: 90 Mins

1. Let X and Y be Gaussian random variables with $E[X]=E[Y]=0$ and $\text{Var}[X]=1$ and $\text{Var}[Y]=4$.
 - a. Sketch the PDFs $f_X(x)$ and $f_Y(y)$ on the same axes. [10]
 - b. What is $P[-1 < X \leq 1] = ?$ [5]
 - c. What is $P[Y > 3.5] = ?$ [5]
2. A source emits eight messages with probabilities $1/3, 1/3, 1/9, 1/9, 1/36, 1/36, 1/36$, and $1/36$ respectively.
 - a. Obtain the compact binary code and find the average length of the codeword. [10]
 - b. Find the entropy of the source. [5]
 - c. Find the efficiency of the binary code. [5]
3. Consider a baseband message signal $m(t) = \cos 150\pi t$
 - a. Sketch the spectrum $M(f)$ [5]
 - b. Sketch the spectrum of the DSB-SC signal $2m(t) \cos 2000\pi t$ [10]
 - c. Identify the USB and LSB spectra [5]
4. A modulating signal, $m(t) = 10 \cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50 \cos(2\pi \times 10^5 t)$. Consider power is dissipated through 1 ohm resistor. Find the following parameters:
 - a. Modulation index [10]
 - b. Carrier power [5]
 - c. Power required for transmitting AM wave [5]
5. Consider a superheterodyne FM receiver designed to receive the frequency band of 88 to 108 MHz with IF of 10.7 MHz.
 - a. What is the range of frequencies generated by the local oscillator? [10]
 - b. Analyze and explain whether it is possible for an FM receiver to receive both a desired FM station and an image station when tuned to the desired frequency. [10]

#1 $E[X] = E[Y] = 0$ $Var[X] = 1$ $Var[Y] = 4$

a)



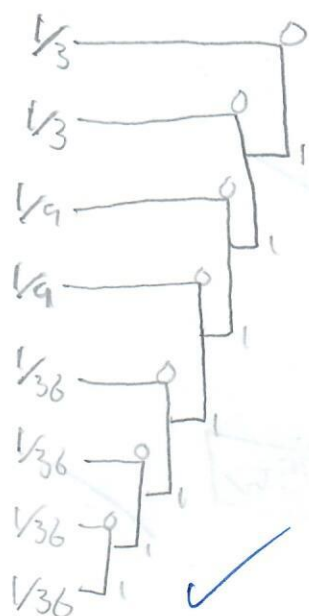
b) $P[-1 < X \leq 1] = P\left(\frac{-1-0}{1} < Z \leq \frac{1-0}{1}\right) = P(-1 < Z \leq 1)$

$\boxed{= 0.6827}$

c) $P[Y > 3.5] = P\left(\frac{Y-E[Y]}{\sigma_Y} > \frac{3.5-0}{2}\right) = P(Z > 1.75) = \boxed{0.041}$

#2 a)

0
10
110
1110
11110
111110
1111110
1111111



$E = \sum P_n n$

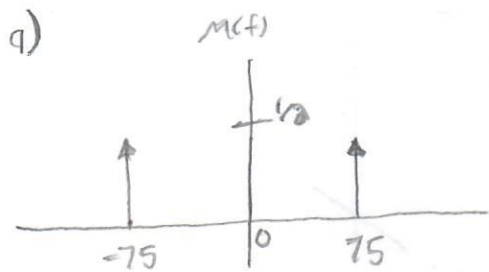
$= 1\left(\frac{1}{3}\right) + 2\left(\frac{1}{3}\right) + 3\left(\frac{1}{9}\right) + 4\left(\frac{1}{9}\right)$

$+ 5\left(\frac{1}{36}\right) + 6\left(\frac{1}{36}\right) + 7\left(\frac{1}{36}\right) + 8\left(\frac{1}{36}\right) = \boxed{2.5}$

b) $H = \sum_{i=1}^n P_i \log_2\left(\frac{1}{P_i}\right) = 2\left(\frac{1}{3} \log_2\left(\frac{1}{\frac{1}{3}}\right)\right) + 2\left(\frac{1}{9} \log_2\left(\frac{1}{\frac{1}{9}}\right)\right) + 4\left(\frac{1}{36} \log_2\left(\frac{1}{\frac{1}{36}}\right)\right) = 2.33$

c) $n = \frac{H}{E} = \frac{2.33}{2.5} = 0.932 \Rightarrow \boxed{93.2\%}$

#3 $m(t) = \cos 150\pi t$



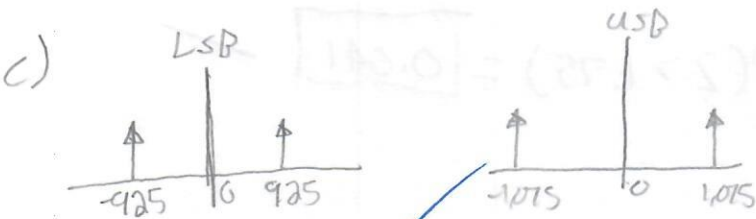
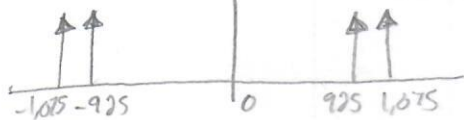
$\omega = 150\pi$

$f = \frac{\omega}{2\pi} = \frac{150\pi}{2\pi} = 75$

$f = \frac{2,000\pi}{2\pi} = 1,000$

b) DSB-SC $2m(t)\cos 2,000\pi t$

$X_{DSB}(f) = M(f-1,000) \cdot M(f+1,000)$



#4 $m(t) = 10\cos(2\pi \times 10^3 t)$ AM
 $c(t) = 50\cos(2\pi \times 10^5 t)$ R = 1 Ω

a) $\mu = \frac{A_m}{A_c} = \frac{10}{50} = 0.2 \Rightarrow \boxed{20\% \text{ modulated}}$

b) $P_c = \frac{A_c^2}{2R} = \frac{50^2}{2} = \boxed{1,250 \text{ W}}$

c) $P_t = P_c(1 + \frac{\mu^2}{2}) = (1,250)(1 + \frac{(0.2)^2}{2}) = \boxed{1,275 \text{ W}}$

#5 88 MHz to 108 MHz

$$f_{IF} = 10.7 \text{ MHz}$$

$$a) f_{LO} = f_{RF} + f_{IF}$$

$$f_{LO, \min} = 88 \times 10^6 + 10.7 \times 10^6$$

$$f_{LO, \max} = 108 \times 10^6 + 10.7 \times 10^6$$

$$\left\{ \begin{array}{l} f_{LO, \min} \\ f_{LO, \max} \end{array} \right\} [98.7 \text{ MHz to } 118.7 \text{ MHz}]$$

$$b) f_{SI} = f_{RF} + 2 \cdot f_{IF}$$

$$= 88 \times 10^6 + 2(10.7 \times 10^6) \text{ to } 108 \times 10^6 + 2(10.7 \times 10^6)$$

$$= 109.4 \text{ MHz to } 129.4 \text{ MHz}$$

Yes, because the frequencies overlap

X - 5

AVERAGE

ELEG 4300 COMMUNICATION THEORY

Test# 1, 3/3/2022, Total: 100

Duration: 90 Mins

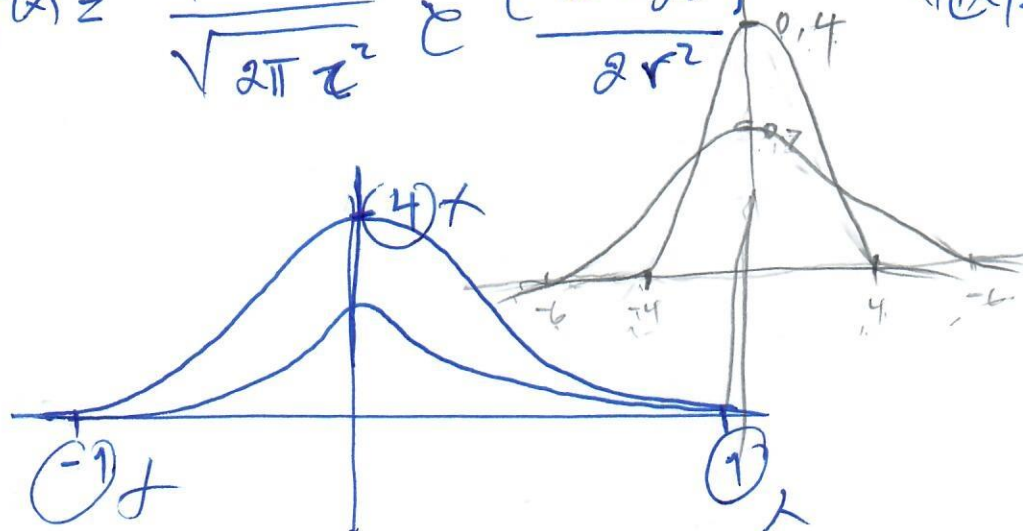
70
100

1. Let X and Y be Gaussian random variables with $E[X]=E[Y]=0$ and $\text{Var}[X]=1$ and $\text{Var}[Y]=4$.
 - a. Sketch the PDFs $f_X(x)$ and $f_Y(y)$ on the same axes. [10]
 - b. What is $P[-1 < X \leq 1]$? [5]
 - c. What is $P[Y > 3.5]$? [5]
2. A source emits eight messages with probabilities $1/3, 1/3, 1/9, 1/9, 1/36, 1/36, 1/36$, and $1/136$ respectively.
 - a. Obtain the compact binary code and find the average length of the codeword. [10]
 - b. Find the entropy of the source. [5]
 - c. Find the efficiency of the binary code. [5]
3. Consider a baseband message signal $m(t) = \cos 150\pi t$ $m(t) = \cos 150\pi t$
 $f = \frac{150\pi}{2\pi} = 75 \text{ Hz}$
 - a. Sketch the spectrum $m(t)$ [5]
 - b. Sketch the spectrum of the DSB-SC signal $2m(t) \cos 2000\pi t$ [10]
 - c. Identify the USB and LSB spectra $m(t) \geq 0$ [5]
4. A modulating signal, $m(t) = 10 \cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50 \cos(2\pi \times 10^5 t)$. Consider power is dissipated through 1 ohm resistor. Find the following parameters:
 - a. Modulation index [10]
 - b. Carrier power [5]
 - c. Power required for transmitting AM wave [5]
5. Consider a superheterodyne FM receiver designed to receive the frequency band of 88 to 108 MHz with IF of 10.7 MHz.
 - a. What is the range of frequencies generated by the local oscillator? [10]
 - b. Analyze and explain whether it is possible for an FM receiver to receive both a desired FM station and an image station when tuned to the desired frequency. [10]

1) let x and y Question (1)

a) sketch the PDF $f_x(x)$ and $f_y(y)$ on the same axes

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma^2} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad \sqrt{1(x)} = 1 \quad \sqrt{1(y)} = 4$$



-5

b) what is $P[-1 < x \leq 1] = 0.5987$ X -5

$$P[-1 < x] = P[-1 < x \leq 1] = \frac{1}{4} = 0.25 \Rightarrow 0.5987$$

$$P[-1 < x \leq 1] = 0.5987$$

c) what is $P[y > 3.5] = \sqrt{0.6406}$

-5

in

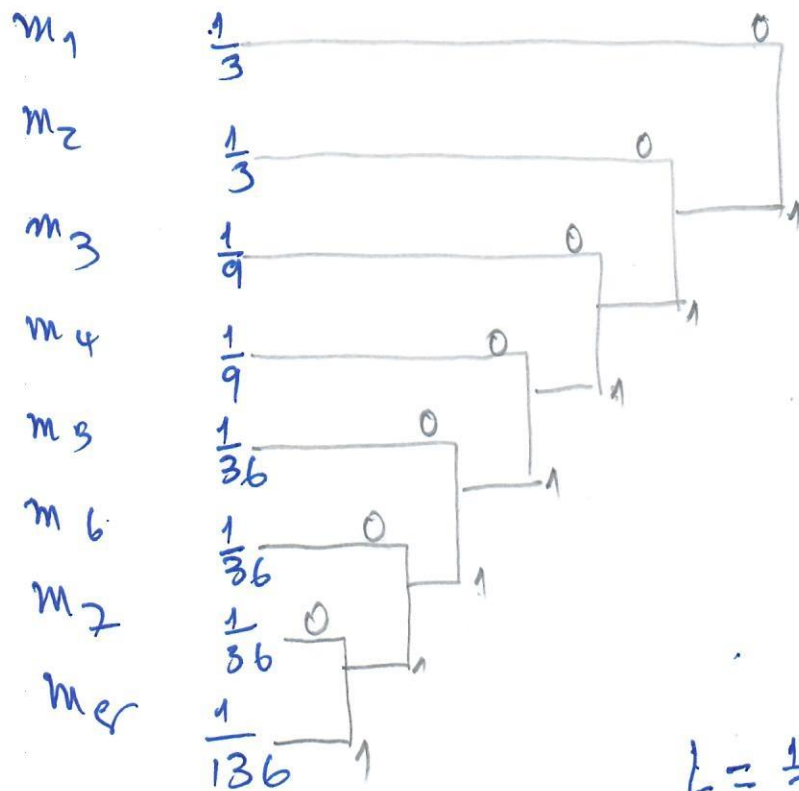
Excm 1 Question 2

2) A Source emit eight message with

$$\frac{1}{3}, \frac{1}{3}, \frac{1}{9}, \frac{1}{9}, \frac{1}{36}, \frac{1}{36}, \frac{1}{36} \text{ and } \frac{1}{136}$$

- binary code

Here is the binary code



0
1 0
1 1 0
1 1 0
1 1 1 0
1 1 1 1 0
1 1 1 1 1 0
1 1 1 1 1 1

$$L = \frac{1}{3}(1) + \frac{1}{3}(2) + \frac{1}{9}(3) + \frac{1}{9}(4) + \frac{1}{36}(5) +$$

$$\frac{1}{36}(6) + \frac{1}{36}(7) + \frac{1}{136}(8)$$

$$L = 2.3366$$

- 1

b) Find the entropy of source

$$H(x) = \sum_{i=1}^M P_i \log_2 \left(\frac{1}{P_i} \right)$$

$$= P_i \left[\log_2(1) - \log_2(P_i) \right]$$

$$H(x) = - \left[P_i \log_2(P_i) \right]$$

Question 2 Continuous Hertz

$$H(x) = - \left[\frac{1}{3} \log_2 \left(\frac{1}{3} \right) + \frac{1}{9} \log_2 \left(\frac{1}{9} \right) + \frac{1}{9} \log_2 \left(\frac{1}{9} \right) + \frac{1}{36} \log_2 \left(\frac{1}{36} \right) + \frac{1}{36} \log_2 \left(\frac{1}{36} \right) + \frac{1}{136} \log_2 \left(\frac{1}{136} \right) \right]$$

