VISVESVARAYA TECHNOLOGICAL UNIVERSITY,
JnanaSangama, Belagavi – 590018

KLS,

VISHWNATHRAO DESHPANDE INSTITUTE OF TECHNOLOGY,
Haliyal – 581329, Uttara Kannada

LABORATORY MANUAL

Course Title	:	**Digital CommunicationLab**
Course Code	:	**BECL504**
Year / Semester	:	**3rd Year/5thSemester**
Academic Year	:	**2025-26**
Course In-Charge	:	**Prof. Nikhil K.** **Prof. Rajeshwari P.**

Department of Electronics and Communication Engineering

21.07.2025

Signature of the Faculty with Date

21.07.2025

HoD

Head of the Department
Dept. of Electronic & Communication Engg.
KLS V.D.I.T. HALIYAL (U.K.)

College Vision and Mission Statements

Vision

To nurture talent & enrich society through excellence in technical education, research & innovation.

Mission

1. To augment innovative pedagogy & kindle quest for interdisciplinary learning & to enhance conceptual understanding.
2. To build competence, professional ethics & develop entrepreneurial thinking.
3. To strengthen industry institute partnership &explore global collaborations.
4. To inculcate culture of socially responsible citizenship.
5. To focus on holistic &sustainable development.

Department Vision, Mission,PEOs and PSOs Statements

Vision

To bring out talented, skilled, and sustainable Electronics and Communication Engineering Graduates through strong domain expertise to serve the Society with greater Professional Ethics.

Mission

1. To create and impart an active learning ambience to accomplish a high degree of Professional competencies
2. To inculcate innovative research and developmental thinking in effective Teaching and Learning processes for solving Societal challenges
3. To deliver the needs and requirements of the latest state of art of the Industry through quality multidisciplinary internship and training programs

PEOs

PEO 1:	To be successful in professional career in electronics, communication and allied industries by acquiring the knowledge in the fundamentals of Electronics and Communication Engineering principles and professional skills.
PEO 2:	To be in a position to analyze real life problems and design socially accepted and economically feasible solutions in the respective fields.
PEO 3:	To exhibit good communication skills in their professional career, lead a team with good leadership traits and good interpersonal relationship with the members related to other engineering streams.
PEO 4:	To involve themselves in lifelong learning and professional development by pursuing higher education and participation in research and development activities.
PEO 5:	To demonstrate professional and ethical responsibilities towards their profession, society and the environment.

PSOs

PSO 1:	An ability to use appropriate modern techniques for analysis, design and development of VLSI and Embedded Systems.

PSO 2: **Understand the architectural specifications of a communication system and determine their performance.**

KLS Vishwanathrao Deshpande Institute of Technology

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Title	:	Digital Communication Lab
Course Code	:	BECL504
Year / Semester	:	3^{rd} / 5^{th} Semester
Academic Year	:	2025-26

Syllabus :

Expt. No.	Content	Page No.
	Implement the Expt 1 to Expt 4 using discrete components.	
1	Generation and demodulation of the Amplitude Shift Keying signal.	01
2	Generation and demodulation of the Phase Shift Keying signal.	04
3	Generation and demodulation of the Frequency Shift Keying signal.	07
4	Generation of DPSK signal and detection of data using DPSK transmitter and receiver.	10
	Expt 5 to Expt 12 Simulation Experiments (Use MOKU: GO / MATLAB / Scilab /Lab VIEW or any other suitable software)	
5	Gram-Schmidt Orthogonalization: To find orthogonal basis vectors for the given set of vectors and plot the orthonormal vectors.	13
6	Simulation of binary baseband signals using a rectangular pulse and estimate the BER for AWGN channel using matched filter receiver.	15
7	Perform the QPSK Modulation and demodulation. Display the signal and its constellation.	17
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9	Encoding and Decoding of Huffman code.	23
10	Encoding and Decoding of binary data using a Hamming code.	25
11	For a given data, use CRC-CCITT polynomial to obtain the CRC code. Verify for the cases, a) Without error) With error	28
12	Encoding and Decoding of Convolution code	30
13	To Generation and Detection of the Amplitude Shift Keying signal using Virtual lab Link: https://kcgcollege.ac.in/Virtual-Lab/Electronics-and-Communication-Engineering/Exp-3/index.html	32

