Department of Electronics & Communication Engineering

LAB MANUAL

SUBJECT: DIGITAL COMMUNICATION [06BEC201]

B.Tech III Year – VI Semester

(Branch: ECE)

BHAGWANT UNIVERSITY

SIKAR ROAD, AJMER

DIGITAL COMMUNICATION LABORATORY
OBJECTIVES:
The purpose of this lab is to explore digital communications with a software radio to understand how each component works together. The lab will cover, analog to digital conversion, modulation, pulse shaping, and noise analysis.
LIST OF EXPERIMENTS

OBJECTIVES:
The purpose of this lab is to explore digital communications with a software radio to understand how each component works together. The lab will cover, analog to digital conversion, modulation, pulse shaping, and noise analysis

1. Signal Sampling and reconstruction
2. Amplitude modulation and demodulation
3. Frequency modulation and demodulation
4. Pulse code modulation and demodulation.
5. a) Delta modulation
   b) Adaptive delta Modulation
6. BFSK modulation and Demodulation
7. BPSK modulation and Demodulation
8. TDM and FDM
9. Line Coding Schemes
10. FSK, PSK and DPSK schemes (Simulation)
Aim:

To study the different types of signal sampling and its reconstruction.

Apparatus Required:

1. Sampling and its reconstruction Kit - DCL 01
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram for natural sampling
2. Connect the power supply in proper polarity to the kit and & switch it on.
3. Using the clock selector switch select 8 KHz sampling frequency and using switch SW2 select 50% duty cycle.
4. The input and output waveforms are measured using DSO.
5. The procedure above is repeated for sample & hold and flat top sampling.

Tabular Column:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (S)</th>
<th>FREQ(HZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/P Signal</td>
<td></td>
<td></td>
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<tr>
<td>Clock Signal</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>O/P</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>a) Natural Sampling</td>
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<td></td>
<td></td>
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<tr>
<td>b) Sample hold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Flat top sampling</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Fig. 1.1 Block Diagram for Natural Sampling

Fig. 1.2 Block Diagram for Sample and Hold

Fig. 1.3 Block Diagram for Flat Top Sampling
Result:

Comparing the reconstructed output of 2\textsuperscript{nd} order Low Pass Butterworth filter for all three types of sampling, it is observed that the output of the sample and hold is the better when compared to the outputs of natural sampling and the flat top sampling.
Aim:

To study an amplitude modulation & demodulation circuit and to calculate modulation index of AM.

Apparatus Required:

1. AM transmitter and receiver kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Set the modulating signal frequency at 1KHz and carrier signal frequency at 500Khz
3. Vary the amplitude of the modulating signal and check for the three following conditions
   a. Modulation index (m) lesser than 1
   b. Modulation index (m) equal to 1
   c. Modulation index (m) greater than 1
Block Diagram

Fig. 2.1 Block Diagram for AM Modulation and Demodulation

MODEL GRAPH

Fig 2.1 Model Graph for AM Modulation and demodulation.
### Result:

Amplitude Modulation and Demodulation are verified in the hardware kit and its waveforms are analyzed for different modulation index.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Am</th>
<th>Ac</th>
<th>Emax</th>
<th>Emin</th>
<th>%M</th>
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</tbody>
</table>
Aim:

To study frequency modulation & demodulation and to calculate modulation index of FM.

Apparatus Required:

1. FM transmitter and receiver kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Set the modulating signal frequency at 1KHz and carrier signal frequency at 500Khz
3. Vary the frequency of the modulating signal and check for the three following conditions
   a. Modulation index (m) lesser than 1
   b. Modulation index (m) equal to 1
   c. Modulation index (m) greater than 1

Tabulation:

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Am</th>
<th>T_L</th>
<th>T_H</th>
<th>F_L</th>
<th>F_H</th>
<th>Freq.Deviation</th>
<th>%M</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
**Block Diagram**

![Block Diagram](image1)

Fig 3.1 Block diagram for FM modulation and demodulation

**Model Graph**

![Model Graph](image2)

Fig 3.2 Model Graph for FM modulation and demodulation

**Result:**

Frequency Modulation and Demodulation are verified in the hardware kit and its waveforms are analyzed for different modulation index.
Aim: To construct and study a PCM transmitter and receiver kit

Apparatus Required:

1. PCM Transmitter and Receiver Kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Connect power supply in proper polarity to kits DCL-03 and DCL-04 and switch it on.
3. Set the function generator, clock generator and speed selection switch SW1 to fast mode.
4. Observe the modulated output and demodulated output.
5. Measure the observed output and with the values plot the graph.