-0.5301347275 $\frac{1}{9} \log_2 \left(\frac{1}{9} \right)$ -0.1453796612

$$H(x) = 0.6753$$

-1

c) The efficiency

$$\eta = \frac{H(x)}{L} \Rightarrow \eta = \frac{0.6753}{2.3366}$$

$$\eta = 0.2890 \text{ or } 28.90\%$$

-1

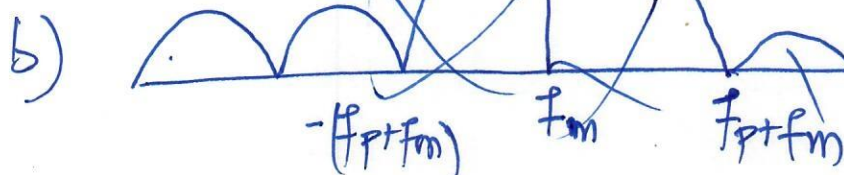
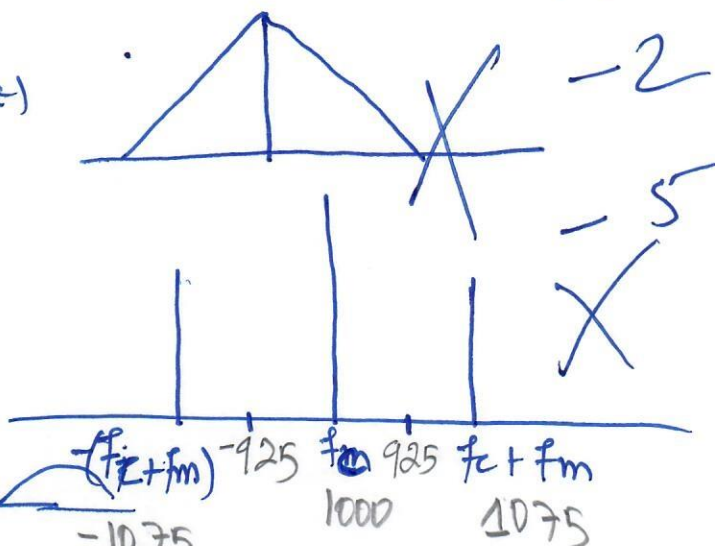
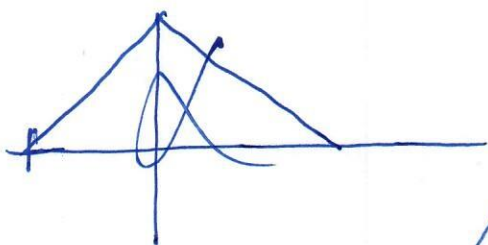
3) Question 3

baseband message signal

$$m(t) = \cos 150\pi t$$

$$DSB-SC = 2m(t) \cos 2000\pi t$$

a) sketch the spectrum $m(t)$



c) identify USB and LSB spectra

$$f_{usb} = f_c + f_m$$

$$= 1000 + 75 \Rightarrow 1075$$

$$f_{usb} = 1075 \text{ Hz}$$

$$f_{lsb} = f_c - f_m$$

$$= 1000 - 75 = 925 \text{ Hz}$$

$$f_{lsb} = 925 \text{ Hz}$$

$$\omega = 2\pi f$$

Let find f_c and f_m

$$2000\pi = 2(1000)\pi$$

$$\Rightarrow f_c = 1000 = 1 \text{ kHz}$$

$$150\pi = 2(75)\pi$$

$$\Rightarrow f_m = 75 \text{ Hz}$$

identify on the drawing?

Question 4

1Fu

A modulation signal $m(t) = 10 \cos(2\pi \times 10^3 t)$

$$c(t) = 50 \cos(2\pi \times 10^5 t)$$

- Modulation index μ

$$\mu = \frac{a_m}{a_c} = \frac{10}{50} = \frac{1}{5} = 0.2$$

$$\boxed{\mu = 0.2}$$

- Carrier power

$$P_c = \frac{A_c^2}{2R}$$

with $R = 1 \Omega$

$$\boxed{P_c = \frac{A_c^2}{2}}$$

$$P_c = \frac{50^2}{2}$$

$$\Rightarrow \boxed{P_c = 1250 \text{ W}}$$

* c) Power required for transmitting AM

$$P_t \neq P_c \quad \text{if } P_m = \frac{A_m^2}{2R} = \frac{10^2}{2} = \underline{\underline{50 \text{ W}}}$$

So the required power is

$$\boxed{P_t = P_c \left[1 + \frac{\mu^2}{2} \right]}$$

$$P_t = 1250 \left[1 + \frac{(0.2)^2}{2} \right]$$

$$\boxed{P_t = 1275 \text{ W}}$$

Q.5 Question (5)

5) Super Heterodyne FM

Frequency band 88 to 108 MHz

a) range [88 MHz - 108 MHz] $f_{IF} = 10.7 \text{ MHz}$

a) what is the range of generated

Given range [88 MHz - 108 MHz]

b) Analysing

$$f_{LO} = f_c \pm f_{IF}$$

This is super-heterodyne. should be $f_{LO} = f_c + f_{IF}$

$$|f_{LO}|_{\min} = f_c - f_{IF} = 88 \text{ MHz} - 10.7 \text{ MHz} = 77.3 \text{ MHz}$$

$$|f_{LO}|_{\min} = 77.3 \text{ MHz}$$

$$|f_{LO}|_{\max} = f_c + f_{IF} \Rightarrow 108 \text{ MHz} + 10.7 \text{ MHz} = 118.7 \text{ MHz}$$

$$|f_{LO}|_{\max} = 118.7 \text{ MHz}$$

Explanation: The FM receiver cannot receive both FM desired FM signal because one of the signal is out of the given range. therefore, cannot be received. So the receiver will receive only one FM which is 77.3 MHz and will not receive 118.7 MHz because it's out of the range.

BELOW AVERAGE

ELEG 4300 COMMUNICATION THEORY

Test# 1, 3/3/2022, Total: 100

Duration: 90 Mins

$$\frac{-1-0}{1} = \frac{-1}{1} \quad -1 < \frac{x-0}{1} < \frac{1-0}{1}$$

$$\Phi = \frac{x-\mu}{\sigma}$$

64

1. Let X and Y be Gaussian random variables with $E[X]=E[Y]=0$ and $\text{Var}[X]=1$ and $\text{Var}[Y]=4$.

a. Sketch the PDFs $f_X(x)$ and $f_Y(y)$ on the same axes. [10]

b. What is $P[-1 < X \leq 1]$? [5]

c. What is $P[Y > 3.5]$? [5]

A source emits eight messages with probabilities $1/3, 1/3, 1/9, 1/9, 1/36, 1/36, 1/36$, and $1/36$ respectively.

a. Obtain the compact binary code and find the average length of the codeword. [10]

b. Find the entropy of the source. [5]

c. Find the efficiency of the binary code. [5]

3. Consider a baseband message signal $m(t) = \cos 150\pi t$

a. Sketch the spectrum $m(t)$ [5]

b. Sketch the spectrum of the DSB-SC signal $2m(t) \cos 2000\pi t$ [10]

c. Identify the USB and LSB spectra [5]

4. A modulating signal, $m(t) = 10 \cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50 \cos(2\pi \times 10^5 t)$. Consider power is dissipated through 1 ohm resistor. Find the following parameters:

a. Modulation index [10]

b. Carrier power [5]

c. Power required for transmitting AM wave [5]

5. Consider a superheterodyne FM receiver designed to receive the frequency band of 88 to 108 MHz with IF of 10.7 MHz.

a. What is the range of frequencies generated by the local oscillator? [10]

b. Analyze and explain whether it is possible for an FM receiver to receive both a desired FM station and an image station when tuned to the desired frequency. [10]

$$1. E[X] = E[Y] = 0$$

$$\text{Var}[X] = 1, \text{Var}[Y] = 4$$

Problem #1

→ 20

$$p_x(x) = \frac{1}{2\pi} e^{-\frac{x^2}{2}}$$

X

$$= \int_{-\infty}^{\infty} e^{-\frac{x^2}{2}}$$

$$\frac{e^x}{2} = \sqrt{2\pi}$$

$$\frac{1}{2} x^2$$

$$\frac{1}{2} \frac{x^3}{3} \frac{x^5}{6}$$

$$E[X] = 0$$

$$\text{Var}[X] = 1$$

$$\begin{aligned} f &= \int e^{-\frac{x^2}{2}} dx \\ f^2 &= \left(\int e^{-\frac{x^2}{2}} dx \right) \left(\int e^{-\frac{y^2}{2}} dy \right) \\ f^2 &= \left(\int e^{-\frac{x^2}{2}} dx \right) \left(\int e^{-\frac{y^2}{2}} dy \right) \\ &= \iint e^{-\frac{1}{2}(x^2+y^2)} dx dy \\ &= \int_0^{2\pi} \int_0^{\infty} r e^{-\frac{1}{2}r^2} dr d\theta \end{aligned}$$

$$f^2 = - \int_0^{2\pi} \left(e^{-\frac{1}{2}r^2} \right) d\theta$$

$$= - \int_0^{2\pi} \left(e^{-\frac{1}{2}r^2} \right) \Big|_0^{\infty} d\theta$$

$$\int_0^{2\pi} (0 - 1) d\theta$$

$$\int_0^{2\pi} 0 d\theta = 2\pi$$

$$f = \sqrt{2\pi}$$

$$u = -\frac{1}{2} r^2$$

$$du = -r dr$$

$$e^x$$

2. 0 m₁
10 m₂
110 m₃
1110 m₄
11100 m₅
11101 m₆
11110 m₇
11111 m₈

$$L = \frac{1}{3}(1) + \frac{1}{3}(2) + \frac{1}{9}(3) + \frac{1}{9}(4) + \frac{1}{36}(6) + \frac{1}{36}(6) + \frac{1}{36}(6) + \frac{1}{36}(6)$$

$$= 1 + \frac{1}{3} + \frac{4}{9} + \frac{2}{3}$$

$$L = \frac{9}{9} + \frac{3}{9} + \frac{4}{9} + \frac{6}{9} = \frac{22}{9} = 2\frac{4}{9} \quad ?$$

$$H(m) = \sum P_i \log_2 \frac{1}{P_i}$$

$$= \sum P_i \log_2 P_i$$

$$= \frac{1}{3} \log_2 \frac{1}{13} + \frac{1}{3} \log_2 \frac{1}{13} + \frac{1}{9} \log_2 \frac{1}{9} + \frac{1}{9} \log_2 \frac{1}{9} + \frac{1}{36} \log_2 \frac{1}{36} + \frac{1}{36} \log_2 \frac{1}{36}$$

$$+ \frac{1}{36} \log_2 \frac{1}{36} + \frac{1}{36} \log_2 \frac{1}{36}$$

$$= \frac{1}{3} \log_2 3 + \frac{1}{3} \log_2 3 + \frac{1}{4} \log_2 9 + \frac{1}{4} \log_2 9 + \frac{1}{36} \log_2 36 + \frac{1}{36} \log_2 36 + \frac{1}{36} \log_2 36$$

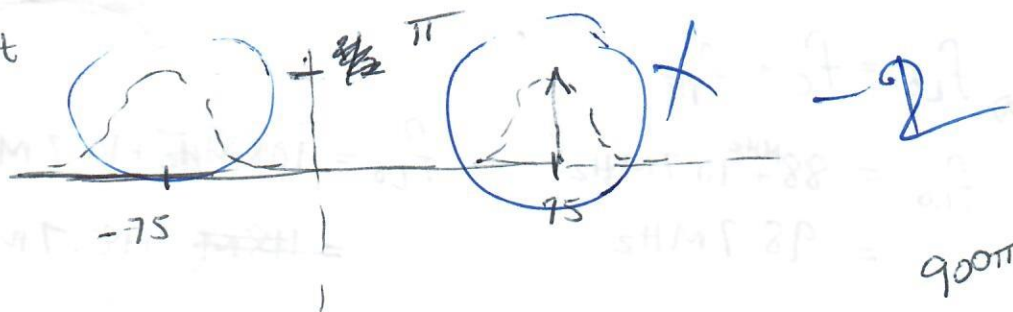
$$= 1.761 + 0.574$$

$$H(m) = 2.3355$$

$$\eta = \frac{H(m)}{L} = \frac{2.3355}{2.4444} = 0.9554 \times 100\%$$

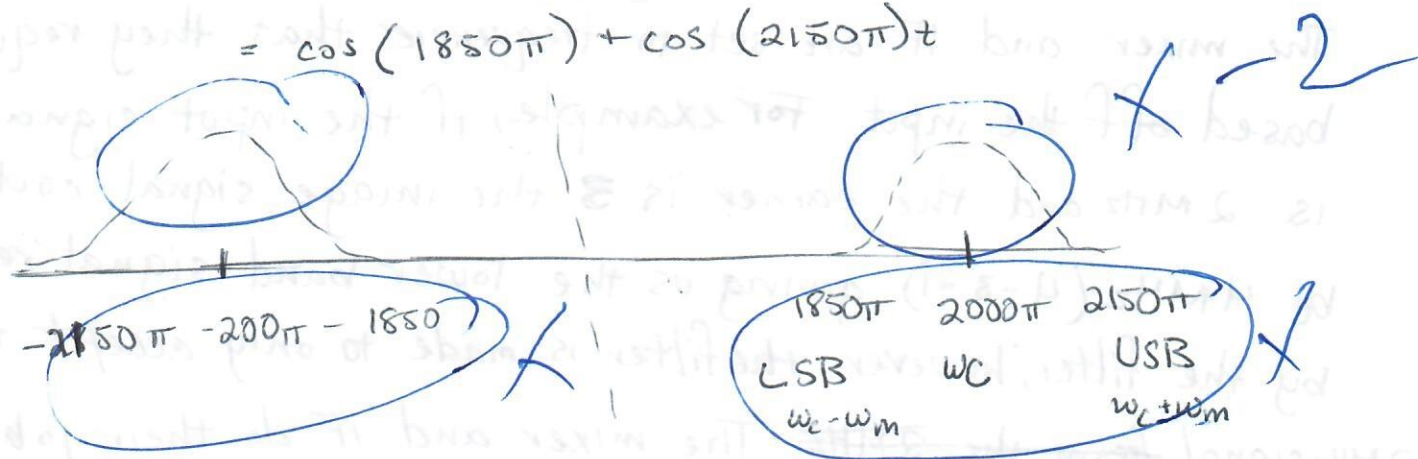
$(94, 47)$.