CLOs	:	• Design of basic digital modulation techniques using electronic hardware. • Simulation of vector computations and derive the orthonormal basis set using Gram Schmidt procedure. • Simulate the digital transmission and reception in AWGN channel • Simulate the digital modulations using software and display the signals and its vector representations. • Implement the source coding algorithms using a suitable software platform. • Simulate the channel coding techniques and perform decoding for error detection and correction
COs	:	**CO1:** Design the basic digital modulation and demodulation circuits for different engineering applications. **CO2:** Design of optimum communication receivers for AWGN channels. **CO3:** Illustration of different digital modulations using the signals and its equivalent vector representations. **CO4:** Implement the source coding and channel coding procedures using suitable software.
CO / PO Mapping	:	**COs:** **CO1** – 1,2,3,12,PSO2; **CO2** – 1,2,3,12,PSO2; **CO3** – 1,2,5,12,PSO2; **CO4** – 1,2,5,12,PSO2 (**POs / PSOs**)
Course Incharge	:	**Prof. Nikhil K** **Prof. Rajeshwari P**

CO-PO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	1									1		2
2	2	2	1									1		2
3	2	2			2							1		2
4	2	2			2							1		2

EXPERIMENT: 01
To Generation and demodulation of the Amplitude Shift Keying signal.

Objectives: i) To study Generation of ASK Signal
ii) To study Demodulation of ASK Signal

Equipments and Components Required:

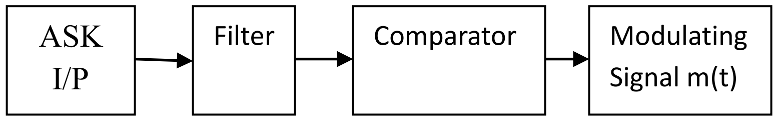
SL.NO	COMPONENTS	QUANTITY
1	Op-amp LM324	01
2	IC 4051	01
3	Resistor (Pot) 100KΩ	02
4	Capacitor 0.1µf	02
5	Diode 1N4001	01
6	CRO	01
7	Signal Generator	02
8	Power supply	01
9	Bread board	01

Theory:

Amplitude Shift Keying (ASK) is a digital modulation scheme where the binary data is transmitted using a carrier signal with two different amplitude levels. For binary 0 and 1, the carrier switches between these two levels. In its simplest form, a carrier is sent during one input
and no carrier is sent during the other. This kind of modulation scheme is called on-off keying. A simple ASK modulator circuit is shown in figure. Here a sinusoidal high frequency carrier signal is sent for logic '0' (-5V) and no carrier is sent for logic '1' (+5V). The transistor works as a switch closes when the input (base) voltage is +5V (logic '1') and shorts the output. When the input voltage is -5V (logic '0'), the switch opens and the carrier signal is directly connected to the output.

The demodulator circuit consists of an envelope detector and a comparator. The diode D selects the positive half cycle of the ASK input. The envelop detector formed by 2.2K resistor and 0.01uF capacitor detects the data out of the ASK input. The Op Amp comparator and the zener diode amplitude limiter convert this detected signal to its original logic levels. The 10K potentiometer may be varied to set suitable reference voltage for the comparator.

Block Diagram of Binary amplitude shift keying demodulation



Circuit diagram:

