SCHEME : K

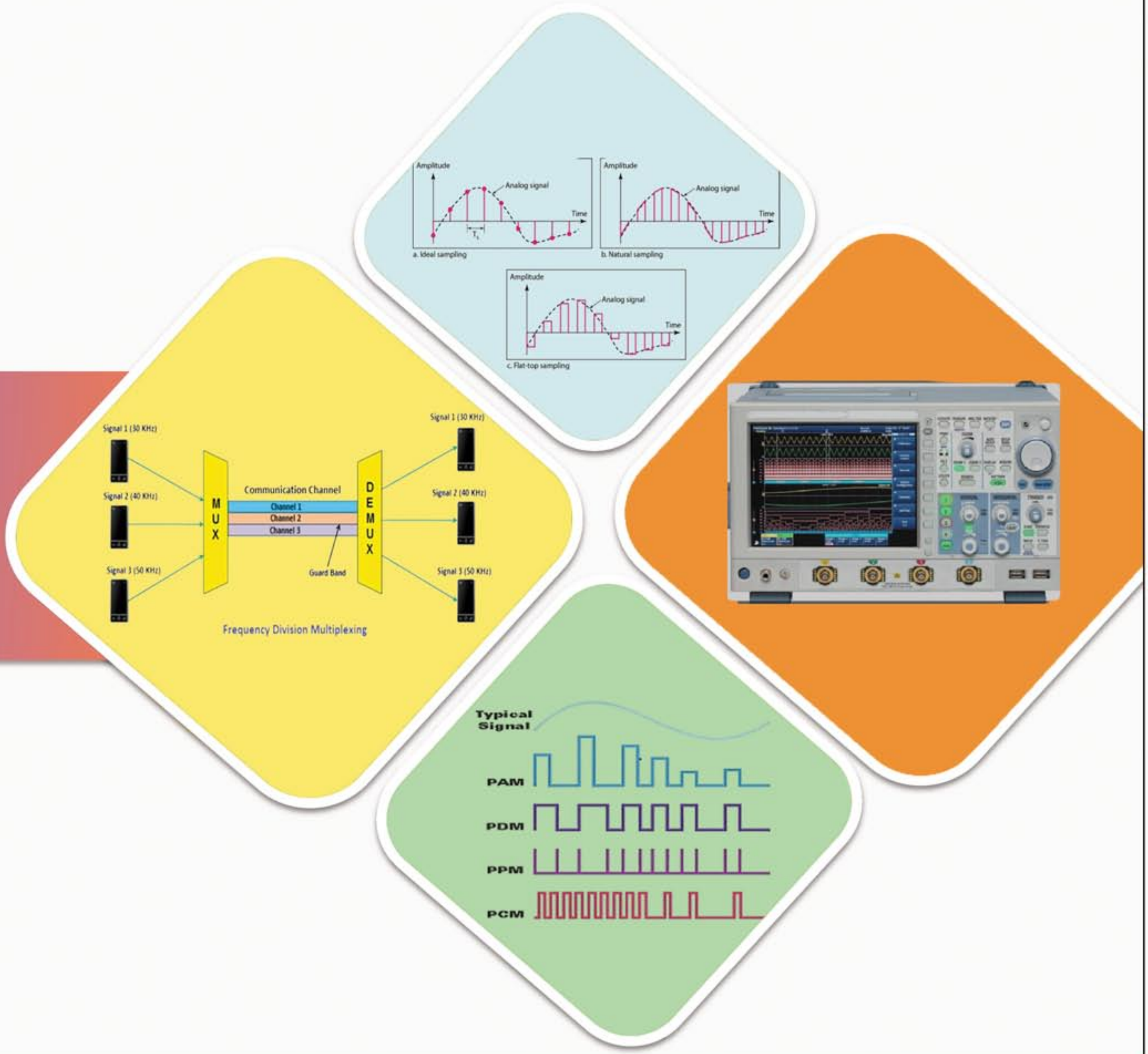
Name : ______________________________

Roll No. : ________________ Year : 20___ 20___

Exam Seat No. : ________________________

LABORATORY MANUAL FOR

DIGITAL COMMUNICATION SYSTEMS (314326)



ELECTRONICS ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

VISION

To ensure that the Diploma Level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE, are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation evaluation and monitoring system along with adequate faculty development Programs.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization
- Well-designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based programs.
- Technical skills do need support for life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual
For

Digital Communication Systems
314326

Semester-IV

DE/EJ/ET/EX/IE

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous)

(ISO 9001:2015) (ISO/IEC 27001:2013)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms ……………………………………….…… Roll .No……………………………..of IVth Semester of Diploma in …………………………………………………… of Institute ………………………………………(Code:) has attained pre-defined practical outcomes satisfactorily in course **Digital Communication Systems 314326** for the academic year 20…. to 20…. as prescribed in the curriculum.

Place:................ Enrollment No:................

Date ……………. Exam. Seat No: ....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative ‘K’ Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ‘vehicle’ to develop this industry identified competency in every student. The practical skills are difficult to develop through ‘chalk and duster’ activity in the classroom situation. Accordingly, the ‘I’ scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age old practice of conducting practical to ‘verify the theory’ (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Communication technologies have undergone radical changes, especially due to convergence of computers and communication. No industry is untouched by the digital communication. This course will enable the diploma engineers to apply facts, concepts and working principles of Digital commendation for the troubleshooting and maintenance of digital communication systems. This course is intended to develop the skills to diagnose and rectify the errors occurred in Digital communication systems. The concepts and principles of digital communication will also lay the foundation to understand the various modern communication systems.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course

Following programme outcomes are expected to be achieved through the practical of the course:

PO1:Basic and Discipline knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics related problems.

PO2: Problem Analysis: Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems

PO3:Design Development and Solution: Plan to design experiments and develop to use the results to solve broad-based Electronics related problems.

PO4:Engineering tools: Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations.

PO5:Engineering Practices for Society, Sustainabilityand Environment: Assess social, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Electronics. Apply Electronics and Telecommunication engineering solutions also for sustainable development practices in social and environmental contexts**:**

PO6:ProjectManagement : Function effectively as a leader and team member in diverse/multidisciplinary teams. Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Electronics and Telecommunication engineering

PO7:Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Electronics and Telecommunication engineering and allied industry.

Practical Course Outcome matrix

Course Outcomes (Cos)						
CO1 - Implement different error control coding schemes for digital communication system. CO2 - Use various pulse code modulation techniques. CO3 - Analyze the performance of different digital modulation techniques. CO4 - Interpret concept of multiplexing and multiple access techniques. CO5 - Interpret the concept of various spread spectrum techniques.						
Pr.No.	Practical Title	CO1	CO2	CO3	CO4	CO5
1.	Generate-a) Unipolar -NRZ,RZ b)Bipolar NRZ(AMI), Manchester code for given Data	√	-	-	-	-
2.	Implementation of various line coding scheme using suitable simulation tool	√	-	-	-	-
3.	Determine error by LRC techniques using suitable Simulation tool	√	-	-	-	-
4.	Determine error by VRC techniques using suitable Simulation tool	√	-	-	-	-
5.	Generation of Hamming code for 4 bits data.	√	-	-	-	-
6.	Error correction using hamming code.	√	-	-	-	-
7.	Generation of natural and flat top sampling signal.	-	√	-	-	-
8.	Determine the Nyquist rate for given signal by using suitable simulation tool.	-	√	-	-	-
9.	Performance of pulse width modulation and demodulation circuit.	-	√	-	-	-
10.	Performance of pulse position modulation and demodulation circuit.	-	√	-	-	-
11.	Generation of Pulse signal using pulse code modulation.	-	√	-	-	-
12.	Implement differential pulse code modulation and demodulation using suitable simulation tool.	-	√	-	-	-
13	Generation of delta modulation and demodulation signal.	-	√	-	-	-
14.	Performance of adaptive delta modulation and demodulation circuit.	-	√	-	-	-
15.	Transmit and receive digital signal using Amplitude shift keying.	-	-	√	-	-
16.	Transmit and receive digital signal using Frequency shift keying.	-	-	√	-	-
17.	Transmit and receive digital signal using Phase shift keying.	-	-	√	-	-
18.	Performance of QPSK modulation and demodulation.	-	-	√	-	-
19.	Performance of QAM modulation and demodulation.	-	-	√	-	-
20.	Multiplexing of signals in TDM using kit.	-	-	-	√	-

Pr.No.	Practical Title	CO1	CO2	CO3	CO4	CO5
21.	Generation of TDM signal using suitable simulation software.	-	-	-	√	-
22.	Multiplexing of signals in FDM using kit.	-	-	-	√	-
23.	Generation of FDM signal using suitable simulation software.	-	-	-	√	-
24.	Generation of CDM signal using suitable simulation software.	-	-	-	√	-
25.	PN sequence generator	-	-	-	-	√
26.	Generation of PN sequence using suitable simulation tool.	-	-	-	-	√
27.	Generation of two channel CDMA-DSSS signal using suitable simulation tool.	-	-	-	-	√
28.	Generation of two channel CDMA-FHSS signal using suitable simulation tool.	-	-	-	-	√

List of Industry Relevant Skills

The following industry relevant skills of the competency "Use basic concept of digital communication in various applications" are expected to be developed in the student by undertaking the practical of this laboratory manual.

1. Generate various line codes.
2. Identify the digital communication system.
3. Interpret waveforms of different digital communication system
4. Select the proper digital communication system as per the requirement.
5. Compare the observed output with the expected output.
6. Use relevant EDA tool for simulating digital communication systems

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each practical
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.
9. If practical is in two parts -Part I and Part II it should be conducted in two weeks.
10. Teacher is expected to refer complete curriculum document and follow guidelines for implementation

Instructions for Students

1. Listen carefully the lecture given by teacher about course, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
6. Student shall refer technical magazines, IS codes and data books.
7. Student should develop habit to submit the practical on date and time.
8. Student should well prepare while submitting write-up of exercise.

Content Page

List of Practicals and Progressive Assessment Sheet

Sr.No.	Practical Outcome	Page No.	Date of perf or man ce	Date of submi ssion	Assess ment marks (25)	Dated sign. of teacher	Remarks (if any)
19.	Performance of QAM modulation and demodulation.	154 to 161					
20.	Multiplexing of signals in TDM using kit.	162 to 168					
21.	*Generation of TDM signal using suitable simulation software.	169 to 177					
22.	*Multiplexing of signals in FDM using kit.	178 to 186					
23.	Generation of FDM signal using suitable simulation software.	187 to 194					
24.	*Generation of CDM signal using suitable simulation software.	195 to 203					
25.	*PN sequence generator	204 to 211					
26.	Generation of PN sequence using suitable simulation tool.	212 to 217					
27.	*Generation of two channel CDMA-DSSS signal using suitable simulation tool.	218 to 225					
28.	Generation of two channel CDMA-FHSS signal using suitable simulation tool.	226 to 234					

Practical No.1: Generate-a) Unipolar -NRZ,RZ b) Bipolar -NRZ(AMI), Manchester code for given data

I Practical Significance

The process of converting binary data into a sequence of bits of the digital signal is known as Line coding. Line coding is an essential aspect of digital communication systems. It involves converting binary data into a format suitable for transmission over a communication channel. Line-coded signal is used to create an "RF signal" that can be sent through free space. The line-coded signal can be converted to bits on an optical disc. In this practical student will convert the given digital data into various line codes.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 1.1 Observe line code for given data.
- LLO 1.2 Measure amplitude for various line code.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

A line code is the code used for data transmission of a digital signal over a transmission line.

Types of Line Coding:

Unipolar Non-Return to Zero (NRZ)

In this type of unipolar signaling, a High in data is represented by a positive pulse called as Mark, which has a duration T_0 equal to the symbol bit duration. A Low in data input has no pulse. It is clearly understood with the help of figure 1.1.

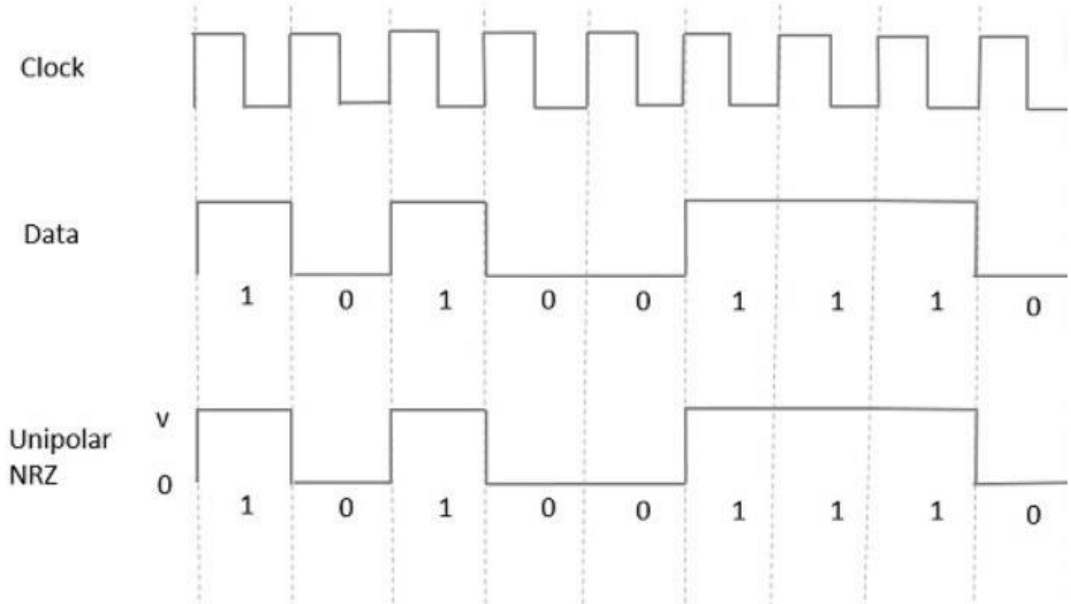


Figure 1.1: Unipolar NRZ

Unipolar Return to Zero (RZ)

In this type of unipolar signaling, a High in data, though represented by a Mark pulse, its duration T0 is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration. It is clearly understood with the help of the figure 1.2

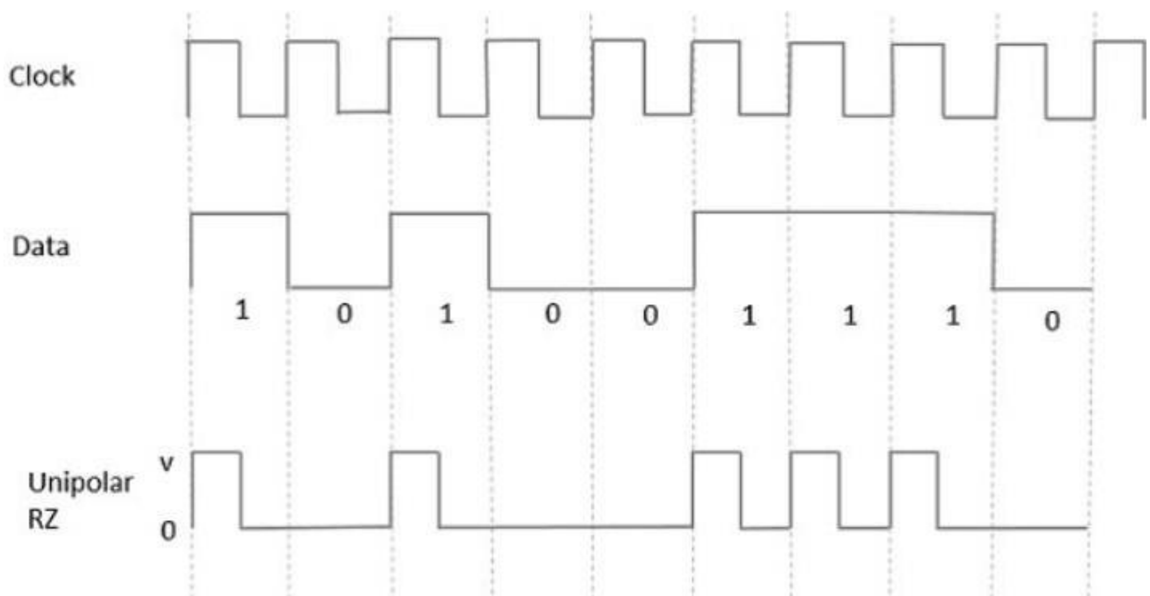


Figure 1.2: Unipolar RZ

Bipolar Signaling:

This is an encoding technique which has three voltage levels namely +, - and 0. Such a signal is called as duo-binary signal. An example of this type is Alternate Mark Inversion (AMI). For a 1, the voltage level gets a transition from + to – or from – to +, having alternate 1s to be of equal polarity. A 0 will have a zero voltage level. We have two types 1. Bipolar NRZ 2. Bipolar RZ or Manchester shown in figure 1.3

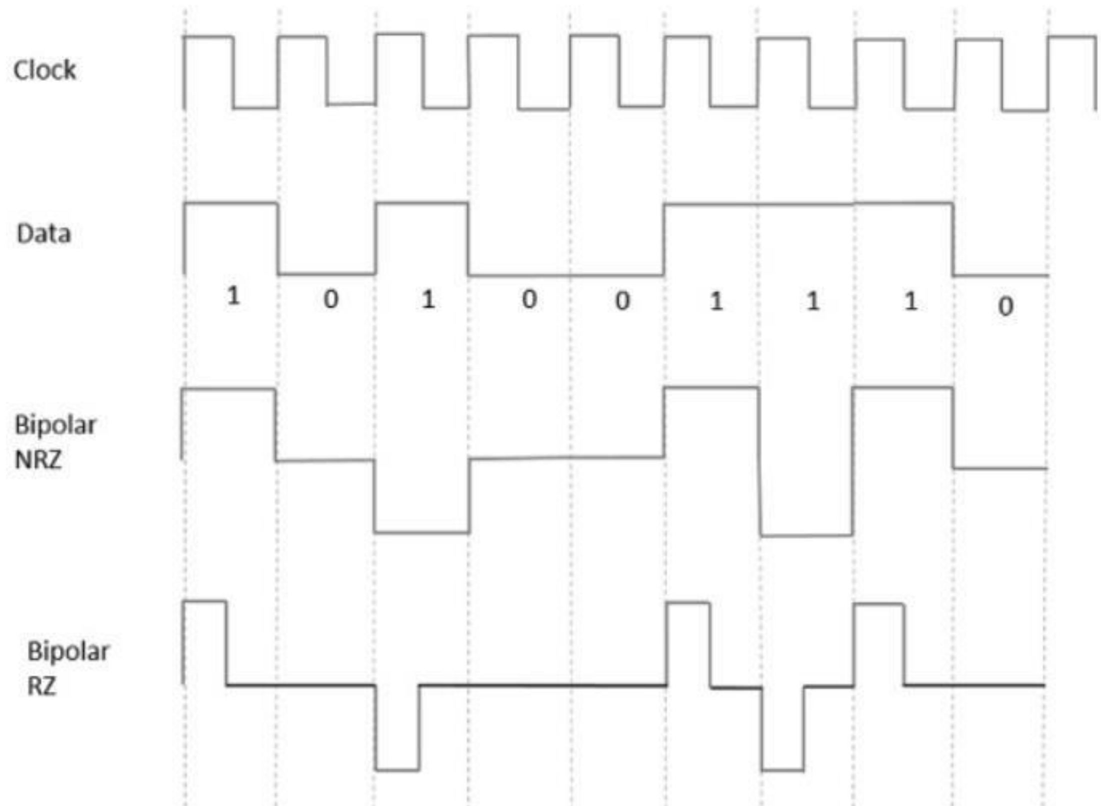


Figure 1.3: Bipolar NRZ and Bipolar RZ

.

VII Practical set up:

a) Sample Experimental set up used in laboratory

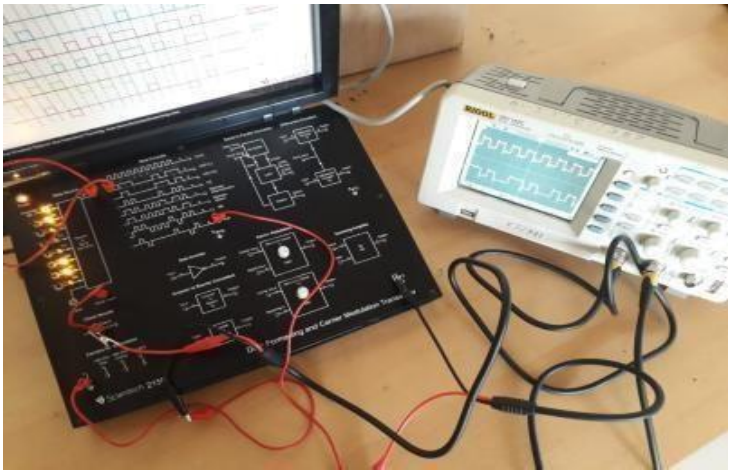


Figure 1.4: Practical set up for line code

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Line Coding Kit	8 bit variable NRZ-L pattern Data Simulator using 8 way DIP Switch,15 clock states constant data pattern,125 KHz serial data pattern or equivalent trainer kit	1
2	CRO/ DSO	50 to 100 MHz dual scope	1
3	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per circuit diagram.

X Procedure

1) Make the connections as shown in figure 1.4
2) Select the input bit stream from kit to set digital word 01110011.
3) Observe the waveforms of unipolar RZ, NRZ and Bipolar NRZ, Manchester line coding formats using CRO/DSO and draw the waveform on graph paper.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observation Table

Table 1:1 Average DC voltage value and Bit duration

Sr. No.	Type of Line code	DC voltage	Bit duration
1	Unipolar NRZ		
2	Unipolar RZ		
3	Bipolar NRZ/AMI		
4	Bipolar RZ		

XIV Result(s)

……………………………………………………………………………………………..

……………………………………………………………………………………………….

..………………………………………………………………………………………………

……………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………..

.........……………………………………………………………………………………….

……………………………………………………………………………………………..

……...

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Draw the unipolar RZ, NRZ waveforms for a binary sequence 10001110.
2. Draw the Bipolar NRZ (AMI) waveforms for a binary sequence 10001010.
3. Draw the unipolar RZ, NRZ waveforms for a binary sequence 11001100.
4. Draw the Bipolar NRZ (AMI), Manchester waveforms for a binary sequence 11101100.

[Space for Answers]

...………………………………………………………………………………….........…

…………………………………………………………………………………………………

……………………………………………………………………………………....………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………...

....

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. Digital Communication - Line Codes (tutorialspoint.com)
2. (55) Practical Performance of Line Coding - YouTube

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.2: Implementation of various line coding scheme using suitable simulation tool

I Practical Significance

Electrical representations of binary code are called “line code”. A line code is code chosen for use within a communications system for transmitting a digital signal down a transmission line. Line-coded signal is used to create an "RF signal" that can be sent through free space. The line-coded signal can be converted to bits on an optical disc .In this practical student will convert the given digital data into various line codes.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 2.1 Observe changes in output of various line coding scheme.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices

VI Relevant Theoretical Background

A line code is the code used for data transmission of a digital signal over a transmission line.

Types of Line Coding:

Unipolar Non-Return to Zero (NRZ)

In this type of unipolar signaling, a High in data is represented by a positive pulse called as Mark, which has a duration T_0 equal to the symbol bit duration. A Low in data input has no pulse. It is clearly understood with the help of figure 2.1.

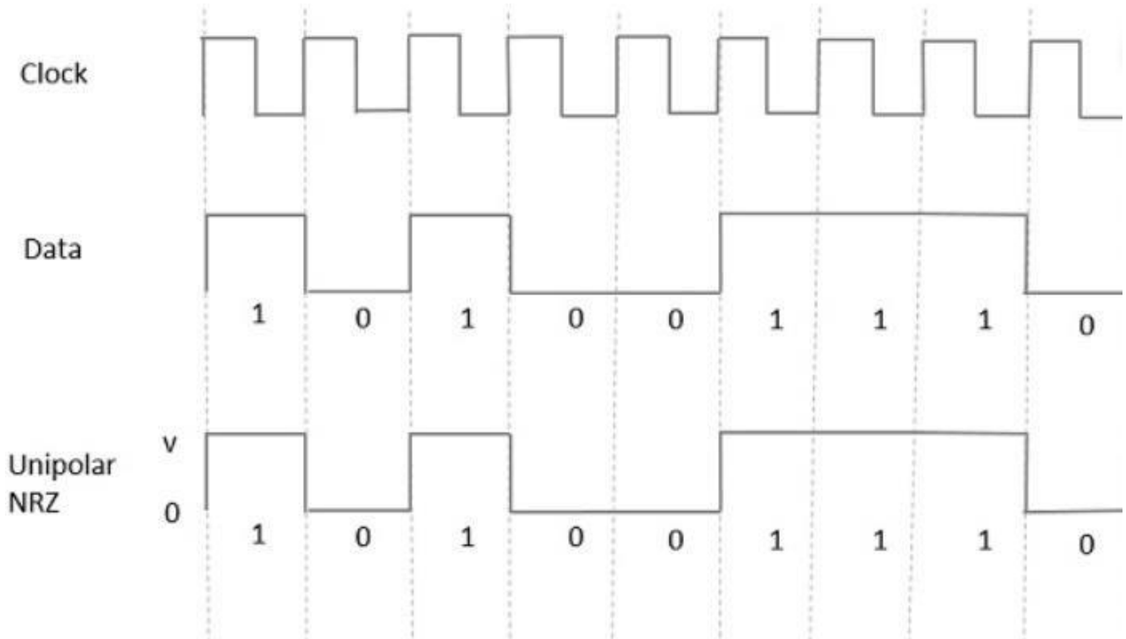


Figure 2.1: Unipolar NRZ

Unipolar Return to Zero (RZ)

In this type of unipolar signaling, a High in data, though represented by a Mark pulse, its duration T0 is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration. It is clearly understood with the help of the figure 2.2

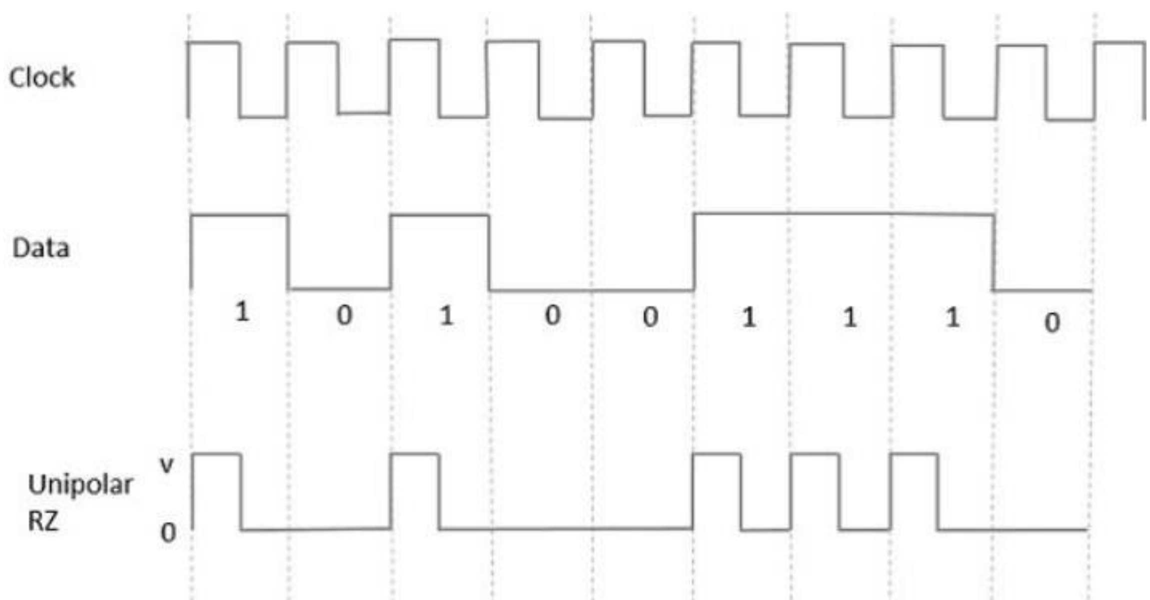


Figure 2.2: Unipolar RZ

Polar Line Coding:

Polar line coding is a type of binary line coding scheme where the signal can take both positive and negative voltage levels. Types of polar line coding schemes are Polar NRZ (Non-Return-to-Zero) and Polar RZ (Return-to-Zero).
In Polar NRZ line coding, each bit in the binary data is represented by a distinct voltage level for the entire bit duration. Binary 1 is represented by positive voltage and Binary 0 is represented by negative voltage. This scheme does not return to zero between the bits. It is efficient in terms of bandwidth because it uses the full bit duration to transmit information.

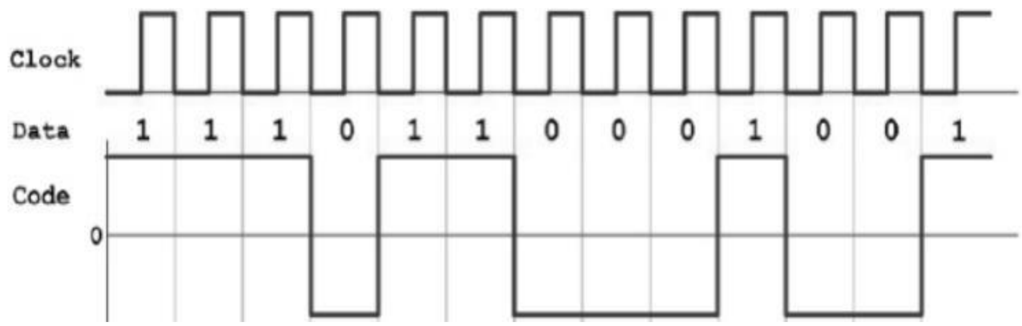


Figure 2.3: Polar NRZ encoding

Manchester Encoding:

Manchester encoding is a combination of RZ and NRZ-L. here, instead of using three values of voltages, we use only two, here logical 1 is represented in two halves, the first half consists of a negative voltage, and the second half is represented as a positive voltage, and logical 0 is also represented in two halves, the first half consists of a positive voltage and the second-half is represented as a negative voltage. The transition in the middle of the bit provides synchronization.

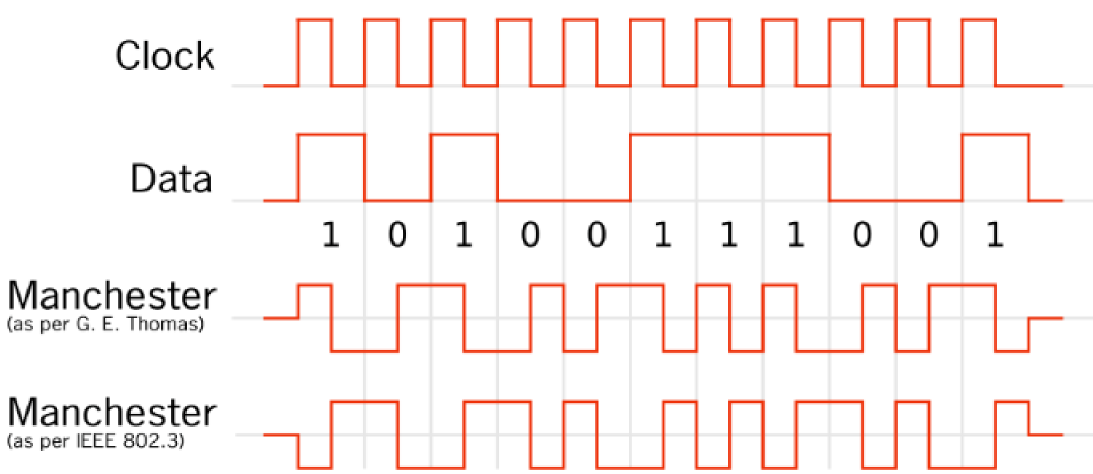


Figure 2.4: Manchester encoding

VII Simulation code:

a) Sample Simulation code for line code generation

```
 % Define the binary data sequence
data = [1 0 1 1 0 1 0 0 1]; % Example binary sequence

% Time vector for plotting
bit_duration = 1; % Duration of each bit
Fs = 100; % Sampling frequency
t = 0:1/Fs:bit_duration*numel(data);

% Unipolar NRZ line code generation
function unipolar_nrz = unipolar_nrz(data, Fs, bit_duration)
    unipolar_nrz = [];
    for bit = data
        if bit == 1
            unipolar_nrz = [unipolar_nrz ones(1, Fs*bit_duration)];
        else
            unipolar_nrz = [unipolar_nrz zeros(1, Fs*bit_duration)];
        end
    end
end
% Polar NRZ line code generation
function polar_nrz = polar_nrz(data, Fs, bit_duration)
    polar_nrz = [];
    for bit = data
        if bit == 1
            polar_nrz = [polar_nrz ones(1, Fs*bit_duration)];
        else
            polar_nrz = [polar_nrz -ones(1, Fs*bit_duration)];
        end
    end
end
% Manchester line code generation
function manchester = manchester(data, Fs, bit_duration)
    manchester = [];
    half_duration = Fs*bit_duration/2;
```

```
    for bit = data
        if bit == 1
            manchester = [manchester ones(1, half_duration) -ones(1, half_duration)];
        else
            manchester = [manchester -ones(1, half_duration) ones(1, half_duration)];
        end
    end
end
% Generate line codes
unipolar_nrz_code = unipolar_nrz(data, Fs, bit_duration);
polar_nrz_code = polar_nrz(data, Fs, bit_duration);
manchester_code = manchester(data, Fs, bit_duration);

% Plotting
figure;
subplot(3, 1, 1);
plot(t(1:length(unipolar_nrz_code)), unipolar_nrz_code, 'LineWidth', 2);
title('Unipolar NRZ Line Code');
xlabel('Time');
ylabel('Amplitude');
grid on;

subplot(3, 1, 2);
plot(t(1:length(polar_nrz_code)), polar_nrz_code, 'LineWidth', 2);
title('Polar NRZ Line Code');
xlabel('Time');
ylabel('Amplitude');
grid on;

subplot(3, 1, 3);
plot(t(1:length(manchester_code)), manchester_code, 'LineWidth', 2);
title('Manchester Line Code');
xlabel('Time');
ylabel('Amplitude');
grid on;
```

Simulation Output:

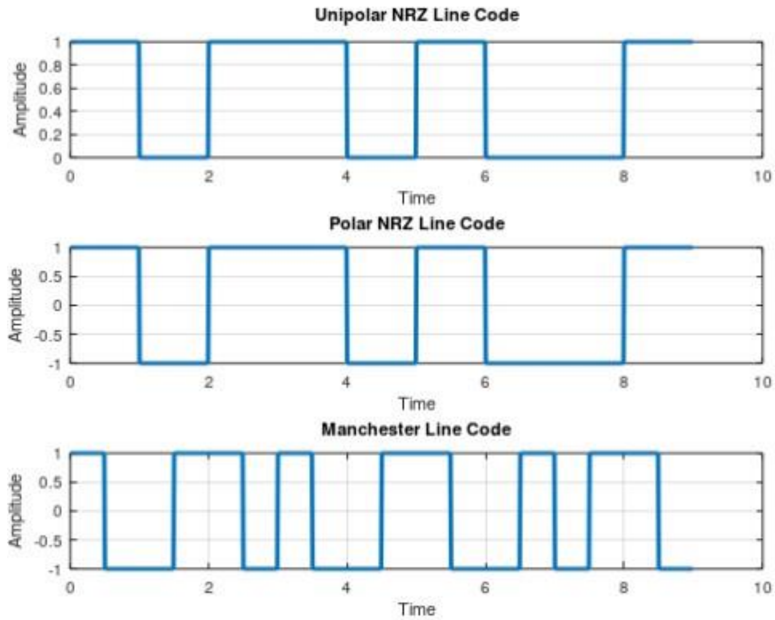


Figure 2.5: Line code output

b) Actual Simulation code for line code generation

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1) Ensure proper earthing to the computer system.
2) Ensure compatibility of computer system with software.
3) Ensure proper installation of simulation software.