3. a) $m(t) = \cos 150\pi t$
 $\omega = 2\pi f_m$
 $150\pi = 2\pi f_m$
 $75 = f_m$



b) $\varphi_{DSB-SC}(t) = 2m(t) \cos 2000\pi t$
 $= 2 \cos 150\pi t \cos 2000\pi t$
 $= \cos(2000\pi - 150\pi) + \cos(2000\pi + 150\pi)$
 $= \cos(1850\pi) + \cos(2150\pi)$

Handwritten notes: $\frac{\pi}{2}$, $\omega = 2\pi f_m$, $10,000\pi = 2\pi$, $5,000$, 500 , 11000π



(9) 2-5

4. $m(t) = 10 \cos(2\pi \times 10^3 t)$, $c(t) = 50 \cos(2\pi \times 10^5 t)$, power dissipated through 1 ohm resistor.

a) $\mu = \frac{m_{max} - m_{min}}{2A + m_{max} + m_{min}} = \frac{10 - (-10)}{2A + 10 + (-10)} = \frac{20}{2A} = 10 \frac{20}{100} = 0.2$

b) $P_c = \frac{A^2}{2} = \frac{50^2}{2} = 1250 \text{ watts}$

c) $\cancel{P_s = \frac{1}{2} m^2(t) = \frac{1}{2} (10^2) = 50 \text{ watts}}$

total = $P_c \left(1 + \frac{\mu^2}{2}\right)$

total Power = $P_s + P_c$
 $= \frac{1}{2} m^2(t) + \frac{A^2}{2}$
 $= 50 \text{ watts} + 1250 \text{ watts}$
 $= 1300 \text{ watts}$

2

5. (a) $f_{LO} = f_c + f_{IF}$

$$f_{LO} = 88^{MHz} + 10.7 MHz$$

$$= 98.7 MHz$$

$$f_{LO} = 108 MHz + 10.7 MHz$$

$$= \cancel{118 MHz} 118.7 MHz$$

range is $[118.7 \text{ to } 98.7 MHz]$

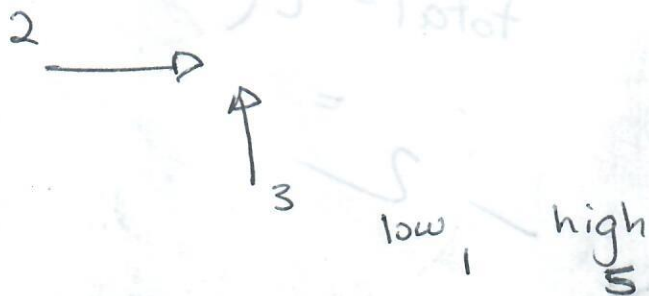
98.7 to 118.7 MHz

(b) ~~The mixer is set a~~

~~The IF is set to a frequency that~~

The mixer and IF are set to frequencies that they require based off the input. For example, if the input signal is 2 MHz and the carrier is ~~3~~. the image signal could be 4 MHz ($4 - 3 = 1$) giving us the lower band signal required by the filter, however, the filter is made to only accept the 2 MHz signal. ~~from the 2 MHz~~ The mixer and IF do their job and carry the signal through the Detector and audio Amp to then be ~~the~~ transformed into a sound signal through the speaker.

2. 5



**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
COMMUNICATION THEORY
SPRING 2022**

Instructor: Dr. Shumon Alam

Title of Assignment

TEST 2

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Check the complex engineering problem characteristics related to this assignment

Test 2 Covered the following topics:

1. Pulse Modulation
2. Baseband Pulse Transmission
3. Signal-Space Analysis

Brief justification of why this assignment is suitable for this outcome

The questions on this section of Test 2 tests the student's ability to identify relevant laws and equations, formulate the solution methodology, and solve the resulting engineering equations in Communication Theory. Test 2 also tests the student's basic concept of communication theory such as sampling, Nyquist's criterion, line coding, PCM coding, and transmission bandwidth requirement, etc..

**OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Solution/ Sample graded student's solution**

ELEG 4300 COMMUNICATION THEORY**Test# 2, 4/4/2022, Total: 100****Duration: 90 Mins**

1. (a) Determine the Nyquist sampling rate of the signal: $4 \operatorname{sinc}(420\pi t)$

[10]

From table we can write: $2B \operatorname{sinc}(2\pi Bt) \leftrightarrow \pi \left(\frac{f}{2B} \right)$

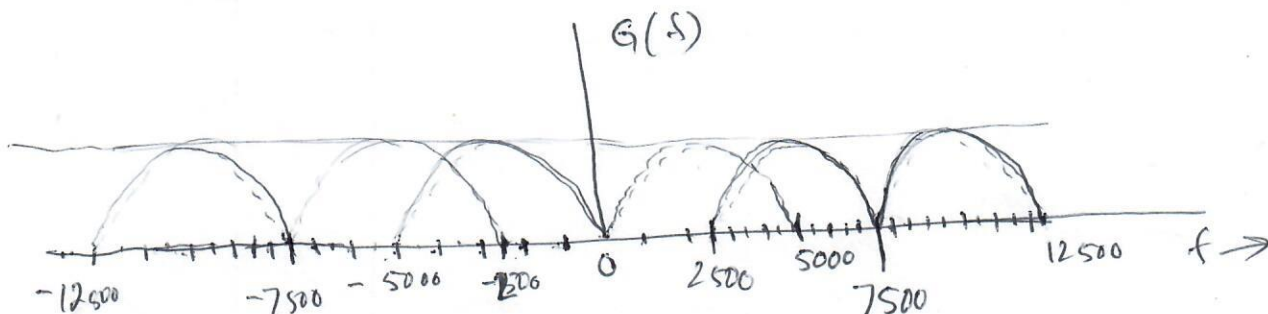
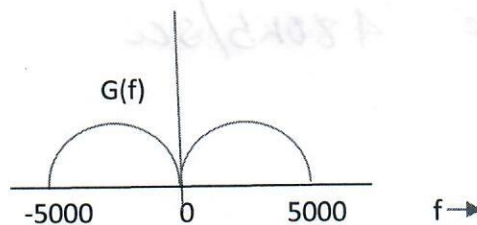
therefore we can write

$$4 \operatorname{sinc}(420\pi t) = \frac{2 \times (2 \times 105)}{105} \operatorname{sinc}(2\pi \cdot 210 t) \leftrightarrow \frac{1}{105} \pi \left(\frac{f}{2 \times 210} \right)$$

The bandwidth of the signal is 210 Hz.

Therefore, the Nyquist rate is 420 Hz (sample/sec).

2. (b) For the $G(f)$ given in Figure 1, sketch the spectrum of its ideally and uniformly sampled signal at the sampling rate of $f_s = 7500$.

[10]

3. A compact disc (CD) records audio signals digitally by using PCM. Let the audio signal bandwidth be 15 KHz.

(a) If the Nyquist samples are uniformly quantized into $L = 65,536$ levels and then binary-coded, determine the number of binary digits required to encode a sample. [10]

$$L = 65,536$$

$$L = 2^n$$

$$\text{if } n = 16, L = 65,536$$

$\therefore$ 16 binary digits are needed to encode each sample.

(b) Determine the number of binary digits per second (bit/s) required to encode the audio signal. [10]

$$\text{bit rate} = \text{Nyquist rate} \times \text{bits/sample}$$

$$= (2 \times 15) \times 16 \text{ Kb/sec.}$$

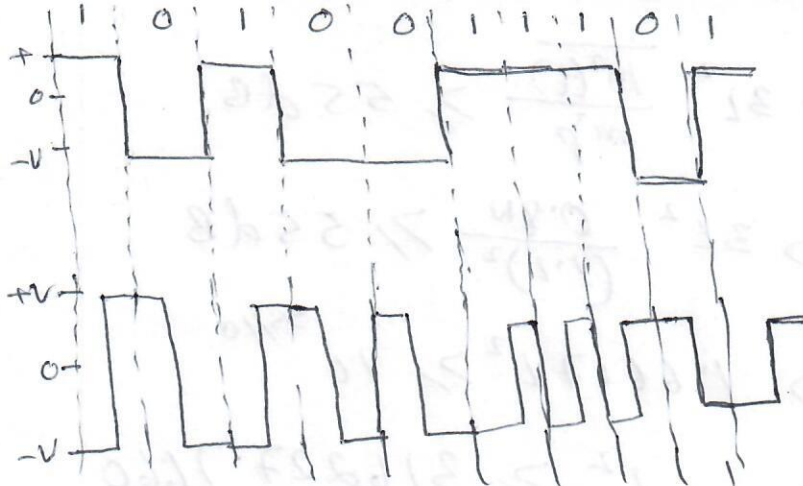
$$= 480 \text{ Kb/sec}$$

4. Sketch (a) Polar NRZ and (b) Manchester line code for 1 0 1 0 0 1 1 1 0 1.

[10+10]

Polar NRZ

Manchester



average Power of 0.8 W

5. A video signal has a bandwidth of 4.5 MHz, and peak voltage of $\pm 1.2V$. The signal is sampled, uniformly quantized, and transmitted via binary polar baseband modulation. The sampling rate is 25% above the Nyquist rate.

- (a) If the required SNR for video quality is at least 55 dB, determine the minimum binary pulse rate (in bits per second) for this baseband transmission.

[10]

$$\frac{S_0}{N_0} = 3L^2 \frac{\overline{m^2(t)}}{m_p^2} \geq 55 \text{ dB}$$

$$\Rightarrow 3L^2 \frac{0.8W}{(1.2)^2} \geq 55 \text{ dB}$$

$$\Rightarrow 1.6667 L^2 \geq 10^{55/10}$$

$$\Rightarrow L^2 \geq 316227.7660$$

$$\therefore L \geq \sqrt{316227.7660} = 562.34$$

Now, $L = 2^n$, if $n=10, L=1024$
 $n=9, L=512$
 $n=8, L=256$

Thus required number of ~~bits~~ bit/sample is 9.

- (b) Find the minimum bandwidth required to transmit this signal without ISI when a raised-cosine pulse shape with roll-off factor $r=0.3$ used.

[10]

The Nyquist sample rate = $2 \times 4.5 = 9 \text{ MHz}$.

Actual sampling rate = $1.25 \times 9 = 11.25 \text{ MHz}$.

Therefore, the minimum binary pulse rate for the baseband transmission is:

$$9 \times 11.25 = 101.25 \text{ MB/s}$$

$$101.25$$

Also; minimum BW;

$$B_T = \left(\frac{1+r}{2} \right) B_b$$

$$= \left(\frac{1+0.3}{2} \right) \overset{101.25}{\cancel{112.5}} \times 10^6 \text{ Hz.}$$

$$\Rightarrow B_T = \frac{\cancel{73.125} \times 10^6 \text{ Hz.}}{65.81 \times 10^6 \text{ Hz.}}$$

ABOVE AVERAGE

Name: _____

(87)

ELEG 4300 COMMUNICATION THEORY

Test# 2, 4/5/2022, Total: 100

Duration: 90 Mins

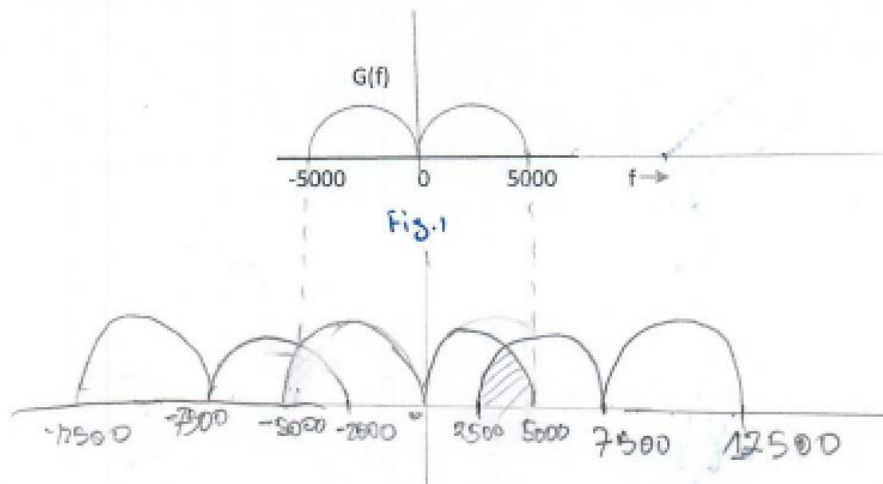
1. (a) Determine the Nyquist sampling rate of the signal: $4 \text{sinc}(420\pi t)$

[10]

$$\begin{aligned}
 &4 \text{sinc}(420\pi t) \rightarrow \text{Convert to the frequency domain } 2B \text{sinc}(2\pi f) \\
 &4 \text{sinc}(420\pi t) \rightarrow \pi \left(\frac{f}{2B} \right) \quad \left[\dots \right] \quad * NR = 2 \times BW \\
 &2 \left(\frac{210}{105} \right) \text{sinc}(2\pi \times 210 t) \rightarrow \quad = 2 \times 210 \\
 &\frac{1}{105} (2 \times 210 \text{sinc}(2\pi \times 210 t)) \quad = 420 \text{ Hz} \\
 &\frac{1}{105} [(2 \times 210) \text{sinc}(2\pi \times 210 t)] \rightarrow \frac{1}{105} \left[\frac{\pi f}{2 \times 210} \right] \quad \boxed{NR = 420 \text{ Hz}} \\
 &\boxed{\text{Bandwidth} = BW = 210 \text{ Hz}}
 \end{aligned}$$

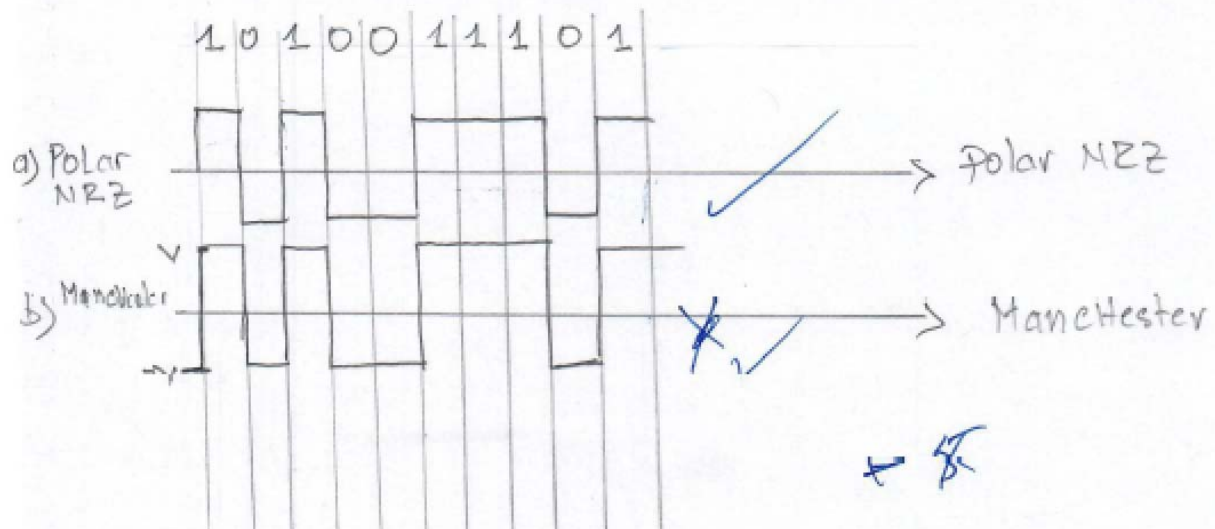
(b) For the $G(f)$ given in Figure 1, sketch the spectrum of its ideally and uniformly sampled signal at the sampling rate of $f_s = 7500$.

[10]



2. Sketch (a) Polar NRZ and (b) Manchester line code for 1010011101.

[10+10]



3. A compact disc (CD) records audio signals digitally by using PCM. Let the audio signal bandwidth be 15 KHz.

(a) If the Nyquist samples are uniformly quantized into $L = 65,536$ levels and then binary-coded, determine the number of binary digits required to encode a sample. [15]

Given The Comp BW = 15 KHz $L = 65,536$

$$L = 2^n \Rightarrow 2 = 2^{16} = 65536$$

$$n = 16$$

(b) Determine the number of binary digits per second (bit/s) required to encode the audio signal. [15]

Determining the Digit/second $20 \times 10^3 \times 2 = 67.2 \times 10^3$

$$\frac{S}{N} = 3L^2 \cdot \left(\frac{m^2(t)}{m^2_p} \right)$$

$$= 3(65,536)^2 \times \left(\frac{0.1}{1} \right) = 91.1 \text{ dB}$$

$$\boxed{\text{Ratio} = 91.1 \text{ dB}}$$

bit/s = ?