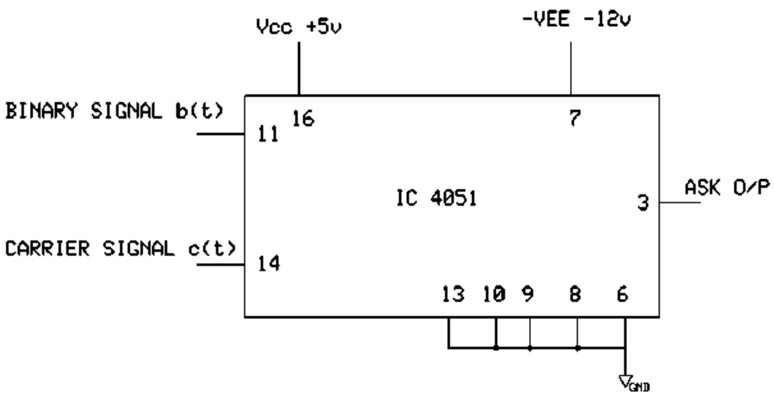
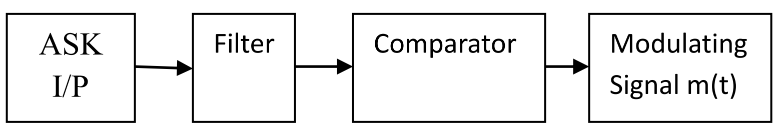


Figure1: ASK Generation

Block Diagram of Binary amplitude shift keying demodulation



Demodulation Circuit

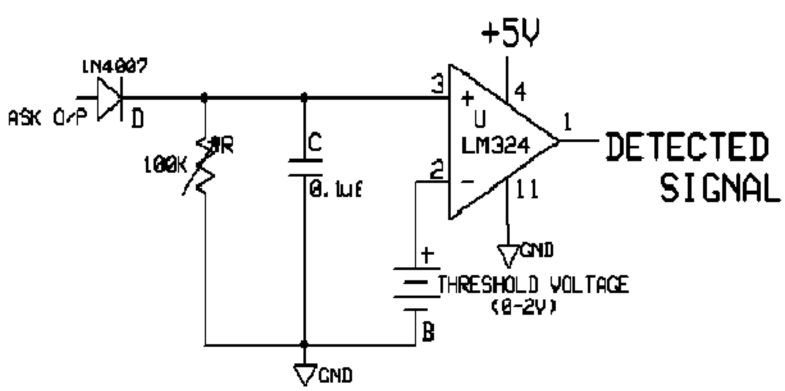
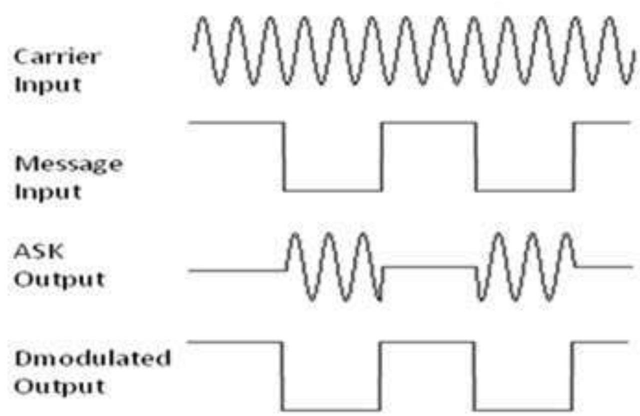


Figure2: ASK Demodulator

Procedure:

1. Test all the components, bread board and probes.
2. Set up the circuits as shown in figure on the bread board.
3. Feed 10Vpp, 500Hz square wave as the message/data input and 2Vpp, 5KHz sine wave as the carrier input.
4. Observe both the message input and ASK output simultaneously on CRO and plot.
5. Apply the ASK output of the modulator to the demodulator input.
6. Observe both the ASK input and the demodulated output simultaneously on CRO. Adjust the reference voltage of the comparator if needed.
7. Plot the waveforms.

Waveforms:



Observation:

Message signal:

1. Message signal Frequency Fm= **..............**Hz.

2. Message signal Amplitude Vm= **..............**volts.

Carrier 1:

1. Carries signal Frequency Fc= **..............**KHz.

2. Carrier signal Amplitude Vc= **..............**volts.

Conclusion: ASK modulator and demodulator circuits were set up and the waveforms were plotted

EXPERIMENT: 02
To study Phase shift keying generation and detection.