Tabular Column:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (s)</th>
<th>FREQUENCY (Hz)</th>
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<tbody>
<tr>
<td>Message Signal_1</td>
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<tr>
<td>Message Signal_2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clock Signal _1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock Signal _2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCM (Modulated Output)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Signal_1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Signal_2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Result:

Pulse Code Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
Aim:
To study the characteristics of delta modulation and demodulation kit.

Apparatus Required:

1. Delta modulation and demodulation Kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Connect power supply in proper polarity to kits DCL-07 and switch it on.
3. Keep the Switch S2 in Delta position.
4. Keep the Switch S4 High.
5. Observe the various tests points in delta demodulator section and observe the reconstructed signal through 2nd order and 4th order filter.

TABULATION

<table>
<thead>
<tr>
<th>Message Signal</th>
<th>Digital Sampler O/P</th>
<th>Integrator -3 O/P</th>
<th>Filter O/P</th>
<th>AMPLITUDE</th>
<th>TIME PERIOD</th>
<th>FREQUENCY</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Message Signal</th>
<th>AMPLITUDE</th>
<th>TIME PERIOD</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Sampler O/P</td>
<td>AMPLITUDE</td>
<td>TIME PERIOD</td>
<td>FREQUENCY</td>
</tr>
<tr>
<td>Integrator -3 O/P</td>
<td>AMPLITUDE</td>
<td>TIME PERIOD</td>
<td>FREQUENCY</td>
</tr>
<tr>
<td>Filter O/P</td>
<td>AMPLITUDE</td>
<td>TIME PERIOD</td>
<td>FREQUENCY</td>
</tr>
</tbody>
</table>
**Block Diagram**

![Block Diagram](image)

**RESULT**

Delta Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
Aim:
To study the characteristics of adaptive delta modulation and demodulation kit.

Apparatus Required:

1. Delta modulation and demodulation Kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Connect power supply in proper polarity to kits DCL-07 and switch it on.
3. Keep the Switch S2 in sigma delta position.
4. Keep the Switch S3 High.
5. Observe the various tests points in demodulator section and observe the reconstructed signal through 2\textsuperscript{nd} order and 4\textsuperscript{th} order filter.

Tabulation

<table>
<thead>
<tr>
<th></th>
<th>AMPLITUDE</th>
<th>TIME PERIOD</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Signal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Sampler O/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrator -3 O/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter O/P</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig 5.1b Block diagram for Adaptive delta modulation and demodulation
Adaptive Delta Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
Aim:

To study the characteristics of Binary Frequency Shift keying (BFSK) modulation and demodulation.

Apparatus Required:

1. BFSK Modulation (DCL-05) and demodulation kit (DCL-06)
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

1. The connections are given as per the block diagram.
2. Connect the power supply in proper polarity to the kit and & switch it on.
3. Set the amplitude of the sine wave as desired.
4. Observe the waveforms at the
   a. Clock
   b. SIN 1 & SIN 2
   c. MODULATOR OUTPUT
   d. FSK OUT
   and plot it on graph paper

Tabulation:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (s)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock Signal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Input 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulator Output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Output</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
RESULT

BFSK Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
Aim:
To construct and study the characteristics of BPSK modulation and demodulation.

Apparatus Required:

1. BPSK Modulation and demodulation kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:

5. The connections are given as per the block diagram.
6. Connect the power supply in proper polarity to the kit and & switch it on.
7. Set the amplitude of the sine wave as desired.
8. Observe the waveforms at the
   a. Clock
   b. SIN 1 & SIN 2
   c. MODULATOR OUTPUT
   d. PSK OUT
   and plot it on graph paper

Tabulation:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (s)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock Signal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulator Output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Output</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
RESULT

BPSK Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
Aim:
To study the Time Division Multiplexing (TDM) and draw its waveforms.