4. A video signal has a bandwidth of 4.5 MHz, average power of 0.8W and peak voltage of $\pm 1.2V$. The signal is sampled, uniformly quantized, and transmitted via binary polar baseband modulation. The sampling rate is 25% above the Nyquist rate.

(a) If the required SNR for video quality is at least 55 dB, determine the minimum binary pulse rate (in bits per second) for this baseband transmission. [15]

$BW = 4.5 \text{ MHz}$ $P = 0.8 \text{ W}$ $\text{Peak } \pm 1.2 \text{ V}$

a) Minimum pulse rate

$$\frac{S}{N} = 2L^2 \left[\frac{m^2(t)}{P(t)} \right] \geq 55 \text{ dB}$$

$L = 129$ and $L = 2^n$

$2^7 = 128$

$2^8 = 256$

So for $L = 129$ n should be 8

$n = 8$

$NR = 2 \times BW$ with $BW = 4.5$

$NR = 2 \times 4.5 = 9 \text{ MHz}$

$NR = 9 \text{ Mbit/s}$

* Sampling at 25% above

$1.25 \times 9 = 11.25 \text{ MHz}$

1 s $\rightarrow$ 2.8 bit

11.25 sampling

R_b should be 4

(b) Find the minimum bandwidth required to transmit this signal without ISI when a raised-cosine pulse shape with roll-off factor $r=0.3$ is used. [15]

$r = 0.3$
 $B_T = \left(\frac{1+r}{2} \right) R_b$

With $BW = 4.5 \text{ MHz}$ then

$R_b = 4.5$

Minimum = $\left(\frac{1+0.3}{2} \right) \times 4.5 =$

$BW_{\min} = 2.65 \text{ MHz}$

AVERAGE

Name: _____

70

ELEG 4300 COMMUNICATION THEORY

Test# 2, 4/5/2022, Total: 100

Duration: 90 Mins

1. (a) Determine the Nyquist sampling rate of the signal: $4 \text{ sinc}(420\pi t)$

[10]

$B \times 2$ $g(t) \longleftrightarrow G(f)$ Nyquist rate $\propto B \times 2$

$$\pi\left(\frac{t}{T}\right) \longleftrightarrow \gamma \text{ sinc}(\pi f \gamma)$$

$$\pi\left(\frac{t}{T}\right) \longleftrightarrow 4 \text{ sinc}(\pi 420 t)$$

$$4 \text{ sinc}(4240 t)$$

$B = \pi 420 t$

$B = 1319 t$ X

~~10~~
-5

- (b) For the $G(f)$ given in Figure 1, sketch the spectrum of its ideally and uniformly sampled signal at the sampling rate of $f_s = 7500$. $\leftarrow$ modulate shift left and right

[10]

Add #

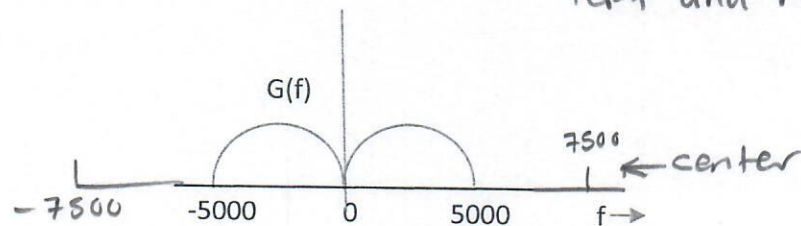
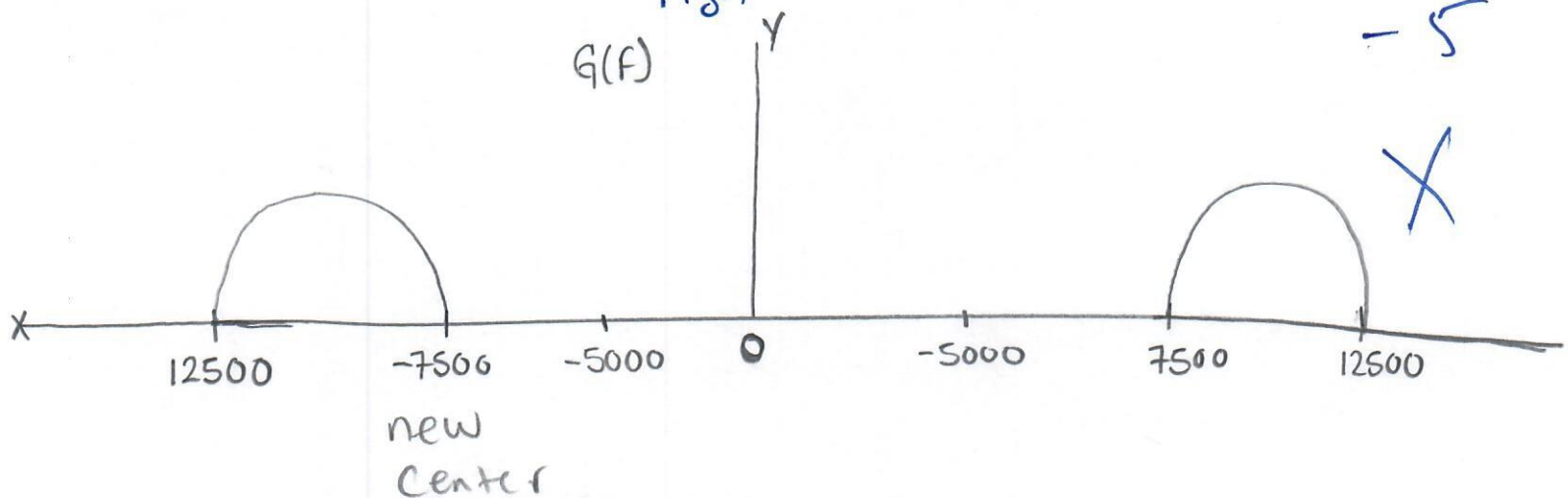


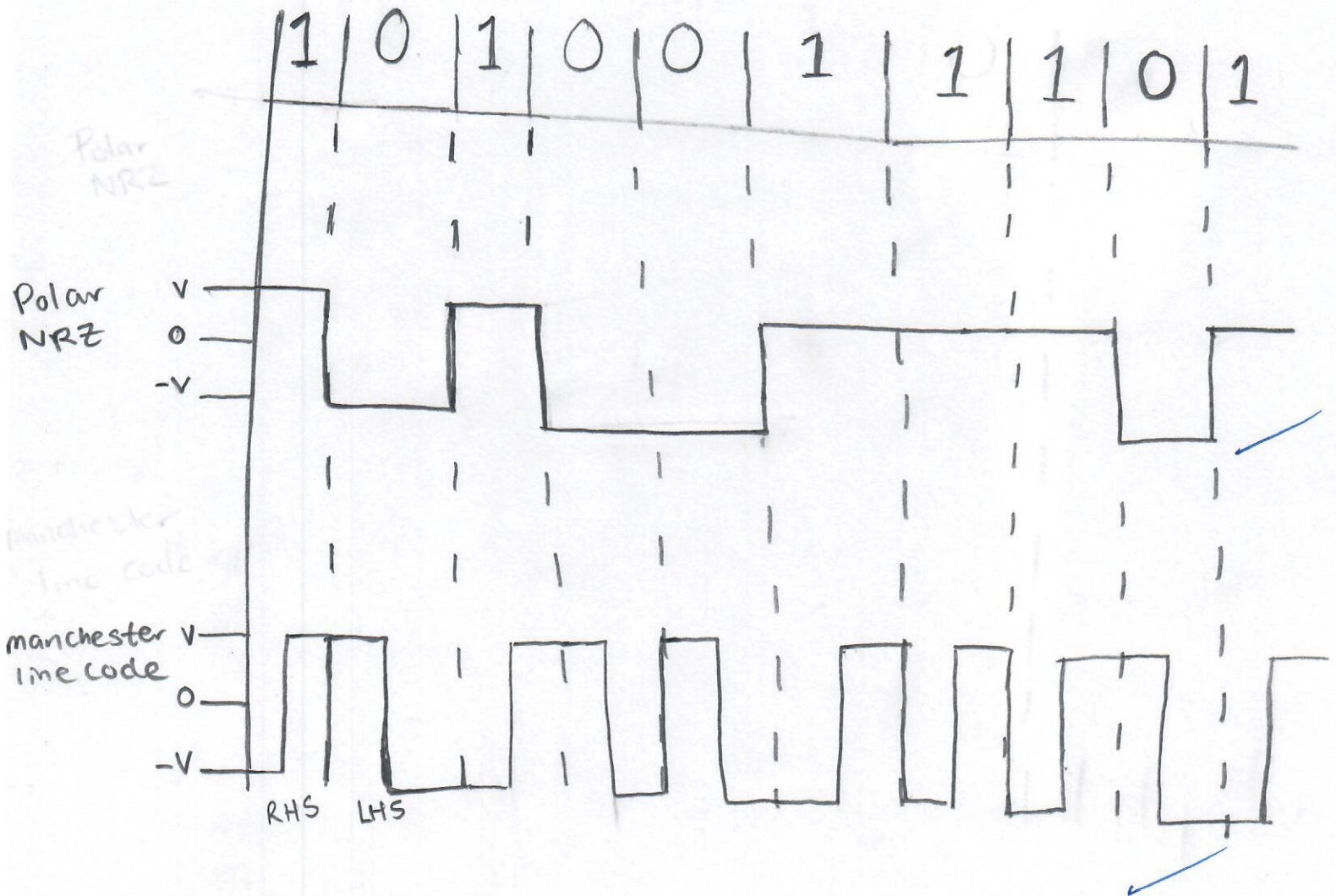
Fig. 1



Polar full period

2. Sketch (a) Polar NRZ and (b) Manchester line code for 1 0 1 0 0 1 1 1 0 1.

[10+10]



pulse code modulation

3. A compact disc (CD) records audio signals digitally by using PCM. Let the audio signal bandwidth be 15 KHz. B.W

(a) If the Nyquist samples are uniformly quantized into $L = 65,536$ levels and then binary-coded, determine the number of binary digits required to encode a sample. [15]

$$B.W = 15 \text{ KHz}$$

$$L = 2^{16} = 65,536$$

$$L = 2^n \text{ bits}$$

$$L = 65,536$$

16 bits needed

(b) Determine the number of binary digits per second (bit/s) required to encode the audio signal. [15]

$$\frac{S}{N} = \frac{3L^2}{[Ln(L+1)]^2}$$

$$= \frac{3 \cdot 2^{16}}{[Ln]}$$

X -15

$$\frac{S}{N} = 3 L^2 \frac{\overline{m^2(t)}}{m^2 p}$$

$$\overline{m^2(t)} = \text{Avg, mess. pwr}$$

$m_p = \text{peak Volt (amplitude)}$

4. A video signal has a bandwidth of 4.5 MHz, average power of 0.8W and peak voltage of $\pm 1.2V$. The signal is sampled, uniformly quantized, and transmitted via binary polar baseband modulation. The sampling rate is 25% above the Nyquist rate.

- (a) If the required SNR for video quality is at least 55 dB, determine the minimum binary pulse rate (in bits per second) for this baseband transmission. [15]

$$BW = 4.5 \text{ MHz}$$

$$\text{Avg pwr} = 0.8$$

$$\text{Peak Volt} = \pm 1.2V$$

At least 55db Signal to noise ratio

min # of pulses or bit/sec

$$\frac{S_0}{N_0} = 3 L^2 \frac{\overline{m^2(t)}}{m^2 p} \geq 55 \text{ dB}$$

$$\frac{0.8}{1.2} = 0.66$$

$$\text{find } L \geq 3 L^2 \frac{0.8W}{1.2V} \geq 10^{5.5}$$

$$\geq 10^{5.5}$$

$$2^8 = 256$$

$$2^9 = 512$$

$$L \geq \sqrt{\frac{10^{5.5}}{2}} = 397.6$$

$$n = 9$$

- (b) Find the minimum bandwidth required to transmit this signal without ISI when a raised-cosine pulse shape with roll-off factor $r=0.3$ is used. [15]

$$\left(1 + \frac{R}{2}\right) \text{ Bit rate}$$

$$BT = \left(\frac{1+r}{2}\right) R_b$$

$$BT = \left(\frac{1+0.3}{2}\right) \text{ Bit Rate}$$

$$BT = \left(\frac{1+0.3}{2}\right) (9) \times$$

$$B.T = 5.85 \times$$

BELOW AVERAGE

Name: _____

65

ELEG 4300 COMMUNICATION THEORY

Test# 2, 4/5/2022, Total: 100

Duration: 90 Mins

1. (a) Determine the Nyquist sampling rate of the signal: $4 \text{ sinc}(420\pi t)$

[10]

~~420π~~ Nyquist = $420 \times 2 = 960 \text{ Hz}$

X -10

- (b) For the $G(f)$ given in Figure 1, sketch the spectrum of its ideally and uniformly sampled signal at the sampling rate of $f_s = 7500$.

[10]

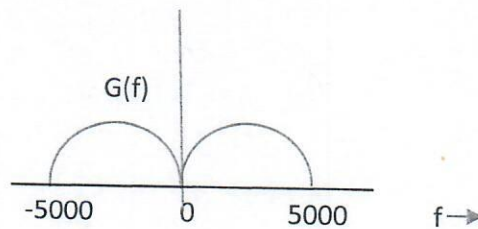
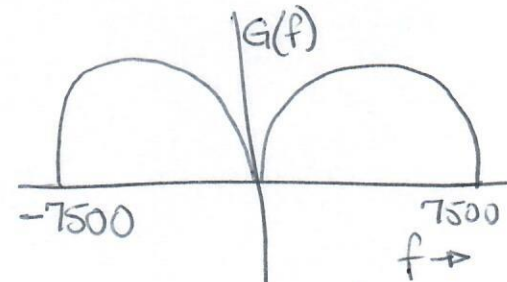
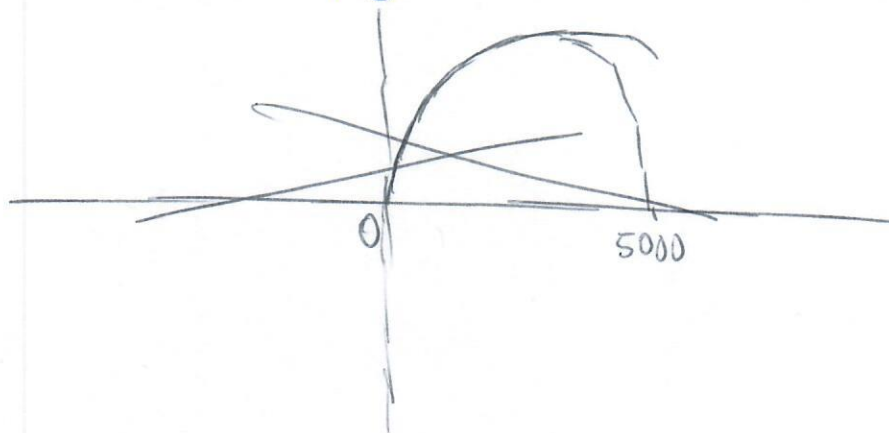