Objectives: To study i) PSK modulated waveforms and observe the phase shift for bit 1 and bit 0 ii) To observe PSK demodulated waveforms and measure modulating signal frequency

Equipments and Components Required:

SL.NO	COMPONENTS	QUANTITY
1	Op-amp LM324	1
2	IC 4051	1
3	Resistor (Pot) 100KΩ	2
4	Capacitor 0.1µf	1
5	Diode 1N4001	1
6	CRO	1
7	Signal Generator	2
8	Power supply	1
9	Bread board	1

Theory:

Phase Shift Keying is a digital modulation Technique. A sinusoidal carrier of a fixed amplitude and frequency is taken. The digital data of 1's and 0's is represented by $s(t) = Accos(2\pi fct)$ and $s(t) = [(2\pi fct + \pi)]$ respectively. If incoming bit is 0, the output is same as the carrier; if it is zero, the output is 180^0 phase shifted version of the carrier signal. For demodulation the PSK signal is converted to ASK signal using OPAMP circuit and then ASK signal is demodulated using an envelope detector and comparator.

Circuit Diagram:

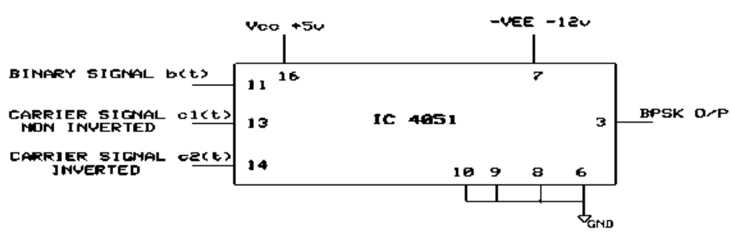
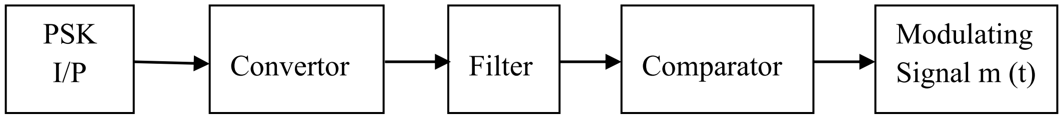


Figure3: PSK generation

Block diagram of Binary phase shift keying Demodulation



Demodulation Circuit

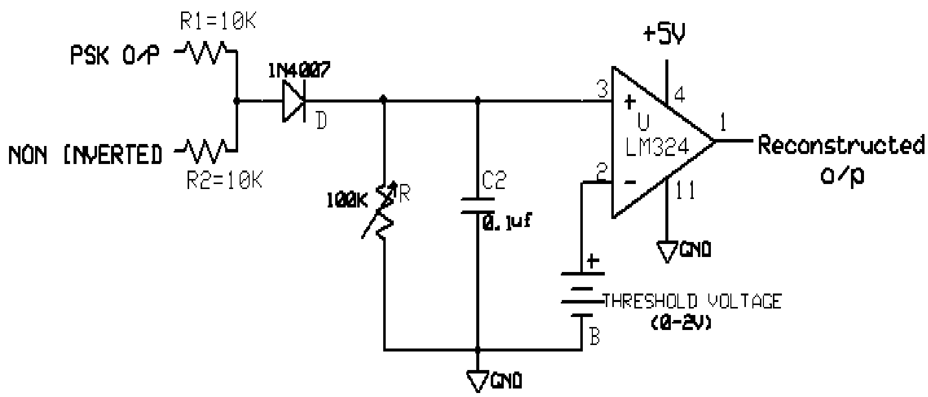


Figure4: PSK Detection

Procedure:

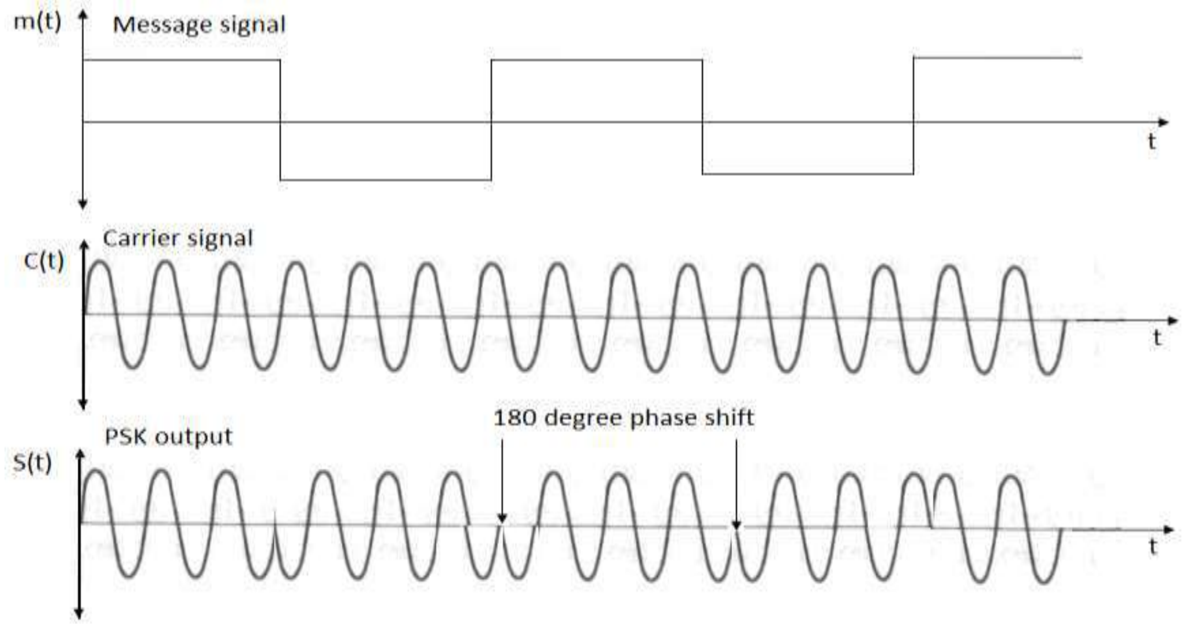
1. Connections are made as per circuit diagram.
2. Set the input voltage to 5V.
3. Set the frequency of the message signal and the two carrier signals of equal frequency and amplitude but one carrier signal is inverted version of other carrier signal.
4. Observe the output PSK modulated waveforms on CRO.
5. For demodulation connections are made as shown in circuit diagram and the detected output signal is observed on CRO.

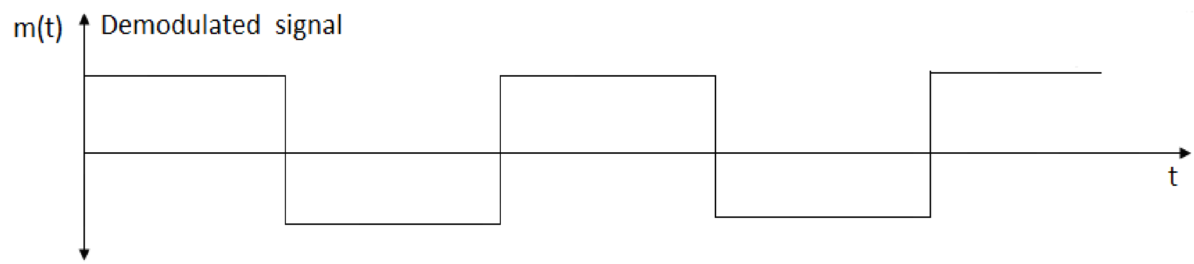
Design:

***Design of Low Pass Filter* (LPF)**

1. Design the LPF for input signal frequency(f_m)
2. Assume C = 0.1µF or 0.01µF or 0.001µF
3. Determine resistor $R = \frac{1}{2\pi fmC}$

Waveforms:





Conclusion: Phase shift keying generation and detection has been verified.

EXPERIMENT: 03
To Generation and demodulation of the Frequency Shift Keying signal.