X Procedure

1) Open the MATLAB.
2) Go to file and create a new file with extension (.m file)
3) Write the MATLAB code in program window.
4) Save the file.
5) Define path directory.
6) Run the program using function key (F5) or use "RUN" command.
7) Observe the output.

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			

XII Actual Procedure

……..

……

..……

……..

……..

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........…………………………………………………………………………………………….

……………………………………………………………………………………………………..

……...

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVIIPractical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Draw the unipolar waveforms for a binary sequence 11001110.
2. Draw the Polar RZ, NRZ waveforms for a binary sequence 10101010.
3. Draw the Manchester waveforms for a binary sequence 11011100.

[Space for Answers]

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

XVIII References/Suggestions for further reading

1. Digital Communication - Line Codes (tutorialspoint.com)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.3: Determine error by LRC techniques using suitable Simulation tool

I Practical Significance

Longitudinal redundancy check (LRC) is also known as 2-D parity check. A block of bit is divided into table or matrix of rows and columns. In order to detect an error, a redundant bit is added to the whole block and this block is transmitted to receiver. The receiver uses this redundant row to detect error. After checking the data for errors, receiver accepts the data and discards the redundant row of bits. This practical is designed to explain how LRC error detecting method is used for serial communication.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 3.1 Generate even parity for given data sequence.

V Relevant Affective Domain related outcome(s)

1) Select proper programming environment.
2) Follow ethical practices

VI Relevant Theoretical Background

In this method, a block of bits is organized in table (rows and columns). Calculate the parity bit for each column and the set of this parity bit is also sending with original data. Let the block of data send is as follows:

11001010 10101010 11001100 11100011

In order to detect an error, a redundant bit is added to the whole block and this block is transmitted to receiver. The receiver uses this redundant row to detect error. After checking the data for errors, receiver accepts the data and discards the redundant row of bits. When the receiver checks the LRC, some of the bits are not follow even parity rule and whole block is discarded. The process of LRC is shown in figure 3.1

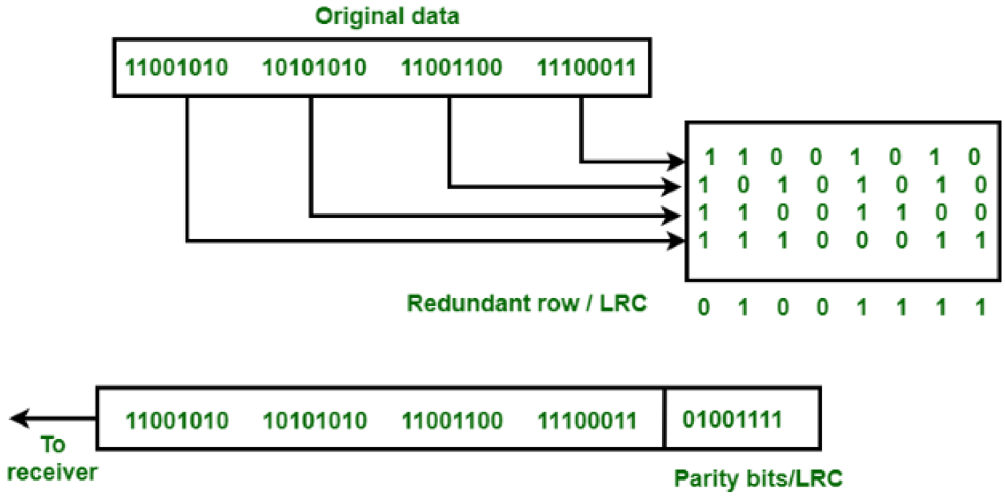


Figure 3.1: LRC Example

VII Simulation Code:

a) Sample " C" code for detection of error using LRC technique

```
#include <stdio.h>
void main()
{
int data[3][4],i,j,a[4],count=0;
printf("Enter 3 numbers in 4 bit binary format e.g:-1 0 1 0\n");
for(i=0;i<3;i++)
{
printf("%d binary number (4bit with space)\n",i+1); for(j=0;j<4;j++)
{
scanf("%d",&data[i][j]);
}
}
for(i=0;i<4;i++)
{
for(j=0;j<3;j++)
{
if(data[j][i]==1) count++;
}
a[i]=count; count=0;
}
for(i=0;i<4;i++)
{
if(a[i]%2==0)
{
```

```
a[i]=0;
}
else
{ a[i]=1;
}
}
printf("\nGiven Data\n"); for(i=0;i<3;i++)
{
for(j=0;j<4;j++)
{
printf("%d ",data[i][j]);
}
printf("\n");
}
printf("\nData\n");
for(i=0;i<3;i++)
{
for(j=0;j<4;j++)
{
printf("%d ",data[i][j]);
}
printf("\n");
}
for(i=0;i<4;i++)
{
printf("%d ",a[i]);
}
printf(" LRC");
}
```

Simulation Output:

```
Enter 3 numbers in 4 bit binary format e.g:-1 0 1 0
1 binary number (4bit with space)
1 0 1 1
2 binary number (4bit with space)
0 1 1 1
3 binary number (4bit with space)
1 1 0 1

Given Data
1 0 1 1
0 1 1 1
1 1 0 1

Data
1 0 1 1
0 1 1 1
1 1 0 1
0 0 0 1  LRC
```

Figure 3.2: LRC Output

b) Actual Simulation code for detection of error using LRC technique

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	**Name of Resource**	**Suggested Broad Specification**	**Quantity**
1	Computer	Suitable specifications as per requirement of simulation software with latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice/HS Sp / Multisim/ Proteus or any other relevant open source software/C programming	1

IX Precautions to be followed

1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open the "C" software.
2. Create New file in "C"
3. Type the program code in command window.
4. Save the file with .C extension.
5. Compile the program code using Alt+C or Alt+F9 command and remove the errors if any.
6. Run the program codes using Alt+R or Ctrl+F9.
7. Enter the valid input.
8. Observe the output

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………

……………………………………………………………………………………………………

..……………………………………………………………………………………………………

……………………………………………………………………………………………………

XIII Observation:

Actual simulation output observed (Student should paste the simulation output**)**

XIV Result(s)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

..………………………………………………………………………………………………

…………………………………………………………………………………………………

XV Interpretation of results

…………………………………………………………………………………………………

........……………………………………………………………………………………………

…………………………………………………………………………………………………

……..

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Determine the LRC for the following ASCII encoded message: “THE KING” Use even parity for LRC refer the ASCII sheet given in Experiment.
2. Determine the LRC for the following ASCII encoded message: “THE HERO” Use odd parity for LRC refer the ASCII sheet given in Experiment.

[Space for Answers]

...………………………………………………………………………………………….........

…………………………………………………………………………………………………

……………………………………………………………………………………….....……

…………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………...

....

....

.............................……………………………………………………………………………

……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
………………………………………………………………………..……………………..…
……………………………………………………………………………………………..……
..……………………………………………………………………………………………………
……………………………………………...
....
....
...................……………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………...
....
....
.................………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………...
....
....
....
....
....
....
....
....

XVIII References/Suggestions for further reading

1. Longitudinal Redundancy Check (LRC)/2-D Parity Check - GeeksforGeeks
2. (17) Longitudinal Redundancy Check (LRC) -YouTube

XVIII Assessment Scheme

Performance Indicators		Weigh tage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

ASCII Coding Sheet

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	0	0	0	NUL	43	101011	53	2B	+
1	1	1	1	SOH	44	101100	54	2C	,
2	10	2	2	STX	45	101101	55	2D	-
3	11	3	3	ETX	46	101110	56	2E	.
4	100	4	4	EOT	47	101111	57	2F	/
5	101	5	5	ENQ	48	110000	60	30	0
6	110	6	6	ACK	49	110001	61	31	1
7	111	7	7	BEL	50	110010	62	32	2
8	1000	10	8	BS	51	110011	63	33	3
9	1001	11	9	HT	52	110100	64	34	4
10	1010	12	0A	LF	53	110101	65	35	5
11	1011	13	0B	VT	54	110110	66	36	6
12	1100	14	0C	FF	55	110111	67	37	7
13	1101	15	0D	CR	56	111000	70	38	8
14	1110	16	0E	SO	57	111001	71	39	9
15	1111	17	0F	SI	58	111010	72	3A	:
16	10000	20	10	DLE	59	111011	73	3B	;
17	10001	21	11	DC1	60	111100	74	3C	<
18	10010	22	12	DC2	61	111101	75	3D	=
19	10011	23	13	DC3	62	111110	76	3E	>
20	10100	24	14	DC4	63	111111	77	3F	?
21	10101	25	15	NAK	64	1000000	100	40	@
22	10110	26	16	SYN	65	1000001	101	41	A
23	10111	27	17	ETB	66	1000010	102	42	B
24	11000	30	18	CAN	67	1000011	103	43	C
25	11001	31	19	EM	68	1000100	104	44	D
26	11010	32	1A	SUB	69	1000101	105	45	E
27	11011	33	1B	ESC	70	1000110	106	46	F
28	11100	34	1C	FS	71	1000111	107	47	G
29	11101	35	1D	GS	72	1001000	110	48	H
30	11110	36	1E	RS	73	1001001	111	49	I
31	11111	37	1F	US	74	1001010	112	4A	J
32	100000	40	20	SP	75	1001011	113	4B	K
33	100001	41	21	!	76	1001100	114	4C	L
34	100010	42	22	“	77	1001101	115	4D	M
35	100011	43	23	#	78	1001110	116	4E	N
36	100100	44	24	$	79	1001111	117	4F	O
37	100101	45	25	%	80	1010000	120	50	P
38	100110	46	26	&	81	1010001	121	51	Q
Decimal	**Binary**	**Octal**	**Hex**	**ASCII**	**Decimal**	**Binary**	**Octal**	**Hex**	**ASCII**

39	100111	47	27	‘	82	1010010	122	52	R
40	101000	50	28	(	83	1010011	123	53	S
41	101001	51	29	)	84	1010100	124	54	T
42	101010	52	2A	*	85	1010101	125	55	U
86	1010110	126	56	V	107	1101011	153	6B	k
87	1010111	127	57	W	108	1101100	154	6C	l
88	1011000	130	58	X	109	1101101	155	6D	m
89	1011001	131	59	Y	110	1101110	156	6E	n
90	1011010	132	5A	Z	111	1101111	157	6F	o
91	1011011	133	5B	[	112	1110000	160	70	p
92	1011100	134	5C	\	113	1110001	161	71	q
93	1011101	135	5D	]	114	1110010	162	72	r
94	1011110	136	5E	^	115	1110011	163	73	s
95	1011111	137	5F	_	116	1110100	164	74	t
96	1100000	140	60	`	117	1110101	165	75	u
97	1100001	141	61	a	118	1110110	166	76	v
98	1100010	142	62	b	119	1110111	167	77	w
99	1100011	143	63	c	120	1111000	170	78	x
100	1100100	144	64	d	121	1111001	171	79	y
101	1100101	145	65	e	122	1111010	172	7A	z
102	1100110	146	66	f	123	1111011	173	7B	{
103	1100111	147	67	g	124	1111100	174	7C		
104	1101000	150	68	h	125	1111101	175	7D	}
105	1101001	151	69	i	126	1111110	176	7E	~
106	1101010	152	6A	j	127	1111111	177	7F	DEL

Practical No.4: Determine error by VRC techniques using suitable Simulation tool

I Practical Significance

The Vertical Redundancy Check (VRC), also known as a parity bit check, is a simple error-detection method used in digital communications. VRC is primarily used for detecting single-bit errors in transmitted or stored data. It appends a parity bit to each data byte, which helps in identifying errors during transmission or retrieval. In serial communication protocols like UART (Universal Asynchronous Receiver/Transmitter), VRC is used to check for errors in each transmitted byte. This practical is designed to explain how VRC error detecting method is used for serial communication.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 3.1 Generate odd parity for given data sequence.

V Relevant Affective Domain related outcome(s)

1) Select proper programming environment.
2) Follow ethical practices

VI Relevant Theoretical Background

Vertical Redundancy Check is also known as Parity Check. In this method, a redundant bit also called parity bit is added to each data unit. This method includes even parity and odd parity. Even parity means the total number of 1s in data is to be even and odd parity means the total number of 1s in data is to be odd.

E**xample –** If the source wants to transmit data unit 1100111 using odd parity to the destination. The source will have to pass through Odd Parity Generator.

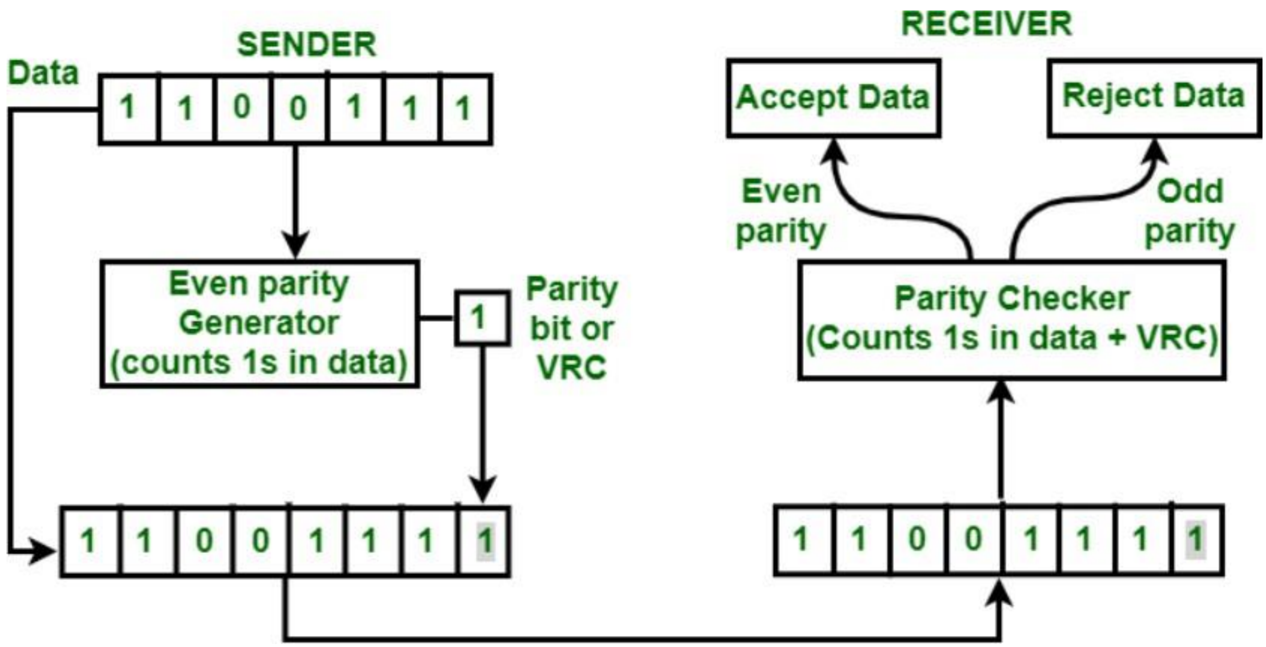


Figure 4.1: VRC Example

VII Sample Simulation Code:

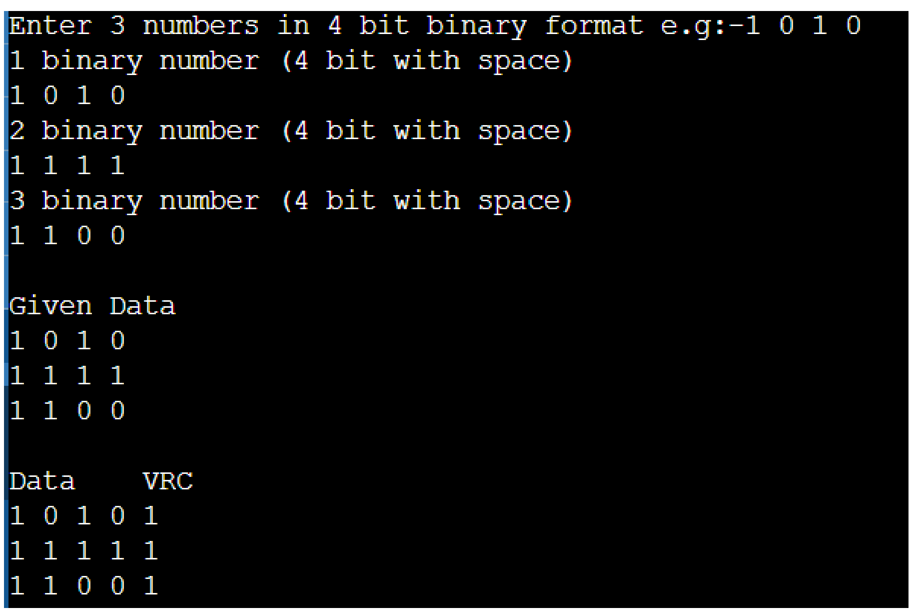
a) Sample " C" code for detection of error using VRC technique

```
#include <stdio.h>
void main()
{
int data[3][5],i,j,a[4],count=0;
printf("Enter 3 numbers in 4 bit binary format e.g:-1 0 1 0\n");

for(i=0;i<3;i++)
{
printf("%d binary number (4 bit with space)\n",i+1); for(j=0;j<4;j++)
{
scanf("%d",&data[i][j]);
}
}
for(i=0;i<3;i++)
{
for(j=0;j<4;j++)
{
if(data[i][j]==1) count++;
}
a[i]=count; count=0;
}
for(i=0;i<4;i++)
{
```

```
if(a[i]%2!=0)
{
data[i][4]=0;
}
else
{
data[i][4]=1;
}
}
printf("\nGiven Data\n"); for(i=0;i<3;i++)
{
for(j=0;j<4;j++)
{
printf("%d ",data[i][j]);
}
printf("\n");
}
printf("\nData       VRC\n"); for(i=0;i<3;i++)
{
for(j=0;j<5;j++)
{
printf("%d ",data[i][j]);
}
printf("\n");
}
}
```

Simulation Output:



```
Enter 3 numbers in 4 bit binary format e.g:-1 0 1 0
1 binary number (4 bit with space)
1 0 1 0
2 binary number (4 bit with space)
1 1 1 1
3 binary number (4 bit with space)
1 1 0 0

Given Data
1 0 1 0
1 1 1 1
1 1 0 0

Data    VRC
1 0 1 0 1
1 1 1 1 1
1 1 0 0 1
```

Figure 4.2: VRC Output

b) Actual code for detection of error using VRC technique

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice/HS Spice / Multisim/ Proteus or any other relevant open source software/C programming	1

IX Precautions to be followed

1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open the “C” software.
2. Create New file in “C”
3. Type the program code in command window.
4. Save the file with .C extension.
5. Compile the program code using Alt+C or Alt+F9 command and remove the errors if any.
6. Run the program codes using Alt+R or Ctrl+F9.
7. Enter the valid input.
8. Observe the output

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observation:

Actual simulation output observed (Student should paste the simulation output**)**

XIV Result(s)

……………………………………………………………………………………………………..

……………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Determine the VRC for the following ASCII encoded message: "MENTOR" Use odd parity for VRC.
2. Determine the VRC for the following ASCII encoded message: "HELLO" Use odd parity for VRC.

[Space for Answers]

...……………………………………………………………………………………………..........…

………

…………………………………………………………………………………………...………

………

………

………………………………………………………………………………...

....

....

..............................……………………………………………………………………………

………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………
………

XVIII References/Suggestions for further reading

1. Vertical Redundancy Check (VRC) or Parity Check - GeeksforGeeks
2. (19) Vertical Redundancy Check (VRC) - YouTube

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.5: Generation of Hamming code for 4 bits data.

I Practical Significance

Hamming code is an error correction system that can detect and correct errors when data is stored or transmitted. Hamming codes are used in applications where single bit errors are common, including DRAM memory chips and satellite communication hardware. Hamming code is used in situations where consistency is more important than efficiency of transmission. Although Hamming codes are the oldest error correcting codes, it is still widely used in the field of mobile communication systems because of the excellent distance property, the good algebraic structure, and the ease of implementation. This practical is designed to explain generation of Hamming code for 4 bit data.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 1.1 Calculate the 7-bit hamming code for given 4 bit data.
- LLO 1.2 Observe connection between the data lines.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Hamming code is basically a linear block code it is error correcting code. The parity bits are inserted in between the data bits shown in Table1.1,the parity bits are inserted at each 2^n bit where n= 0,1,2,…….,n. thus P_1 is at $2^0 = 1$. P_2 is at $2^1 = 2$. P_4 is at $2^2 = 4$ shown in the Table.5.1

Table 5.1. Hamming code word

d_7	d_6	d_5	P_4	d_3	P_2	P_1

Where d_3, d_5, d_6, d_7 are data bits and P_1, P_2, P_4 are parity bits.
Selection of parity bits for 7 bit hamming code

P_1- P_1 is calculated using even / odd parity considering bits 1:- 1, 3, 5, 7.
P_2- P_2 is calculated using even / odd parity considering bits 2:- 2, 3, 6, 7.
P_4- P_4 is calculated using even / odd parity considering bits 4:- 4, 5, 6, 7.

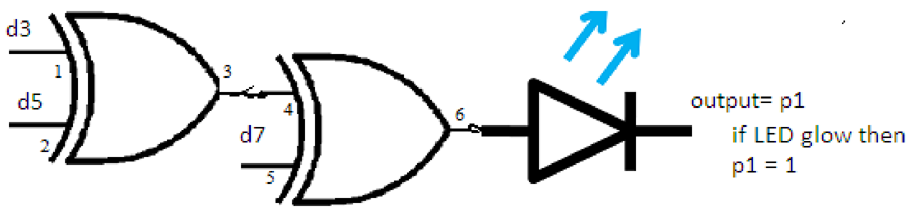


Figure 5.1: Circuit diagram for generation of P_1

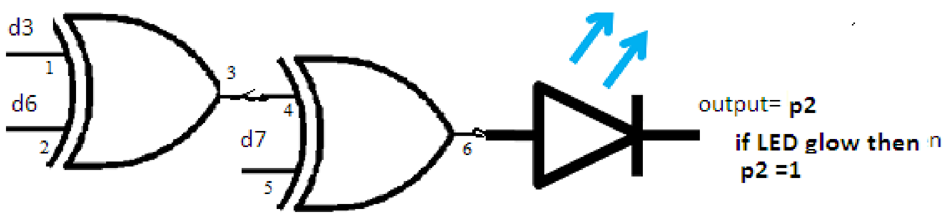


Figure 5.2: Circuit diagram for generation of P2

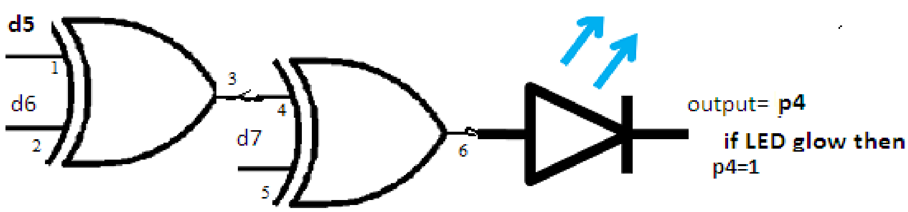


Figure 5.3: Circuit diagram for generation of P4

VII Practical set up:

a) Sample Experimental set up used in laboratory

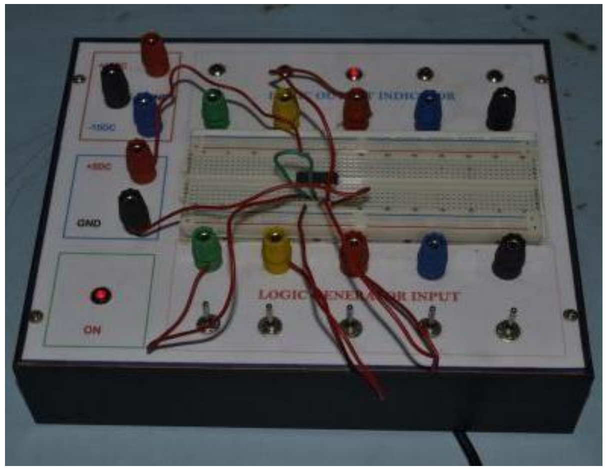


Figure 5.4: Practical set up for generation of P1 using IC 7486

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	1
2	Switch(Simplex)	Toggle Switch	1
3	LED	1.8V to 2.2V	1
4	IC 7486	TTL EX-OR gate	1
5	Bread board	5.5cm x 17cm	1
6	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per circuit diagram.

X Procedure

1. Assume four data bits 1011 [d_3=1, d_5=1,d_6=0,d_7=1] for generation of parity bits(P_1,P_2 and P_4)
2. Generation of P_1:
   i. Mount EX-OR IC on bread board as shown in figure 5.1.
   ii. Make connection as shown in figure5.1
   iii. Switch ON the power supply.
   iv. Check output of figure 5.1 Note the value of P_1 in table 5.2.
   v. Generation of P_1 is shown in figure 5.4
3. For generation of P_2:
   i. Mount EX-OR IC on bread board as shown in figure 5.4
   ii. Make connection as shown in figure5.2
   iii. Switch ON the power supply.
   iv. Check output of figure 5.2 Note the value of P_2 in table5.2.
4. For generation of P_4:
   i. Mount EX-OR IC on bread board as shown in figure 5.4.
   ii. Make connection as shown in figure5.3
   iii. Switch ON the power supply.
   iv. Check output of figure 5.3 Note the value of P_4 in table 5.2.
5. Put all values of data bits (d_3, d_5, d_6 and d_7) and parity bits (P_1, P_2 and P_4) in table5.2 to get hamming code.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			
5			
6			
7			

XII Actual Procedure

…………………………………………………………………………………………………..

……………………………………………………………………………………………………

..…………………………………………………………………………………………………

…………………………………………………………………………………………………..

XIII Observation Table

Table 5.2: Hamming code word

d_7	d_6	d_5	P_4	d_3	P_2	P_1

XIV Result(s)

…………………………………………………………………………………………………..

……………………………………………………………………………………………………

..…………………………………………………………………………………………………

…………………………………………………………………………………………………..

XV Interpretation of results

…………………………………………………………………………………………………..

.........……………………………………………………………………………………………

…………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Generate Hamming code for odd parity if data is 1011.
2. Generate Hamming code for even parity if data is 1000.

[Space for Answers]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……

……

……

……

……

……

……

……

XVIII References/Suggestions for further reading

1. Hamming Code Practical (youtube.com)
2. What is Hamming code and how does it work? (techtarget.com)

XIX Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.6: Error correction using Hamming code.

I Practical Significance

Hamming code is a set of error-correction code s that can be used to detect and correct biterrors that can occur when computer data is moved or stored Due to the limited redundancy that Hamming codes add to the data, they can only detect and correct errors when the error rate is low. This is the case in computer memory (ECC memory), where bit errors are extremely rare and Hamming codes are widely used. This practical is designed to explain how to correct one bit error using hamming code.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO1-Implement different error control coding schemes for digital communication system.

IV Laboratory Learning Outcome(s)

- LLO 6.1 Determine the position of error in given data.
- LLO 6.2 Correct the detected error.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Hamming code is basically a linear block code it is error correcting code. Error detection by using Hamming code is as follows.

To each group of m information bits k parity bits are added to form (m+k) bit code as shown in Table 6.1

Table6.1: Format of hamming code word

d_7	d_6	d_5	C_3	d_3	C_2	C_1

Location of each of the (m+k) digits is assigned a decimal value. The k parity bits are placed in positions 1, 2… 2k-1 positions.–K parity checks are performed on selected digits of each code word. At the receiving end the parity bits are recalculated. The decimal value of the k parity bits provides the bit-position in error, if any

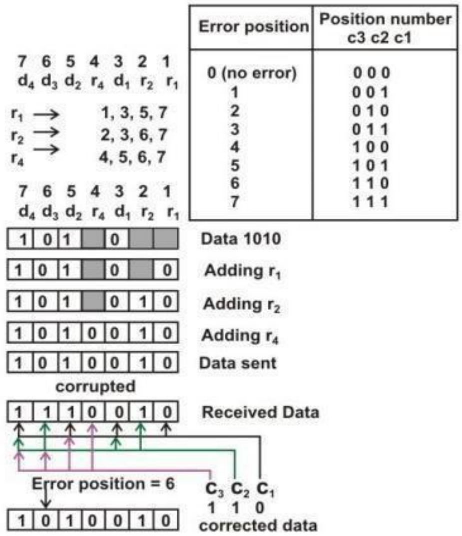


Figure 6.1: Use of Hamming code for error correction for a 4-bits data
[Courtesy: *http://nptel.ac.in/courses/106105080/pdf/M3L2.pdf]*

Figure 6.1 shows how hamming code is used for correction for 4-bit numbers ($d_4d_3d_2d_1$) with the help of three redundant bits ($C_3C_2C_1$). For the example data 1010, first C_1 (0) is calculated considering the parity of the bit positions, 1, 3, 5 and 7. Then the parity bits C_2 is calculated considering bit positions 2, 3, 6 and 7. Finally, the parity bits $C_3$is calculated considering bit positions 4, 5, 6 and 7 as shown. If any corruption occurs in any of the transmitted code 1010010, the bit position in error can be found out bycalculating $C_3C_2C_1$ at the receiving end. For example, if the received code word is1110010, the recalculated value of $C_3C_2C_1$ is 110, which indicates that bit position in error is 6, the decimal value of 110.

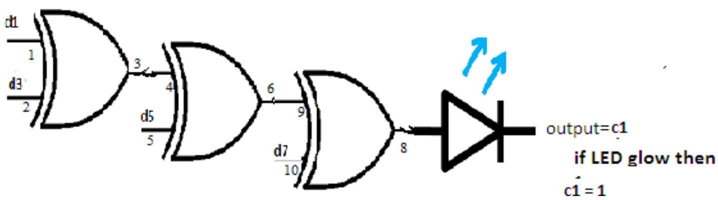


Figure6.2: Circuit diagram for generation of C_1

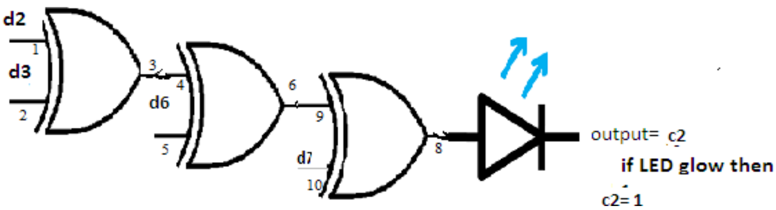


Figure6.3: Circuit diagram for generation of C_2

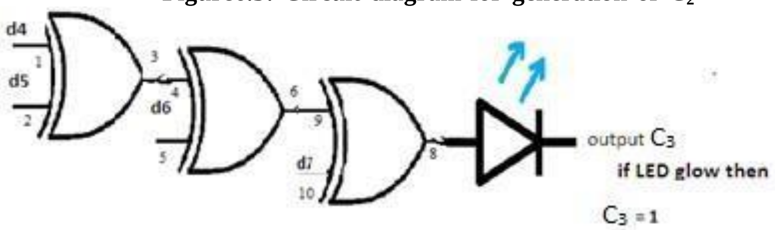


Figure6.4: Circuit diagram for generation of C_3.

VII Practical set up:

a) **Sample Experimental set up used in laboratory**

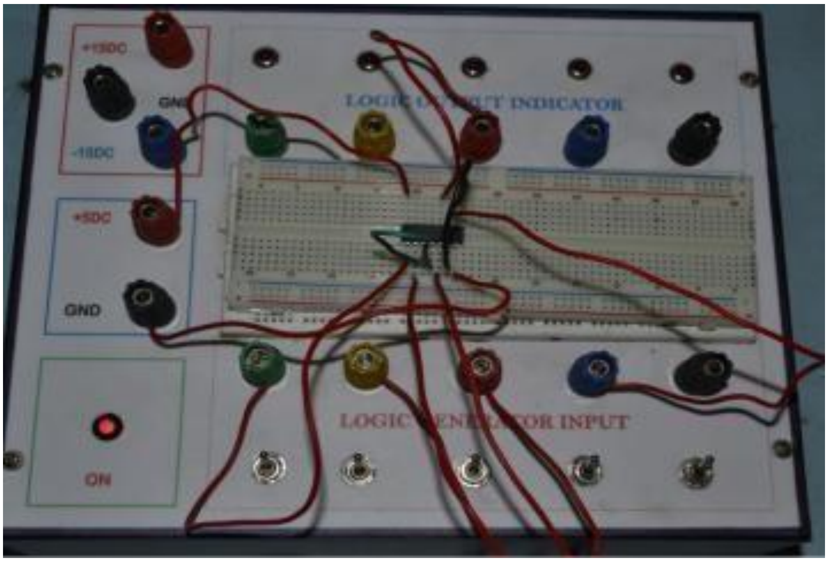


Figure 6.5: Practical set up for finding value of C_1

b) **Actual Practical Setup(**Students should draw practical set up used in theirlaboratory)

VIII Resources required

Sr. No.	Instruments /Components	Specifications	Quantity
1.	DC Regulated power supply	Variable DC power supply 0-30V, 2A, SC protection, display for voltage and current.	1
2	Switch(Simplex)	Toggle Switch	1
3	LED	1.8V to 2.2V	1
4	IC 7486	EX-OR gate	1
5	Bread board	5.5cm x 17cm	1
6	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure:

1. Assume received hamming code word is 1110101 [d_1=1, d_2=0, d_3=1, d_4=0, d_5=1, d_6=1, d_7=1) to find C_1, C_2 and C_3.

2. **For C_1:**
   i. Mount EX-OR IC on bread board as shown in figure 6.5.
   ii. Make connection as shown in figure6.2
   iii. Switch ON the power supply.
   iv. Check output of figure 6.2 Note the value of c1 in table 6.2
   v. Generation of C_1 is shown in figure 6.5

3. **For C_2:**
   i. Mount EX-OR IC on bread board as shown in figure 6.5.
   ii. Make connection as shown in figure6.3
   iii. Switch ON the power supply.
   iv. Check output of figure 6.3 Note the value of C_2 in table 6.2

4. **For C_3:**
   i. Mount EX-OR IC on bread board as shown in figure 6.5.
   ii. Make connection as shown in figure 6.4
   iii. Switch ON the power supply.
   iv. Check output of figure 6.4 Note the value of C_3 in table 6.2
   v. Table 2.2indicates position of incorrect bit **$(C_3C_2C_1)_{10}$** where error is present.
   vi. Invert (0 to 1 or 1 to 0) the value of incorrect bit to obtain correct code word.
   vii. Write the correct code word in table6.3.