Fig-1



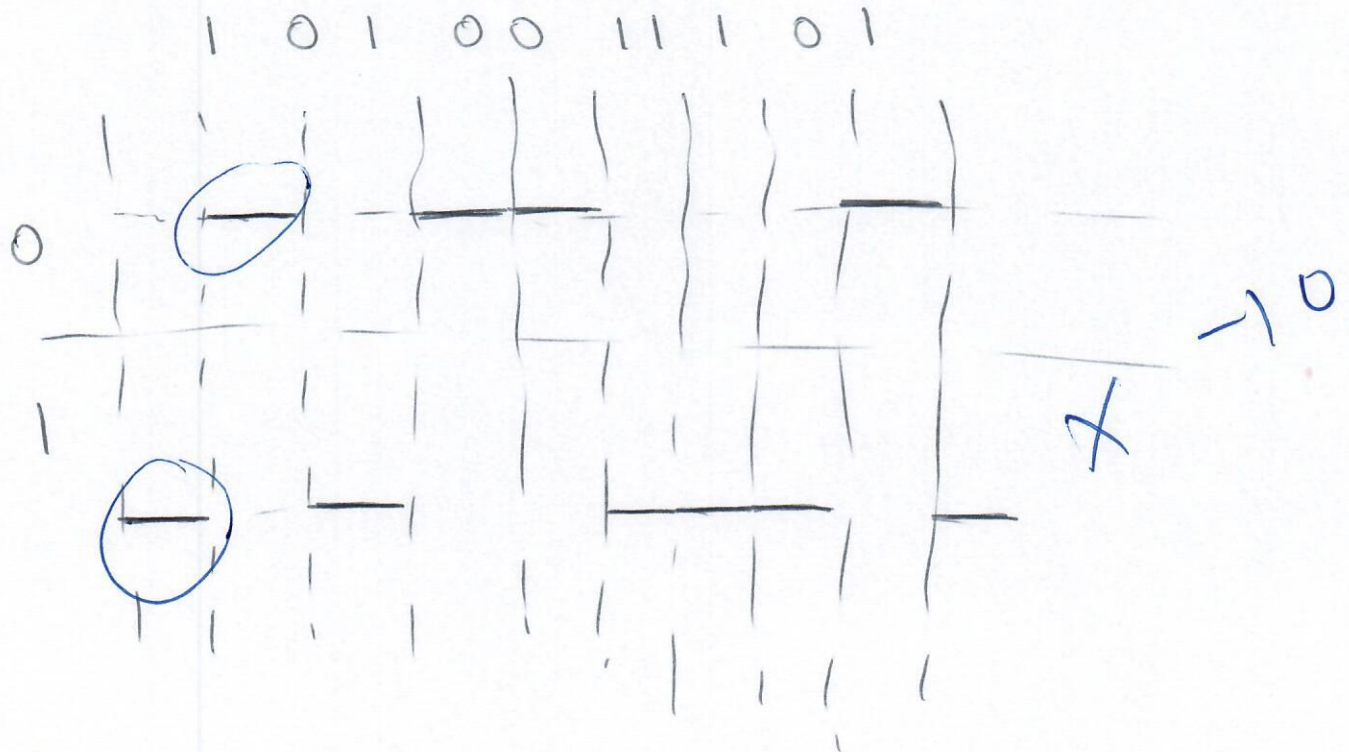
X

-10

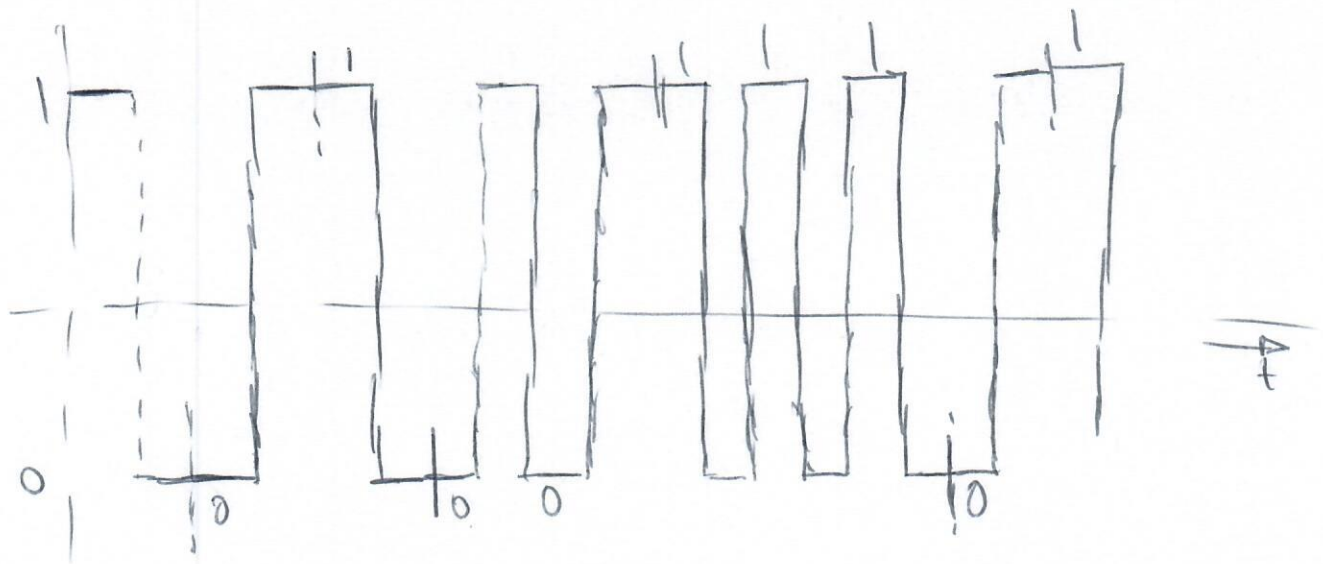
2. Sketch (a) Polar NRZ and (b) Manchester line code for 1 0 1 0 0 1 1 1 0 1.

[10+10]

a) Polar NRZ



b) Manchester



~~map = 0.1~~
~~P_m = 0.11~~

3. A compact disc (CD) records audio signals digitally by using PCM. Let the audio signal bandwidth be 15 KHz.

(a) If the Nyquist samples are uniformly quantized into $L = 65,536$ levels and then binary-coded, determine the number of binary digits required to encode a sample. [15]

$$2^{12} = 4096$$

$$2^{14} = 16,384$$

$$2^{15} = 32,768$$

$$2^{16} = 65,536$$

$$L = 65,536 \text{ levels}$$

$$L = 2^n$$

$$L = 2^{16}$$

$$= 16 \text{ bits}$$



(b) Determine the number of binary digits per second (bit/s) required to encode the audio signal. [15]

~~$$R_b = \frac{2}{1+r} B_T$$~~

~~$$R_b = \frac{2}{1} (15 \text{ KHz})$$~~

~~$$R_b = 30 \text{ Kbit/s}$$~~

$$R_b = 16 \times 15 \text{ KHz}$$

$$= 240,000 \text{ bits/s}$$

X - 15

4. A video signal has a bandwidth of 4.5 MHz , average power of 0.8 W and peak voltage of $\pm 1.2 \text{ V}$. The signal is sampled, uniformly quantized, and transmitted via binary polar baseband modulation. The sampling rate is 25% above the Nyquist rate.

- (a) If the required SNR for video quality is at least 55 dB , determine the minimum binary pulse rate (in bits per second) for this baseband transmission. [15]

$$55 \text{ dB} = 316227.766$$

need L
sampling rate

$$\text{SNR} = 3L^2 \frac{P_m}{m_p^2}$$

$$316227.766 = 3L^2 \left(\frac{0.8}{(1.2)^2} \right)$$

$$316227.766 = L^2 (1.66\bar{6})$$

$$189736.66 = L^2$$

$$435.587 = L$$

$$512 \approx L$$

$$2^n = 512$$

$$n = 9$$



$$\text{Nyquist} = 2 \times 4.5 \text{ MHz} = 9 \text{ MHz}$$

$$\text{Sampling} = 1.25 \times 9 \text{ MHz} = 11.25 \text{ MHz}$$

$$M = 11.25 \text{ MHz} \times 9 = 101,250,000 \text{ bits/s or}$$

$$101.25 \text{ M bits/s}$$



- (b) Find the minimum bandwidth required to transmit this signal without ISI when a raised-cosine pulse shape with roll-off factor $r=0.3$ is used. [15]

$$R_b = \frac{2}{(1+r)} B_T$$

$$B_T = R_b \left(\frac{1+r}{2} \right)$$

$$= 101.25 \text{ Mbits/s} \left(\frac{1.3}{2} \right)$$

$$= 65,812,500 \text{ MHz}$$

$$\text{or } 65.8125 \text{ MHz}$$



V. PROJECT

OUTCOME SPECIFIC ASSIGNMENTS USED TO ASSESS OUTCOMES

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
COMMUNICATION THEORY
SPRING 2022**

Instructor: Dr. Shumon Alam

Title of Assignment

Final Project

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Engineering design characteristics related to this assignment

Involves identifying the specific needs to be met by defining/understanding the problem and developing plans for the project to satisfy the need

Involves conducting a review of the literature and performing the preliminary design by generating alternative ideas/solutions and applying creativity

Involves mathematical analysis and simulation

Brief justification of why this assignment is suitable for this outcome

The final project for the semester required the students to design and simulate a coherent digital communication system with BER analysis. The final reports demonstrate the students' ability to design a digital communication system by choosing correct components and parameters to satisfy the requirement using a simulation tool (e.g. Simulink). The rubric, developed from the performance criteria for the outcome, used to assess this outcome is also provided to demonstrate student performance in the performance criteria areas.

ELEG 4300 Communication Theory Project
Spring 2022
Final Project (Project 2)

Assigned:	03/22/2022
Assignment Type:	Group Project
Reporting Requirements:	Status report every week
Analysis Requirements:	Use communication theory to match with simulation results
Final Project Presentation:	04/28/2022
Final Report Due:	05/10/2022

Project Description:

Apply communication theory to design and simulate a coherent digital communication system with BER analysis. Use a given modulation scheme with the following conditions:

Carrier frequency $f_c = 20$ kHz, 0° phase offset

Bit Time, $T_b = 1$ msec

Use a Random integer generator as the data source (unipolar binary data)

Modulated wave amplitude $A = 5$ V peak

AWGN Channel.

Modulation Scheme:

- a. Binary ASK, (Group 4)
- b. Binary FSK, (Group 3)
- c. Binary PSK (Group 2)
- d. 4-ASK with Gray coding (Consider 4-level ASK amplitude: 0 V, 1.666 V, 3.333 V, and 5 V) (Group 1)

The report should include the following items:

- a. Introduction: Discuss the theory
- b. Simulation model (you can use Simulink or other simulation tool)
- c. Explain each block of the model
- d. Results:
 - Show various outputs
 - Compare the observed and theoretical bit error data for given E_b/N_0 (0, 3, 6, 9, 12, 40, 50, 90 dB)
 - Find the bandwidth of the modulated signal as the percentage of the total power
- e. Conclusions

ABOVE AVERAGE

SAMPLE GRADING SCHEME AND GRADED FINAL REPORT AND PRESENTATION FROM STUDENT GROUP

GRADING SCHEME

	Point Assigned	Point Received
1. Ability to Define/Understand the Problem and then Plan the Project	15	14
2. Ability to Conduct a Review of the Literature, Generate Ideas, and Apply Creativity	25	24
3. Ability to Perform Preliminary and Detailed Design	25	22
4. Ability to Perform Simulation	25	22
5. Ability to deliver the project through a presentation	10	8
Total	100	90

PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING



ELEG 4300 Communication Theory

Project 2

Topic: Binary PSK Modulation

Submitted by:

Team 1

Submission Date: (5/3/2022)

Instructor: Dr. Shumon Alam

Project Topic: Binary Phase Shift Keying (PSK)

Introduction: Theory Discussion

Phase Shift Keying (PSK) refers to a digital modulation technique in which the sine and cosine inputs of a radio wave vary at a specific time, altering the phase of the carrier signal. Binary PSK is the simplest type of phase-shift keying. It is also known as Phase Reversal Keying (PRK) or 2-phase PSK.

Binary Phase Shift Keying has two phases. Each of these phases is separated by 180° . In this technique, two phase-reversals on the sine wave carrier occur at 0° and 180° . It can handle a surprisingly high level of noise and/or distortion before the demodulator outputs a wrong decision. On the downside, it may not be suitable for applications with a high data-rate since it can only modulate 1 bit per symbol.

Binary PSK is essentially a Double Sideband Suppressed Carrier (DSBSC) scheme for digital information. The modulation of Binary PSK is achieved through a balanced modulator, whose inputs consist of the carrier sine wave, on the one hand, and the binary sequence on the other. If one of the binary inputs is zero, then the phase output will be 0° . If one of the inputs is high, then the phase reversal will be 180° . The sine wave output from the modulator will be the inverted 180° phase-shifted input carrier. This is usually a function of the data signal.

The demodulation of Binary PSK is achieved using a mixer, double-input detector circuit, bandpass filter, and an oscillator circuit, which all collectively make up the BPSK demodulator. The first stage of demodulation involves using the mixer and the bandpass filter to recover the band-limited message signal.

This, in turn, generates the baseband signal, which is then used to regenerate the binary bitstream. The final phase of demodulation involves using the bit-clock rate to produce the original binary signal at the detector circuit.

Lastly, some of the examples of coherent modulation techniques are binary phase shift keying (BSK), amplitude shift keying (ASK), frequency shift keying (FSK) and continuous phase modulation. Coherent modulation emphasizes that the receiver needs the phase information of the transmitter (the carrier phase) to recover the transmitted data at receiver side. On the contrary, in non-coherent systems the receiver does not need the phase information of the transmitter carrier to recover the signal. To conclude, Binary PSK has a wide range of applications in Bluetooth communication, Radio-frequency identification (RFID), and wireless LANs.