Objectives: To study i)FSK modulated waveforms and measure f1 and f2
ii) To observe FSK demodulated waveforms and measure modulating signal frequency

Equipments and Components Required:

SL.NO	COMPONENTS	QUANTITY
1	Op-amp LM324	1
2	IC 4051	1
3	Resistor (Pot) 100KΩ	2
4	Capacitor 0.1µf	2
5	Diode 1N4001	1
6	CRO	1
7	Signal Generator	2
8	Power supply	1
9	Bread board	1

Theory:

Frequency Shift Keying is the process of generating a modulated signal from a digital data input. If the incoming bit is 1, a signal with frequency f1 is sent for the duration of the bit Tb. If the bit is 0, a signal with frequency f2 is sent for the duration of this bit. This is the basic principle behind FSK modulation.
A FSK modulated waveforms is represented by

$$s(t) = \begin{cases} A\cos(2\pi f1t) & \text{for symbol '1'} \\ A\cos(2\pi f2t) & \text{for symbol '0'} \end{cases}$$

Circuit Diagram:

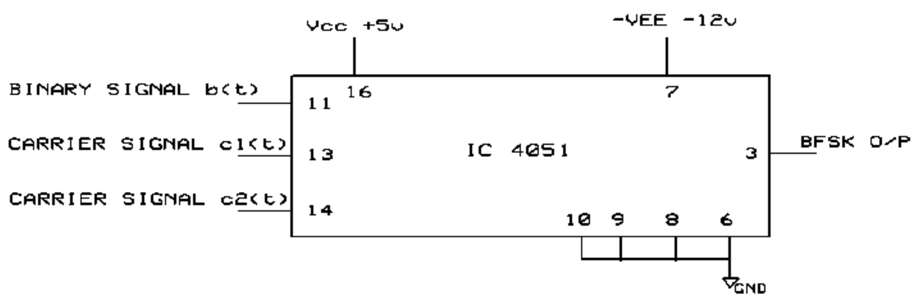
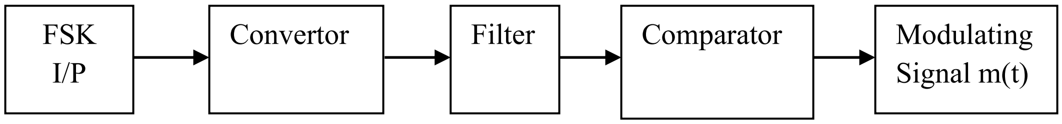


Figure5: FSK generation

<u>Block diagram of Binary frequency shift keying Demodulation</u>



<u>Demodulation Circuit</u>

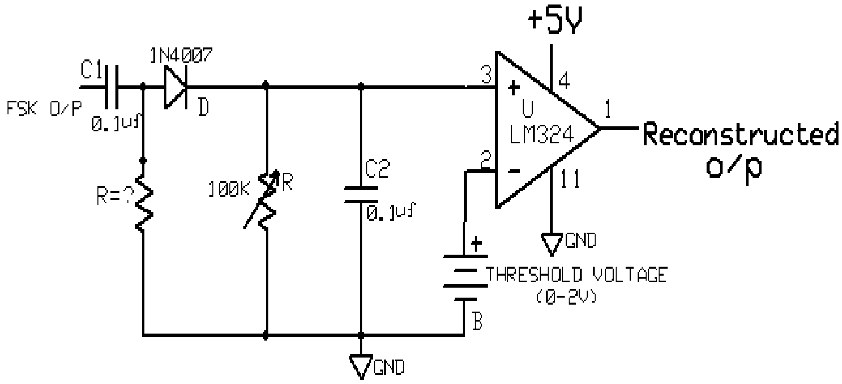


Figure6: FSK Detection

<u>Procedure</u>:

1. Connections are made as per circuit diagram.
2. Set the input voltage to 5V.
3. Set the frequency of the message signal and the two carrier frequency f_1 and f_2 such that $f_1 > f_2$ or $f_2 > f_1$.
4. Observe the output FSK modulated waveforms on CRO.
5. For demodulation connections are made as shown in circuit diagram and the detected output is observed on CRO.