Waste management:

1. Turn off all the equipment's.
2. Remove the connection and submit the wires and equipments.

XI Resources used (with major specifications)

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			
3.			
4.			
5.			

XII Actual Procedure

....
....
....
....
....

XIII Observations:

d_7	d_6	d_5	d_4	d_3	d_2	d_1

Table6.2: position of incorrect bit

C_3	C_2	C_1

Table6.3: corrected code word

XIV Results

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions and Recommendation

....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. If the 7- bit Hamming code word received by a receiver is 1011011. Assuming the even parity state whether the received code word is correct or wrong? If wrong locate the bit in error.
2. If the 7- bit Hamming code word received by a receiver is 1010111. Assuming the even parity state whether the received code word is correct or wrong? If wrong locate the bit in error.

[Space for Answers]

....
....
....

....

....

....

....

....

....

....

....

....

XIX References / Suggestions for further Reading

1. https://en.wikipedia.org/wiki/Hamming(7,4).
2. http://users.cis.fiu.edu/~downeyt/cop3402/hamming.html.

XX Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various out put on trainer kit	20 %
4	Handling of the kit, Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 7: Generation of natural and flat top sampling signal

I Practical Significance

In modern communication, sampling has the wide application of various forms: such as A/D conversion, digital communications, audio and video signal processing and radar signal processing. In this practical, students will understand nature of natural and flat top samples.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO2- Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 7.1 Build connection of natural and flat top sampling circuit.
- LLO 7.2 Illustrate the difference observe in waveform natural and flat top sampled signal.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Handle instruments carefully.

VI Relevant Theoretical Background

Sampling is the reduction of a continuous-time signal to a discrete-time signal. Types of sampling are:

1) **Natural Sampling:** It is a practical method of sampling in which pulse have finite width equal to τ. Sampling is done in accordance with the carrier signal which is digital in nature.it is shown in figure 7.1

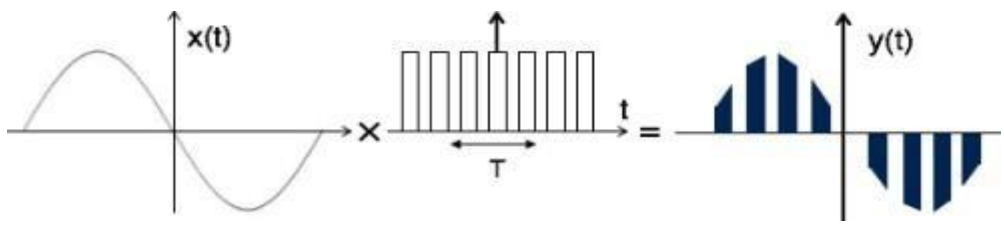


Figure 7.1: Natural sampling process

[Courtesy:https://www.tutorialspoint.com/signals_and_systems/signals_sampling_techniques.htm]

2) **Flat top sampling:** it is like natural sampling i.e.; practical in nature. In comparison to natural sampling flat top sampling can be easily obtained. In this sampling techniques, the top of the samples remains constant and is equal to the instantaneous value of the message signal x (t) at the start of sampling process. Sample and hold circuits are used in this type of sampling. During transmission, noise is introduced at top of the transmission pulse which can be easily removed if the pulse is in the form of flat top.it is shown in figure 7.2

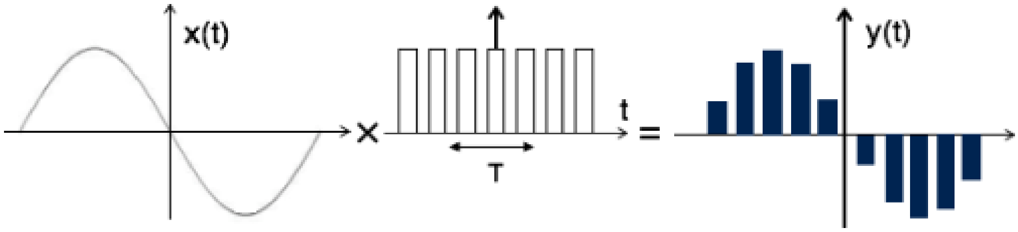


Figure 7.2: Flat top sampling process

[Courtesy:https://www.tutorialspoint.com/signals_and_systems/signals_sampling_techniques.htm]

Circuit Diagram

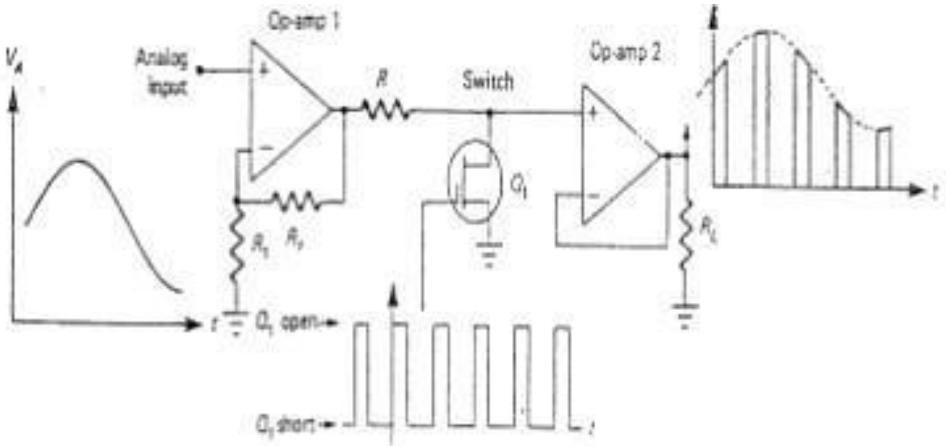


Figure 7.3: Natural sampling

- *[Courtesy:https://www.google.co.in/search?q=natural+and+flat+top+sampling+in+communication&source=lnms&tbm=isch&sa=X&ved=0ahUKEwielcXQva_cAhXGL48KHfgfCF0Q_AUICigB&biw=1024&bih=662#imgrc=wt4ODsGgLj0iTM:]*

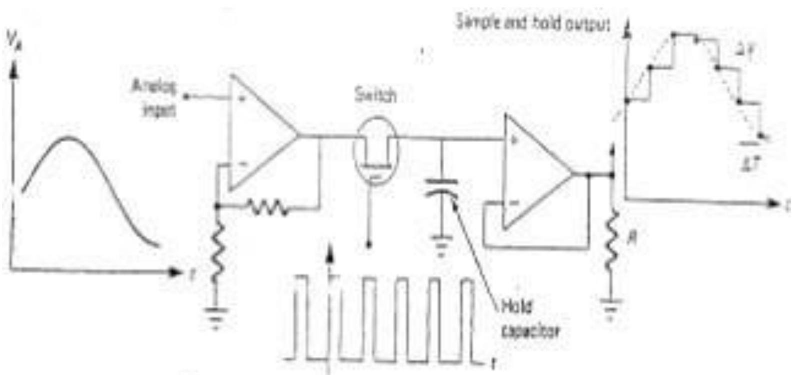


Figure 7.4: Flat-top sampling

- *[Courtesy:https://www.google.co.in/search?q=natural+and+flat+top+sampling+in+communication&source=lnms&tbm=isch&sa=X&ved=0ahUKEwielcXQva_cAhXGL48KHfgfCF0Q_AUICigB&biw=1024&bih=662#imgrc=wt4ODsGgLj0iTM:]*

VII Practical set up

a) Sample Experimental set up used in laboratory

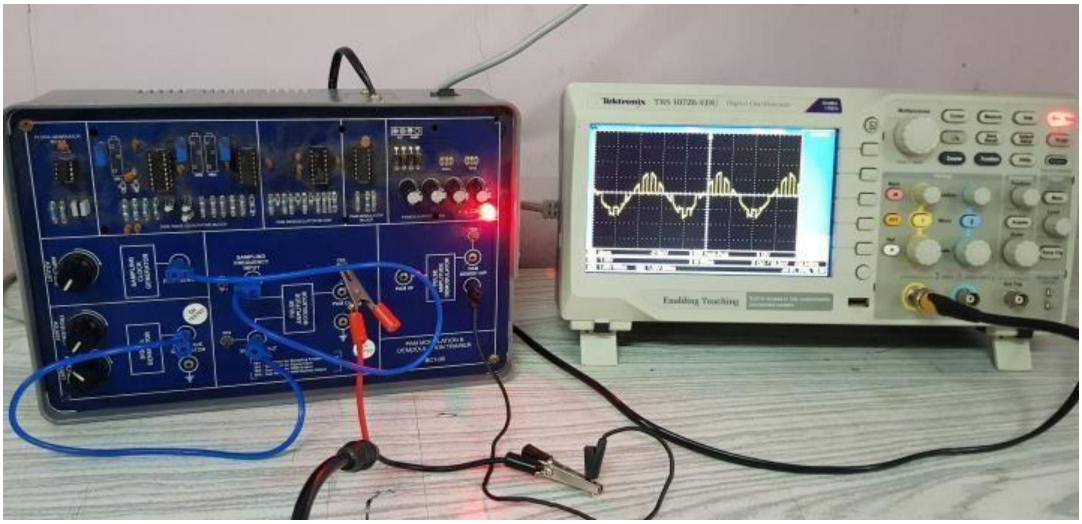


Figure 7.5: Practical set up for Natural sampling

b) Actual Practical set up used in laboratory

(Natural Sampling & Flat top Sampling)

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	DC Regulated power supply	Variable DC power supply 0-30V, 2A, SC protection, display for voltage and current.	1
2.	Dual trace cathode ray oscilloscope / Digital storage oscilloscope	20MHz dual trace oscilloscope / / 25 MHz Dual Trace Digital Storage Oscilloscope	1
3.	PAM and PCM modulator kit/ Flat top Sampling trainer Kit	Sampling Frequency 110KHz for PAM, Sampling Frequency 8 to 12KHz for PCM or equivalent trainer kit	1

IX Precautions to be Followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. For Natural sampling

i. Use PAM modulator kit for natural sampling.
ii. Make the connection as per the Figure7.5.
iii. Switch ON the power supply.
iv. Adjust the sampling frequency of 8 kHz pulse and input signal of $1V_{PP}$, 1 kHz.
v. Observe the waveforms of input signal, sampling signal and output of PAM modulator (natural samples) on CRO/DSO
vi. Draw the waveforms of input signal, sampling signal and output of PAM modulator (natural samples) on graph paper.

2. For Flat-top sampling

i. Use PCM modulator kit for flat–top sampling.
ii. Make the connection as per the Figure7.6.
iii. Switch ON the power supply.
iv. Adjust the sampling frequency of 8 kHz and input signal of $1V_{PP}$, 1 kHz.
v. Observe the waveforms of input signal, sampling signal and output of sampled and hold circuit (flat-top samples) on CRO/DSO
vi. Draw the waveforms of input signal, sampling signal and output of sampled and hold circuit (flat-top samples) on graph paper.
vii. After completion of practical switch off the supply, remove the connection and submit the wires and equipments.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity
		Make	Details	
1.				
2.				
3.				

XII Actual Procedure

....
....
....
....
....

XIII Observations

Natural Sampling

Input Signal Frequency:

Sampling Signal Frequency:

Number of Samples in One Cycle:

Sr. No.	Sample Number	Sample Amplitude
1		
2		
3		
4		
5		

Flat top Sampling

Input Signal Frequency:

Sampling Signal Frequency:

Number of Samples in One Cycle:

Sr. No.	Sample Number	Sample Amplitude
1		
2		
3		
4		
5		

XIV Results

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions

....
....
....
....
....
....
....

XVII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design ***more such questions so as to ensure the achievement of identified CO.***

1. Select input frequency 500Hz and sampling frequency 16 KHz apply to PCM kit and observe output of sample and hold circuit. Draw the same.
2. Compare natural sampling and flat top sampling

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....

Scale

X-axis -

Y-axis -

XVIII References / Suggestions for further Reading

1. https://www.tutorialspoint.com/signals_and_systems/signals_sampling_techniques.htm.
2. https://www.youtube.com/watch?v=WUCMavXbJo4.

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various out put on trainer kit	20 %
4	Handling of the kit, Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25Marks)		100 %

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Determine the Nyquist rate for given signal by using suitable simulation tool.

I Practical Significance

Sampling theorem is one of the very basic theorems in the field of digital processing and communication which has gained increasing importance because of its many advantages over its analog counterpart. Sampling refers to picking out values of the signalfor certain values of the independent variables. A band limited signal can be reconstructed exactly if it is sampled at a rate at least twice the maximum frequency component in it. This practical is designed to view the effect of different conditions of sampling rate on the output.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications**

III Course Level Learning Outcome

- CO2- Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 8.1 Analyze Nyquist implications on signal generation and reconstruction.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices.

VI Relevant Theoretical Background

A continuous time signal can be represented in its samples and can be recovered back when sampling frequency f_s is greater than or equal to the twice the highest frequency component of message signal. i.e.

$$Fs \geq 2Fm$$

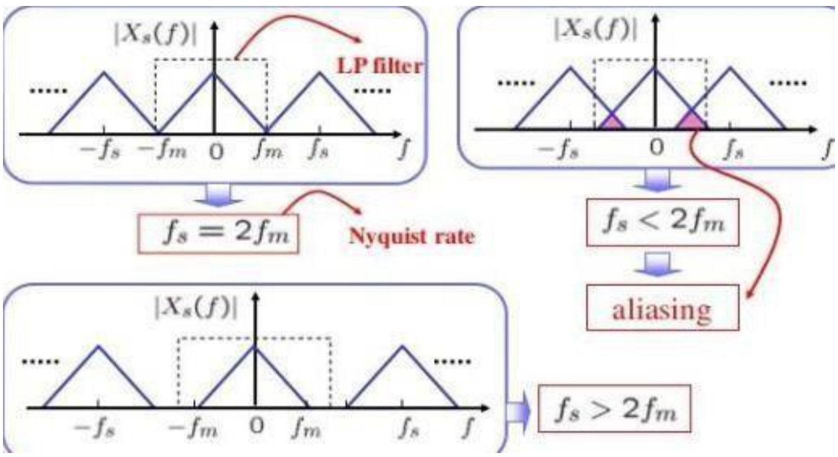


Figure: 8.1: Output waveforms for different condition of sampling rate

VII Simulation Code

a) Sample Code for Sampling theorem

```
clc;
clear
all;close
all;
t=-
10:0.01:10;
T=8;
Fm= 1/T;
X=
cos(2*pi*Fm*t);
Fs1=1.2*Fm;
Fs2=2*Fm
;
Fs3=8*Fm
;         n1=-
5:1:5;
xn1=cos(2*pi*n1*Fm/Fs1
);subplot(2,2,1);
plot (t,X);
xlabel('Time in seconds');
ylabel('X(t)');
title ('contineous time signal');
subplot(2,2,2);
stem
(n1,xn1);hold
on;
plot (n1,xn1);
xlabel('N');
ylabel('X(n)');
title ('Discrete time signal with
Fs<2Fm');n2=-5:1:5;
xn2=cos(3*pi*n2*Fm/Fs2
);subplot(2,2,3);
stem
(n2,xn2);hold
on;
plot (n2,xn2);
xlabel('N');
ylabel('X(n)');
title ('Discrete time signal with Fs<2Fm');
```

Simulation output:

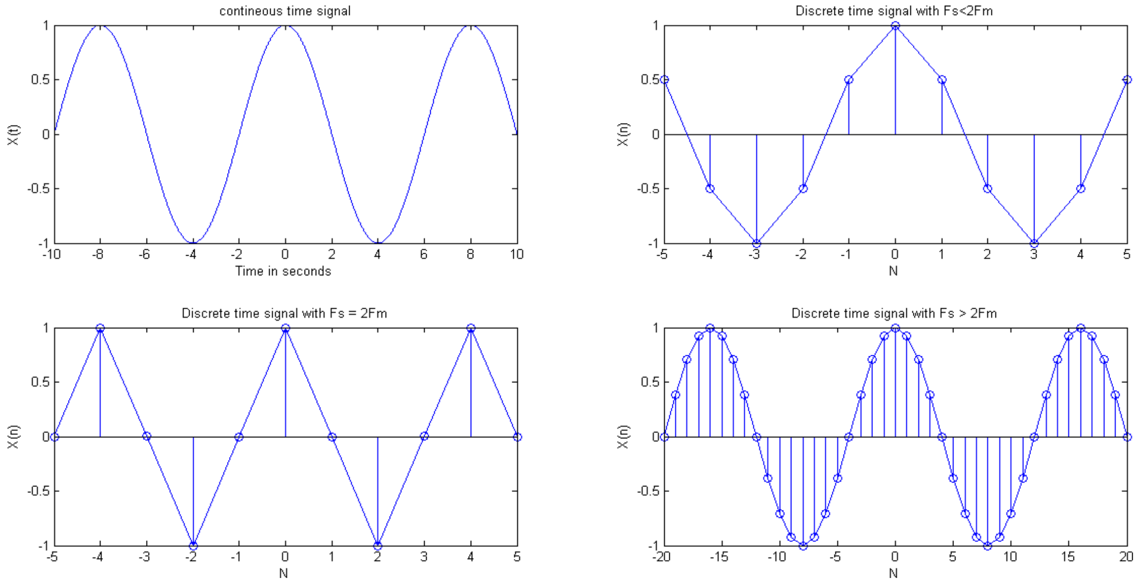


Figure: 8.2: Output for different Sampling condition

b) Actual Simulation Code

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	Computer	Suitable specifications as per requirementof simulation software with Latest Processor	1
2.	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any otherrelevant open source software	1

IX Precautions

1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open the MATLAB.
2. Go to file and create a new file with extension (.m file)
3. Write the MATLAB code in program window.
4. Save the file.
5. Define path directory.
6. Run the program using function key (F5) or use "RUN" command.
7. Observe the output.
8. After completion of practical shut down the PC and switch off the supply.

Waste management:

1. Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			

XII Actual Procedure

....

....

....

....

....

....

....

....

XIII Observations

Actual Simulation Output Observed (Student should paste the Simulation Output)

XIV Result(s)

....
....
....

XV Interpretation of results

....
....
....

XVI Conclusions and Recommendation

....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must designmore such questions so as to ensure the achievement of identified CO.

1. Use some different simulation tool and test the output for the given sampling condition.
2. State the effect of aliasing in communication system.

[Space for Answers]

Scale

X-axis -

Y-axis -

XV References / Suggestions for further Reading

1. https://www.tutorialspoint.com/signals_and_systems/signals_sampling_theorem.htm
2. https://www.google.co.in/search?q=sampling+theorem&sa
3. http://engineering-matlab.blogspot.com/2011/03/matlab-program-to-implement- sampling.html

XVI Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of simulation software	10 %
2	Building of diagram	20 %
3	Measuring values from PC Screen	20 %
4	Working in team	10 %
Product related (10 Marks)		**40%**
5	Correctness of output	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.9: Performance of pulse width modulation and demodulation circuit.

I Practical Significance

In communication systems, PWM is used to encode analog signals or digital data into a pulse train. The performance of the PWM demodulation circuit ensures accurate extraction of the original signal, maintaining signal integrity over transmission channels. This is vital for reliable data communication in systems like wireless communication and telemetry.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO2- Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 9.1 Generate modulated and demodulated signal on DSO.
- LLO 9.2 Measure width of pulses according to input data.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.
- Exhibit positive attitudes towards teamwork.

VI Relevant Theoretical Background

In digital communication, different modulation techniques are used to transmit data or message to receiver over a communication channel. One such technique is Pulse width modulation. Pulse Width Modulation (PWM) is a widely used technique in electronics and control systems. It involves the modulation of a pulse signal's width while keeping its frequency constant.

PWM Modulation:

In figure 9.1 shows PWM modulation message signal and a carrier waveform being input into a modulator, resulting in the creation of a Pulse Amplitude Modulated (PAM) signal. PAM signal is then directed to the non-inverting input of a comparator. Simultaneously, a ramp signal generated by a sawtooth generator is directed to the inverting input of the same comparator. The two signals are combined and compared with a reference voltage within the comparator circuit. Comparator's settings are adjusted to ensure that the reference voltage intersects with the slope of the waveform. Initiation of the Pulse Width Modulation (PWM) pulse coincides with the starting edge of the ramp signal, and the duration of the pulse is determined by the workings of the comparator circuit.

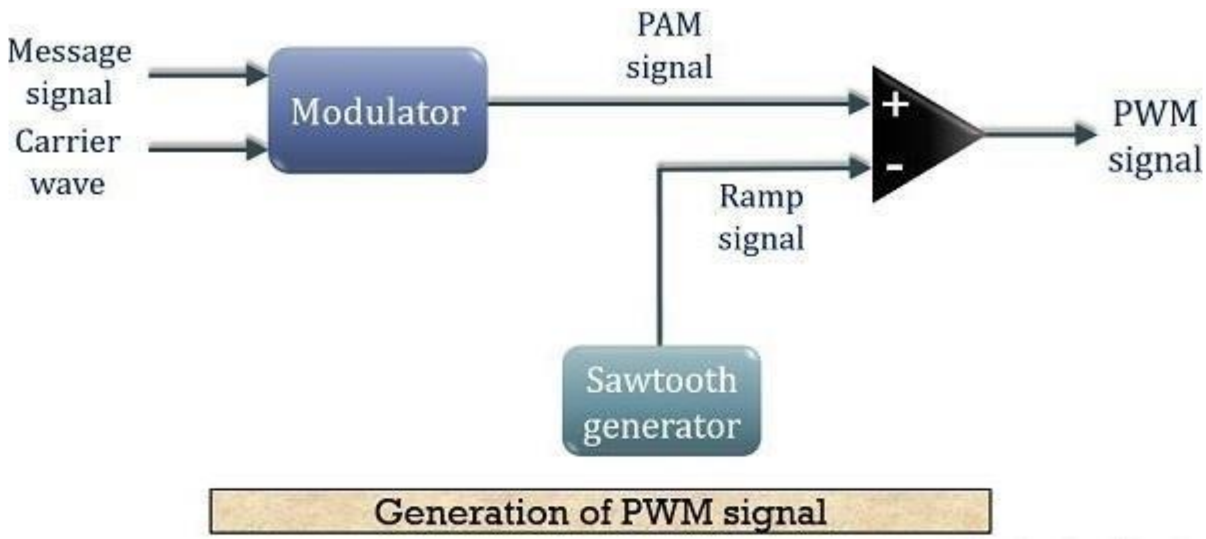


Figure 9.1: PWM modulation

PWM Demodulation:

The PWM and the carrier signals are connected to the inputs of a product detector, and then a sequence of pulses having the width inversely proportional to the width of PWM pulse presents at output. When the signal passes through the low-pass filter, a demodulated signal is obtained.

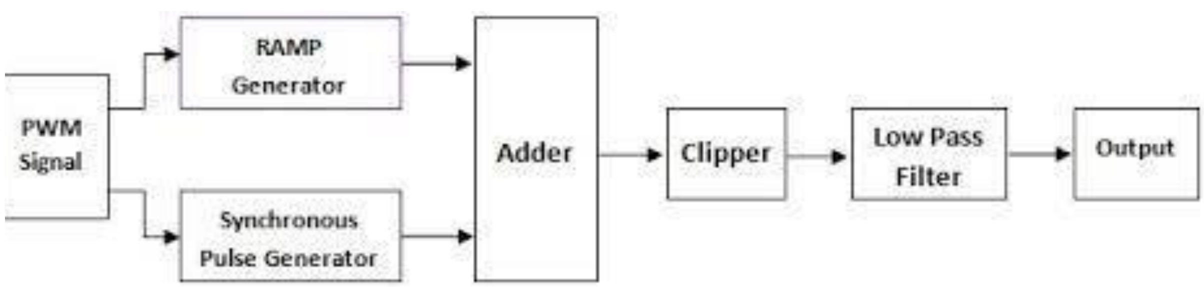


Figure 9.2: PWM demodulation

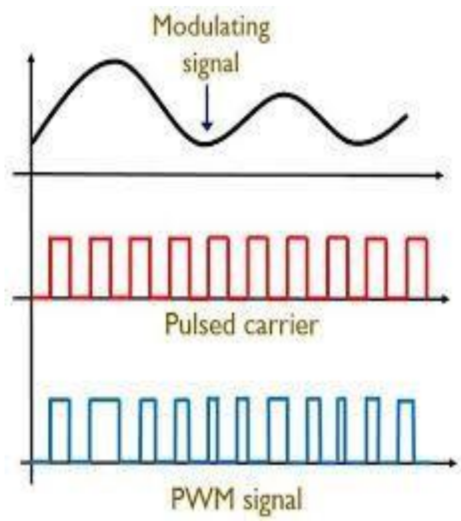


Figure 9.3: PWM modulation waveform

VII Practical set up :

a) Sample experiment set up used in laboratory

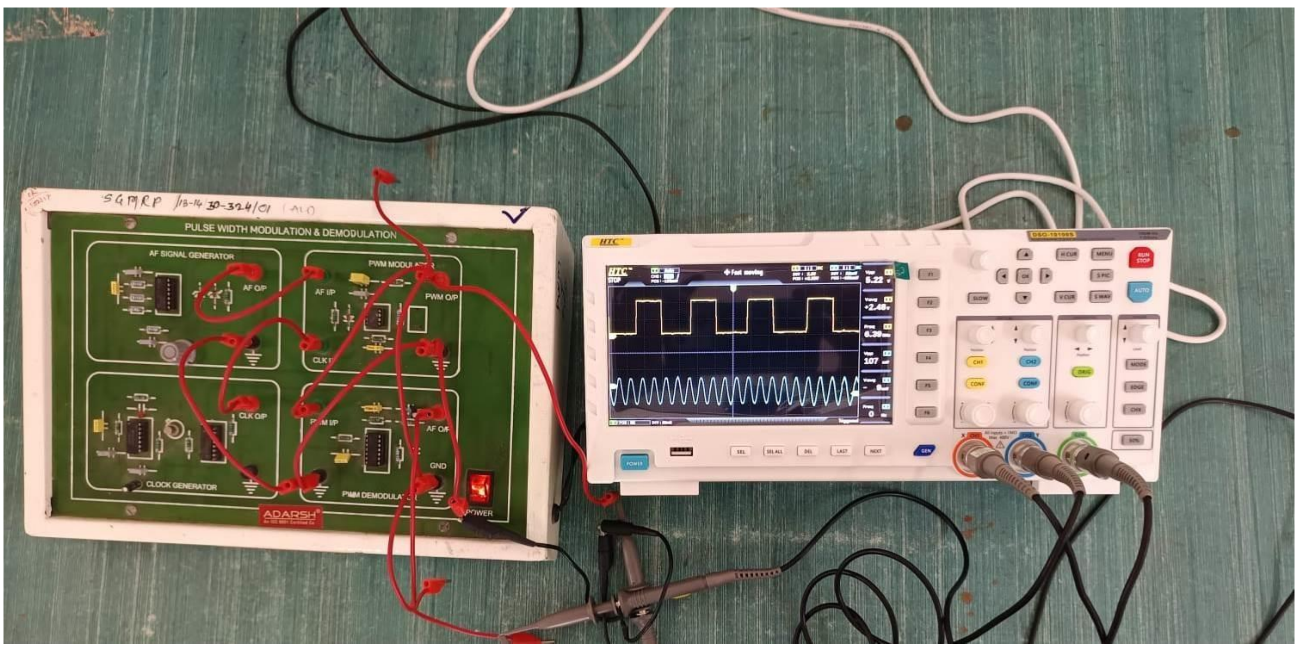


Figure 9.4: Practical set up for PWM modulation and demodulation

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	Power supply	Variable DC power supply 0-30V,0-2A , SC protection , Digital meters	1
3	PWM Trainer kit	PWM trainer kit, frequency 20kHz,5V DC	1
4	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make the connection as per circuit diagram.
2. Switch ON the power supply.
3. Connect the Channel 1 of CRO/DSO in between PWM Output & Ground (Modulated Signal)
4. Connect the Channel 2 of CRO/DSO in between Sine Wave & Ground (Modulating Signal)
5. Observe the output of PWM Input and output waveform on CRO/DSO.
6. Connect the Channel 1 of CRO/DSO in between PWM demodulation & Ground (Demodulated Signal)
7. Observe the output of PWM I demodulated waveform on CRO/DSO.

8. Draw the waveform on graph showing digital input signal, carrier signal, modulated signal and demodulated signal.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			
4			
5			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observation Table

Table 15:1 Waveforms at Various stages of PWM

Sr. No.	Output at	Amplitude	Time period	Waveform
1	**Modulating signal**			
2	**Pulse signal**			
3	**PWM output**			
4	**Demodulator output**			

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........…………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

………………………………………………………………………………………………….

………………………………………………………………………………………………….

………………………………………………………………………………………………….

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Discuss the Bandwidth requirements of PWM.
2. What is the difference between discrete and continuous wave modulation?

[Space for Answers]

...…………………………………………………………………………………………..........…

………………………………………………………………………………………………….

……………………………………………………………………………………….....………

………………………………………………………………………………………………….

………………………………………………………………………………………………….

………………………………………………………………………...

....

....

...........................…………………………………………………………………………

…………………………………………………………………………………………...……

…………………………………………………………………………………………....…

…………………………………………………………………………………………....…

…………………………………………………………………………………………....…

…………………………………………………………………...…………………….....……

……………………………………………………………………………………...………

………………………………………………………………………………………………….

………………………………………………...

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. https://www.geeksforgeeks.org/pulse-width-modulation-pwm/
2. https://electronicscoach.com/pulse-width-modulation.html
3. Virtual Labs (kcgcollege.ac.in)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.10: Performance of pulse position modulation and demodulation circuit.

I Practical Significance

PPM modulation and demodulation offer practical advantages such as bandwidth efficiency, noise resilience, and simplicity of implementation, making well-suited for a wide range of digital communication applications and systems.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

.

III Course Level Learning Outcome(s)

- CO2 -Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 10.1 Determine the position of pulses as per change in input signal.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

PPM is a modulation technique where the position of the pulse within a time frame varies according to the amplitude of the input signal. Each pulse represents a symbol, and the timing of these pulses carries the encoded information.

Figure10.1 shows PPM generation in this PAM signal is generated from the modulator once, and further, it is processed at the comparator to produce a PWM signal. After that, the output of the comparator is given to a monostable multivibrator which is negative edge triggered. Thus, with the trailing edge of the PWM signal, the output of the monostable goes high. Thus, a pulse of the PPM signal starts by the trailing edge of the PWM signal. Here, it is to be noted that the high output duration mainly depends on the multivibrator’s RC components. So this is the main reason why a stable width pulse is attained in the case of the PPM signal.

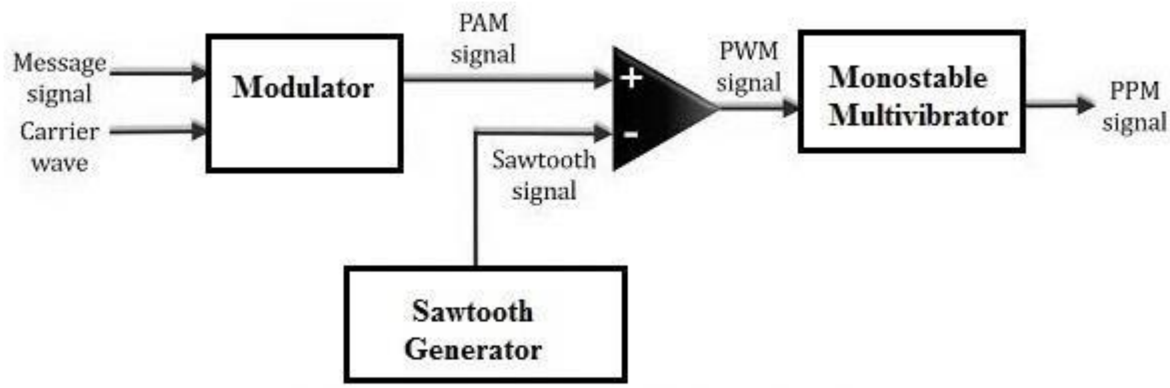


Figure 10.1: Generation of Pulse Position Modulation

The detection of the pulse position modulation is shown Figure 10.2 . The PPM signal which is transmitted from the modulation circuit will get distorted with the noise throughout transmission. So this distorted signal will reach the demodulator circuit. The pulse generator used in this circuit will produce a pulsed waveform with a fixed duration. This waveform is given to the SR FF's reset pin. The reference pulse generator produces a reference pulse with a fixed period once a transmitted PPM signal is given to it. So this reference pulse is utilized to set the SR FF. At the output of the FF, these set & reset signals will generate a PWM signal. Further, this signal is processed to give the original message signal.