MATLAB Simulink model image

Scope for Modulated Wave (Time domain and power spectral density)

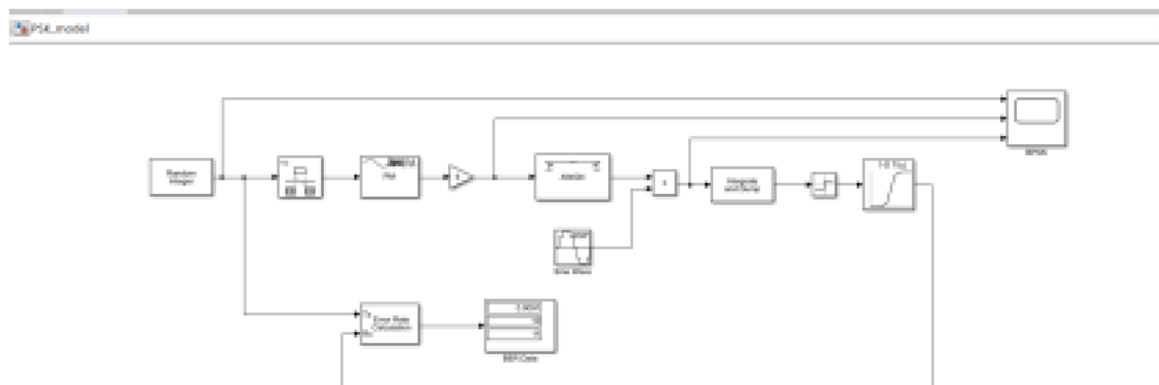


Figure 1: PSK Simulink Model

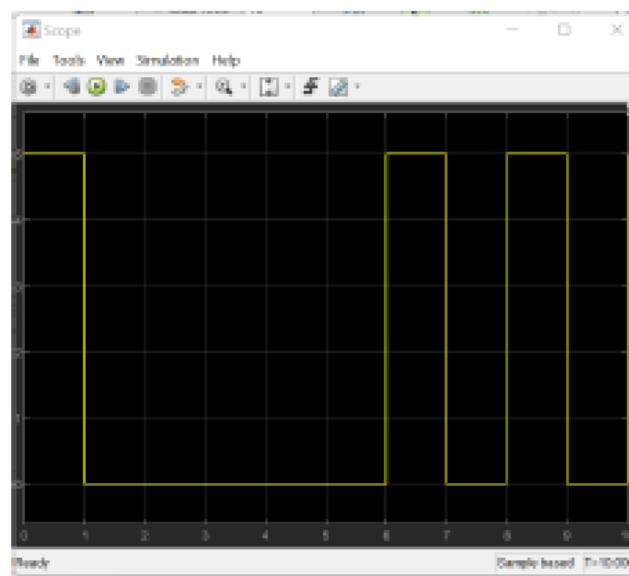
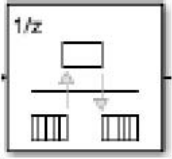
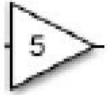
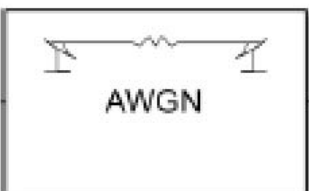
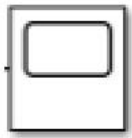
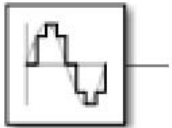
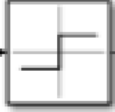
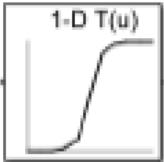
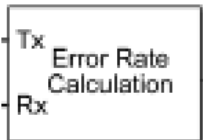


Figure 2: Modulated Wave

Explanation of each block in our simulation:

<u>Component</u>	<u>Technical Description</u>
 Random Integer	The <u>Random Integer Generator</u> block generates uniformly distributed random integers in the range $[0, M-1]$, where M is specified by the Set size parameter. Use this block to generate random binary-valued or integer-valued data.
	The <u>Rate Transition</u> block transfers data from the output of a block operating at one rate to the input of a block operating at a different rate. Use the block parameters to trade data integrity and deterministic transfer for faster response or lower memory requirements.
 PM	The <u>PM Modulator Passband</u> block modulates using phase modulation. The output is a passband representation of the modulated signal. The output signal's frequency varies with the input signal's amplitude. Both the input and output signals are real scalar signals.
	The <u>Gain</u> block multiplies the input by a constant value (gain). The input and the gain can each be a scalar, vector, or matrix.
 AWGN	The <u>AWGN Channel</u> block adds white Gaussian noise to the input signal. It inherits the sample time from the input signal.
 BPSK	The <u>Scope</u> block displays signals generated during simulation
 Reference	The <u>Sine Wave</u> block outputs a sinusoidal waveform. The block can operate in time-based or sample-based mode.

	The <u>Product</u> block outputs the result of multiplying two inputs: two scalars, a scalar and a nonscalar, or two nonscalars that have the same dimensions.
	The <u>Integrate and Dump</u> block creates a cumulative sum of the discrete-time input signal, while resetting the sum to zero according to a fixed schedule.
	For real inputs, the <u>Sign</u> block outputs the sign of the input.
	The 1-D, 2-D, and n-D <u>Lookup Table</u> blocks evaluate a sampled representation of a function in N variables.
	The <u>Error Rate Calculation</u> block compares input data from a transmitter with input data from a receiver. The block calculates the error rate as a running statistic by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.
	The <u>Display</u> block shows the value of the input data. You can specify the frequency of the display. For numeric input data, you can also specify the format of display.

Results:

In the scope outputs, there are three graphs. According to our Simulink model, the first graph represents the input signal (random integer generator). The second graph shows the modulated signal (Phase Modulation). The third graph displays the demodulated signal (AWGN).

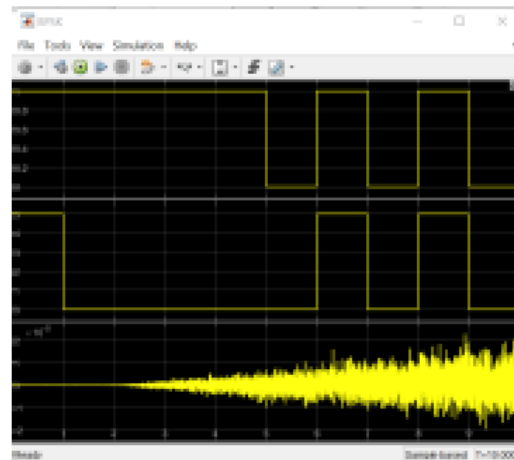


Figure 3: Scope output of 0 dB

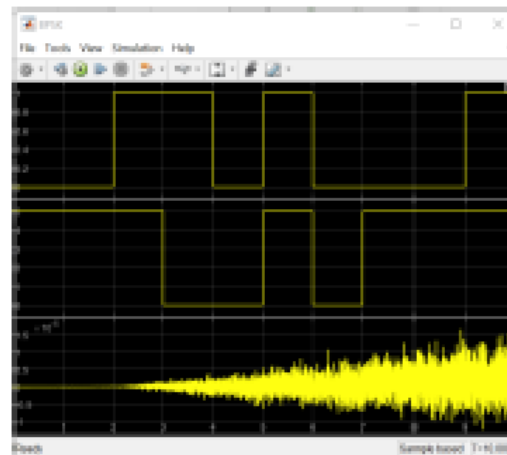


Figure 4: Scope output of 3 dB

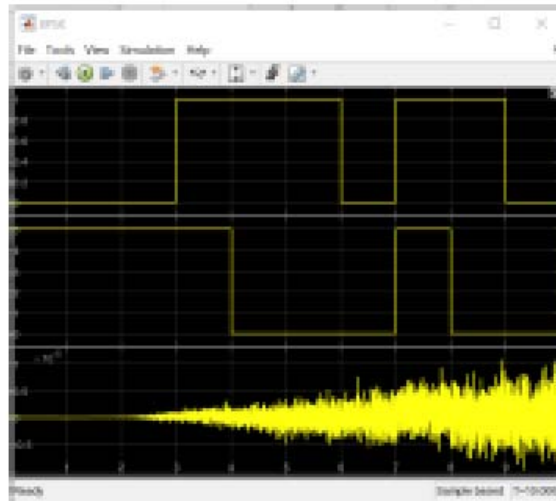


Figure 5: Scope output of 6 dB

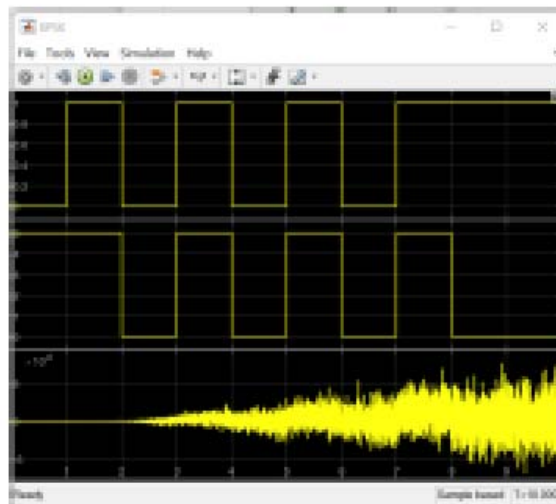


Figure 6: Scope output of 9 dB

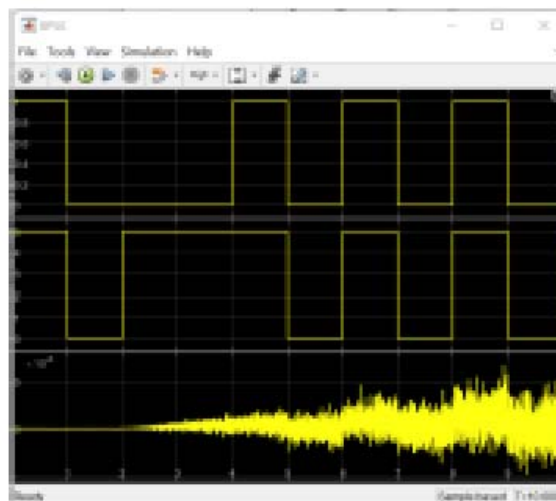


Figure 7: Scope output of 12 dB

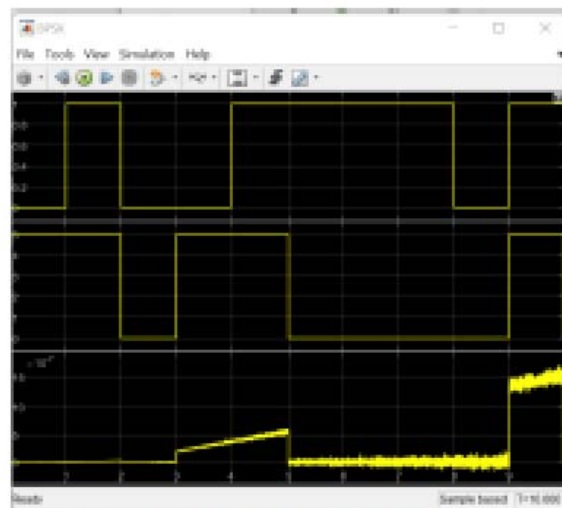


Figure 8: Scope output of 40 dB

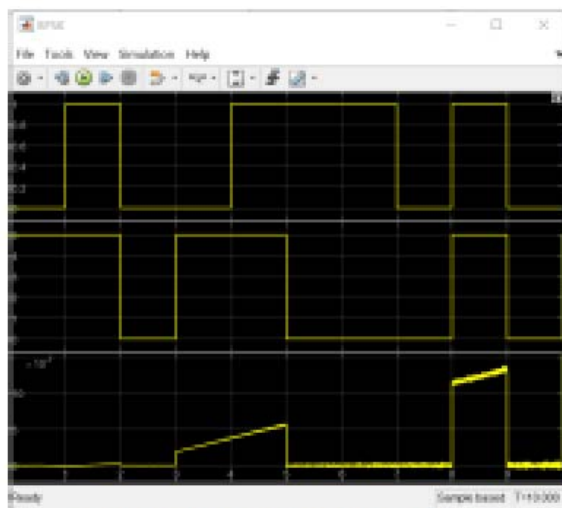


Figure 9: Scope output of 50 dB

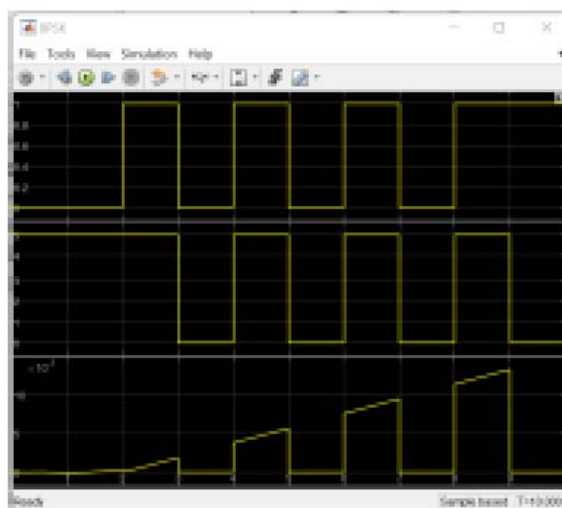


Figure 10: Scope output of 90 dB

As shown in Figure 3, the demodulated signal is very noisy and does not resemble the modulated signal. By Figure 6, a noticeable change occurs in the graph that becomes more defined in Figure 7. Figure 8 abruptly increases the SNR (Signal Noise Ratio) to 40 dB and creates the most stable graph seen thus far. By Figure 10, the SNR is set to 90 dB and the demodulated signal has far less noise thus making it resemble the shape of the modulated signal.

Calculations

Average probability of error BPSK

$$P_e = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

$E_b/N_0 = 0$	$\longrightarrow$	$P_e = 0$
$E_b/N_0 = 3$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{3}) = 0.866$
$E_b/N_0 = 6$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{6}) = 1.224$
$E_b/N_0 = 9$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{9}) = 1.500$
$E_b/N_0 = 12$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{12}) = 1.732$
$E_b/N_0 = 40$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{40}) = 1.822$
$E_b/N_0 = 50$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{50}) = 1.876$
$E_b/N_0 = 90$	$\longrightarrow$	$P_e = \frac{1}{2} \operatorname{erfc}(\sqrt{90}) = 1.899$

Conclusions

In summary, binary phase shift keying (BPSK) is a digital modulation scheme that conveys data by modulating two different phases of a reference signal (the carrier wave f_c). The constellation points chosen are usually positioned with uniform angular spacing around a circle giving maximum phase-separation between adjacent points and thus the best immunity to corruption.

References:

- https://www.mathworks.com/help/comm/ref/randomintegergenerator.html?searchHighlight=random%20integer%20&s_tid=srchtitle_random%20integer%20_2
- https://www.mathworks.com/help/simulink/slref/ratetransition.html?searchHighlight=rate%20transition&s_tid=srchtitle_rate%20transition_1
- https://www.mathworks.com/help/comm/ref/modulatorpassband.html?searchHighlight=modulator%20passband&s_tid=srchtitle_modulator%20passband_1
- https://www.mathworks.com/help/simulink/slref/gain.html?searchHighlight=Gain&s_tid=srchtitle_Gain_1
- https://www.mathworks.com/help/comm/ref/awgnchannel.html?searchHighlight=awgn&s_tid=srchtitle_awgn_3
- https://www.mathworks.com/help/simulink/slref/scope.html?searchHighlight=scope&s_tid=srchtitle_scope_1
- https://www.mathworks.com/help/simulink/slref/sinewave.html?searchHighlight=sine%20wave&s_tid=srchtitle_sine%20wave_1
- https://www.mathworks.com/help/simulink/slref/product.html?searchHighlight=product&s_tid=srchtitle_product_1
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- https://www.mathworks.com/help/simulink/slref/sign.html?searchHighlight=sign&s_tid=srchtitle_sign_3
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- https://www.mathworks.com/help/comm/ref/errorratecalculation.html?searchHighlight=error%20rate%20&s_tid=srchtitle_error%20rate%20_1
- https://www.mathworks.com/help/simulink/slref/display.html?searchHighlight=display&s_tid=srchtitle_display_1

AVERAGE

SAMPLE GRADING SCHEME AND GRADED FINAL REPORT AND PRESENTATION FROM STUDENT GROUP

GRADING SCHEME

	Point Assigned	Point Received
1. Ability to Define/Understand the Problem and then Plan the Project	15	10
2. Ability to Conduct a Review of the Literature, Generate Ideas, and Apply Creativity	25	15
3. Ability to Perform Preliminary and Detailed Design	25	18
4. Ability to Perform Simulation	25	20
5. Ability to deliver the project through a presentation	10	8
Total	100	71

Prairie View A&M University
College of Engineering



ELEG 4300 Project 2

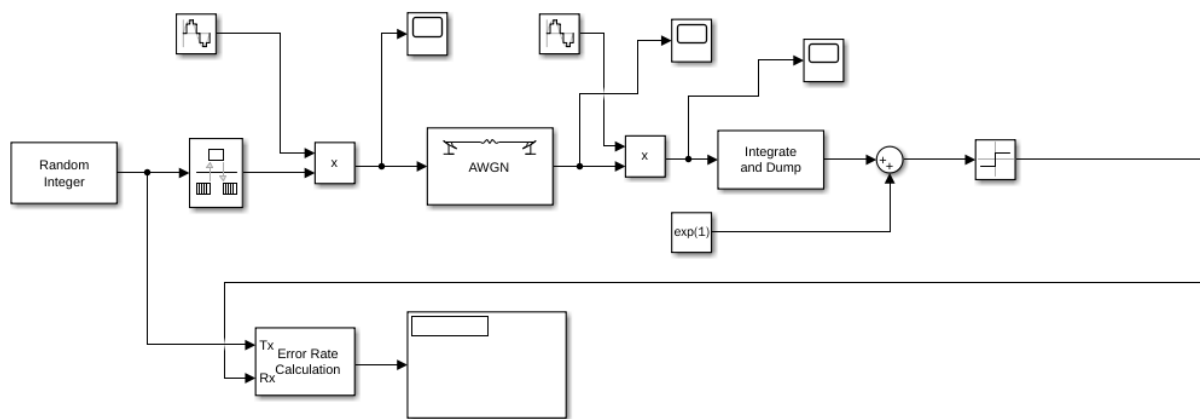
5/3/2022

Dr. Shumon Alam

Introduction

Amplitude Shift Keying (ASK) is a type of amplitude modulation in which frequency is shifting while frequency and phase remain constant. In Binary Amplitude Shift Keying (BASK), there are two symbols that are each represented by one bit. ~~Because there are two bits, the~~ system is binary. In real life application, ASK is the optical fiber application. The simulation that we will be creating will be a coherent digital communication system. We will make our system coherent by having a carrier frequency to be modulated.