<u>Design</u>:

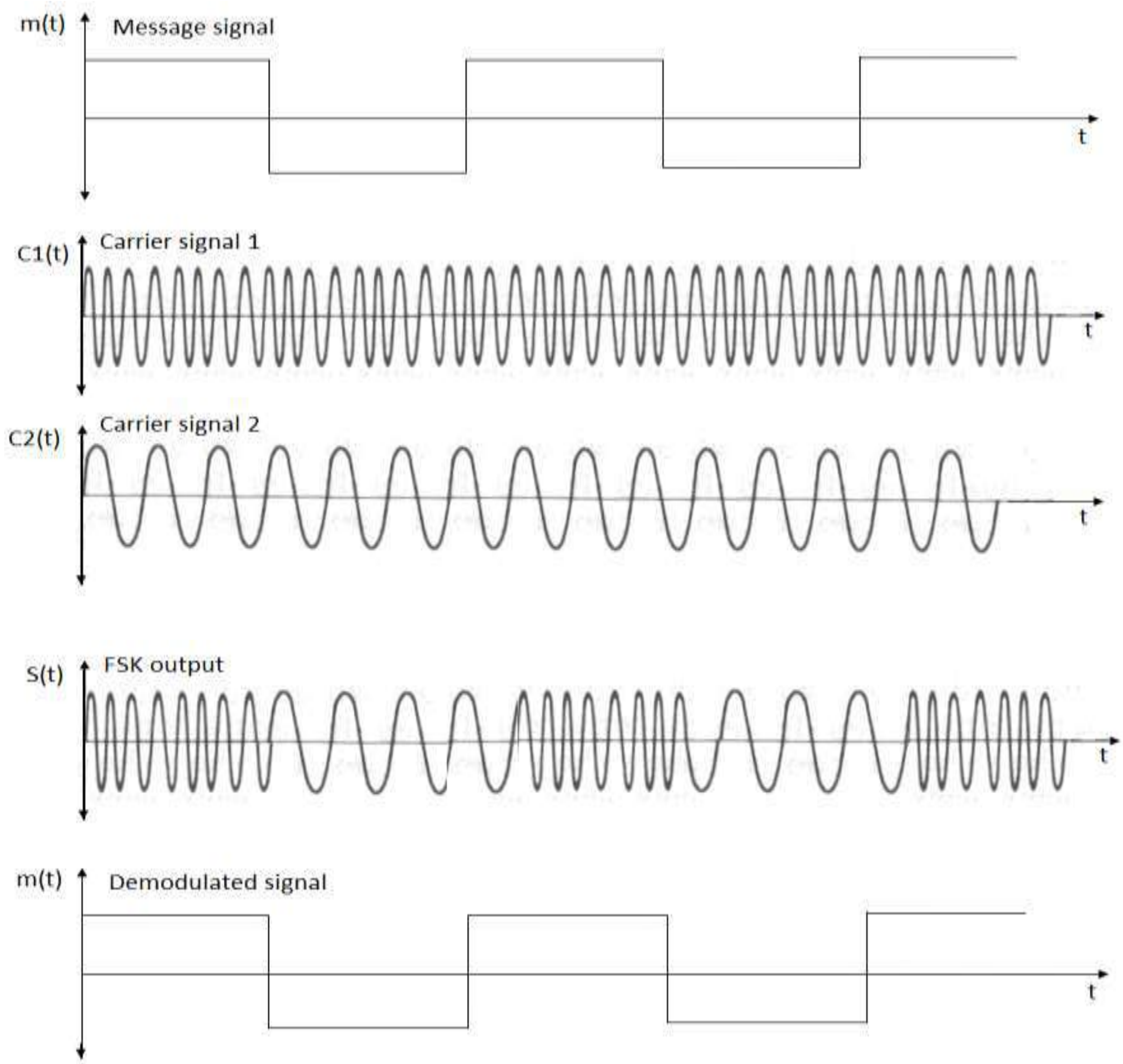
***Design of High Pass Filter*(HPF)**

1. Design the HPF for lower cut-off frequency (e.g. assume $f_{c1} < f_{c2}$)
2. Assume C = 0.1µF or 0.01µF or 0.001µF
3. Determine resistor $R = \frac{1}{2\pi f c1 C}$

***Design of Low Pass Filter* (LPF)**

1. Design the LPF for input signal frequency(f_m)
2. Assume C = 0.1µF or 0.01µF or 0.001µF
3. Determine resistor $R = \frac{1}{2\pi f m C}$

Waveforms:



Conclusion: Frequency shift keying generation and detection has been verified.