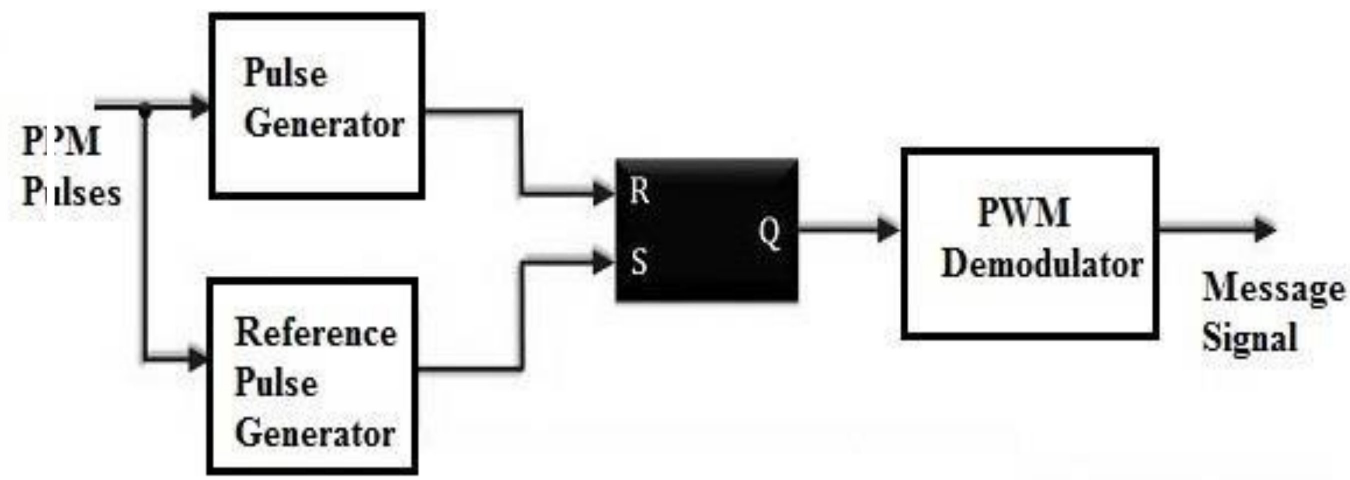


Figure 10.2: Detection of PPM Signal

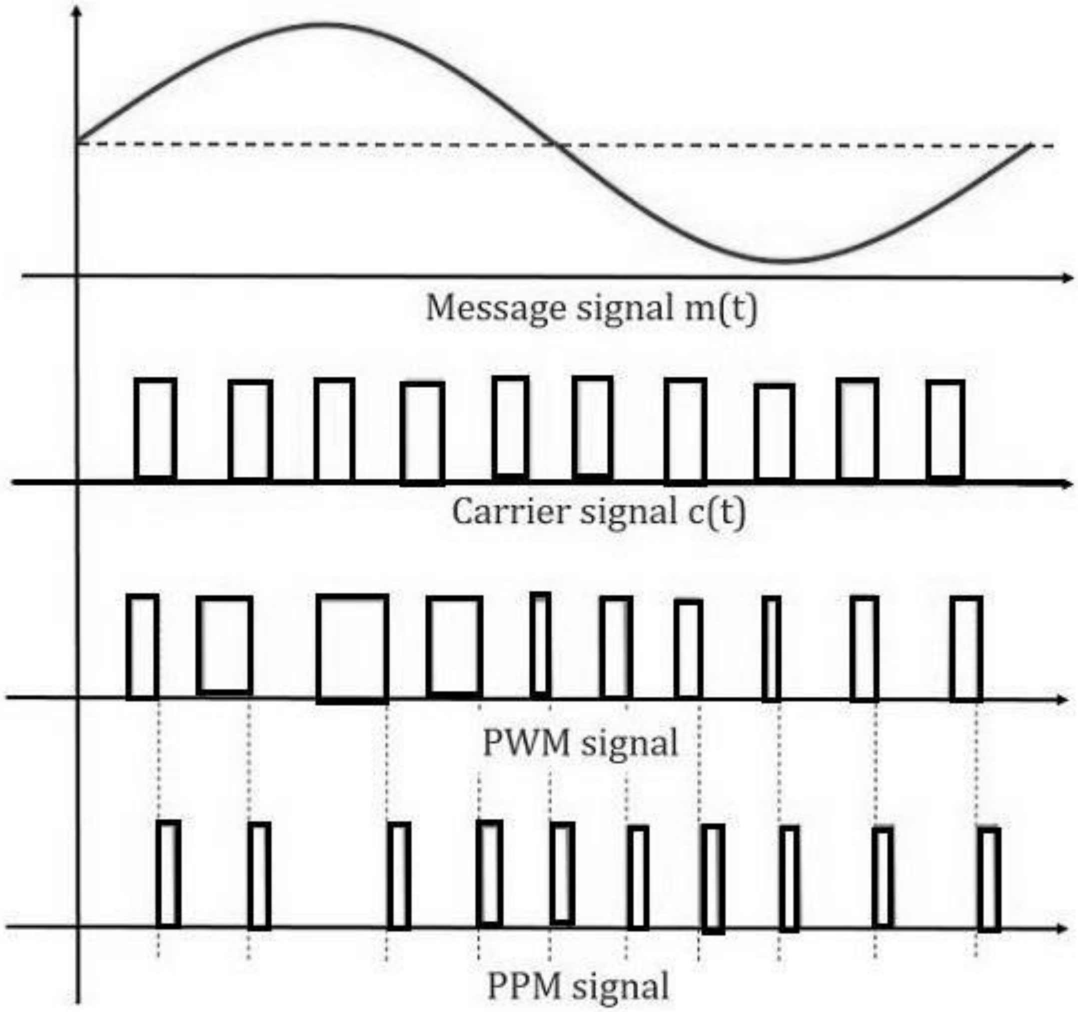


Figure 10.3: PPM wave form

VII Practical set up:

a) Sample experiment set up used in laboratory

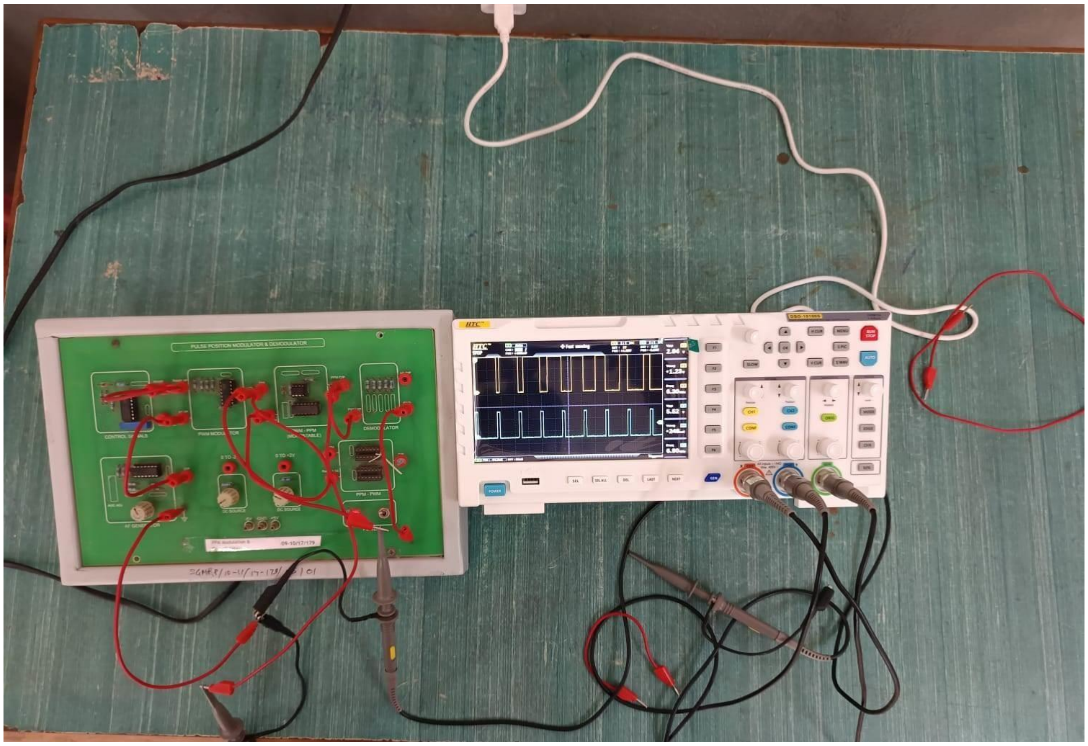


Figure 10.4: Practical set up for Pulse position modulation

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage Oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	PPM Trainer kit	Input frequency (20 KHz), Sampling frequency (8,16) KHz or equivalent trainer kit	1
3	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Switch ON the power supply.
2. Make connections as per figure 10.1 .
3. Observe the output waveform at various block output of PPM modulator.
4. Connect the output of PPM modulator to demodulator the input.
5. Observe the output of PPM demodulator
6. Draw observed waveforms on the graph paper.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

XIII Observation Table

Table 14:1 Waveforms at Various stages of ADM

Sr. No.	Output at	Amplitude	Frequency	Waveform
1	Message signal			
2	Carrier signal			
3	PPM signal		-----------	
4	Demodulated Signal			

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………

……………………………………………………………………………………………………..

……...

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1 What is the minimum sampling frequency of PPM?
2 What is use of mono-stable multivibrator in PPM ?

[Space for Answers]

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. https://www.elprocus.com/pulse-position-modulation (elprocus.com)
2. Digital Communication - PPM Modulation (tutorialspoint.com)
3. **https://www.geeksforgeeks.org/pulse-position-modulation-ppm/**

XVIII Assessment Scheme

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.11: Generation of Pulse signal using pulse code modulation.

I Practical Significance

Pulse Code Modulation (PCM) is defined as the conversion of sampled analog signals into digital signals which are in the form of a series of ‘on’ or ‘off’ amplitudes represented as binary 0 and 1. It is the standard form for digital audio in computers and various Blu-ray, compact disc and DVD formats. This practical is designed to explain how different types of information signals which are analog in nature can be converted to digital form.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

.

III Course Level Learning Outcome(s)

- CO2 -Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 11.1 Determine output binary data as per input data.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

The Pulse Code Modulation consists of three steps, which are sampling, quantization and coding**.**

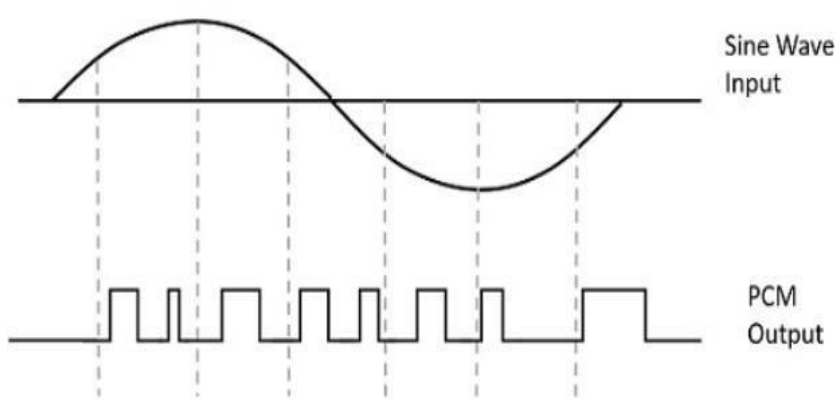


Figure 11.1: **PCM input-output waveforms**

As seen in figure 11.1, an input analog signal which is in the form of a sine wave, is converted into a digital signal with discrete values. Pulse code modulation helps in the digitization process by allowing easy conversion of analog signals into digital signals, which can then be processed into digital outputs.

The transmitter section of a Pulse Code Modulator circuit consists of Sampling, Quantizing and Encoding, which are performed in the analog-to-digital converter section. The low pass filter prior to sampling prevents aliasing of the message signal. The basic operations in the receiver section are regeneration of impaired signals, decoding, and reconstruction of the quantized pulse train as shown in figure 11.2.

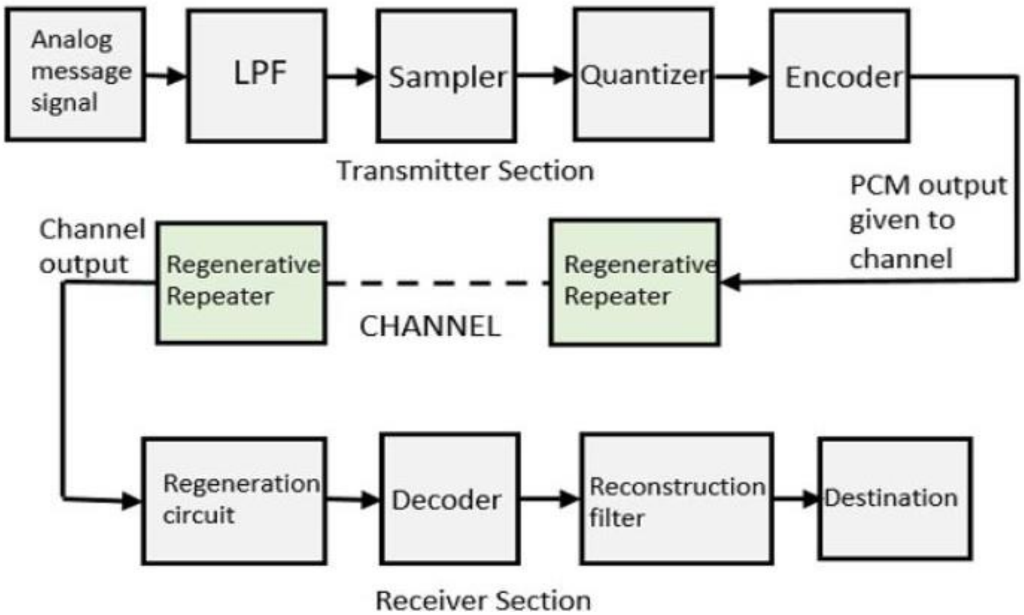


Figure 11.2: **Basic Elements of PCM system**

VII Practical set up:

a) Sample experiment set up used in laboratory

Figure 11.3: **Practical set up for PCM**

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage Oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	PCM Trainer kit	On board modulating sine wave generator 300 Hz – 3.4 KHz, on board sampling pulse generator fast mode – 1.2 – 1.4 MHz, slow mode 0.8 Hz – 1.2 Hz or equivalent trainer kit	1
3	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make the connection as per the available trainer kit.
2. Switch ON the power supply.
3. Set the input analog signal at (1-2 V_{PP}, 500Hz) from function generator.
4. Connect the above signal to the input of trainer kit.
5. Observe the waveform at the output of each block of PCM transmitter.
6. Measure the frequency and voltage of input modulating signal, sampling signal.
7. Connect the PCM modulated waveform to the input of PCM demodulator.
8. Observe the demodulated waveforms with and without filter.
9. Measure the frequency and voltage of LPF output of demodulator.
10. Draw observed waveforms on the graph paper.
11. Verify from the above observations that the given sampling frequency is greater than the $2f_{max}$ (where f_{max} is the modulating frequency).

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

…………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..…………………………………………………………………………………………………

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

XIII Observation Table

Table 11:1 Waveforms at Various stages of PCM

Sr. No.	Output at	Amplitude	Time period	Frequency	Waveform
1	Input signal				
2	Sampling signal				
3	A to D converter	-			
4	Demodulated output without filter				
5	Demodulated output with filter				

XIV Result(s)

…………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

…………………………………………………………………………………………………..

XV Interpretation of results

…………………………………………………………………………………………………..

.........……………………………………………………………………………………………

…………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Refer the Experiment Manual provided by trainer supply and find which circuit or IC is used for
   i. Sampling,
   ii. Quantizing
   iii. Encoding

2. Check if any single IC can do all the three process given in question one.
3. Change the sampling frequency and draw the corresponding PCM output.
4. Change the input frequency and keep the sampling frequency as per above and draw the corresponding PCM output.
5. Name the ADC IC used in your experimental kit.

[Space for Answers]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. Pulse Code Modulation (tutorialspoint.com)
2. Pulse Code Modulation: Diagram, Types, Advantages, Uses (testbook.com)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.12 : Implement differential pulse code modulation and demodulation using suitable simulation tool

I Practical Significance

Differential Pulse Code Modulation (DPCM) is a signal encoding technique that is used to convert analog signals into digital signals. DPCM encodes the difference between the actual sample and its predicted value based on previous samples. This prediction helps to reduce the amount of data needed to represent the signal, as typically, the difference between successive samples is smaller than the absolute value of the samples. This practical designed to explain how different types of information signals which are analog in nature can be converted to digital form.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO2 -Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 12.1 Generate and verify the DPCM signal using simulation software.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices

VI Relevant Theoretical Background

The differential pulse code modulation works on the principle of prediction. The value of the present sample is predicted from the past samples. The prediction may not be exact but it is very close to the actual sample value. The sampled signal is denoted by x(nTs) and predicted signal is denoted by xˆ(nTs).The comparator finds out the difference between the actual sample value x(nTs) and predicted sample value xˆ(nTs).This is known as prediction error and it is denoted by e(nTs).

The predicted value is produced by using a prediction filter. The quantizer output signal eq(nTs) and previous prediction is added and given as input to the prediction filter. This signal is called xq(nTs). This makes the prediction more and more close to the actual sampled signal. We can observe that the quantized error signal eq(nTs) is very small and can be encoded by using small number of bits. Thus number of bits per sample are reduced in DPCM.

The block diagram of DPCM Transmitter consists of Quantizer and Predictor with two summer circuits. DPCM Receiver consists of a decoder, a predictor and a summer circuit.

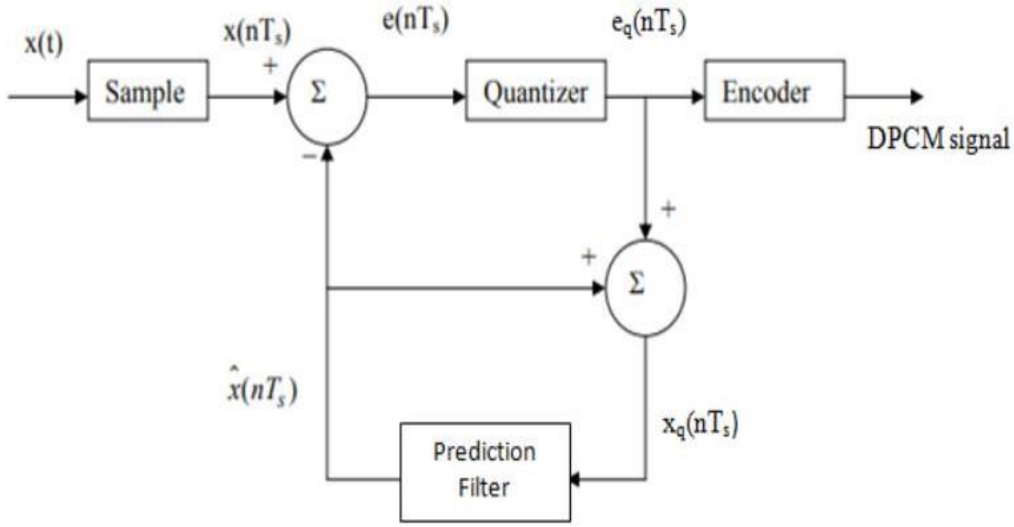


Figure 12.1: DPCM transmitter / Modulator

DPCM Receiver consists of a decoder, a predictor and a summer circuit. The decoder first reconstructs the quantized error signal from incoming binary signal. The prediction filter output and quantized error signals are summed up to give the quantized version of the original signal.

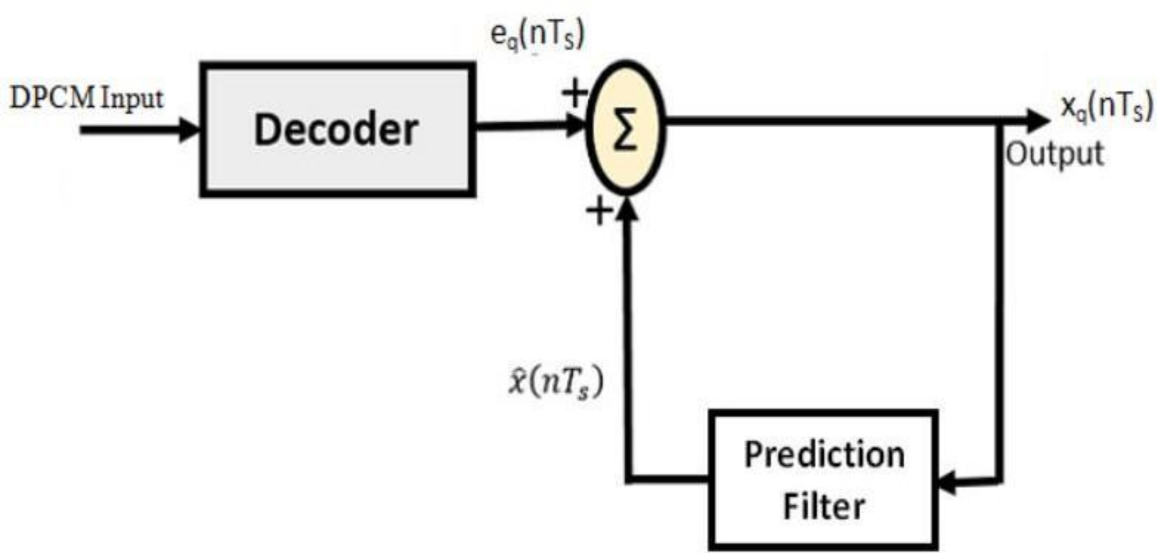


Figure 12.2: DPCM Receiver/ Demodulator

VII Simulation code :

a) Sample Simulation code used in laboratory

```
% Parameters
fs = 1000;          % Sampling frequency in Hz
t = 0:1/fs:1;       % Time vector from 0 to 1 second
f = 5;              % Frequency of the input signal in Hz
amplitude = 1;      % Amplitude of the input signal
bits = 3;           % Number of bits for quantization
% Generate a sine wave signal
x = amplitude * sin(2 * pi * f * t);
% Normalize the signal to the range [0, 1]
x_norm = (x - min(x)) / (max(x) - min(x));
% Quantize the normalized signal
quant_levels = 2^bits;
x_quant = round(x_norm * (quant_levels - 1));
% Normalize the quantized signal back to the range of the original signal
x_pcm = (x_quant / (quant_levels - 1)) * (max(x) - min(x)) + min(x);
% Differential Pulse Code Modulation (DPCM)
x_dpcm = zeros(size(x_pcm));
x_dpcm(1) = x_pcm(1); % The first value remains the same
for i = 2:length(x_pcm)
    x_dpcm(i) = x_pcm(i) - x_pcm(i-1);
end
% Quantize the DPCM signal
dpcm_quant_levels = 2^bits;
x_dpcm_quant = round((x_dpcm - min(x_dpcm)) / (max(x_dpcm) - min(x_dpcm)) * (dpcm_quant_levels - 1));
x_dpcm_quant = x_dpcm_quant / (dpcm_quant_levels - 1) * (max(x_dpcm) - min(x_dpcm)) + min(x_dpcm);
% Reconstruct the original signal from the DPCM signal
x_reconstructed = zeros(size(x_pcm));
x_reconstructed(1) = x_dpcm_quant(1); % The first value remains the same
for i = 2:length(x_dpcm_quant)
    x_reconstructed(i) = x_reconstructed(i-1) + x_dpcm_quant(i);
end
% Plot the original and DPCM signals
figure;
subplot(4,1,1);
```

```
plot(t, x);
title('Original Analog Signal');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(4,1,2);
plot(t, x_pcm);
title('PCM Signal');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(4,1,3);
stem(t, x_dpcm);
title('DPCM Signal');
xlabel('Time (s)');
ylabel('Difference');
subplot(4,1,4);
plot(t, x_reconstructed);
title('Reconstructed Signal from DPCM');
xlabel('Time (s)');
ylabel('Amplitude');
```

Simulation Output:

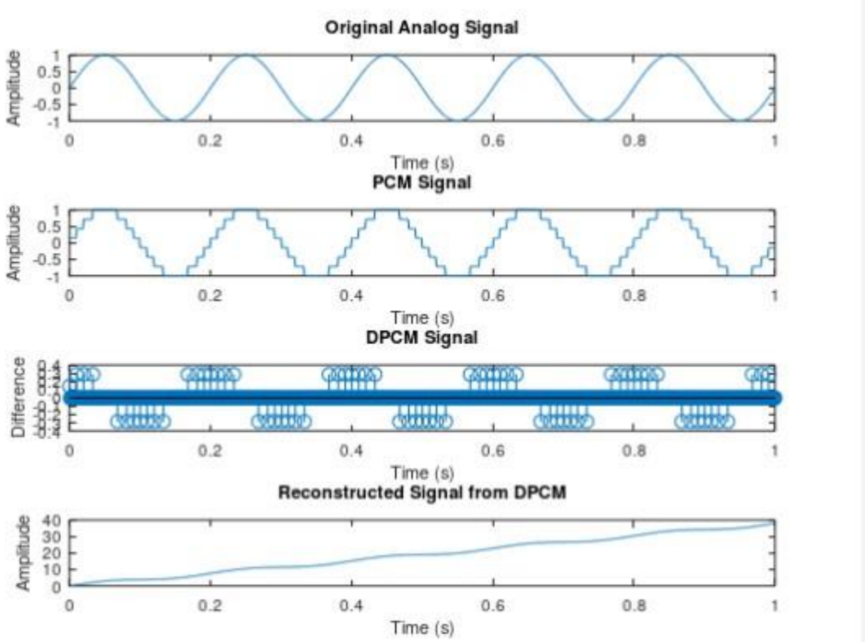


Figure 12.3: DPCM output

b) **Actual simulation code used in laboratory**

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1) Ensure proper earthing to the computer system.
2) Ensure compatibility of computer system with software.
3) Ensure proper installation of simulation software.

X Procedure

1) Open the MATLAB.
2) Go to file and create a new file with extension (.m file)
3) Write the MATLAB code in program window.
4) Save the file.
5) Define path directory.
6) Run the program using function key (F5) or use "RUN" command.
7) Observe the output.

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

………………………………………………………………………………………………………..

……………………………………………………………………………………………………….

..………………………………………………………………………………………………………

………………………………………………………………………………………………………..

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Result(s)

…………………………………………………………………………………………………..

………………………………………………………………………………………………….

..…………………………………………………………………………………………………

…………………………………………………………………………………………………..

XV Interpretation of results

…………………………………………………………………………………………………..

.........………………………………………………………………………………………….

…………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVIIPractical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Explain the role of predictor in DPCM.
2. Explain the difference between PCM and DPCM.

[Space for Answers]

XVIII References/Suggestions for further reading

1. Digital Communication - Differential PCM (tutorialspoint.com)
2. Differential pulse-code modulation - Wikipedia

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.13: Generation of delta modulation and demodulation signal.

I Practical Significance

In PCM the signaling rate and transmission channel bandwidth are quite large since it transmits all the bits which are used to code a sample. To overcome this problem, Delta modulation is used. A delta modulation is an analog-to-digital and digital-to-analog signal conversion technique used for transmission of voice information. DM is the simplest form of differential pulse-code modulation (DPCM) where the difference between successive samples is encoded into n-bit data streams. In delta modulation, the transmitted data are reduced to a 1-bit data stream. This practical is designed to explain how different types of information signals which are analog in nature can be converted to digital form.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO2 -Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 13.1 Observe and verify delta modulated and demodulated signal.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Delta modulation has its roots in Differential pulse code modulation method. It is also known as the simplified form of Differential pulse code modulation. This modulation is also called one bitter two-level version of Differential pulse signal. Here, the difference between the present sample and previous approximated sample is quantized into two levels i.e. $\pm\delta$. corresponding to positive and negative differences, respectively. It provides a staircase approximation of over-sampled base-band, if the approximation falls below the signal at any sampling instant, it is increased by δ. Provided that the signal does not change too rapidly from sample to sample, we find that the stair case approximation remains within $\pm\delta$ of the input signal. The symbol δ denotes the absolute value of the two representation levels of the one-bit quantizer used in the DM.

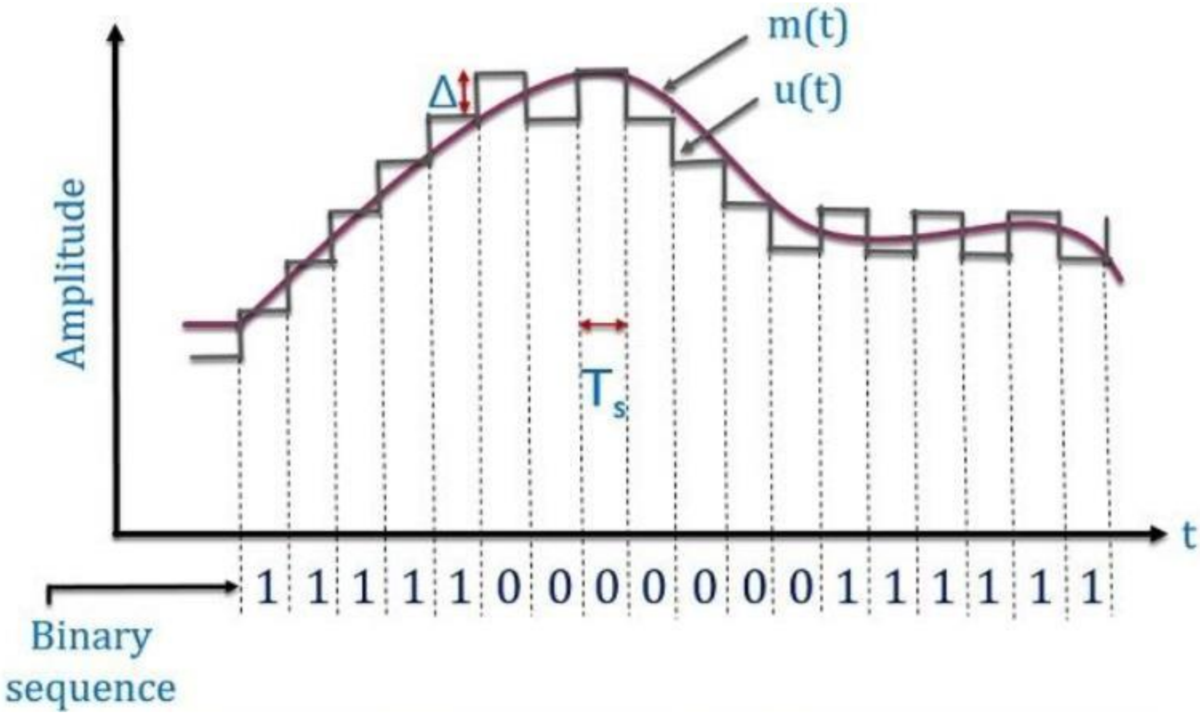


Figure 13.1: Waveform representation of delta modulation

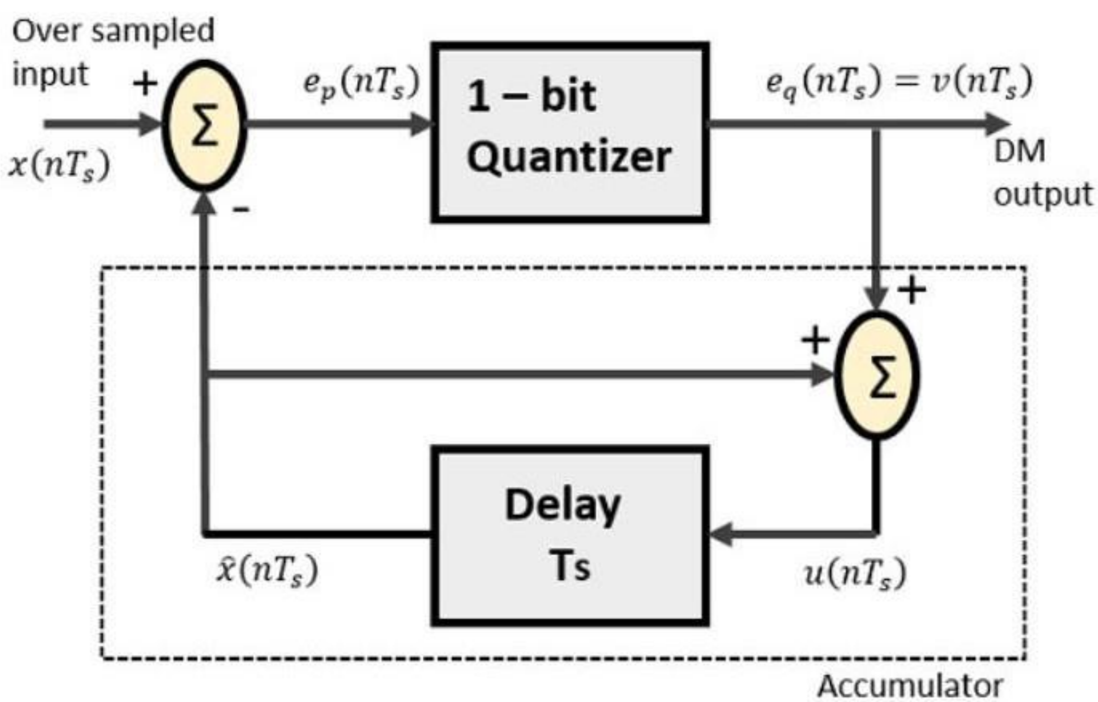


Figure 13.2: Delta modulation Transmitter

In the receiver the stair case approximation u(t) is reconstructed by passing the incoming sequence of positive and negative pulses through an accumulator in a manner similar to that used in the transmitter. The out of –band quantization noise in the high frequency staircase waveform u(t) is rejected by passing it through a low- pass filter with a band-width equal to the original signal bandwidth.

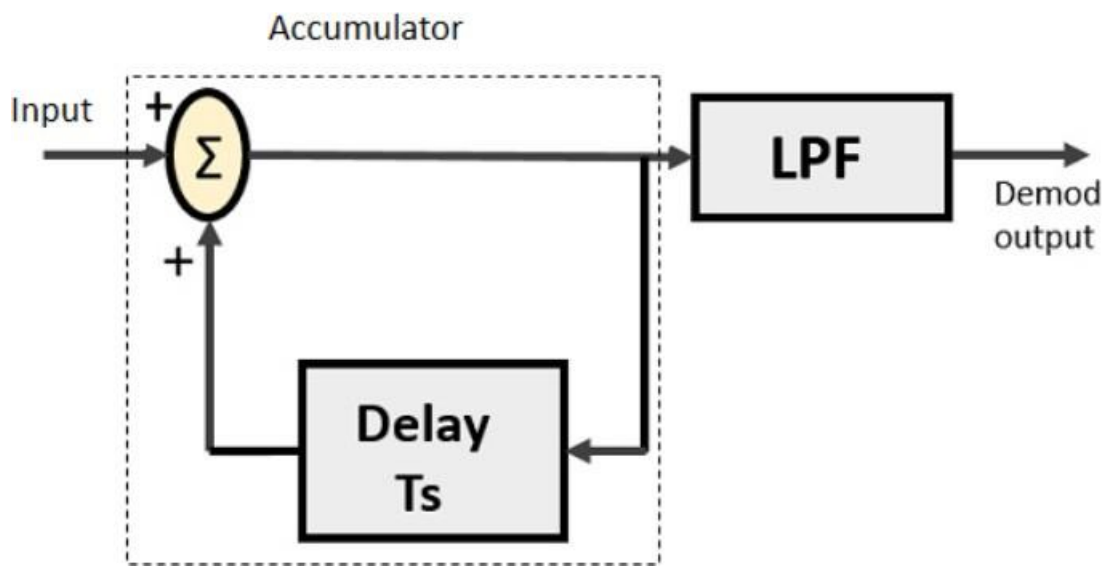


Figure 13.3: Delta modulation Receiver

VII Practical set up:

a) Sample experiment set up used in laboratory

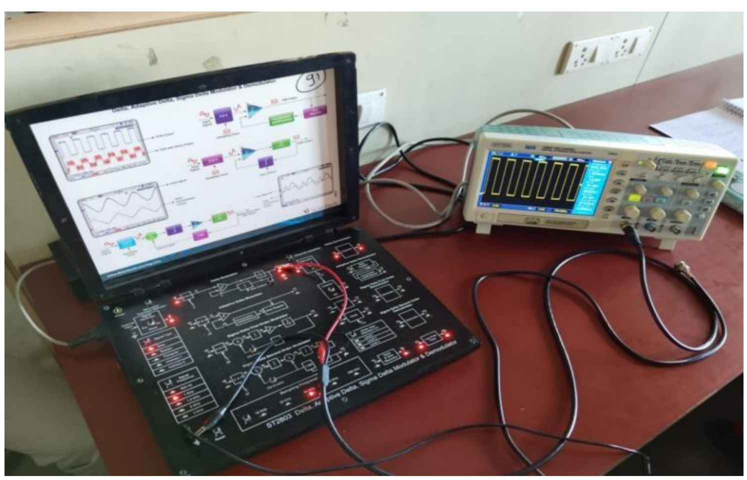


Figure 13.4: Practical set up for Delta modulation

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	DM Trainer kit	Input frequency (250Hz,500Hz,1 KHz, 2 KHz), Sampling frequency (8,16,32,64) KHz or equivalent trainer kit	1
3	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Switch ON the power supply.
2. Select Delta modulation mode.
3. Set the input information signal at $1V_{pp}$, 500 Hz.
4. Select the sampling frequency of 8 KHz.
5. Observe the output waveform at various block output of DM modulator.
6. Connect the output of DM modulator to demodulator the input.
7. Observe the output of DM demodulator
8. Observe the waveform at the output of filter by connecting the output of demodulator to the input of low pass filter.
9. Repeat the above procedure from step 3 to 7 for sampling frequency of 16 KHz and 32 KHz.
10. Draw observed waveforms on the graph paper.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

…………………………………………………………………………………………………..