MATLAB Simulink model



Block Explanation

The Random Integer block is the source that will generate a random integer between a fixed range. The system that we have created is binary, therefore a 1 or 0 will be generated. The rate transition block transfers the data at different rates. The sine wave block is the carrier wave that will be modulated with the random integer generator. The multiplier block is the product modulator. The AWGN channel block is the Additive White Gaussian Noise which is the noise interference from nature. It is present in wireless connection because there will be some noise when transmitting waves through air. The Error Rate Calculation block compares the bit transmitted and the bit received to find out how much was received in error. The Integrate and Dump block discretely integrates the sum of signal then resets it to zero according to the set schedule. This filter is ideal for coherent integration systems that have additive white Gaussian noise. The Euler's block calculates Euler's number to the exponential of one. The scope is used to display the generated signal at a given point. The sign block indicates an output of -1, 0, or 1 based on whether the input is less than, equal to, or greater than zero. The add block adds the two input sources together.

Results

In order to get an accurate calculation of BER, we used a MatLab code to display the BER for the given Eb/N0 values. In figure 1 below, the code that we used is displayed. The displayed graph of Eb/N0 vs BER graph is displayed in figure 2.

```

EbN0dB=0:3:12
EbN0=10.^(EbN0dB/10);
Pe_bask=0.5*erfc(sqrt(EbN0/4));
semilogy(EbN0dB,Pe_bask,'r*');
legend('BASK')
xlabel('EbN0 (dB)')
ylabel('BER')
grid on

```

Figure 1

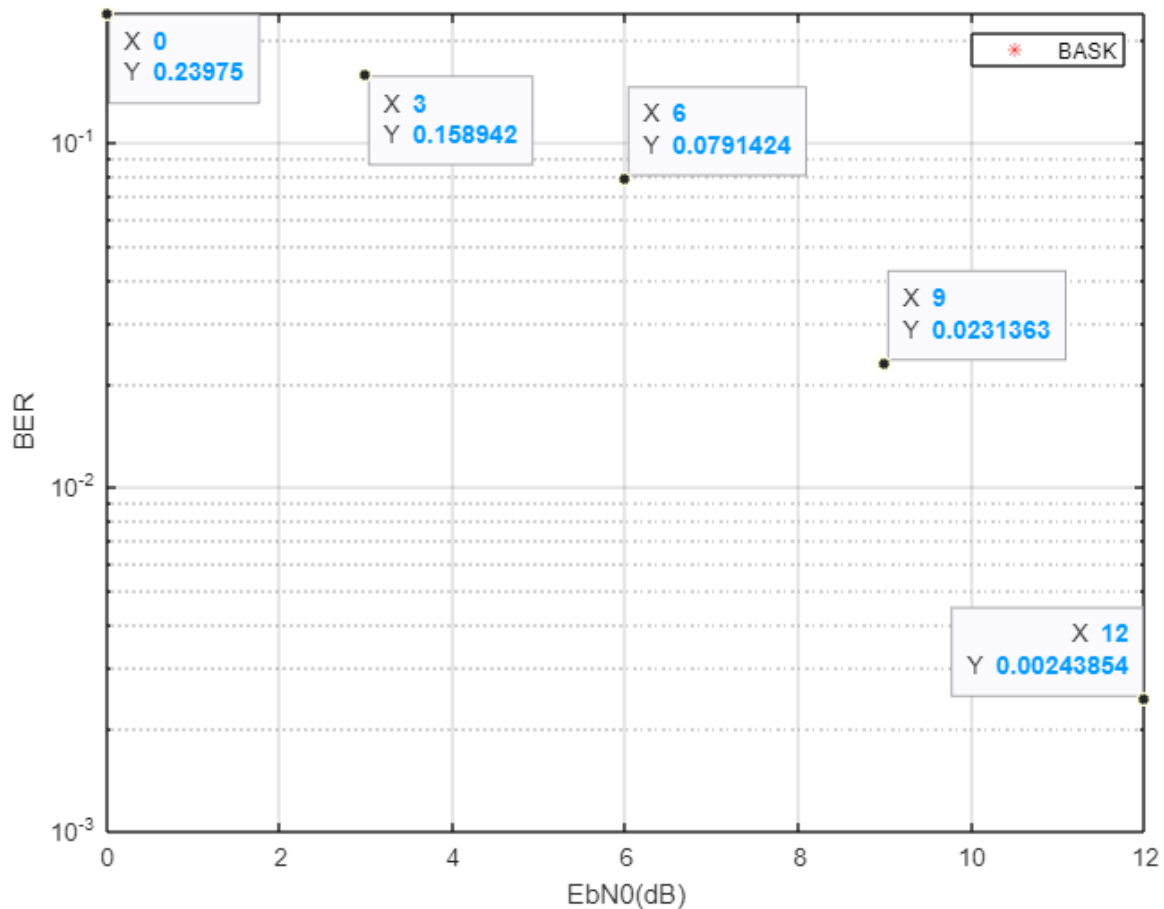


Figure 2

In figures 2 and 3, the Eb/N0 values are shown below followed by the BER values. When we calculated the BER for 40 dB, 50 dB, and 90 dB, the values were too close to zero to be displayed.

EbN0dB =

0 3 6 9 12

Pe_bask =

239.750061093477e-003 158.942189053476e-003 79.1424312580902e-003 23.1363260692925e-003 2.43853690831621e-003

Figure 2

EbN0dB =

40 50 60 70 80 90

Pe_bask =

0.000000000000e+000 0.000000000000e+000 0.000000000000e+000 0.000000000000e+000 0.000000000000e+000 0.000000000000e+000

Figure 3

The display in the following figures are the received values from the block diagram with the differences in the AWGN.

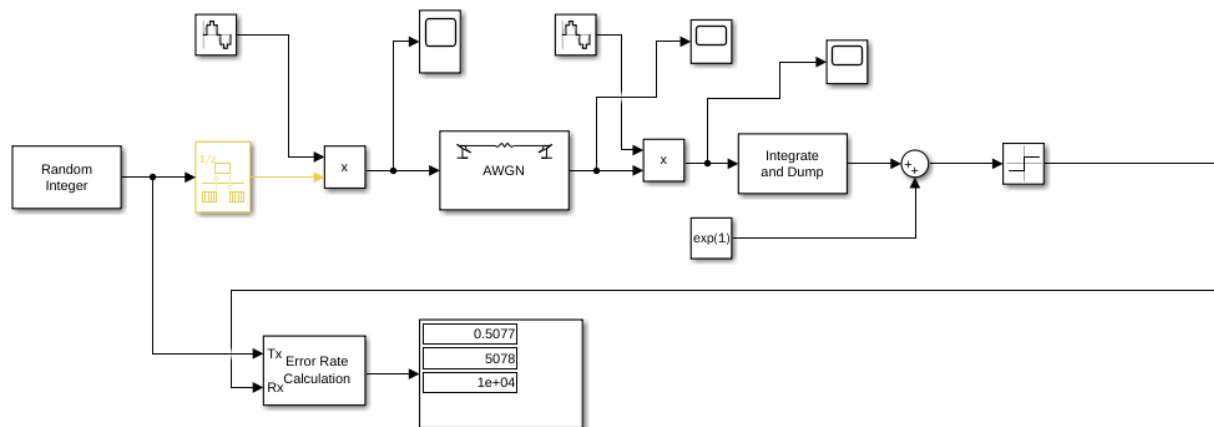


Figure 4 (0 Eb/No)

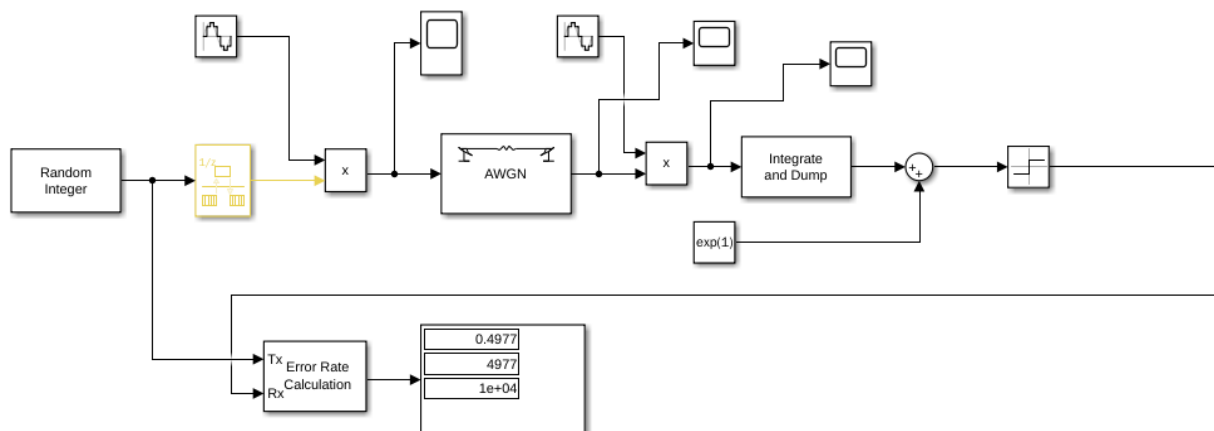


Figure 5 (3 Eb/No)

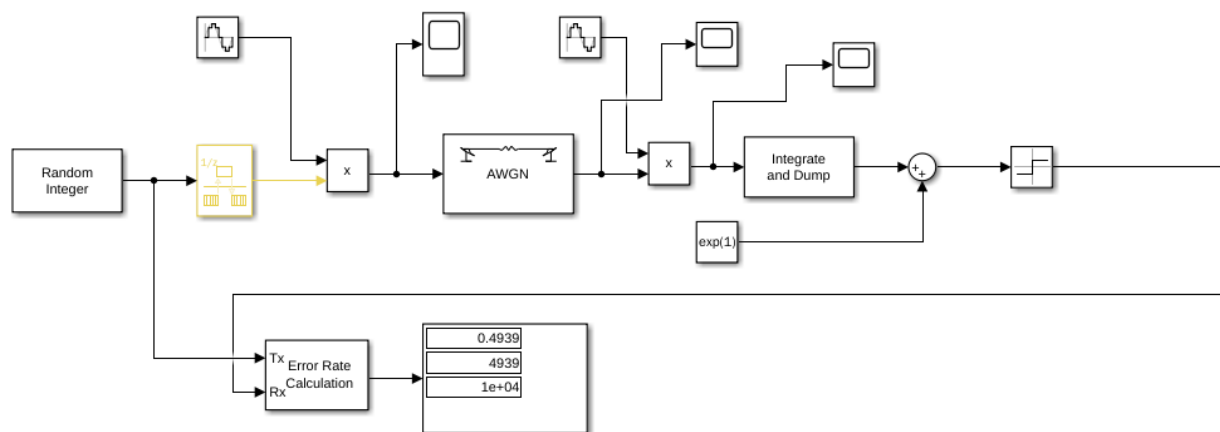


Figure 6 (6 Eb/No)

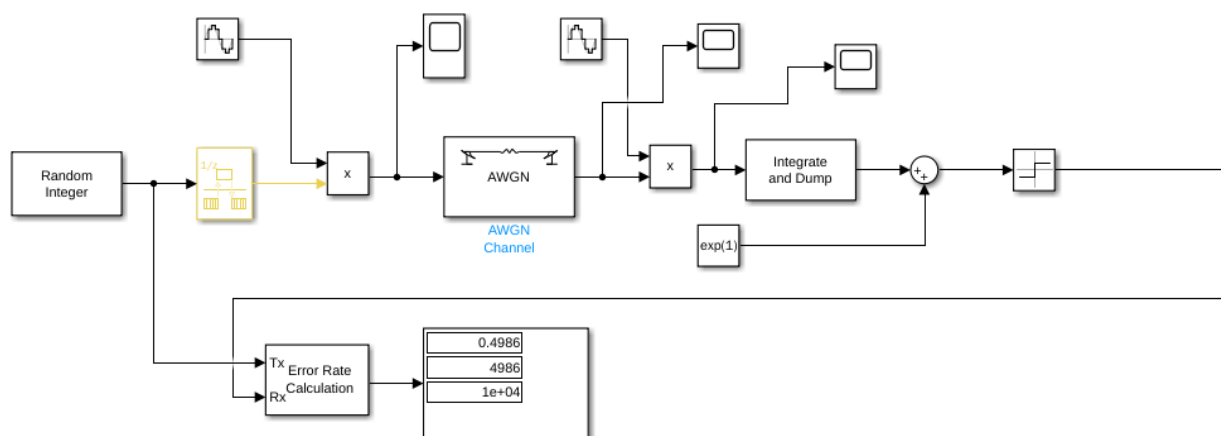


Figure 7 (9 Eb/No)