Apparatus Required:
1. DCL 02 TDM kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

Procedure:
1. The connections are given as per the block diagram.
2. Connect the power supply in proper polarity to the kit and & switch it on.
3. Set the amplitude of the sine wave as desired.
4. Observe the following waveforms at the
   a. Input Channel
   b. Multiplexer Output (TXD)
   c. Reconstructed Signal (OUT0, OUT1, OUT2, OUT3)
and plot it on graph paper

Tabulation:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (s)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARRIER (CLK)</td>
<td></td>
<td>TON=</td>
<td>TOFF=</td>
</tr>
<tr>
<td>MODULATING1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULATING2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULATING3</td>
<td></td>
<td></td>
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<tr>
<td>MODULATING4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULATED</td>
<td>V1=</td>
<td>T1=</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V2=</td>
<td>T2=</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V3=</td>
<td>T3=</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V4=</td>
<td>T4=</td>
<td></td>
</tr>
<tr>
<td>DEMODULATED</td>
<td>V1=</td>
<td>T1=</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V2=</td>
<td>T2=</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V3=</td>
<td>T3=</td>
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</tr>
<tr>
<td></td>
<td>V4=</td>
<td>T4=</td>
<td></td>
</tr>
</tbody>
</table>
RESULT

TDM Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
**Aim:**
To study the Frequency Division Multiplexing (FDM) and draw its waveforms.

**Apparatus Required:**
1. ACL 06 FDM kit
2. Digital Storage Oscilloscope (DSO)
3. Power supply
4. Patch cords

**Procedure:**
1. The connections are given as per the block diagram.
2. Connect the power supply in proper polarity to the kit and switch it on.
3. Observe the following waveforms at the
   a. Input Channel
   b. Multiplexer Output (TXD)
   c. Reconstructed Signal (OUT0, OUT1, OUT2, OUT3)
and plot it on graph paper

**Block Diagram:**

Fig 8.1b Block diagram for Frequency Division Multiplexing
**Tabular Column:**

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>AMPLITUDE (V)</th>
<th>TIME PERIOD (s)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulated Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Output 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demodulated Output 2</td>
<td></td>
<td></td>
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</tbody>
</table>

**Model graph**

**RESULT**

FDM Modulation and Demodulation are verified in the hardware kit and its waveforms are studied.
AIM:
To perform data coding and decoding techniques for phase encoded format.

APPARATUS REQUIRED
1. Experiment kits DCL-05 & DCL-06
2. Patch cords
3. Power supply

DIAGRAM:
THEORY

This phase – encoded – group consists of

a) Biphase – level
b) Biphase – mark
c) Biphase – Space

With the Biphase – L ‘one’ is represented by a half bit wide pulse partitioned during the first half the bit interval and a ‘zero’ is represent by a half bit white pulse partitioned during the second half of the bit interval.

PROCEDURE

1. Connections are given as per the circuit diagram

2. Connect CLOCK and data generated on DCL-05 to coding CLOCK IN and data input respectively by means of patch cords.

3. Connect the coded data NRZ – L on DCL-05 to corresponding DATA INPUT NRZ–L of the decoding logic on DCL-06

4. Keep the switches SW2 for NRZ-L to ON position

5. Observe the coded and decoded signal on the oscilloscope, Observe the waveform

TABULATION:

<table>
<thead>
<tr>
<th>SIGNALS</th>
<th>AMPLITUDE (V)</th>
<th>TIME (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MODEL GRAPH:

RESULT:

The data coding and decoding techniques for phase encoded format are studied.
AIM
To write a program to perform ASK, FSK & PSK using MATLAB and to obtain its output waveforms.