…………………………………………………………………………………………………

..………………………………………………………………………………………………

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

XIII Observation Table

Table 13:1 Waveforms at Various stages of DM

Sr. No.	Output at	Amplitude	Time period	Frequency	Waveform
1	Input signal				
2	Sampling signal				
3	Integrator signal				
4	DM modulator output				
5	DM demodulator output without filter				
6	DM demodulator output with filter				

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………

……………………………………………………………………………………………………..

……...

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1 Observe the effect of increasing or decreasing amplitude of input signal on DM output.
2 Observe the effect of increase or decrease in amplitude of input signal on integrator output.

3 Observe the effect of increase in sampling frequency on integrator output.
4 Observe the effect of increase in sampling frequency on DM output.

[Space for Answers]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. Explain Delta Modulation in detail with suitable diagram. (electronicspost.com)
2. Digital Communication - Delta Modulation (tutorialspoint.com)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.14: Performance of adaptive delta modulation and demodulation circuit.

I Practical Significance

Adaptive delta modulation is the refined form of delta modulation. This method was introduced to solve the granular noise and slope overload error caused during delta modulation. This Modulation method is similar to delta modulation except that the step size is variable according to the input signal in Adaptive delta Modulation whereas it is a fixed value in delta modulation.

This practical is designed to explain how slope overload error is reduced in ADM.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

.

III Course Level Learning Outcome(s)

- CO2 -Use various pulse code modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 14.1 Observe how quantization error is removed in ADM.
- LLO 14.2 Measure the quantization error.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

In Adaptive Delta Modulation, the step size of the staircase signal is not fixed and changes depending upon the input signal. The transmitter circuit consists of a summer, quantizer, Delay circuit, and a logic circuit for step size control. The baseband signal X(nTs) is given as input to the circuit. The feedback circuit present in the transmitter is an integrator. The integrator generates the staircase approximation of the previous sample.

At the summer circuit, the difference between the present sample and staircase approximation of previous sample e(nTs) is calculated. This error signal is passed to the quantizer, where a quantized value is generated. The step size control block controls the step size of the next approximation based on either the quantized value is high or low. The quantized signal is given as output.

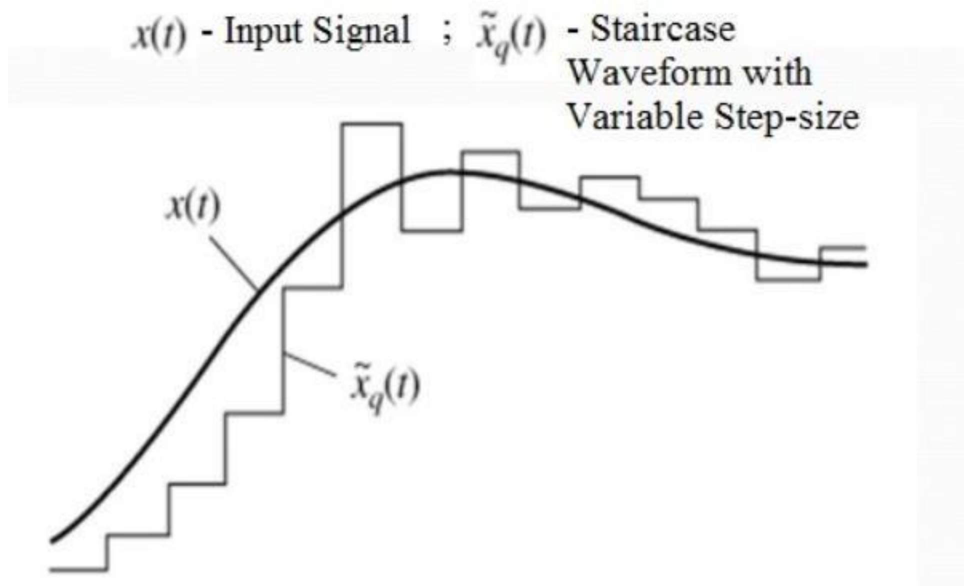


Figure 14.1: Waveform representation of adaptive delta modulation

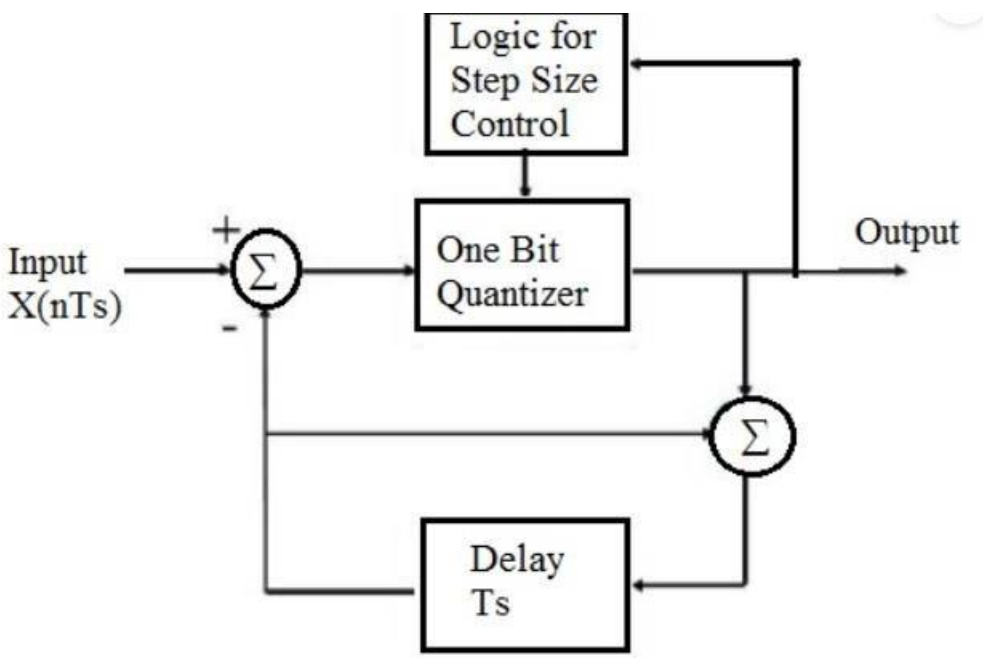


Figure 14.2: Adaptive delta modulation Transmitter

The ADM receiver has two parts. The first part is used to produce the step size from the incoming bits. The bits are then applied to the second part of the receiver which contains an accumulator. The function of the accumulator is to build up the staircase waveform. The signal is then passed through a low pass filter which is used to smoothen the staircase waveform and reconstruct the original signal.

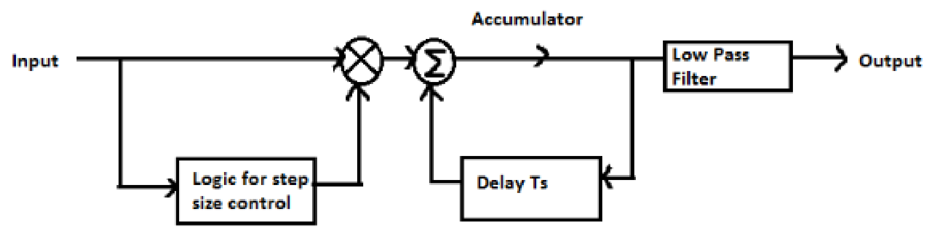


Figure 14.3: Adaptive Delta modulation Receiver

VII Practical set up:

a) Sample experiment set up used in laboratory

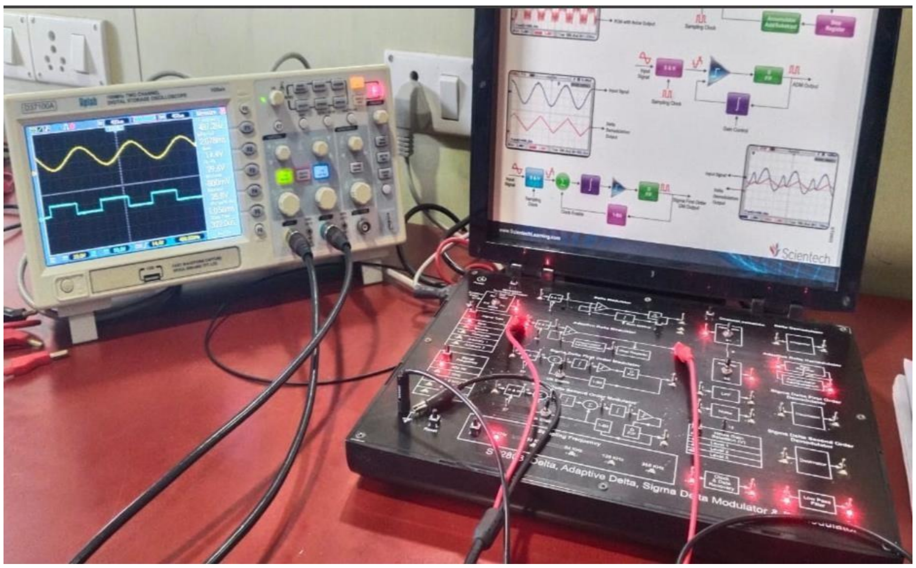


Figure 14.4: Practical set up for Adaptive delta modulation

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage Oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	ADM Trainer kit	Input frequency (250Hz,500Hz,1 KHz, 2 KHz), Sampling frequency (8,16,32,64) KHz or equivalent trainer kit	1
3	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Switch ON the power supply.
2. Select Adaptive delta modulation mode.
3. Set the input information signal at $1V_{pp}$, 500 Hz.
4. Select the sampling frequency of 8 KHz.
5. Observe the output waveform at various block output of DM modulator.
6. Connect the output of ADM modulator to demodulator the input.
7. Observe the output of ADM demodulator
8. Observe the waveform at the output of filter by connecting the output of demodulator to the input of low pass filter.
9. Repeat the above procedure from step 3 to 7 for sampling frequency of 16 KHz and 32 KHz.
10. Draw observed waveforms on the graph paper.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..
……………………………………………………………………………………………………….
..……………………………………………………………………………………………………
……………………………………………………………………………………………………..

XIII Observation Table

Table 14:1 Waveforms at Various stages of ADM

Sr. No.	Output at	Amplitude	Time period	Frequency	Waveform
1	Input signal				
2	Sampling signal				
3	Integrator signal				
4	ADM modulator output				
5	ADM demodulator output without filter				
6	ADM demodulator output with filter				

XIV Result(s)

……………………………………………………………………………………………………..
……………………………………………………………………………………………………….
..……………………………………………………………………………………………………
……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..
.........………………………………………………………………………………………………
……………………………………………………………………………………………………..
……...

XVI Conclusion and recommendation

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. In which applications is Adaptive Delta Modulation preferred over other modulation techniques.
2. Explain the steps involved in setting up a simulation of an ADM system using software tools like MATLAB or Simulink. What parameters would you need to adjust to evaluate its performance.
3. Observe the effect on the retrieved information signal by varying sampling frequency.

[Space for Answers]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. Adaptive Delta Modulation - Block Diagram and Applications (elprocus.com)
2. Digital Communication - Delta Modulation (tutorialspoint.com)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.15: Transmit and receive digital signal using Amplitude shift keying.

I Practical Significance

Amplitude Shift Keying (ASK) is a digital modulation technique. It transmits the digital information by varying the amplitude of a carrier signal. The amplitude of an analog carrier signal varies in accordance with the bit stream (modulating signal) where frequency and phase are keeping constant. Amplitude shift keying having wide range of application in real world which includes radio, television, and digital data transmission. This practical is designed to explain how change of amplitude in to level corresponds to logic 1 and logic 0.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO3 -Analyze performance of different digital modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 15.1 Measure amplitude level of output signal according binary data.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.
- Exhibit positive attitudes towards teamwork.

VI Relevant Theoretical Background

In digital communication, different modulation techniques are used to transmit data or message to receiver over a communication channel. One such technique is Amplitude Shift Keying (ASK). It is a modulation technique that alters the amplitude of a carrier signal to transmit the information over channel. In ASK, a high-amplitude carrier signal is used to represent a binary „1,‟ and a low-amplitude carrier signal represents a binary „0.‟

When the switch is closed – for all the logic HIGH time intervals i.e. when the input signal having logic 1 during those intervals the switch is closed and it is multiplied with the carrier signal which is generating from the function generator for the same duration.

When the switch is opened – when the input signal having logic 0, the switch is opened and there is no output signal will be generated. Because the input binary signal logic 0 having no voltage, so during these intervals when the carrier signal multiples with it, zero output will come. The output is zero for all logic 0 intervals of the input binary signal.

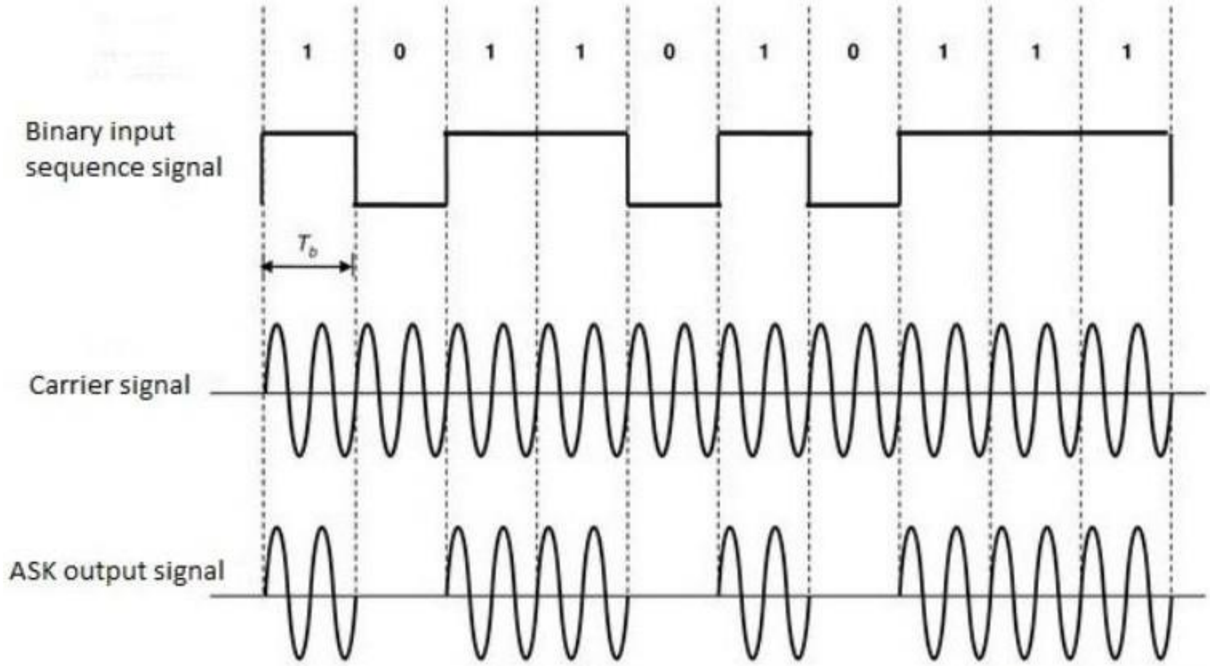


Figure 15.1: ASK modulation waveform

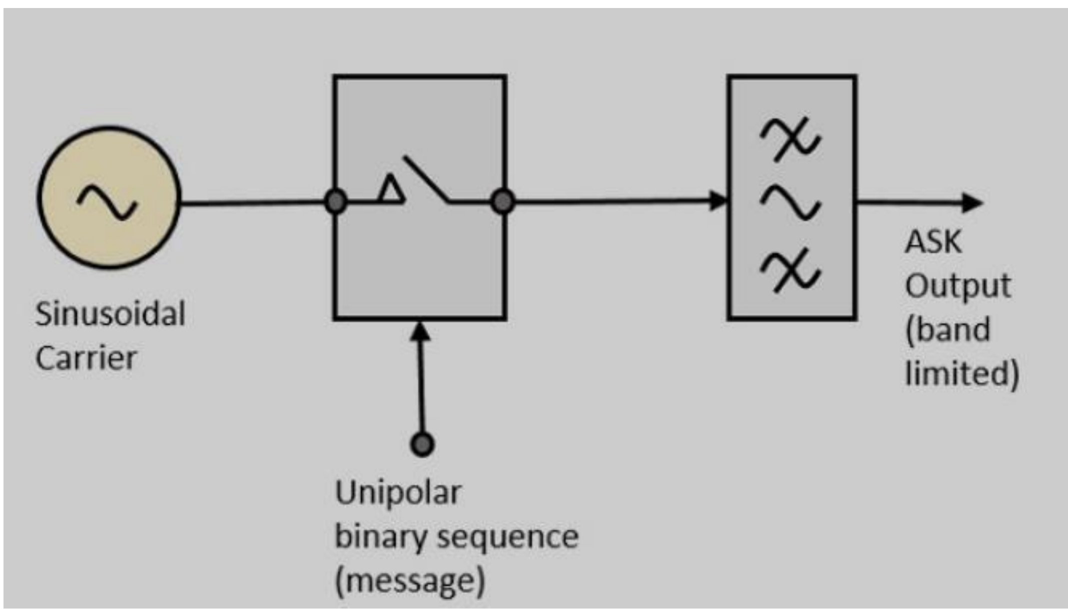


Figure 15.2: ASK modulator

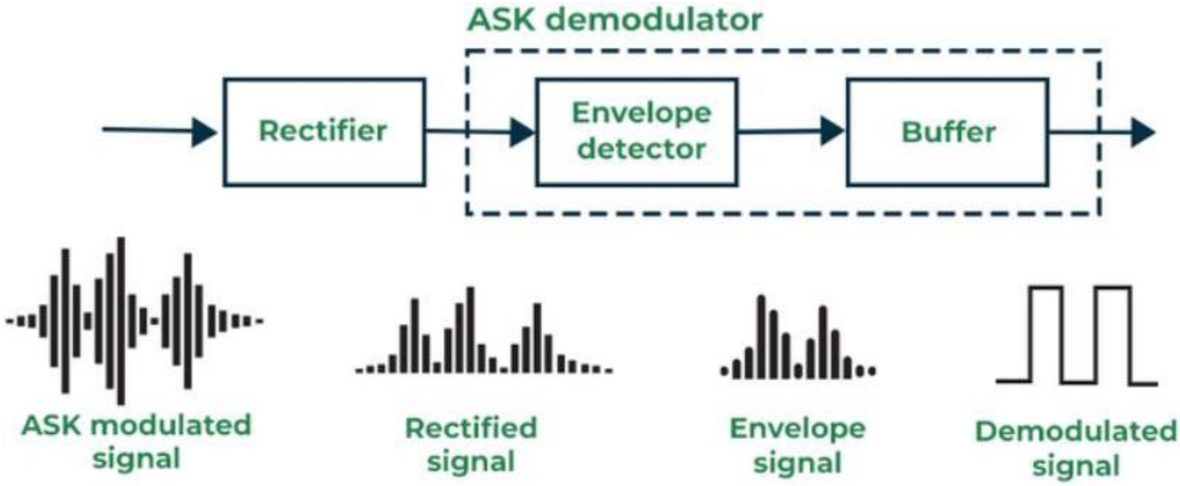


Figure 15.3: ASK Demodulator

VII Practical set up :

a) Sample experiment set up used in laboratory

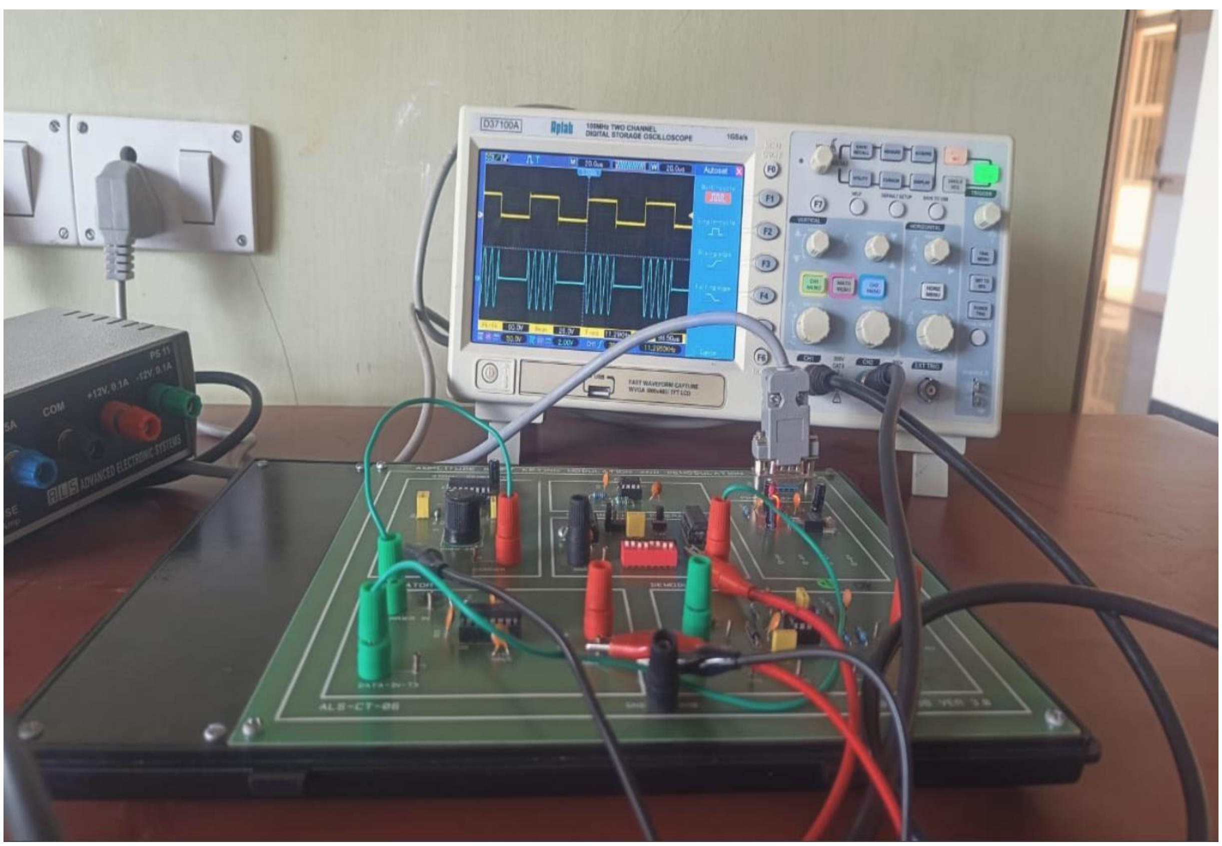


Figure 15.4: Practical set up for ASK modulation

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	Power supply	Variable DC power supply 0-30V,0-2A , SC protection , Digital meters	1
3	ASK Trainer kit	Data clock frequency 2 KHz, 4KHz, 8 KHz, 16 KHz,data 8 bit, 16 bit, 32 bit, 64 bit or equivalent trainer kit	1
4	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make the connection as per circuit diagram.
2. Switch ON the power supply.
3. Connect digital input signal 1010110 on to the trainer kit of ASK modulator.
4. Observe the output of ASK modulator on CRO.
5. Connect output of ASK modulator to input of ASK demodulator.

6. Observe the output of ASK demodulator.
7. Draw the waveform on graph showing digital input signal, carrier signal, modulated signal and demodulated signal.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observation Table

Table 15:1 Waveforms at Various stages of ASK

Sr. No.	Output at	Amplitude	Time period	Frequency	Waveform
1	Input signal bit stream				
2	Carrier signal				
3	ASK modulator output				
4	ASK demodulator output				

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

..........………………………………………………………………………………………….

……………………………………………………………………………………………..

……...

XVI Conclusion and recommendation

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Note down the amplitude of ASK modulated waveform for Logic "1" and Logic "0".
2. Perform same practical for ON-OFF shift key (OOK) and note down amplitude of ASK modulated waveform for logic"1" and logic "0".
3. Discuss the impact of noise on ASK modulation and how you might mitigate its effects.
4. A digital signal (binary data) can be used to control a switch that toggles the carrier signal on and off or changes its amplitude. Whether this can be achieved using a transistor or a logic gate.

[Space for Answers]

...……………………………………………………………………………………..........…

…………………………………………………………………………………………

……………………………………………………………………………………....………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………...

....

....

...............................……………………………………………………………………………

……………………………………………………………………………………...……

……………………………………………………………………………………….…

……………………………………………………………………………………….…

……………………………………………………………………………………….…

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. Amplitude Shift Keying (tutorialspoint.com)
2. Amplitude-shift keying - Wikipedia
3. Virtual Labs (kcgcollege.ac.in)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.16: Transmit and receive digital signal using Frequency Shift Keying (FSK)

I Practical Significance

FSK technology is used for communication systems such as amateur radio, caller ID and emergency broadcasts. This practical is designed to explain how modem converts the binary data from a computer to FSK for transmission over telephone lines, cables, optical fiber, or wireless media. The modem also converts incoming FSK signals to digital low and high states, which the computer can understand. In this practical student are able to view shifts in frequency as per the input digital data.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO4- Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 16.1 Build connections for FSK kit.
- LLO 16.2 observe demodulated signal as per transmitted binary data.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Frequency-shift keying (FSK) is a method of transmitting digital signals. The two binary states, logic 0 (low) and 1 (high), are each represented by an analog waveform. Logic 0 is represented by a wave at a specific frequency, and logic1 is represented by a wave at a different frequency. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary(0sand1s)information. With this scheme, the "1" is called the mark frequency and the "0" is calledthe space frequency.

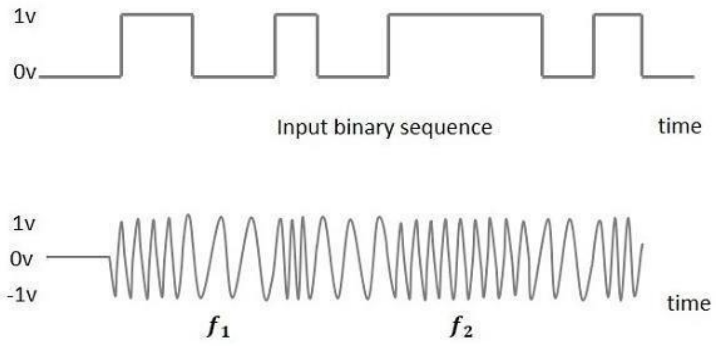


Figure 16.1: FSK Input –Output waveform

Block Diagram

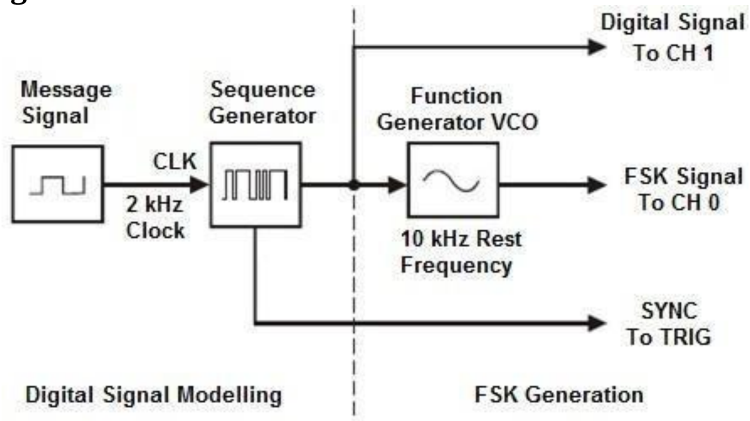


Figure 16.2: FSK Signal Transmission

*[**Courtesy:**http://www.evalidate.in/lab2/pages/FSKS/FSK/FSK_T.html]*

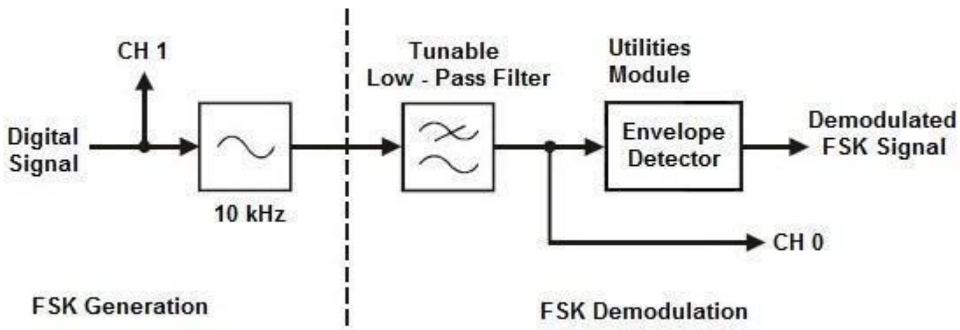


Figure 16.3: FSK Signal Receiving

*[**Courtesy:**http://www.evalidate.in/lab2/pages/Demod-FSK/DFSK/DFSK_T.html]*

VII Practical Set up

a) Sample Experimental set up used in laboratory

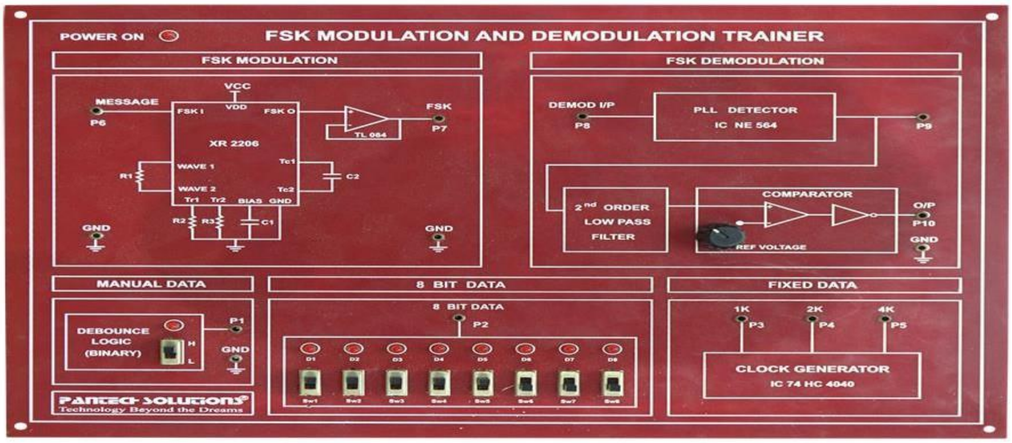


Figure 16.4: FSK Trainer kit

b) Actual Practical Setup (Students should draw practical set up used in their laboratory)

VIII Resources required

Sr. No.	Instruments /Components	Specifications	Quantity
1.	Dual trace cathode rayoscilloscope / Digital storage oscilloscope	20MHz dual trace oscilloscope /25MHz Dual Trace Digital Storage Oscilloscope	1
2.	Power supply	Variable D C power supply 0 -30 V ,2A with SC protection , Digitalmeters	1

3.	FSK Trainer kit	Four type selectable data clock frequency 2 KHz, 4 KHz, 8 KHz,16 KHz, and four selectable typesbit data 8 bit, 16 bit, 32 bit, 64 bit or equivalent trainer kit	1
4.	Connecting wires	CRO probes, patch chords	2

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connectionsas per the circuit diagram.

X Procedure

1. Make the connection as per circuit diagram.
2. Switch ON the power supply.
3. Select the input bit stream of 1010110 and connect it to input terminals of FSKmodulator.
4. Observe the output of FSK modulator on CRO.
5. Connect output of FSK modulator to input of FSK demodulator.
6. Observe the output of FSK demodulator.
7. Draw the waveform on graph showing digital input signal, carrier signal, modulatedsignal and demodulated signal.
8. After completion of practical switch off the supply, remove the connection andsubmit the wires and equipments.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used (with major specifications)

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			
3.			
4.			
5.			

XII Actual Procedure

....
....
....
....
....
....
....
....

XIII Observations and Calculations

Table 16.1: Waveforms at Various stages of FSK

Sr. No.	Input signal	Modulated output signal Frequency	Waveform
1	Logic "1"		
2	Logic "0"		

XIV Results

Modulated signal frequency for Logic"1" =
Modulated signal frequency for Logic"0" =

XV Interpretation of results

....
....
....
....
....
....

XVI Conclusions and Recommendation

....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must designmore such questions so as to ensure the achievement of identified CO.

1. Name the IC used in FSK modulator and demodulator experimental set up.
2. State the value of supply voltage applied to the trainer kit.
3. Apply input waveform 11110000 to FSK trainer kit and draw the corresponding FSKoutput waveform.

[Space for Answers]

....
....
....
....
....

Scale

X-axis -

Y-axis -

XVIII References / Suggestions for further Reading

1. http://www.allsyllabus.com/aj/note/ECE/Digital%20Communication/unit3/index.php#.W0MQ69UzbIU
2. http://www.evalidate.in/lab2/pages/Demod-FSK/DFSK/DFSK_T.html
3. http://www.rfwireless-world.com/Terminology/ASK-vs-FSK-vs-PSK.html

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various output on trainer kit	20 %
4	Handling of the kit ,Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			**Dated Signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 17: Transmit and receive digital signal using Phase Shift Keying (PSK).

I Practical Significance

PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications. PSK has a bandwidth which is lower than that of FSK signal. It has very good noise immunity. This practical enable the students to generate and decode BPSK signal.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO3- Analyze performance of different digital modulation techniques.

IV Laboratory Learning Outcomes(s)

- LLO 17.1 Measure the phase shift according binary data.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Phase Shift Keying (PSK) is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time with respect to the given digital input Figure 16.1 shows PSK/BPSK modulator.

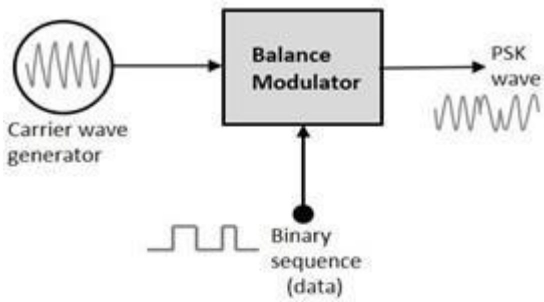


Figure 17.1: Generation of PSK/BPSK Modulator

Courstey:https://www.tutorialspoint.com/digital_communication/digital_communication_phase_shift_keying.htm]

In BPSK modulation, phase of the carrier signal is changed according to the data bit to be transmitted. Keeping its frequency and amplitude constant as shown in Figure 17.2

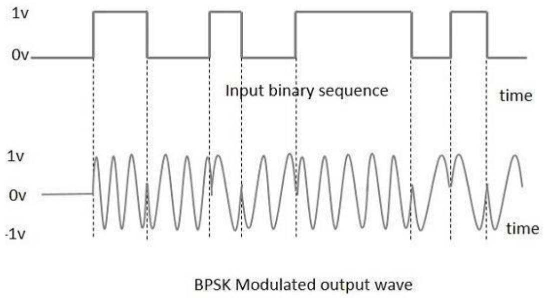


Figure 17.2: Waveform of PSK/BPSK modulation

[Courstey:https://www.tutorialspoint.com/digital_communication/digital_communication_phase_shift_keying.htm]

BPSK demodulator

Figure 17.3 shows BPSK demodulator. The BPSK modulating signal is demodulated with a synchronous detection system. The synchronous detection system uses a modulator to multiply the received signal and regenerated carrier wave. The frequency and phase of the regenerated carrier wave must match (synchronize with) the carrier wave used on the transmitting end.