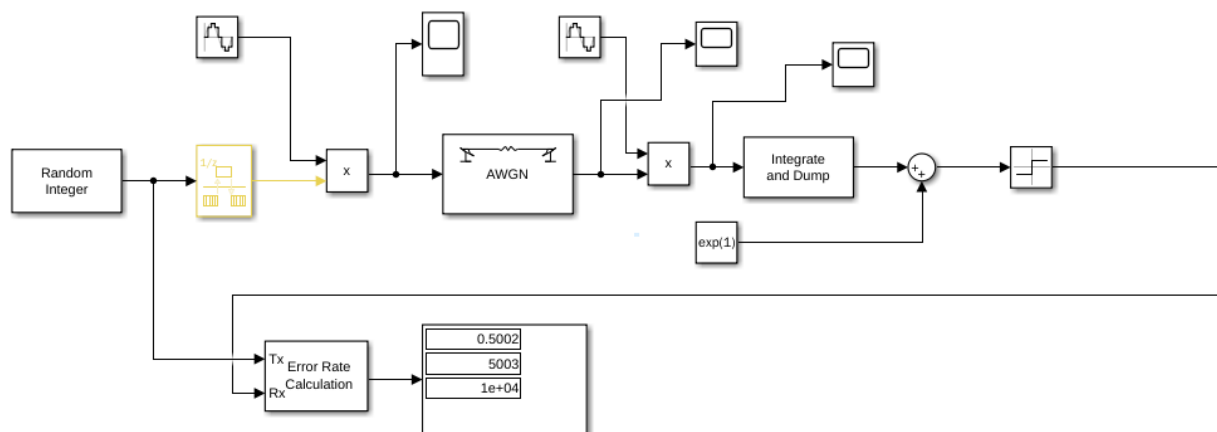


Figure 8 (12 Eb/No)

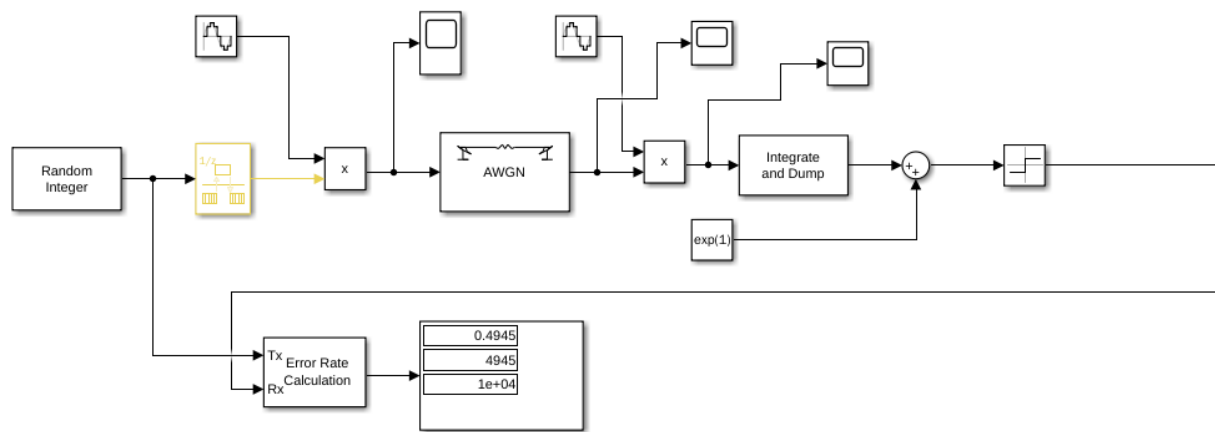


Figure 9 (40 Eb/No)

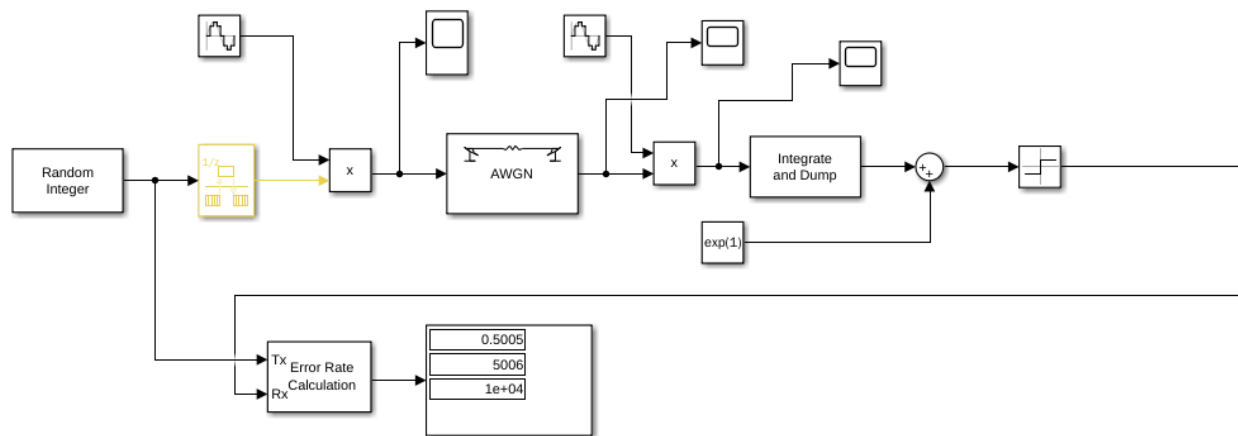


Figure 10 (50 Eb/No)

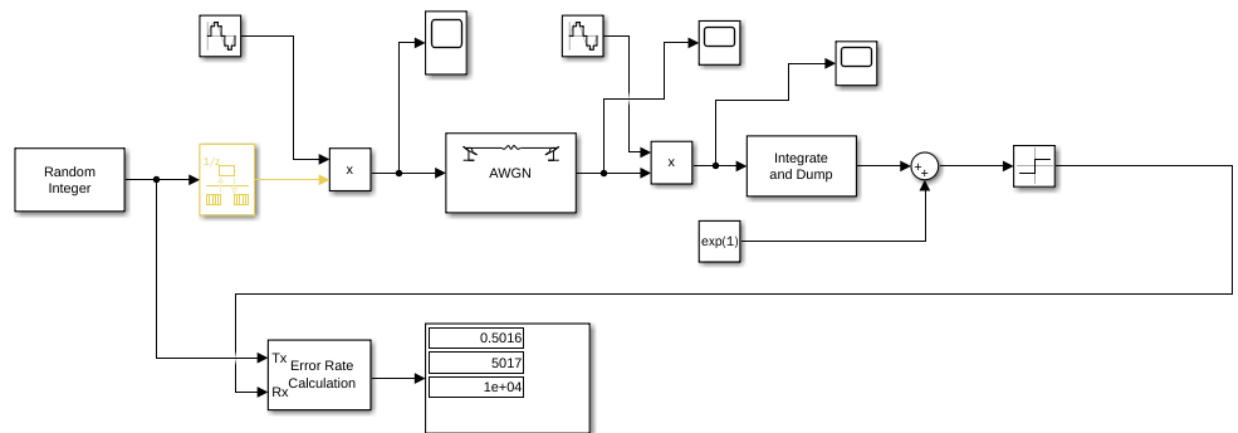
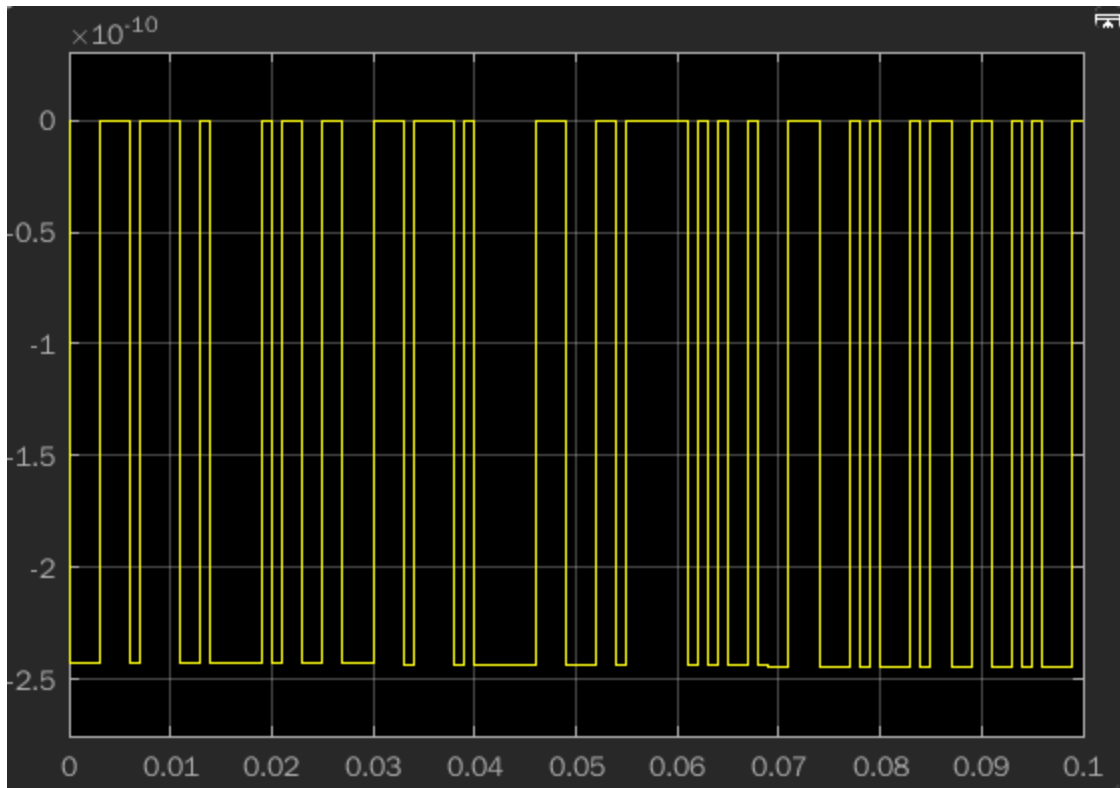
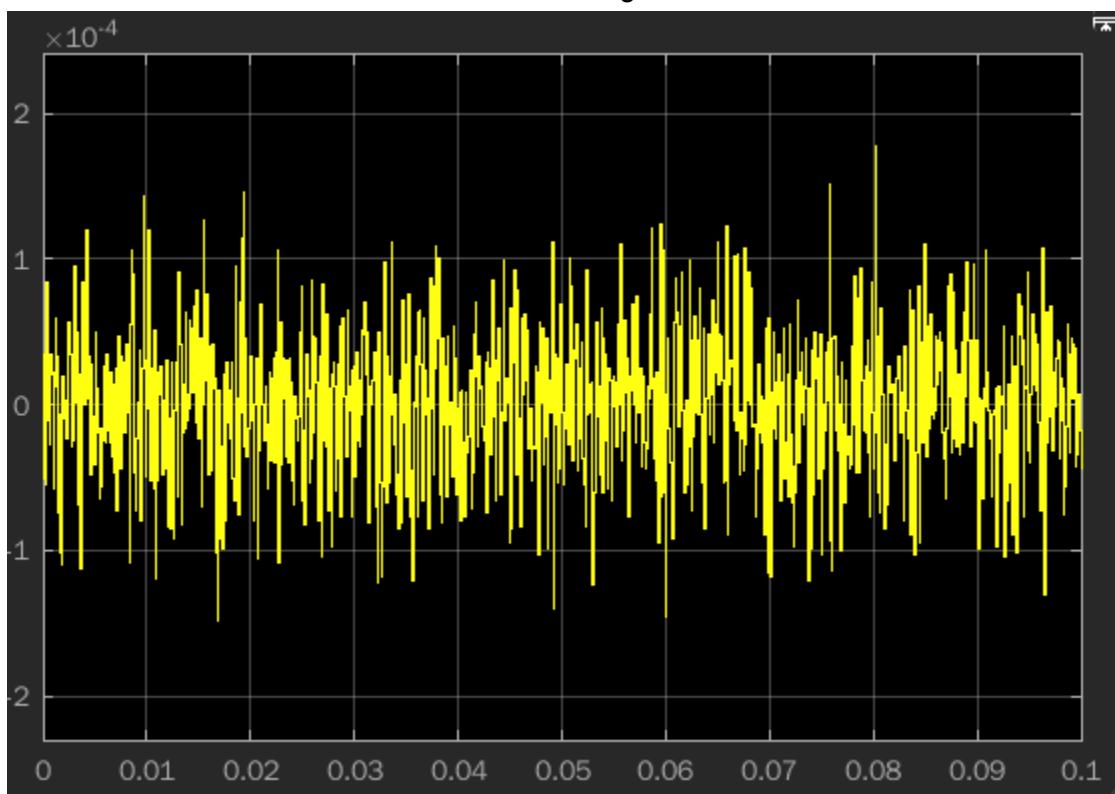


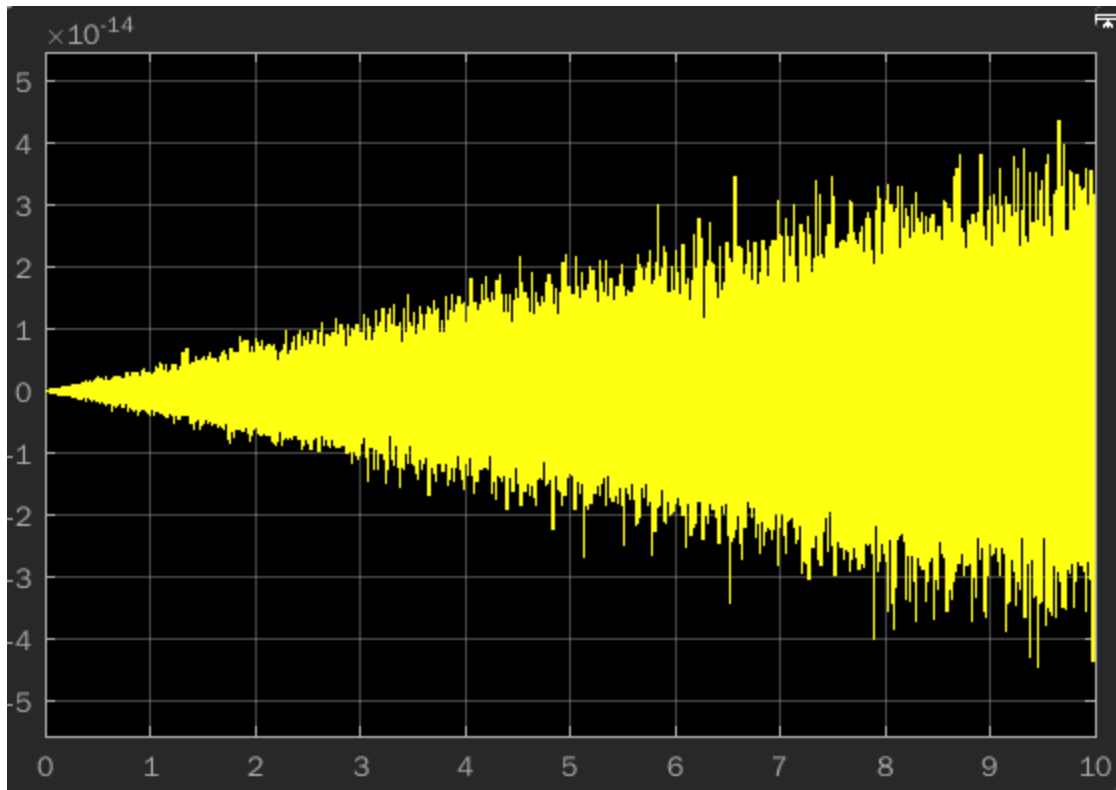
Figure 11 (90 Eb/No)



Modulated Signal



AWGN modulated signal



Demodulated signal with AWGN

The modulation is small less than 0Hz so the band width of the signal at 98% is $2(20\text{kHz})=40\text{kHz}$. Also, the graphs have to take into calculation that it is using the sample time.

Conclusions

In our project, we simulated a binary amplitude shift keying modulation. The modulation was very small and is attributed to the sample size that was used. In the same size used the frequency was changed from the equation used and it caused for the small modulated signal. With a larger sample time a larger modulated signal may have been received.