APPARATUS REQUIRED
Personal computer, MATLAB R2012a

PROCEDURE
1. Click start, select All programs, select MATLAB R2012a
2. Click file, select new M-file
3. Type the program
4. Save it with extension.m
5. Click RUN to obtain the output waveform

PROGRAM
ASK
clc % for clearing the command window
close all % for closing all the window except command window
clear all % for deleting all the variables from the memory
fc1=input('Enter the freq of 1st Sine Wave carrier:');
fcl=amp; % for periodic
fc2=input('Enter the freq of 2nd Sine Wave carrier:');
fp=amp; % for periodic
amp=amp/2;
t=0:0.001:1;
c1=amp.*sin(2*pi*fc1*t);
c2=amp.*sin(2*pi*fc2*t);
plot(t,c1)
xlabel('Time')
ylabel('Amplitude')
title('Carrier 1 Wave')
plot(t,c1)
subplot(5,1,2)
plot(t,c2)
xlabel('Time')
ylabel('Amplitude')
title('Carrier 2 Wave')
m=amp.*square(2*pi*fp*t)+amp;
subplot(5,1,3)
plot(t,m)
xlabel('Time')
ylabel('Amplitude')
title('Binary Message Pulses')
for i=0:1000
    if m(i+1)==0
        mm(i+1)=c2(i+1);
    else
        mm(i+1)=c1(i+1);
    end
end
subplot(5,1,4)
plot(t,mm)
xlabel('Time')
ylabel('Amplitude')
title('Modulated Wave')
for i=0:1000
    if mm(i+1)==c2(i+1)
        dm(i+1)=m(i+1);
    else
        dm(i+1)=m(i+1);
    end
end
subplot(5,1,5)
plot(t,dm)
xlabel('Time')
ylabel('Amplitude')
title('Demodulated signal')
Fig 10.1 Matlab Simulation of ASK

FSK

clc %for clearing the command window
close all %for closing all the window except command
window clear all %for deleting all the variables from the
memory fc1=input('Enter the freq of 1st Sine Wave carrier:');
f2=fc2=input('Enter the freq of 2nd Sine Wave carrier:');
fp=input('Enter the freq of Periodic Binary pulse (Message):');
amp=input('Enter the amplitude (For Both Carrier & Binary Pulse Message):'); amp=amp/2;
t=0:0.001:1;
c1=amp.*sin(2*pi*fc1*t);
c2=amp.*sin(2*pi*fc2*t);
subplot(5,1,1);
plot(t,c1)
xlabel('Time')
ylabel('Amplitude')
title('Carrier 1 Wave')
subplot(5,1,2)
plot(t,c2)
xlabel('Time')
ylabel('Amplitude')
title('Carrier 2 Wave')
m=amp.*square(2*pi*fp*t)+amp;
subplot(5,1,3)
plot(t,m)
xlabel('Time')
ylabel('Amplitude')
title('Binary Message Pulses')
for i=0:1000
    if m(i+1)==0
        mm(i+1)=c2(i+1);
    else
        mm(i+1)=c1(i+1);
    end
end
subplot(5,1,4)
plot(t,mm)
xlabel('Time')
ylabel('Amplitude')
title('Modulated Wave')
for i=0:1000
    if mm(i+1)==c2(i+1)
        dm(i+1)=m(i+1);
    else
        dm(i+1)=m(i+1);
    end
end
subplot(5,1,5)
plot(t,dm)
xlabel('Time')
ylabel('Amplitude')
title('Demodulated signal')
**PSK**
clear all;
cle;
close all;
set(0,'defaultlinelinewidth',2);
A=5;
t=0:.001:1;
f1=input('Carrier Sine wave frequency ='); f2=input('Message frequency =');
x=A.*sin(2*pi*f1*t);%Carrier Sine
subplot(4,1,1);%Carrier Sine
plot(t,x);
xlabel('time');
ylabel('Amplitude');
title('Carrier');
grid on;
u=square(2*pi*f2*t); % Message signal
subplot(4,1,2);
plot(t,u);
xlabel('time');
ylabel('Amplitude');
title('Message Signal');
grid on;
v=x.*u; % Sine wave multiplied with square wave
subplot(4,1,3);
plot(t,v);
xlabel('t');
ylabel('y');
title('PSK');
grid on;
d=v./x; % Sine wave multiplied with square wave
subplot(4,1,4);
plot(t,d);
xlabel('t');
ylabel('y');
title('Demodulated PSK');
grid on;
RESULT

Thus the program for performing frequency shift keying using MATLAB was performed.