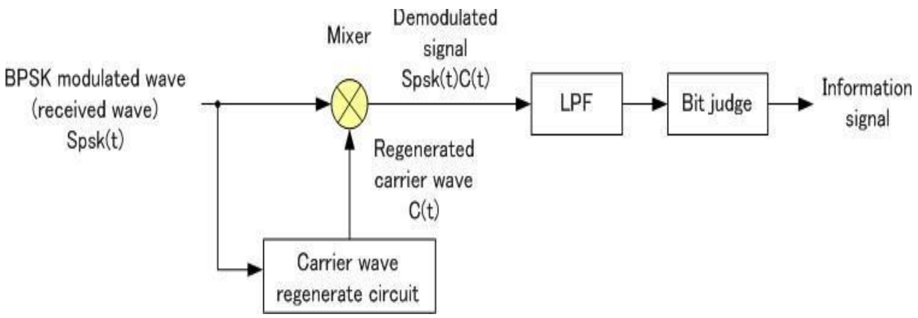


Figure 17.3: PSK/BPSK demodulator

[Courstey:https://www.tutorialspoint.com/digital_communication/digital_communication_phase_shift_keying.htm]

VII Practical Set up

a) Sample Experimental Set up used in laboratory

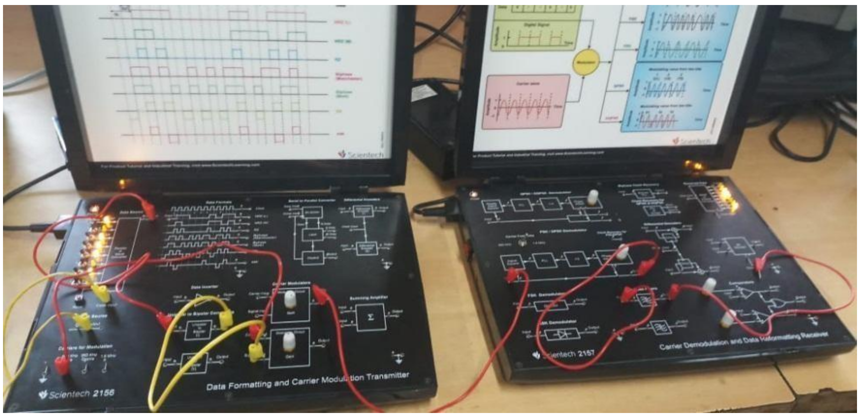


Figure17.4: Practical set up for PSK/BPSK modulation and demodulation

b) Actual Experimental Setup used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1	PSK modulator and demodulator trainer kit	Four type selectable data clock frequency 2 KHz, 4 KHz, 8 KHz, 16 KHz, And four selectable types bit data 8 bit, 16 bit, 32 bit, 64 bit or equivalent trainer kit	1
2	CRO / DSO	25 MHz, dual Trace / Bandwidth 30MHz – 200MHz	1
3	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the experiment adjust proper volt/div and times/div selection on CRO/DSO.

X Procedure

1. Make connections as shown in figure 17.4
2. Select input data 11001011 from data generator using switches and connect it to bipolar convertor.
3. Connect bipolar data to signal input of balanced modulator.
4. Select carrier signal from carrier generator and connect it to carrier input of balanced modulator.
5. Switch on the power supply.
6. Connect DSO/CRO probe at output of balanced modulator.
7. Observe output waveforms of balanced modulator on CRO.
8. Write output signal phase shift with respect to carrier for input signal (logic 1 and logic 0) in observation table16.1.
9. For BPSK demodulation connect output of balanced modulator to input of BPSK demodulator kit as shown in figure 16.4

10. Observe output of low pass filter on DSO/CRO.
11. Draw the waveform of input data, carrier signal, BPSK signal and output of low pass filter on graph paper for observed value.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Actual Resources used (with major specifications)

Sr. No.	Instruments /Components	Specifications	Quantity
1			
2			
3			
4			

XII Actual procedure followed

....
....
....
....
....

XIII Precautions followed

....
....
....
....
....

XIV Observations

Table 17.1: Measurement of phase shift of given carrier

Sr. No.	Input Signal	Modulated output signal phase shift w.r.t. carrier
1	Logic 0	
2	Logic 1	

XV Result

As input signal is at logic 1 output signal phase shift with respect to carrier is ….................................. (180^0 / No Change).

XVI Interpretation of result

....
....
....
....

XVII Conclusions

....
....
....
....

XVIII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw BPSK modulated waveforms for input data 11110000.
2. Draw BPSK modulated waveforms for input data 10101010

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

Scale

X-axis -

Y-axis -

XIX References / Suggestions for further Reading

1. http://www.ques10.com/p/3631/explain-the-operating-principle-working-of-trans-1/.
2. https://www.gaussianwaves.com/2010/04/bpsk-modulation-and-demodulation-2/.

XX Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various out put on trainer kit	20 %
4	Handling of the kit, Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.18: Performance of Quadrature Phase shift keying(QPSK) modulation and demodulation.

I Practical Significance

Quadrature phase shift keying (QPSK) modulation technique is the most widely used modulation scheme in modern digital communication system; it provides high performance on bandwidth efficiency and bit error rate. This practical is designed to explain how QPSK modulation is used in the design of wireless modem.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Outcome(s)

- CO-3 Analyze performance of different digital modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 18.1 Verify the transmitted digital signal according to the original binary data using QPSK modulation.
- LLO 18.2 Measure phase shifts corresponding to the binary data.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

The Quadrature Phase Shift Keying (QPSK) is a variation of BPSK, and it is also a Double Side Band Suppressed Carrier (DSBSC) modulation scheme, which sends two bits of digital information at a time, called as dibits. Instead of the conversion of digital bits into a series of digital stream, it converts them into bit pairs. This decreases the data bit rate to half, which allows space for the other users. Hence with less bandwidth many user can send or receive the information.

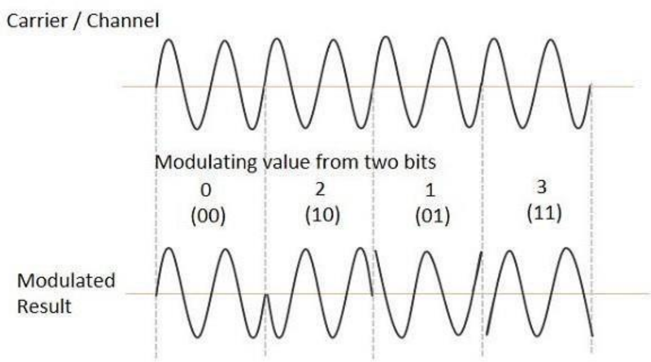


Figure 18.1: QPSK output waveform

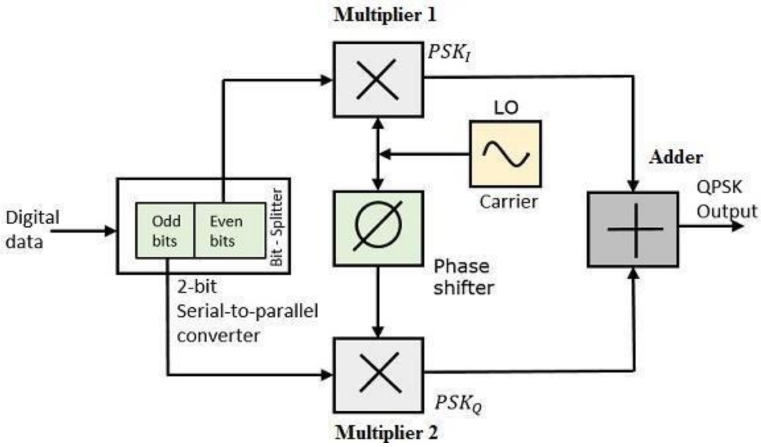


Figure 18.2: QPSK modulator

[Courtesy:- *https://www.tutorialspoint.com/digital_communication/digital_communication_quadrature_phase_shift_keying.htm]*

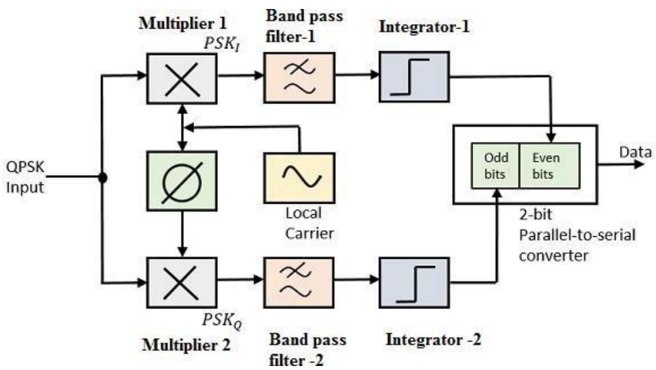


Figure 18.3: QPSK demodulator

[Courtesy:- *https://www.tutorialspoint.com/digital_communication/digital_communication_quadrature_phase_shift_keying.htm]*

VII Practical set up:

a) Sample Experimental set up used in laboratory

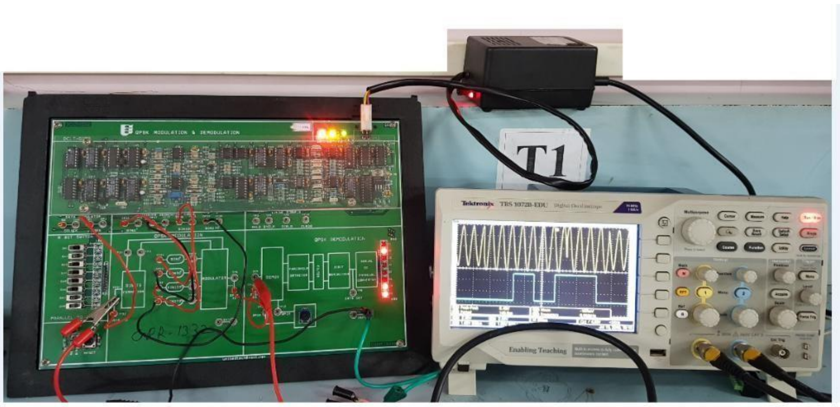


Figure 18.4: QPSK modulator and demodulator practical set up

b) Actual Practical Setup used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	Dual trace cathode ray oscilloscope / Digitalstorage oscilloscope	20MHz dual trace oscilloscope /25 MHz Dual Trace Digital StorageOscilloscope	1
2.	Power supply	Variable D C power supply 0-30V,0-2A with SC protection ,Digital Meters	1
3.	QPSK Trainer kit	On board 8 bit data pattern generation, sinusoidal signals 8 KHz, 4 KHz bit rate, 500 Hz byterate or equivalent trainer kit	1
4.	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connectionsas per the circuit diagram.

X Procedure

1. Make the connection as per Figure18.4.
2. Switch ON the power supply.
3. Connect data to the DATA IN of trainer kit.
4. Connect carrier generator block to respective sine degrees on the kit.
5. Observe the QPSK modulated output by varying data switches for different patternsof data.

6. Connect modulated output of QPSK to the input of receiver block of QPSK demodulator.
7. Compare the LED output of QPSK demodulator kit with input data pattern applied tothe QPSK modulator.
8. Draw the observed output waveforms of QPSK modulator and demodulator on thegraph paper.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments

XI Resources used

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			
3.			

XII Actual procedure

....
....
....
....
....
....
....
....
....
....
....

XIII Observations and Calculations

Table18.1: Waveforms at Various stages of QPSK

Sr. No.	Output at	Waveform
1	**Input data bit stream**	
2	**QPSK modulator output**	
3	**QPSK demodulator output**	

Table18.2: Measurement of phase shift for Input signal bits

Sr. No.	Input signal bits	Phase shift in the carrier
1	00	
2	01	
3	10	
4	11	

XIV Results

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions and Recommendation

....
....
....
....
....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must designmore such questions so as to ensure the achievement of identified CO.

1. State the rate of QPSK modem gives the input IC number of QPSK modulator anddemodulator.
2. Change the data pattern at the input and observe its corresponding waveform.

[Space for Answers]

....
....
....
....
....

Scale

X-axis -

Y-axis -

XVIII References / Suggestions for further Reading

1. https://www.tutorialspoint.com/digital_communication/digital_communication_differential_pcm.htm
2. http://www.rfwireless-world.com/Terminology/QPSK-vs-OQPSK-vs-pi-4QPSK.html

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various output on trainer kit	20 %
4	Handling of the kit ,Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.19: Performance of Quadrature amplitude Modulation (QAM) modulation and demodulation.

I Practical Significance

QAM is a method of combining two amplitude-modulated (AM) signals into a single channel, thereby doubling the effective bandwidth. QAM is used in wireless applications like the PAL and NTSC television systems, where the different channels, which are provided by QAM, enable the transmission of the components of Chroma or colour information to TV sets. It is often used for radio communication systems from regular cellular to LTE including Wi-Max and Wi-Fi. In this practical students are able to view hoe two signals (I, Q) gets modulated on career and 90^0shifted careers.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO-3 Analyze performance of different digital modulation techniques.

IV Laboratory Learning Outcome(s)

- LLO 19.1 Measure the amplitude and phase shifts according to the binary data.
- LLO 19.2 Observe the transmitted signal in the time and frequency domain.

V Relevant Affective domain unrelated Outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Quadrature amplitude modulation (QAM) is a technique used to transmit two digital bit streams or two analog signals by modulating or changing the amplitudes of two carrier waves so that they differ in phase by 90 degrees, a quarter of a cycle, hence the name quadrature. One signal is called the "I" signal and the other is the "Q" signal, which can be mathematically represented by a cosine and a sine wave, respectively. QAM combines the two carriers and sends the combined signals in a single transmission to be separated and extracted at the destination. The signals are demodulated, and the data are then extracted from each and recombined to form the original modulating information.

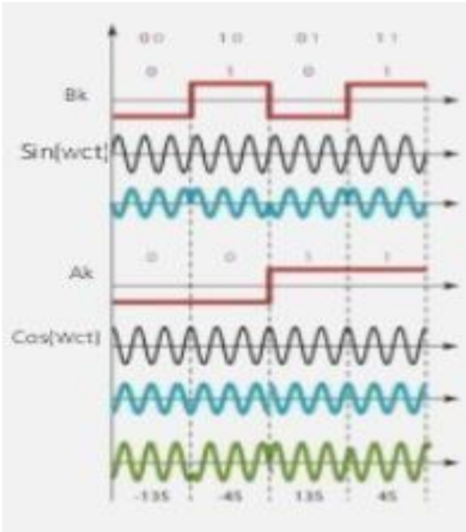


Figure 19.1: QAM Input- Output waveform

VII Practical set up:

a) Sample Block Diagram

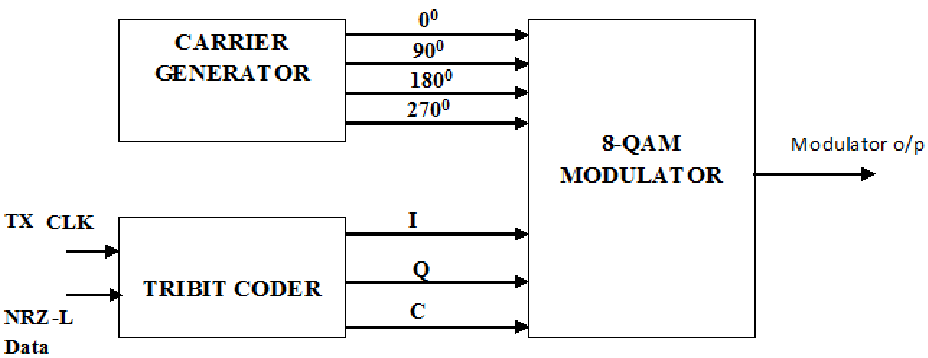


Figure 19.2: QAM modulator

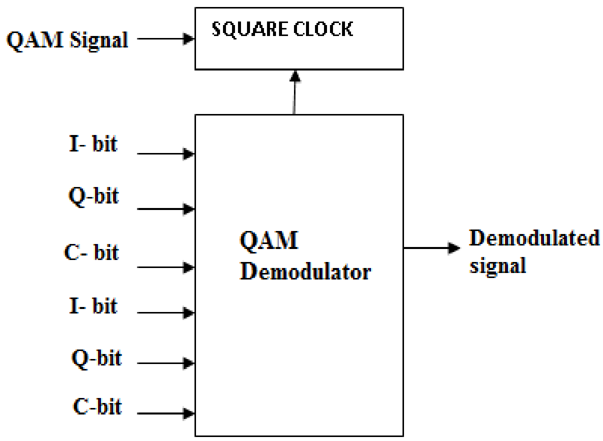


Figure 19.3: QAM demodulator

b) Actual Experimental set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	Dual trace cathode ray oscilloscope / Digital storage Oscilloscope	30MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2.	Power supply	Variable D C power supply 0-30V,0-2A , SC protection Digital meters	1
3.	QAM Trainer kit	NRZ-L , tribit decoded data(I, Q, C), differential decoded I and Q bits, receiver clock generated PLL method or equivalent trainer kit	1
4.	Connecting wires	CRO probes, patch chords	2

IX Precautions

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make the connection as per circuit diagram.
2. Switch ON the power supply.
3. Connect data pattern to NRZ-L coder.
4. Connect NRZ-L coder to data of TRIBIT coder.
5. Connect clock to CLK of TRIBIT coder.
6. Connect the tribit data I-bit, Q-bit and C-bit to control input of carrier modulator respectively.
7. Connect sine carrier to the input of carrier generator.
8. Observe the output waveform of QAM modulator.
9. Connect QAM modulated signal to input of QAM demodulator.
10. Connect I-bit, Q-bit and C-bit output of QAM demodulator to I-bit, Q-bit and C-bit of data decoder.
11. Observe the decoded data and compare with input data pattern.
12. Draw the observed output waveforms of QAM modulator and demodulator on the graph paper.

Waste management

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			
3.			
4.			

XII Actual procedure followed

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

Observations and Calculations

Table19.1: Waveforms at Various stages of QAM

Sr. No.	Input signal tribits	Phase	Amplitude
1	000		
2	001		
3	010		
4	011		
5	100		
6	101		
7	110		
8	111		

XIII Result(s)

....
....
....
....

XIV Interpretation of results

....
....
....
....

XV Conclusions and Recommendation

....
....
....
....

XVI Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Observe the shift in phase and amplitude of carrier when input bit pattern changed from 011 to 101.
2. Observe the shift in phase and amplitude of carrier when input bit pattern changed from 101 to 011.
3. "QAM is best choice for efficient use of bandwidth" Justify it.

[Space for Answers]

Scale

X-axis -

Y-axis -

XVII References / Suggestions for further Reading

1. https://www.slideshare.net/ahsanhalini/quadrature-amplitude-modulation-
2. https://www.radio-electronics.com/info/rf-technology-design/quadrature-amplitude-modulation-qam/what-is-qam-tutorial.php

XVIII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various output on trainer kit	20 %
4	Handling of the kit ,Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 20: Multiplexing of signals in Time-division multiplexing (TDM) using kit.

I Practical Significance

Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern. Time division multiplexing (TDM) has many applications, including wire line telephone systems and some cellular telephone systems. In this practical, students will multiplex individual signal on one common line at transmitter and demultiplex it at other end.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications**

III Course Level Learning Outcome(s)

- CO4- Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 20.1- Build connections for TDM kit.
- LLO 20.2- Measure the amplitude and frequency of TDM signal.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Handle instruments carefully.

VI Relevant Theoretical Background

Multiplexing is used to increase the channel capacity. Time division multiplexing (TDM) is a method in which different information signals transmitted over a common carrier one after other. Each information signal transmitted over short interval of time. TDM is suitable for transmission of digital signal. figure 20.1 shows working of TDM transmitter and receiver.

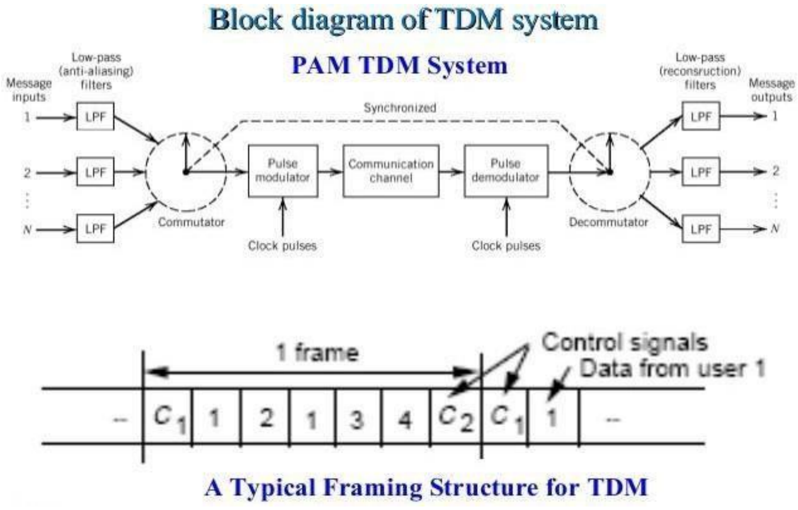


Figure 20.1: TDM transmitter and receiver

[Courtesy:https://www.google.co.in/search?q=TDM+transmitter+and+receiver+block+diagram&tbm=isch&source=iu&ictx=1&fir=Lh2PEUjQ1_A_LM%253A%252CWgOhhlCgRZjvvM%252C_&usg=__fAo6avhHHzF5JHfYfWpUI7JbTNA%3D&sa=X&ved=0ahUKEwjF0KDep6_cAhXKMY8KHWraDnYQ9QEINDAG&biw=1366&bih=613#imgrc=Lh2PEUjQ1_A_LM:]

VII Practical set up

a) Sample Experimental set up used in Laboratory

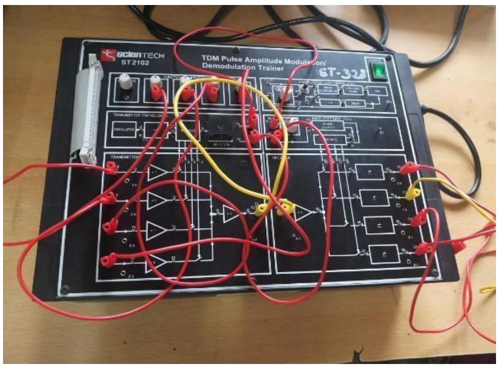


Figure20.2: TDM transmitter and receiver

VIII Actual Experimental set up used in Laboratory

IX Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	TDM Modem trainer kit	Four input sine wave generator 25 Hz, 500 Hz, 1 KHz, 2 KHz; on board sampling pulse generator frequency range 2 KHz – 64 KHz or equivalent trainer kit	1
2.	CRO / DSO	25MHz, dual scope Bandwidth 30MHz – 200MHz Analog Channels 2-4	1
3.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

X Precautions to be Followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the experiment adjust proper volt/div and times/div selection on CRO/DSO.

XI Procedure

1. Make connections as shown in figure 20.2.
2. Select any four input signals and connect it to four channels of TDM transmitter.
3. Connect output of TDM transmitter to CRO/DSO and observe output.
4. Connect output of TDM transmitter to input of TDM receiver as shown in figure 20.2.
5. Connect the output of channel 1, channel 2, channel 3, channel 4 of TDM receiver to CRO/DSO and observe output.
6. Note values of amplitude and frequency of input signal and output signal present at channel 1, 2, 3 and 4 of TDM transmitter and TDM receiver respectively in observation table21.1.
7. Plot wave forms for observed signals.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure

....
....
....
....
....
....
....
....

XIV Observations

Table 20.1: Measurement of amplitude and frequency of input signal and output signal

Sr. No.	Information	Values at TDM transmitter	Received signal	Values at TDM receiver
1	Input signal at channel 1	Amplitude = Frequency =	output signal at channel 1	Amplitude = Frequency =
2	Input signal at channel 2	Amplitude = Frequency =	output signal at channel 2	Amplitude = Frequency =
3	Input signal at channel 3	Amplitude = Frequency =	output signal at channel 3	Amplitude = Frequency =
4	Input signal at channel 4	Amplitude = Frequency =	output signal at channel 4	Amplitude = Frequency =

XV Result(s)

....
....
....
....

XVI Interpretation of results

....
....
....
....

XVII Conclusions

....
....
....
....

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more ***such questions so as to ensure the achievement of identified CO.***

1. Change the input signal frequency and draw the output waveforms of TDM transmitter.
2. Explain how TDM is used in communication application now days in day to day life.

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

Scale

X-axis -

Y-axis -

XIX References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=pL3jnnue9Hc.
2. http://ecomputernotes.com/computernetworkingnotes/network-technologies/time-division-multiplexing.

XX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various out put on trainer kit	20 %
4	Handling of the kit, Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.21: Generation of TDM signal using suitable simulation software

I Practical Significance

Time division multiplexing (TDM) is a technique used to transmit multiple signals simultaneously over a single communication channel. In TDM, the channel is divided into several time slots, and each signal is transmitted during its allocated time slot. As a result, several signals share the channel without interfering with each other. Time division multiplexing (TDM) has many applications in ISDN telephone lines, PSTN. In this practical, students will generate TDM signal using simulation software.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO4 -Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 21.1 Use simulation software to visualize the TDM signal.
- LLO 21.2 Determine the bandwidth and data rate of TDM signal.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices.
- Exhibit positive attitudes towards teamwork.

VI Relevant Theoretical Background

Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern. It can be used when the bit rate of the transmission medium exceeds that of the signal to be transmitted.

Once the analog signals have been sampled, they are converted into digital signals and then multiplexed into a single data stream. The data stream is divided into frames, each further divided into multiple time slots. The number of time slots per frame is determined by the number of signals that need to be transmitted and the available bandwidth. Each signal is allocated a specific time slot within each frame.

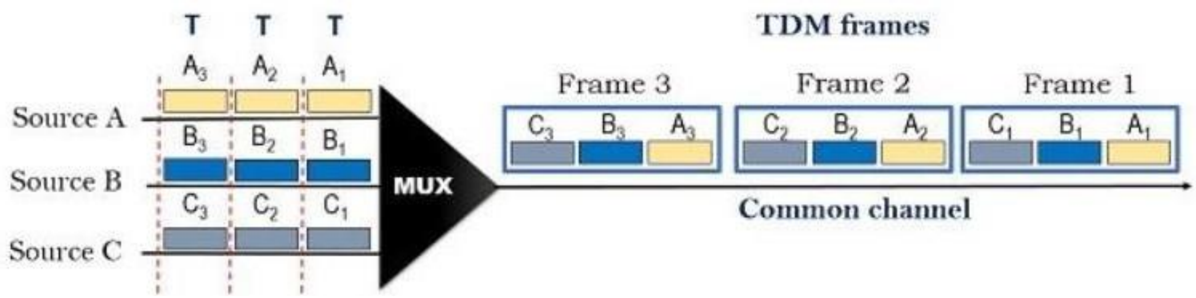


Figure 21.1: TDM working Principle

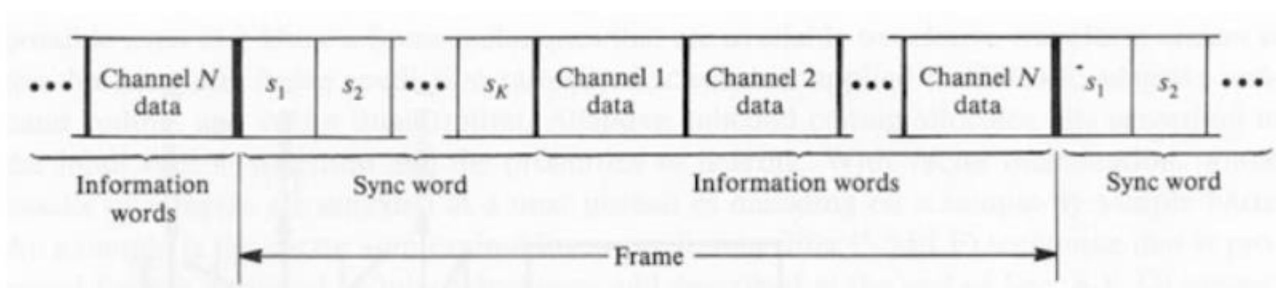


Figure 21.2: TDM frame sync format

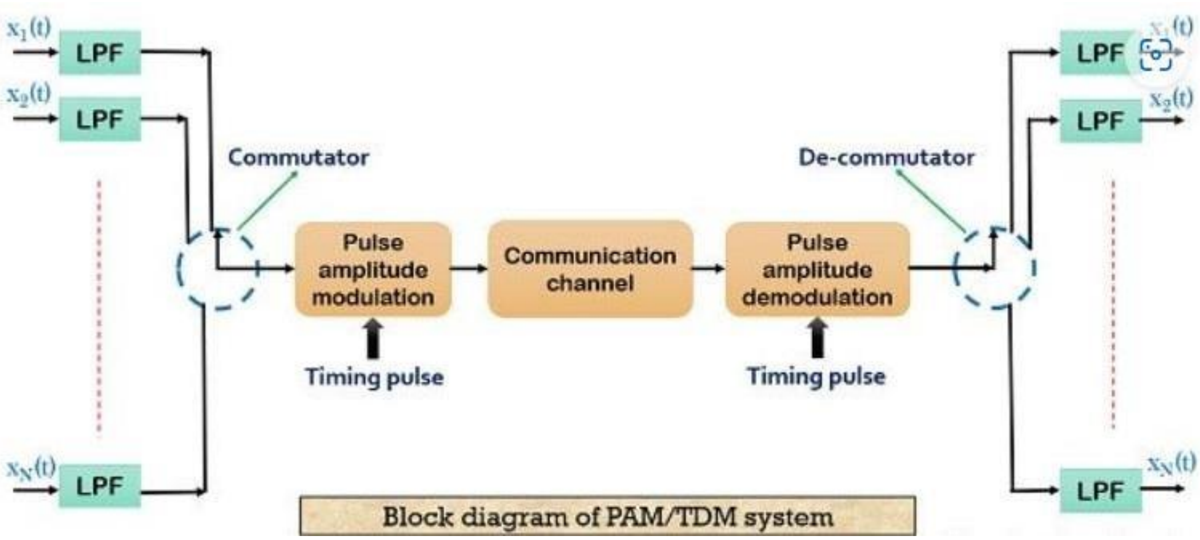


Figure 21.3: TDM transmitter and receiver

VII Simulation code :

a) Sample Simulation code used in laboratory

```
% Parameters
Fs = 1000;       % Sampling frequency
T = 1;           % Duration in seconds
t = 0:1/Fs:T-1/Fs;% Time vector

% Generate two signals
f1 = 50;         % Frequency of first signal
f2 = 120;        % Frequency of second signal
signal1 = sin(2*pi*f1*t);
signal2 = cos(2*pi*f2*t);

% Plot original signals
figure;
subplot(3,1,1);
plot(t, signal1);
title('Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,1,2);
plot(t, signal2);
title('Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');

% Multiplexing
TDM_signal = zeros(1, 2*length(signal1));
TDM_signal(1:2:end) = signal1;
TDM_signal(2:2:end) = signal2;

% Plot multiplexed signal
subplot(3,1,3);
plot(0:1/(2*Fs):T-1/(2*Fs), TDM_signal);
title('TDM Signal');
xlabel('Time (s)');
ylabel('Amplitude');

% Demultiplexing
demux_signal1 = TDM_signal(1:2:end);
demux_signal2 = TDM_signal(2:2:end);

% Plot demultiplexed signals
figure;
subplot(2,1,1);
plot(t, demux_signal1);
```

```
title('Demultiplexed Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,1,2);
plot(t, demux_signal2);
title('Demultiplexed Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');
```

Simulation Output:

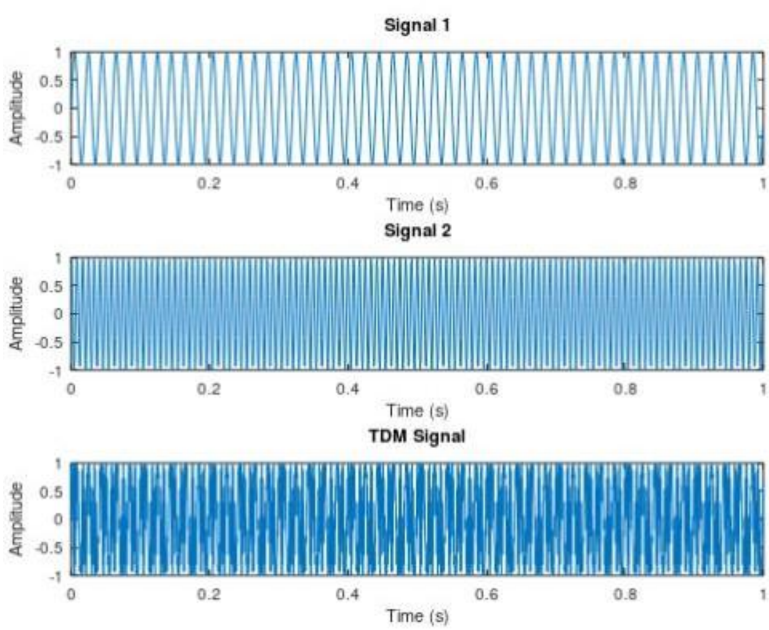


Figure 21.4: TDM Modulated output

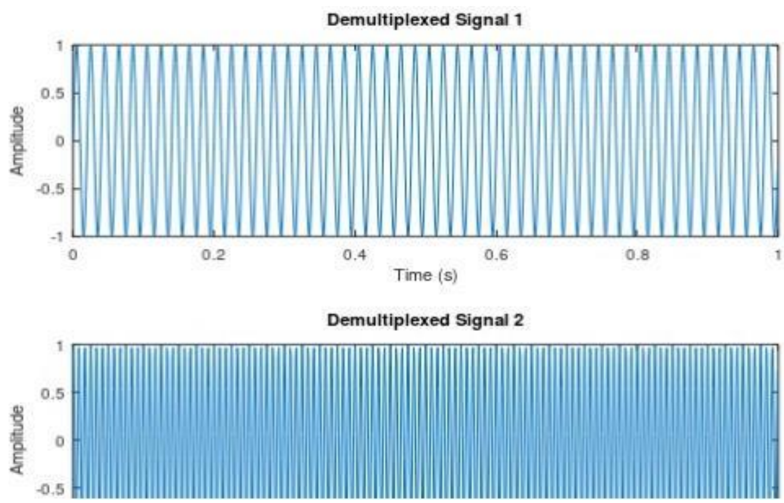


Figure 21.5: TDM Demodulated output

b) Actual simulation code used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1) Ensure proper earthing to the computer system.
2) Ensure compatibility of computer system with software.
3) Ensure proper installation of simulation software.

X Procedure

1) Open the MATLAB.
2) Go to file and create a new file with extension (.m file)
3) Write the MATLAB code in program window.
4) Save the file.
5) Define path directory.
6) Run the program using function key (F5) or use "RUN" command.
7) Observe the output.

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Observe the output Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Create a TDM frame that consist of 4 time slot ,one for each user.
2. State the function of commutator and decommutator switches

[Space for Answers]

XVIII References/Suggestions for further reading

1. Time Division Multiplexing : Block Diagram, Working & Its Uses (elprocus.com)
2. Time division Multiplexing (TDM) (multiplexingandmultipleaccess.blogspot.com)
3. Lab 7 TIME-DIVISION MULTIPLEXER USING CHANNEL-SELECT CLOCK SIGNALS - Multisim Live

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.22: Multiplexing of signals in FDM using kit.

I Practical Significance

In Frequency-division multiplexing (FDM) numerous signals are combined for transmission on a single communication line or channel. Each signal is assigned a different frequency (sub channel) within the main channel. It is used in public telephones and in cable TV systems and in AM and FM broadcasting as it does not need synchronization between its transmitter and receiver. It is simpler and easy for demodulation. In this practical, students will mix two or more analog signals using FDM multiplexer and retrieve the original signal using FDM de-multiplxer.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO4 -Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 22.1 Build connection for FDM kit.
- LLO 22.2 Measure frequency of FDM signal.

V Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

In Frequency division multiplexing simultaneous transmission of the signal takes place over a common channel in which the channel bandwidth is divided into various sub-channels. These sub-channels comprised of different frequency slots for carrying individual signal during transmission. Figure 22.1 is given below to understand how multiple signals can be transmitted over a common channel.

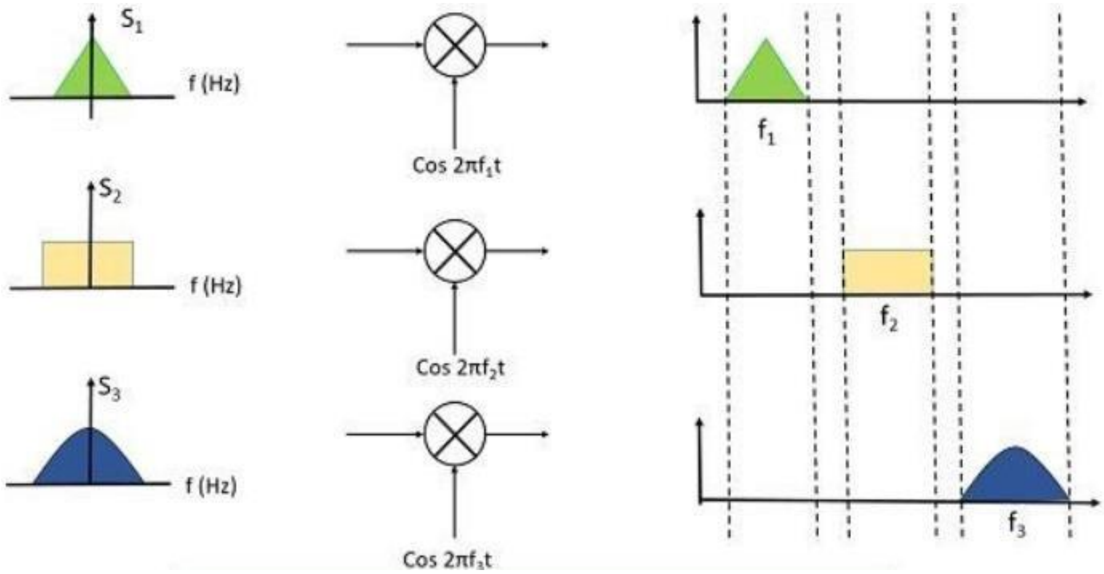


Figure 22.1: Signal modulation with different carrier frequency

FDM transmitter:

The numerous signals that are to be transmitted along a common channel modulate different carriers in the modulating section. The output of the modulator will have multiple signals of different carrier frequency. The modulated signals are then fed to a linear mixer which is different from a normal mixer. Linear mixer simply produces the algebraic sum of the generated modulated signals. The combined signal at the output of the mixer is then transmitted along a single channel.

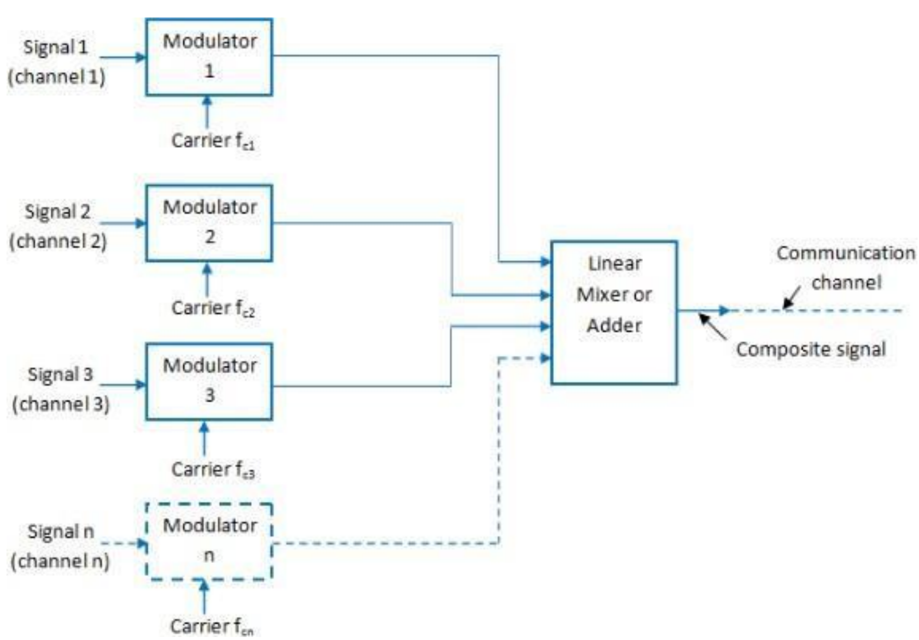


Figure 22.2: Block diagram of FDM transmitter

FDM Receiver:

The receiver section will have a composite signal that was transmitted by the linear mixer over a channel. This composite signal is then fed to different filters mainly BPF each having a centre frequency corresponding to the carrier frequency. The BPF passes the channel information without any distortion. BPF rejects signals of all other frequencies and accepts the signal of the desired centre frequency. The signals after being processed by the BPF goes to individual demodulator section where demodulation of the signals takes place to separate modulating signal from that of the carrier signal.

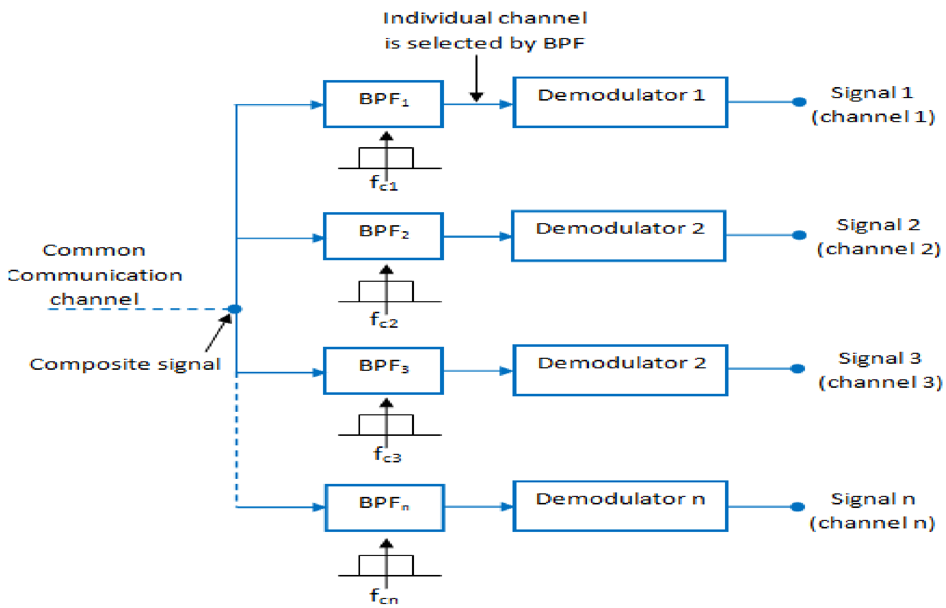


Figure 22.3: Block diagram of FDM receiver

VII Practical set up:

a) Actual Practical set up used in laboratory

Figure 22.4: Practical set up for FDM system

b) Actual Practical set up used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Dual trace cathode ray oscilloscope / Digital storage oscilloscope	20 MHz dual trace oscilloscope / 25 MHz Dual Trace Digital Storage Oscilloscope	1
2	FDM generation and detection trainer kit	Two input variable sine wave generator frequency range 1KHz – 4 KHz, on board sampling pulse generator frequency range 2 KHz –64 KHz or equivalent trainer kit	1
3	Connecting wires	CRO probes, attenuation probes, patch chords	2

IX Precautions to be followed

1) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make connections as shown in figure 22.4.
2. Select any two input signals and connect it to two channels of FDM transmitter.
3. Connect output of FDM transmitter to CRO/DSO and observe output.
4. Connect output of FDM transmitter to input of FDM receiver as shown in figure 22.4
5. Connect the output of channel 1 and channel 2 of FDM receiver to CRO/DSO and observe output.
6. Write values of amplitude and frequency of input signal and output signal present at channel 1 and 2 of FDM transmitter and FDM receiver respectively in observation table 22.1.

7. Plot wave forms for observed signals.

Waste management:

1. Use DSO instead of CRO to save energy.
2. Turn off all the equipments.
3. Remove the connection and submit the wires and equipments.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observation Table

Table 22:1 Measurement of amplitude and frequency of input signal and output signal

Sr. No	Information	Values at FDM transmitter	Received signal	Values at FDM receiver
1	Input signal at channel 1	Amplitude = Frequency =	Output signal at channel 1	Amplitude = Frequency =
2	Input signal at channel 2	Amplitude = Frequency =	Output signal at channel 2	Amplitude = Frequency =

XIV Result(s)

……………………………………………………………………………………………………..

……………………………………………………………………………………………………….

..……………………………………………………………………………………….……………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Write the number of IC used as FDM mux/demux in your experimental set up.
2. List application of FDM used in day-to-day electronic communication.

[Space for Answers]

...……………………………………………………………………………………………..........…

………………………………………………………………………………………………………

……………………………………………………………………………………………....………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

…………………………………………………………………………...

....

....

..............................……………………………………………………………………………

……………………………………………………………………………………………...……

…………………………………………………………………………………………………...…

Scale

X-axis -

Y-axis -

XVIII References/Suggestions for further reading

1. What is Frequency division multiplexing? Working and hierarchy - Electronicscoach
2. NITTTR (nitttrc.edu.in)

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.23: Generation of FDM signal using suitable simulation software

I Practical Significance

In telecommunications, frequency-division multiplexing (FDM) is a technique by which the total bandwidth available in a communication medium is divided into a series of non- overlapping frequency sub-bands, each of which is used to carry a separate signal. This allows a single transmission medium such as the radio spectrum, a cable or optical fiber to be shared by multiple independent signals. In this practical, students will generate a FDM signal using simulation software and reconstruct the same.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO4 -Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 23.1 Use simulation software to visualize the FDM signal.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices.
- Exhibit positive attitudes towards teamwork.

VI Relevant Theoretical Background

In Frequency Division Multiplexing, the different message signals are modulated at the different carrier frequencies. In this way, the modulated signals are separate from each other in the frequency domain. The modulated signals are combined together to form the composite signal and this signal is sent over the shared medium or channel. To avoid the interference between the two message signal, some guard band is also kept between the two message signals. Generally, the FDM systems are used for multiplexing the analog signal.

At the receiver, using the bandpass filter, each modulated signal is separated from the composite signal and demultiplexed. And by passing the demultiplexed signal through the low pass filter, it is possible to recover each message signal. In the Frequency Division Multiplexing System, the bandwidth of the transmission line or the link is always greater than the required bandwidth for transmitting of all signals.

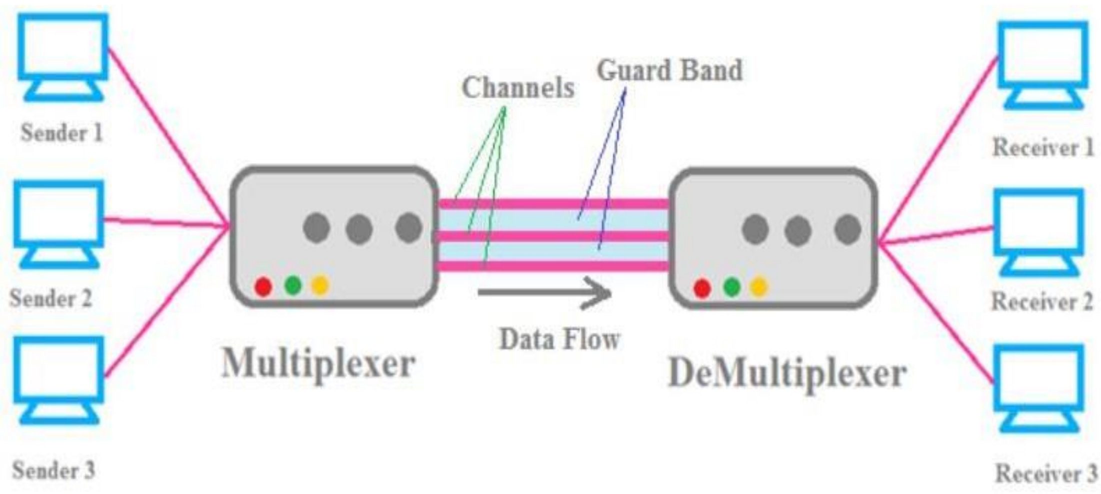


Figure 23.1: Frequency division multiplexing and demultiplexing

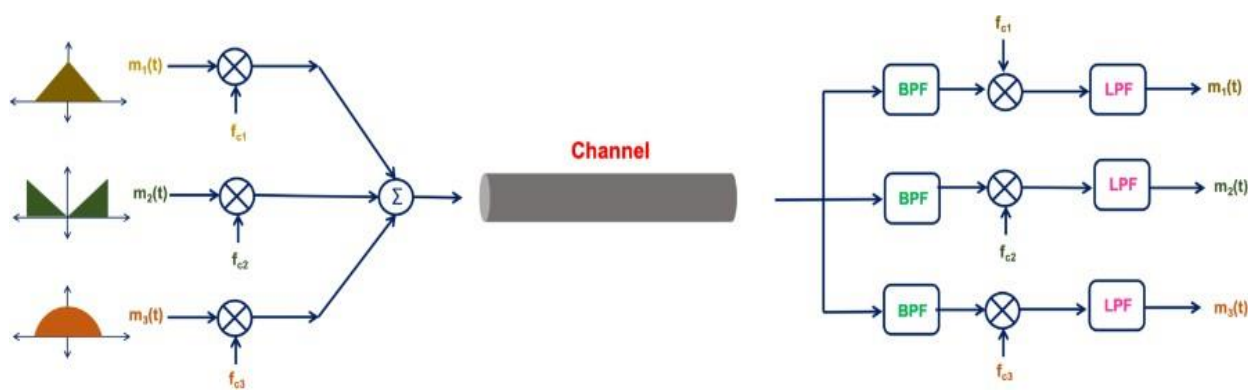


Figure 23.2: FDM transmitter and receiver

VII Simulation code :

a) Sample Simulation code used in laboratory

```
% Parameters
fs = 1000;          % Sampling frequency (Hz)
t = 0:1/fs:1-1/fs;  % Time vector (1 second duration)
f1 = 10;            % Frequency of Signal 1 (Hz)
f2 = 20;            % Frequency of Signal 2 (Hz)
f3 = 30;            % Frequency of Signal 3 (Hz)
% Generate signals
signal1 = sin(2*pi*f1*t);
signal2 = sin(2*pi*f2*t);
signal3 = sin(2*pi*f3*t);
% Combine signals (FDM)
fdm_signal = signal1 + signal2 + signal3;
```

```
% Plot signals
figure;
subplot(4,1,1);
plot(t, signal1);
title('Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(4,1,2);
plot(t, signal2);
title('Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(4,1,3);
plot(t, signal3);
title('Signal 3');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(4,1,4);
plot(t, fdm_signal);
title('FDM Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

Simulation Output:

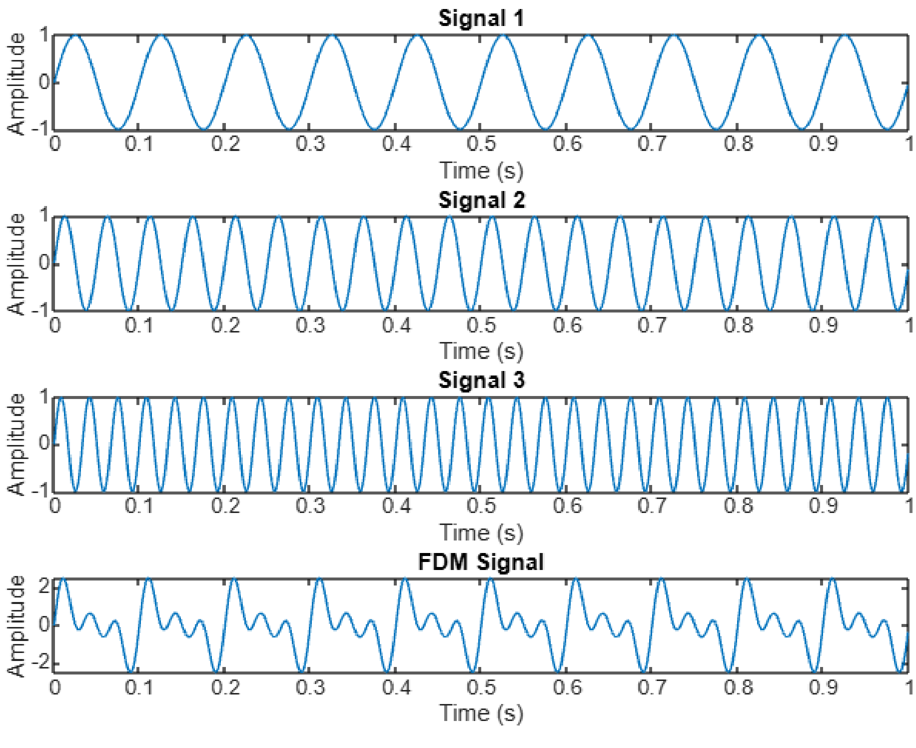


Figure 23.3: FDM Modulated output

b) **Actual simulation code used in laboratory**

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1) Ensure proper earthing to the computer system.
2) Ensure compatibility of computer system with software.
3) Ensure proper installation of simulation software.

X Procedure

1) Open the MATLAB.
2) Go to file and create a new file with extension (.m file)
3) Write the MATLAB code in program window.
4) Save the file.
5) Define path directory.
6) Run the program using function key (F5) or use "RUN" command.
7) Observe the output.

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Observe the output Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

……………………………………………………………………………………………………..

.………………………………………………………………………………………………….

..………………………………………………………………………………………………

……………………………………………………………………………………………………..

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........…………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.

1. Calculate the bandwidth required for the combined signal if each original signal has a bandwidth of 2 kHz.
2. If the combined signal is transmitted over the channel, write the equation for the combined signal.

[Space for Answers]

...………………………………………………………………………………………….........…

………………………………………………………………………………………………………

…………………………………………………………………………………………...………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………...

....

....

..............................……………………………………………………………………………

XVIII References/Suggestions for further reading

1. NITTTR (nitttrc.edu.in)
2. Frequency Division Multiplexing Overview & Applications - Lesson | Study.com

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.24: Generation of CDM signal using suitable simulation software

I Practical Significance

Code division multiplexing (CDM) allows multiple users to share the same frequency spectrum simultaneously. Unlike Frequency Division Multiplexing (FDM) or Time Division Multiplexing (TDM), which require dividing the available bandwidth into separate frequency bands or time slots, CDM overlays multiple signals on the same frequency band. This efficient use of spectrum is particularly beneficial in crowded frequency environments. CDM efficiently utilize available bandwidth, enhance communication security, and provide robust performance in various environments. In this practical, students will generate a CDM signal using simulation software and reconstruct the same.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO4 -Interpret concept of multiplexing and multiple access techniques.

IV Laboratory Learning Outcome(s)

- LLO 23.1 Use simulation software to visualize the CDM signal.

V Relevant Affective Domain related outcome(s)

- Select proper programming environment.
- Follow ethical practices.
- Exhibit positive attitudes towards teamwork.

VI Relevant Theoretical Background

CDM uses spread spectrum technology in wireless communication because each channel is encoded to broadcast over a wider range than the original signal used. Code division multiplexing separates one signal from another by giving each signal a series of bits called the spreading code. This spreading is combined with the original signal to form a new coded data stream, which is then sent to the shared medium. Then the demultiplexer, knowing the code, can recover the original signal by removing the spread code, called backpropagation.

Initially, for transmission, the pseudorandom code generator generates a unique spreading code. This random code sequence is multiplied by the input data stream that the user actually wants to transmit. For each individual user, willing to transmit over that channel, a specific PN code will be generated for spreading the bit sequence. the modulator (PSK type) performs the modulation of obtained bit sequence with a carrier signal thereby providing a BPSK modulated signal as

output. This signal is then broadcasted using an antenna.
To get the original data stream (for de-spreading) the PN code generated at the receiver end must be same as that produced as the transmitting end for each individual user. After multiplication with the de-spreading code, original data is retrieved by the receiving station.

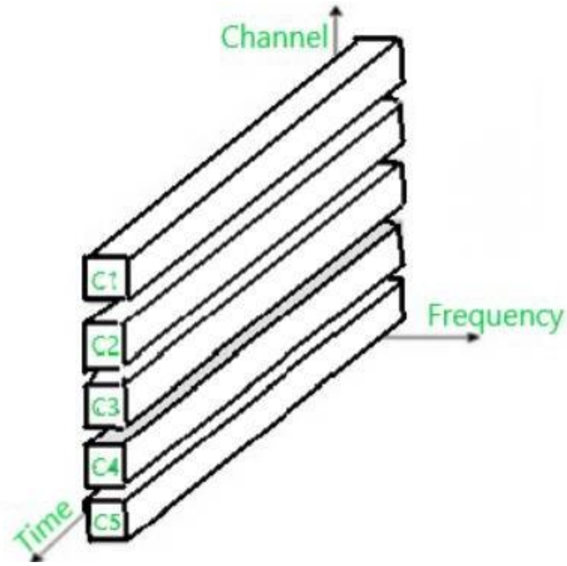


Figure 24.1: Code division multiplexing

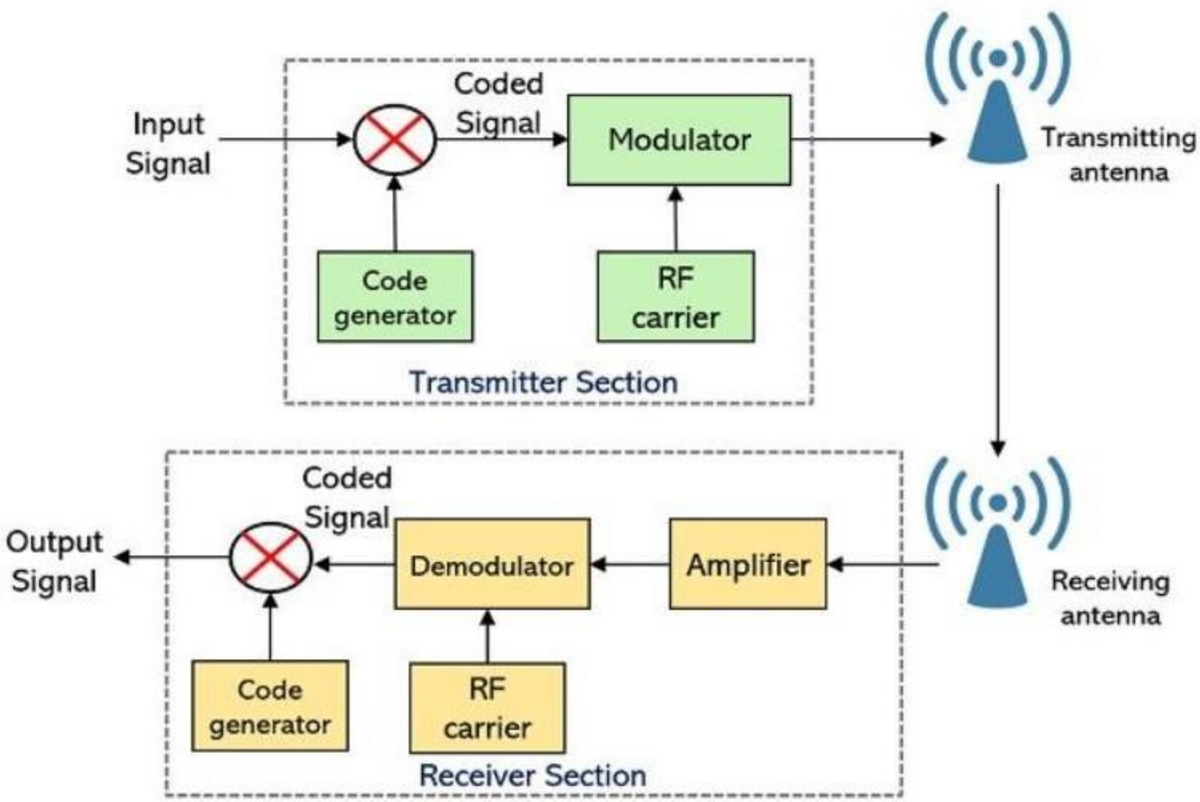


Figure 24.2: CDM transmitter and receiver

VII Simulation code:

a) Sample Simulation code used in laboratory

```
% Parameters
fs = 1000;           % Sampling frequency
t = 0:1/fs:1-1/fs;    % Time vector
f1 = 50;             % Frequency of first signal
f2 = 100;            % Frequency of second signal

% Original signals
signal1 = sin(2*pi*f1*t);
signal2 = cos(2*pi*f2*t);


% Spreading codes (orthogonal codes)
code1 = [1 1 -1 -1];
code2 = [1 -1 1 -1];

% Repeat codes to match the length of the signals
spread_code1 = repmat(code1, 1, length(signal1)/length(code1));
spread_code2 = repmat(code2, 1, length(signal2)/length(code2));

% Spread the signals
spread_signal1 = signal1 .* spread_code1;
spread_signal2 = signal2 .* spread_code2;

% Combine signals for CDM
combined_signal = spread_signal1 + spread_signal2;

% Demodulate signals
demodulated1 = combined_signal .* spread_code1;
demodulated2 = combined_signal .* spread_code2;

% Integrate over each code period to retrieve original signals
recovered1 = zeros(1, length(t)/length(code1));
recovered2 = zeros(1, length(t)/length(code2));

for i = 1:length(recovered1)
   start_idx = (i-1)*length(code1) + 1;
   end_idx = i*length(code1);
   recovered1(i) = sum(demodulated1(start_idx:end_idx));
   recovered2(i) = sum(demodulated2(start_idx:end_idx));
end

% Normalize recovered signals
recovered1 = recovered1 / max(abs(recovered1));
recovered2 = recovered2 / max(abs(recovered2));
```

```
% Plot original and recovered signals
figure;

subplot(3,2,1);
plot(t, signal1);
title('Original Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,2,2);
plot(t, signal2);
title('Original Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,2,3);
plot(t, spread_signal1);
title('Spread Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,2,4);
plot(t, spread_signal2);
title('Spread Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,2,5);
plot(linspace(0, 1, length(recovered1)), recovered1);
title('Recovered Signal 1');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,2,6);
plot(linspace(0, 1, length(recovered2)), recovered2);
title('Recovered Signal 2');
xlabel('Time (s)');
ylabel('Amplitude');
```

Simulation Output:

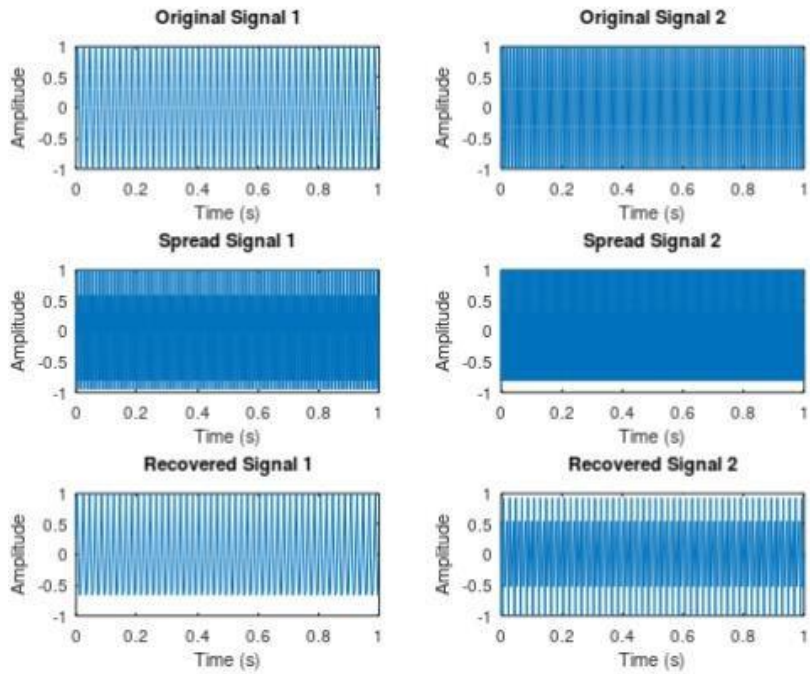


Figure 24.3: CDM input and output

b) **Actual simulation code used in laboratory**

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1) Ensure proper earthing to the computer system.
2) Ensure compatibility of computer system with software.
3) Ensure proper installation of simulation software.

X Procedure

1) Open the MATLAB.
2) Go to file and create a new file with extension (.m file)
3) Write the MATLAB code in program window.
4) Save the file.
5) Define path directory.
6) Run the program using function key (F5) or use "RUN" command.
7) Observe the output.

Waste management:

1) Shut down the PC and switch off the supply to save energy.

XI Observe the output Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1			
2			
3			

XII Actual Procedure

…………………………………………………………………………………………………..

…………………………………………………………………………………………………

..………………………………………………………………………………………………

…………………………………………………………………………………………………..

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Result(s)

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….

..……………………………………………………………………………………………………

……………………………………………………………………………………………………..

XV Interpretation of results

……………………………………………………………………………………………………..

.........……………………………………………………………………………………………….

……………………………………………………………………………………………………..

……..

XVI Conclusion and recommendation

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

XVII Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.

1. Assign a unique 4-bit orthogonal code to each of the 4 users.
2. Demonstrate how the signals from all users are combined in the transmission channel.
3. Show how the receiver can decode the combined signal to retrieve the original data bits for each user.

[Space for Answers]

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

XVIII References/Suggestions for further reading

1. NITTTR (nitttrc.edu.in)
2. Types of Multiplexing in Data Communications - GeeksforGeeks

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of simulation software	10%
2	Building of diagram	20%
3	Measuring values from PC screen	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Correctness of output	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 25: PN sequence Generator.

I Practical Significance

Pseudo-Noise coding sequence is used in spread spectrum techniques. It is used in cryptographic devices, electronic musical instruments. Spread spectrum technology has blossomed from military technology in to one of the fundamental building blocks in current and next generation wireless system .From cellular to cordless to wireless LAN (WLAN) system. In this practical, students design PN-Sequence for given data length and calculate its maximum length.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO5 -Interpret the concept of various spread spectrum techniques.

IV Laboratory Learning Outcome(s)

- LLO 25.1 Select desired maximum length N for the PN sequence.
- LLO 25.2 Obtain the output bits of the PN sequence.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Handle instruments carefully.

VI Relevant Theoretical Background

A coded sequence of 1's and 0's with certain auto-correlation properties called as Pseudo-Noise coding sequence is used in spread spectrum techniques.it is generated by a shift register and EX-OR gate. Maximum length of PN sequence has a period of 2^m-1 clock cycles where m is number of flip-flops in shift register. All flip-flops operate on same clock.at each clock pulse .the state of each flip-flop is shifted to next one. Figure
25.1 shows 4bit PN –Sequence Generator of maximum length of 15 bits. After every 15clockplusesPN-Sequencewillrepeat

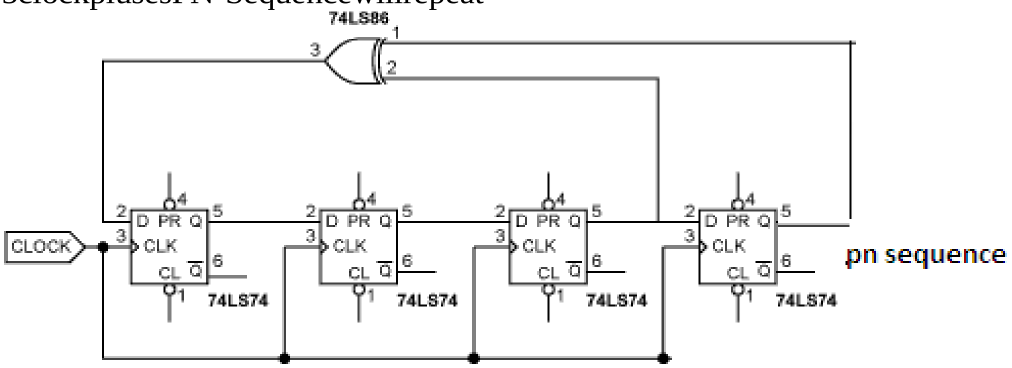


Figure 25.1: 4bit PN-Sequence Generator

[Courtesy:https://electronics.stackexchange.com/questions/30521/random-bit-sequence-using-verilog]

VII Practical Circuit Diagram

a) Sample Circuit Diagram

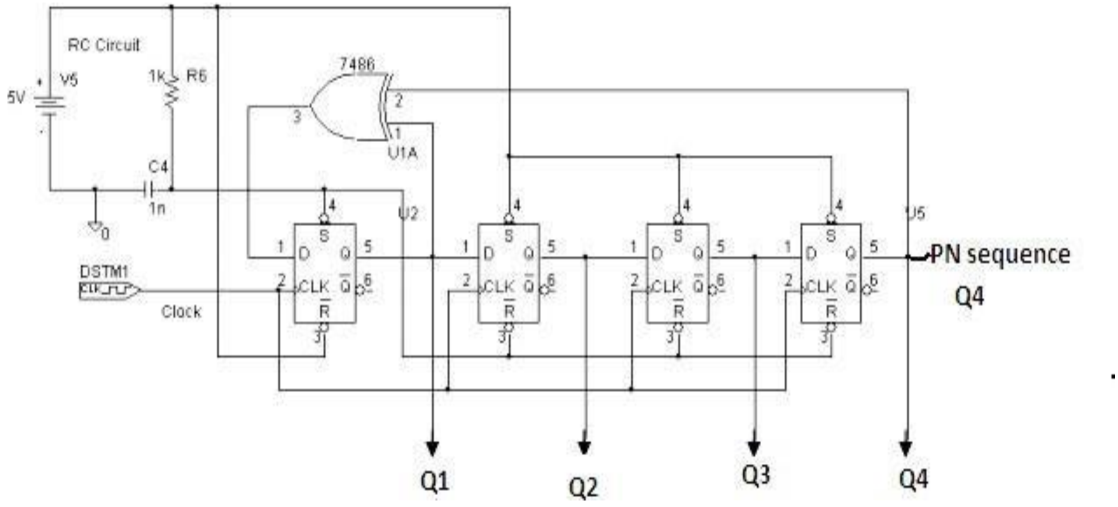


Figure 25.2: 4 bit PN-Sequence Generator

[Courtesy:http://shodhganga.inflibnet.ac.in/bitstream/10603/39978/14/14_chapter%204.pdf]

b) Sample Practical Setup

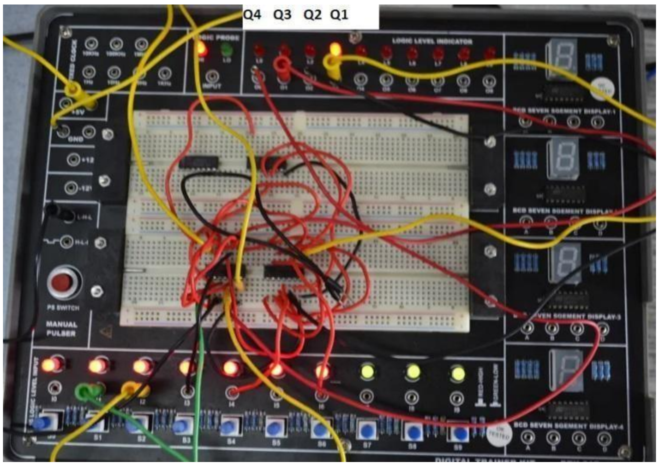


Figure 25.3: Practical setup for 4-Bit PN-Sequence generator

c) Actual Practical set up used in laboratory

(Student should draw practical set up used in their laboratory**)**

VIII Resources required

Sr. No.	Instruments /Components	Specifications	Quantity
1.	DC Regulated power supply	Variable DC power supply 0-30V, 2A, SC protection, display for voltage and current.	1
2.	LED	1.8V to 2.2V	4
3.	IC 7486 (EX-OR gate),	TTL Family	1
4.	IC7474(D-flip-flop)	TTL Family	2
5.	Digital trainer kit (if required)	Data Switches: 8 No's, DC Power supply: +5V, +12V, (0-12V), Pulse Generator: square Frequency range: 1Hz to700KHZ, Seven Segment Display: 1 Nos, 1 Buzzer or equivalent trainer kit.	1
6.	Bread board	5.5cm x 17cm	1
7.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be Followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make connections as shown in figure 25.2.
2. Connect LEDs at output of each flip-flop to check status of Q_1,Q_2,Q_3 and Q_4
3. Switch ON the power supply.
4. Clear all flip-flops.
5. Initialize the initial state to 0001($Q_4Q_3Q_2Q_1$) using preset terminal
6. Apply 1st clock signal and observe outputs ,
7. Write the state of Q_1,Q_2,Q_3,Q_4 in observation table 25.1
8. Repeat step 6 and 7up to 14th clock pulse.
9. At 15th clock pulse state of Q_1, Q_2, Q_3, Q_4 is same as initial state.
10. Draw the Sequence on graph paper.

Waste management:

1. Turn off all the equipments.
2. Remove the connection and submit the wires and equipments.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure

....

....

....

....

....

XIII Observations :

Table 25.1: Generation of PN sequence

Sr. No.	Clock	State of Shift Register				Mod.2 adder Output	PN Sequence (Q_4)
		Q_1	Q_2	Q_3	Q_4	$Q_3 \oplus Q_4$	
1	Initial state	1	0	0	0	0	0
2	1						
3	2						
4	3						
5	4						
6	5						
7	6						
8	7						
9	8						
10	9						
11	10						
12	11						
13	12						
14	13						
15	14						
16	15						

XIV Result(s)

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions

....
....
....
....

XVII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Generate PN sequence for initial state 1010
2. At initial state 0000 what should be PN sequence

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

Scale

X-axis -

Y-axis -

XVIII References / Suggestions for further Reading

1. https://en.wikipedia.org/wiki/Pseudorandom_noise.
2. https://www.youtube.com/watch?v=GrA46JJ0xbU.

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Identification of different blocks on trainer kit	10 %
2	Preparation of Experimental set up	20 %
3	Observation and measurement of various out put on trainer kit	20 %
4	Handling of the kit, Working in team	10 %
Product related (10 Marks)		**40%**
5	Interpretation of result	15 %
6	Conclusions	05 %
7	Practical related questions	15 %
8	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 26: Generation PN sequence using suitable simulation software.

I Practical Significance

The PN Sequence Generator block generates a sequence of pseudorandom binary numbers using a linear-feedback shift register (LFSR). A pseudo noise sequence can be used in a pseudorandom scrambler and descrambler. It can also be used in a direct- sequence spread-spectrum system. In this practical, students will simulate PN-Sequencefor given data length using simulation software.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employe expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO5- Interpret the concept of various spread spectrum techniques.

IV Laboratory Learning Outcome(s)

- LLO 26.1 Determine PN sequence.

V Relevant Affective domain related Outcome(s)

- Select proper programming environment.
- Follow ethical practices

VI Relevant Theoretical Background

Pseudo-Noise (PN) sequences are commonly used to generate noise that is approximately "white". It has applications in scrambling, cryptography, and spread-spectrum communications. It is also commonly referred to as the Pseudo-Random Binary Sequence (PRBS). These are very widely used in communication standards these days. The qualifier "pseudo" implies that the sequence is not truly random. Actually, it is periodic with a (possibly large) period, and exhibits some characteristics of a random white sequence within that period. PN sequences are generated by Linear Feedback Shift Registers(LFSR)

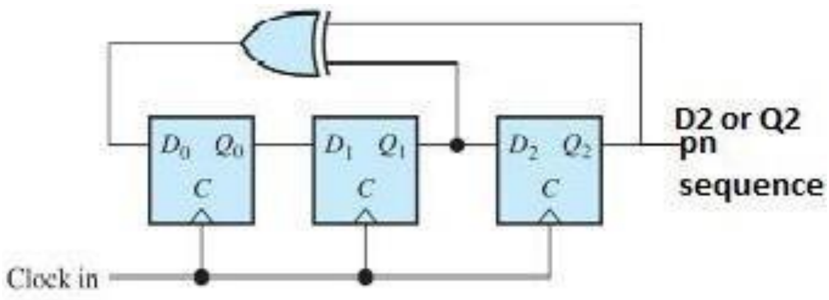


Figure 26.1: PN-Sequence Generator

VII Sample simulation code:

a) PN-sequence Generation using MATLAB

```
clear
clc
G=63;  % Code length
%Generation of first m-sequence using generator polynomial
[45]sd1 =[0 0 0 0 1];     % Initial state of Shift register
PN1=[];                   % First m-
sequencefor j=1:G
   PN1=[PN1 sd1(5)];
if
      sd1(1)==sd
      1(4)
      temp1=0;
else temp1=1;
end
sd1(1)=sd1(2)
;
sd1(2)=sd1(3);
sd1(3)=sd1(4);
sd1(4)=sd1(5);
sd1(5)=temp1
;end
subplot(3,1,1)
stem(PN1)
title('M-sequence generated by generator polynomial [45]')
```

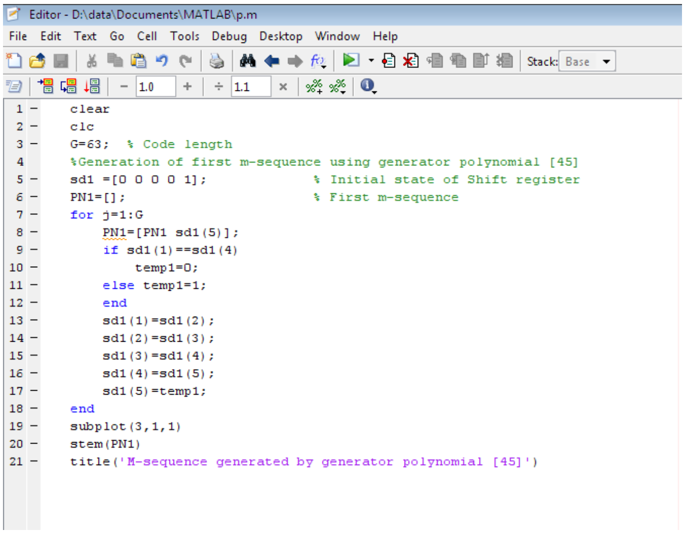


Figure 26.2: Code of PN-Sequence Generator

Output of above code:

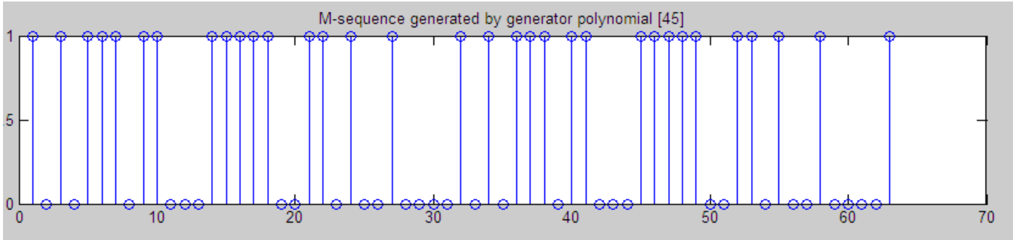


Figure 26.3: Output of PN-Sequence Generator

b) Actual Simulation Code

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1.	Computer	Latest Specifications with highend Processor suitable for simulation software	1
2.	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions

1. Ensure proper earthling to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open MATLAB
2. Go to file and create a new (.m) file.
3. Type the above code in the code window.
4. Save the file.
5. Define the path directory.
6. Run the program using F5 key or run command.
7. Observe the generated PN Sequence in command window.
8. Paste the print out under observations heading.

Waste management:

1. Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			

XII Actual procedure

....
....
....
....
....
....
....
....
....
....

XIII Observations and Calculations Actual PN sequence observed
(Student should paste the PN sequence waveform**)**

XIV Interpretation of results

....
....
....
....

XV Conclusions & Recommendation

....
....
....
....
....

XVI Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Generate PN-sequence of length 15.
2. List the application of PN sequence in digital communication.

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....
....

XX References / Suggestions for further Reading

1. https://www.mathworks.com/help/comm/ref/pnsequencegenerator.html.
2. https://www.youtube.com/watch?v=GrA46JJ0xbU.

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of simulation software	10 %
2	Building of diagram	20 %
3	Measuring values from PC Screen	20 %
4	Working in team	10 %
Product related (10 Marks)		**40%**
5	Correctness of output	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated Signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.27: Generate two channel CDMA-DSSS signal using suitable simulation tool.

I Practical Significance

CDMA technology is known as a spread-spectrum technique which allows many users to occupy the same time and frequency allocations in a given band and space. Individual conversations are encoded with the help of pseudo-random digital sequence. This practical is designed to explain how two different signals can be send using CDMA- DSSS and reconstructed successfully at other end.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

1. CO5- Interpret the concept of various spread spectrum techniques.

IV Laboratory Learning Outcome(s)

1. LLO 27.1 Observe CDMA signal with the spreading sequences for each channel.
2. LLO 27.2 Recover original message signal from modulated signal.

V Relevant Affective domain unrelated Outcome(s)

1. Select proper programming environment
2. Follow ethical practices.

VI Relevant Theoretical Background

CDMA technology is known as a spread-spectrum technique which allows many users to occupy the same time and frequency allocations in a given band and space.
Types of Spread Spectrum Communications: There are two types of spread spectrum communications:

1. Frequency Hopping
2. Direct Sequence

CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency.

Block Diagram

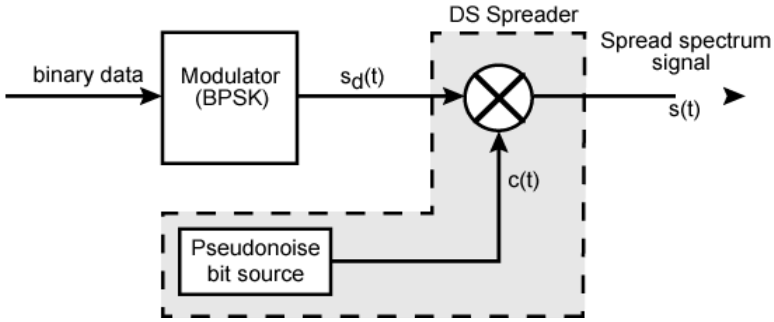


Figure 27.1: CDMA-DSSS Transmitter

*[**Courtesy:**https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt]*

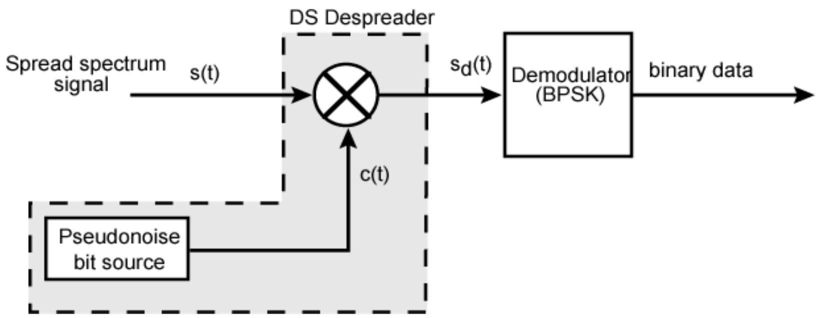


Figure 27.2: CDMA-DSSS Receiver

*[**Courtesy:**https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt]*

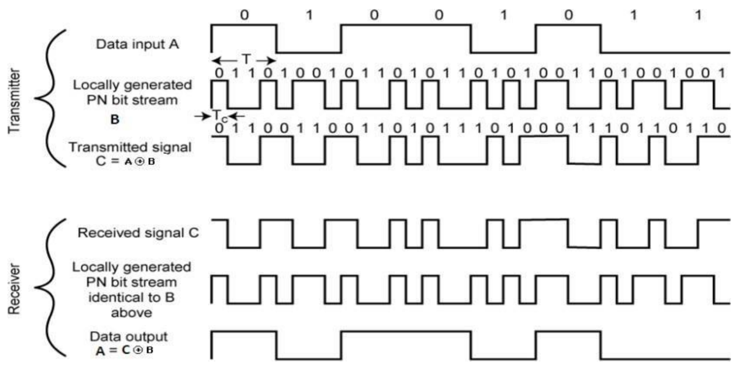


Figure 27.3:CDMA-DSSS waveforms

*[**Courtesy:**https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt]*

VII Simulation code:

a) Sample Simulation code used in laboratory

```
clc;
close all;
clear all;
b=input('Enter The input Bits : ');
ln=length(b);
% Converting bit 0 to -1
for i=1:ln
if b(i)==0
b(i)=-1;
end
end
% Generating the bit sequence with each bit 8 samples long
k=1;
for i=1:ln
for j=1:8
bb(k)=b(i);
j=j+1;
k=k+1;
end
i=i+1;
end
len=length(bb);
subplot(2,1,1);
stairs(bb,'linewidth',2); axis([0 len -2 3]);
title('ORIGINAL BIT SEQUENCE b(t)');
% Generating the pseudo random bit pattern for spreading
pr_sig=round(rand(1,len));
for i=1:len
if pr_sig(i)==0
pr_sig(i)=-1;
end
end
subplot(2,1,2);
stairs(pr_sig,'linewidth',2); axis([0 len -2 3]);
title('PSEUDORANDOM BIT SEQUENCE pr_sig(t)');
% Multiplying bit sequence with Pseudorandom Sequence
for i=1:len
bbs(i)=bb(i).*pr_sig(i);
end
% Modulating the hopped signal
dsss=[];
t=0:1/10:2*pi;
c1=cos(t);
c2=cos(t+pi);
for k=1:len
if bbs(1,k)==-1
dsss=[dsss  c1];
else
```

```
dsss=[dsss c2];
end
end
figure,
subplot(2,1,1);
stairs(bbs,'linewidth',2); axis([0 len -2 3]);
title('MULTIPLIER OUTPUT SEQUENCE b(t)*pr_sig(t)');
subplot(2,1,2);
plot(dsss);
title(' DS-SS SIGNAL...');
```

Simulation Output:

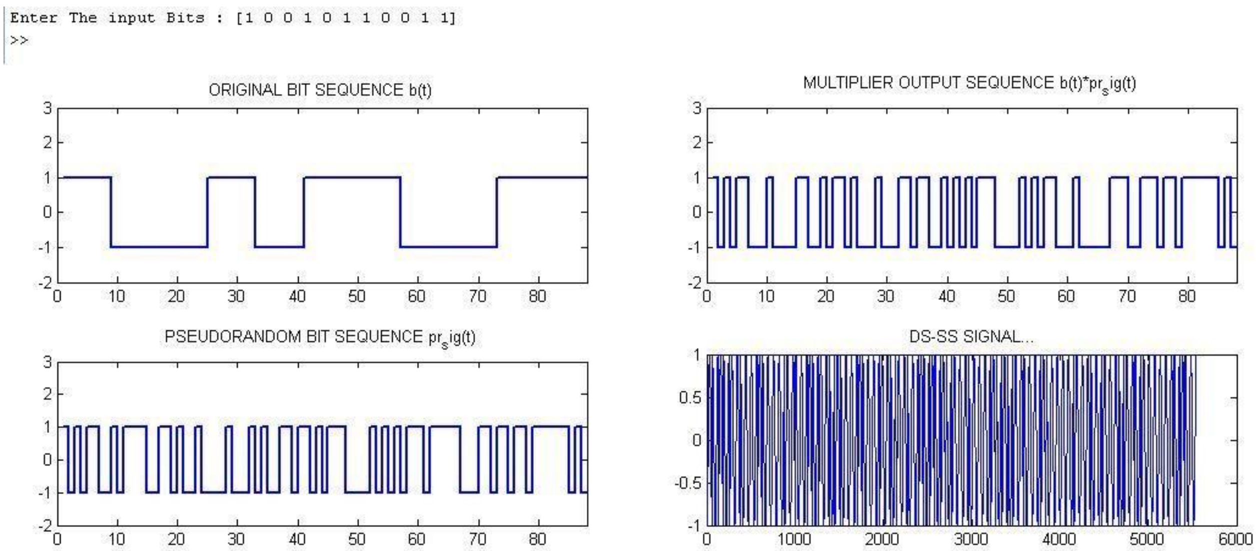


Figure 27.4: DSSS simulation output waveforms

a) Actual Simulation code used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus or any other relevant open source software	1

IX Precautions to be followed

1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open the MATLAB.
2. Go to file and create a new file with extension (.m file)
3. Write the MATLAB code in program window.
4. Save the file.
5. Define path directory.
6. Run the program using function key (F5) or use "RUN" command.
7. Observe the output.

Waste management:

1. Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Name of Resource	Specifications	Quantity
1.			
2.			
3.			

XII Actual Procedure followed

....

....

....

....

....

....

....

....

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Results

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions and Recommendation

....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Use PN-sequence for the Direct Sequence Spread Spectrum (DSSS) signal to trace the DSSS signal corresponding to 2 different bit patterns and the same PN - Sequence used as the modulator
2. Observe the DSSS signal corresponding to 2 different bit patterns for clock frequency 120KHz

[Space for Answers]

XVIII References / Suggestions for further Reading

1. https://www.elprocus.com/cdma-technology-working-applications/
2. https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt
3. www.ccs.neu.edu/home/rraj/Courses/G250/S05/Lectures/SpreadSpectrum.ppt

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of simulation software	10 %
2	Building of diagram	20 %
3	Measuring values from PC screen	20 %
4	Working in teams	10 %
Product related (10 Marks)		**40%**
5	Correctness of output	10 %
6	Interpretation of result	05 %
7	Conclusion	05 %
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.28: Generate two channel CDMA-FHSS signal using suitable simulation tool.

I Practical Significance

Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many channels, using pseudorandom sequence known to both transmitter and receiver. It also used in Bluetooth wireless data transfer. Thispractical is designed to explain how generated FHSS signal is used in many space systems and avionics systems for multiple access communications, protection against jamming and interference and various Communication, Command and Control applications.

II Industry/Employer Expected Outcome(s)

The aim of this course is to attend following industry/employer expected outcome through various teaching learning experiences:

- **Use basic concept of digital communication in various applications.**

III Course Level Learning Outcome(s)

- CO5- Interpret the concept of various spread spectrum techniques.

IV Laboratory Learning Outcome(s)

- LLO 28.1 Modulate the data using spreading sequences for each channel.
- LLO 28.2 Recover original message signal from modulated signal.

V Relevant Affective domain unrelated Outcome(s)

- Follow safe practices.
- Handle instruments carefully.
- Follow ethical practices.

VI Relevant Theoretical Background

Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many channels using pseudorandom sequence known to both transmitter and receiver. It is used as a multiple access method in the code division multiple access (CDMA) scheme frequency-hopping code division multiple access (FH-CDMA). Each available frequency band is divided into sub-frequencies.Signals rapidly change ("hop") among these in a predetermined order.

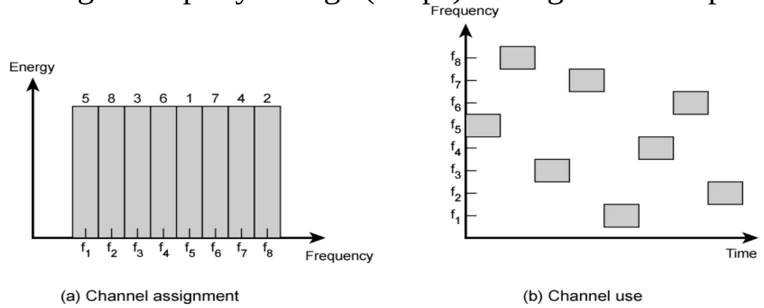


Figure 28.1: CDMA-FHSS concept

[Courtesy:https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt]

Block diagram

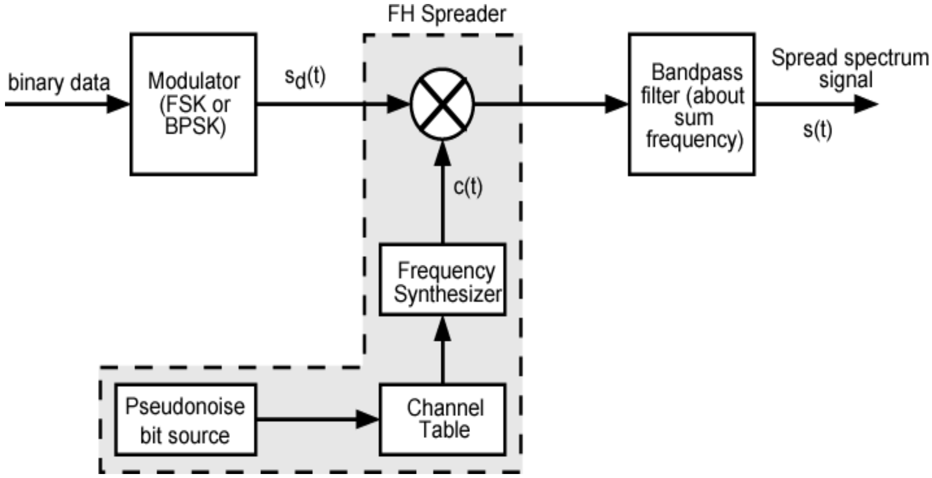


Figure 28.2: CDMA-FHSS Transmitter

[Courtesy:https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt]

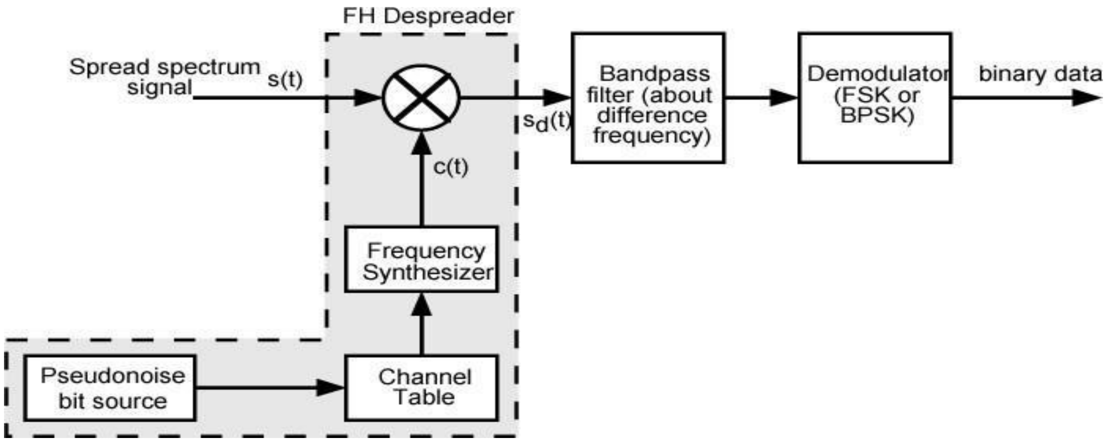


Figure 28.3: CDMA-FHSS Receiver

[*Courtesy:https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt*]

VII Simulation Code:

a) Sample Simulation code used in laboratory

```
clc
clear

% Generation of Sample bits
sequence=round(rand(1,20));     % Generating 20 bits
input_signal=[];               % input signal declaration
carrier_signal=[];             % carrier signal declaration
time=[0:2*pi/119:2*pi];         % Number of samples - Creating a vector of 120 total
values including end point [0:0.052:6.28]
```

```
for k = 1 :20
if sequence(1,k)==0
sig=-ones(1,120);   % -1 value for binary input 0
else
sig=ones(1,120);    % +1 value for binary input 1
end
c=cos(time);            % Carrier frequency is calculated.
carrier_signal = [carrier_signal c];  %signal that is generated which will transmitted
with input signal
input_signal = [input_signal sig];    %Original signal to be transmitted
end

figure(1)
subplot(4,1,1);
plot(input_signal);    % Plotting input signal
axis([-100 2400 -1.5 1.5]);
title('\bf\it Original 20 bit Sequence');

% BPSK Modulation of the signal
bpsk_mod_signal=input_signal.*carrier_signal;  % Modulating the signal
subplot(4,1,2);
plot(bpsk_mod_signal);  %Plotting BPSK Modulated signal
axis([-100 2400 -1.5 1.5]);
title('\bf\it BPSK Modulated Signal');

% Preparation of 6 new carrier frequencies
%6 frequencies are randomly selected by the PN sequence generator
time1=[0:2*pi/9:2*pi];  %[0:0.698:6.28]
time2=[0:2*pi/19:2*pi]; %[0:0.331:6.28]
time3=[0:2*pi/29:2*pi]; %[0:0.217:6.28]
time4=[0:2*pi/39:2*pi]; %[0:0.161:6.28]
time5=[0:2*pi/59:2*pi]; %[0:0.106:6.28]
time6=[0:2*pi/119:2*pi];%[0:0.052:6.28]
carrier1=cos(time1);
carrier1=[carrier1 carrier1 carrier1 carrier1 carrier1 carrier1 carrier1 carrier1 carrier1
carrier1 carrier1 carrier1];
carrier2=cos(time2);
carrier2=[carrier2 carrier2 carrier2 carrier2 carrier2 carrier2];
carrier3=cos(time3);
carrier3=[carrier3 carrier3 carrier3 carrier3];
carrier4=cos(time4);
carrier4=[carrier4 carrier4 carrier4];
carrier5=cos(time5);
carrier5=[carrier5 carrier5];
carrier6=cos(time6);

% Random frequency hopps to form a spread signal
spread_signal=[];
for n=1:20
c=randi([1 6],1,1);    %6 frequencies are randomly are selected by the PN generator
```

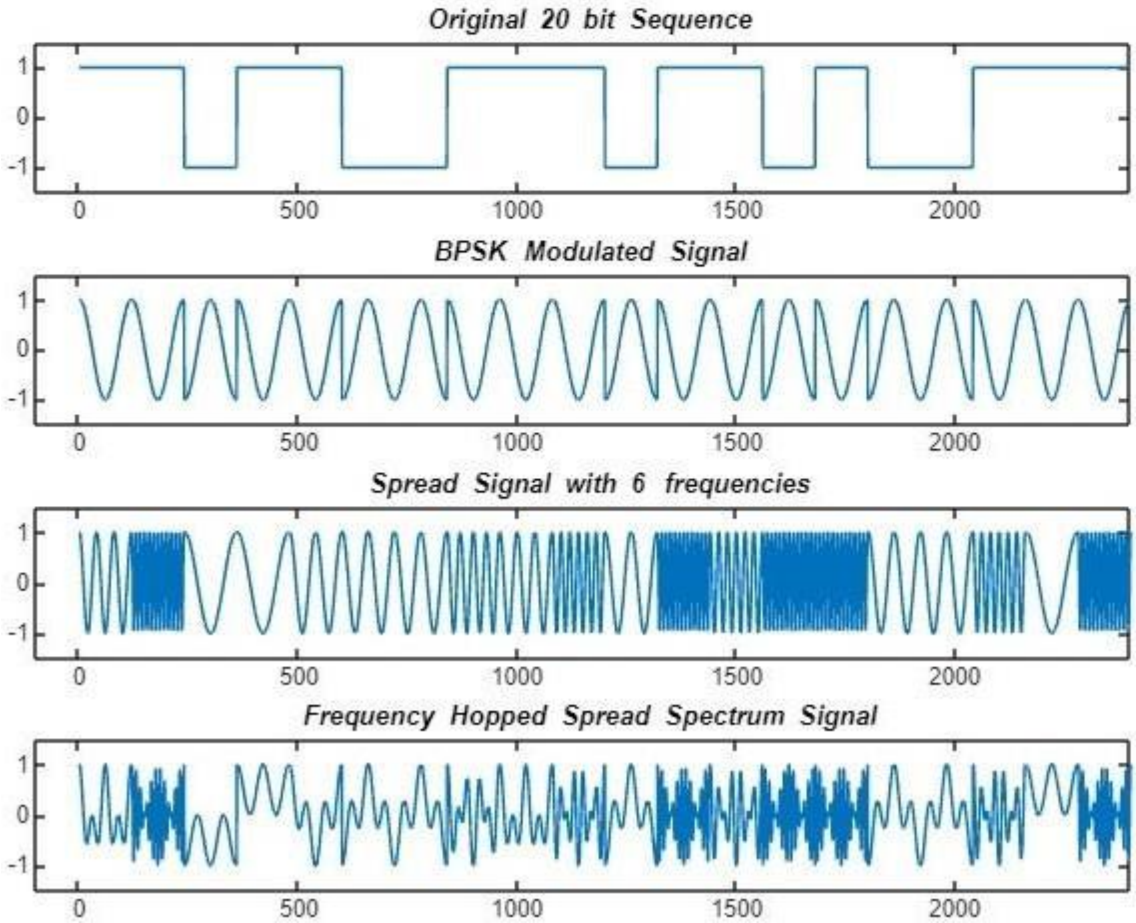
```
          switch(c)
     case(1)
     spread_signal=[spread_signal carrier1];
     case(2)
     spread_signal=[spread_signal carrier2];
     case(3)
     spread_signal=[spread_signal carrier3];
     case(4)
     spread_signal=[spread_signal carrier4];
     case(5)
     spread_signal=[spread_signal carrier5];
     case(6)
     spread_signal=[spread_signal carrier6];
          end
          end
          subplot(4,1,3)
          plot([1:2400],spread_signal);
          axis([-100 2400 -1.5 1.5]);
          title('\bf\it Spread Signal with 6 frequencies');

          % Spreading BPSK Signal
          freq_hopped_sig=bpsk_mod_signal.*spread_signal;     %This is the signal which is
          being finallay transmitted
          subplot(4,1,4)
          plot([1:2400],freq_hopped_sig);
          axis([-100 2400 -1.5 1.5]);
          title('\bf\it Frequency Hopped Spread Spectrum Signal');

          % Demodulation of BPSK Signal
          bpsk_demodulated=freq_hopped_sig./spread_signal;        %The received signal is
          FFH demodualted
          figure(2)
          subplot(2,1,1)
          plot([1:2400],bpsk_demodulated);
          axis([-100 2400 -1.5 1.5]);
          title('\bf Demodulated BPSK Signal from Wide Spread');

          original_BPSK_signal=bpsk_demodulated./carrier_signal;      %FFH demodulated
          signal is data demodulated by means of BPSK Signal
          subplot(2,1,2)
          plot([1:2400],original_BPSK_signal);
          axis([-100 2400 -1.5 1.5]);
          title('\bf Transmitted Original Bit Sequence');
```

Simulation Output



b) Actual Simulation code used in laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No.	Instruments /Components	Specifications	Quantity
1	Computer	Suitable specifications as per requirement of simulation software with Latest Processor	1
2	Simulation Software	Lab view/ MATLAB /SCILAB/P Spice /HS Spice / Multisim/ Proteus other relevant open source soft	1

IX Precautions to be followed

1. Ensure proper earthing to the computer system.
2. Ensure compatibility of computer system with software.
3. Ensure proper installation of simulation software.

X Procedure

1. Open the MATLAB.
2. Go to file and create a new file with extension (.m file)
3. Write the MATLAB code in program window.
4. Save the file.
5. Define path directory.
6. Run the program using function key (F5) or use "RUN" command.
7. Observe the output.

Waste management:

1. Shut down the PC and switch off the supply to save energy.

XI Resources used

Sr. No.	Instruments /Components	Specifications	Quantity
1.			
2.			
3.			

XII Actual Procedure followed

....
....
....
....
....
....
....
....
....

XIII Observations

Actual simulation output observed (Student should paste the simulation output)

XIV Results

....
....
....
....

XV Interpretation of results

....
....
....
....

XVI Conclusions and Recommendation

....
....
....
....

XVII Practical related Questions

Note: Below few sample questions are given for the reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Use PN-Sequence to measure the frequency of the FHSS Modulator for the Frequency Hopped Spread Spectrum (FHSS) signal and the same PN -Sequence used as the modulator
2. Observe the FHSS signal corresponding to 2 different bit patterns for clock frequency 60KHz

[Space for Answers]

....
....
....
....
....
....
....
....
....
....
....
....

XVIII References / Suggestions for further Reading

1. https://www.elprocus.com/cdma-technology-working-applications/
2. https://www2.rivier.edu/faculty/vriabov/CS553_ST7_Ch09-SpreadSpectrum.ppt
3. www.ccs.neu.edu/home/rraj/Courses/G250/S05/Lectures/SpreadSpectrum.ppt

XIX Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of simulation software	10 %
2	Building of diagram	20 %
3	Measuring values from PC screen	20 %
4	Working in teams	10 %
Product related (10 Marks)		**40%**
5	Correctness of output	10 %
6	Interpretation of result	05 %
7	Conclusion	05 %
8	Practical related questions	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related(10)**	**Total(25)**	