EXPERIMENT: 04
To study Differential Phase shift keying Transmitter and Receiver.

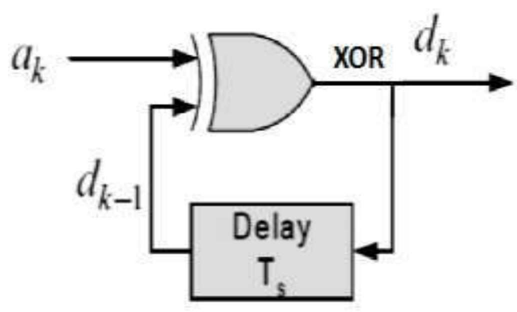
Objectives: i) To understand DPSK modulation scheme.
ii) To understand difference between BPSK and DPSK.

Equipments and Components Required:

SL.NO	COMPONENTS	SPECIFICATIONS	QUANTITY
1	IC D-FF	7474	1
2	IC EX-OR	7486	1
3	Digital trainer kit	-	1
4	Connecting wires	patch chords	

Theory:

Differential phase shift keying (DPSK) is a common form of phase modulation conveys data by changing the phase of carrier wave.Thusit can be regarded as a noncoherent version of BPSK. DPSK eliminates the need for a coherent reference signal at the receiver by combination of two basic operations: i) Differential encoding of binary input ii) Phase Shift keying (PSK). For symbol 0, a carrier signal with 180˚ phase shift is transmitted and for symbol 1, a carrier signal with 0˚ phase shift (phase unchanged) is transmitted. In DPSK Transmitter, Binary input data with an arbitrary bit as reference is differentially encoded with XOR encoder.



a_k	d_{k-1}	d_k
0	0	0
0	1	1
1	0	1
1	1	0

DPSK receiver implementation merely requires that sample valuesbe stored, thereby avoiding the need for delay lines that may be needed otherwise. During the demodulation, the DPSK signal is converted into a +5v square wavesignal using a transistor and is applied to one input of an EXOR gate. To thesecond input of the gate, carrier signal is applied after conversion into a +5v signal. So the, EX-OR gate output is equivalent to the differential signal of themodulating data. This differential data is applied to the one input of an XOR gate and to the second input, after one-bit delay the same signalis given. So the output of this is modulating signal.

Circuit Diagram:

Encoder

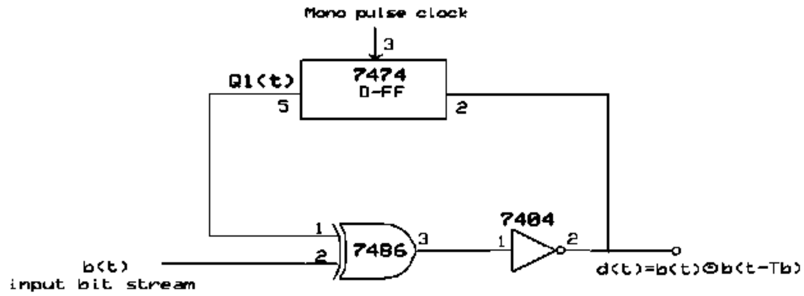


Figure7: DPSK Transmitter (Generation)

Decoder

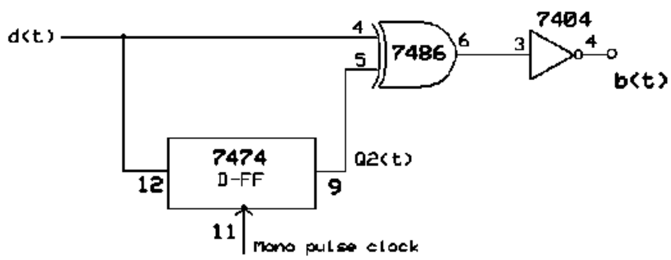


Figure8: DPSK Receiver (Detection)

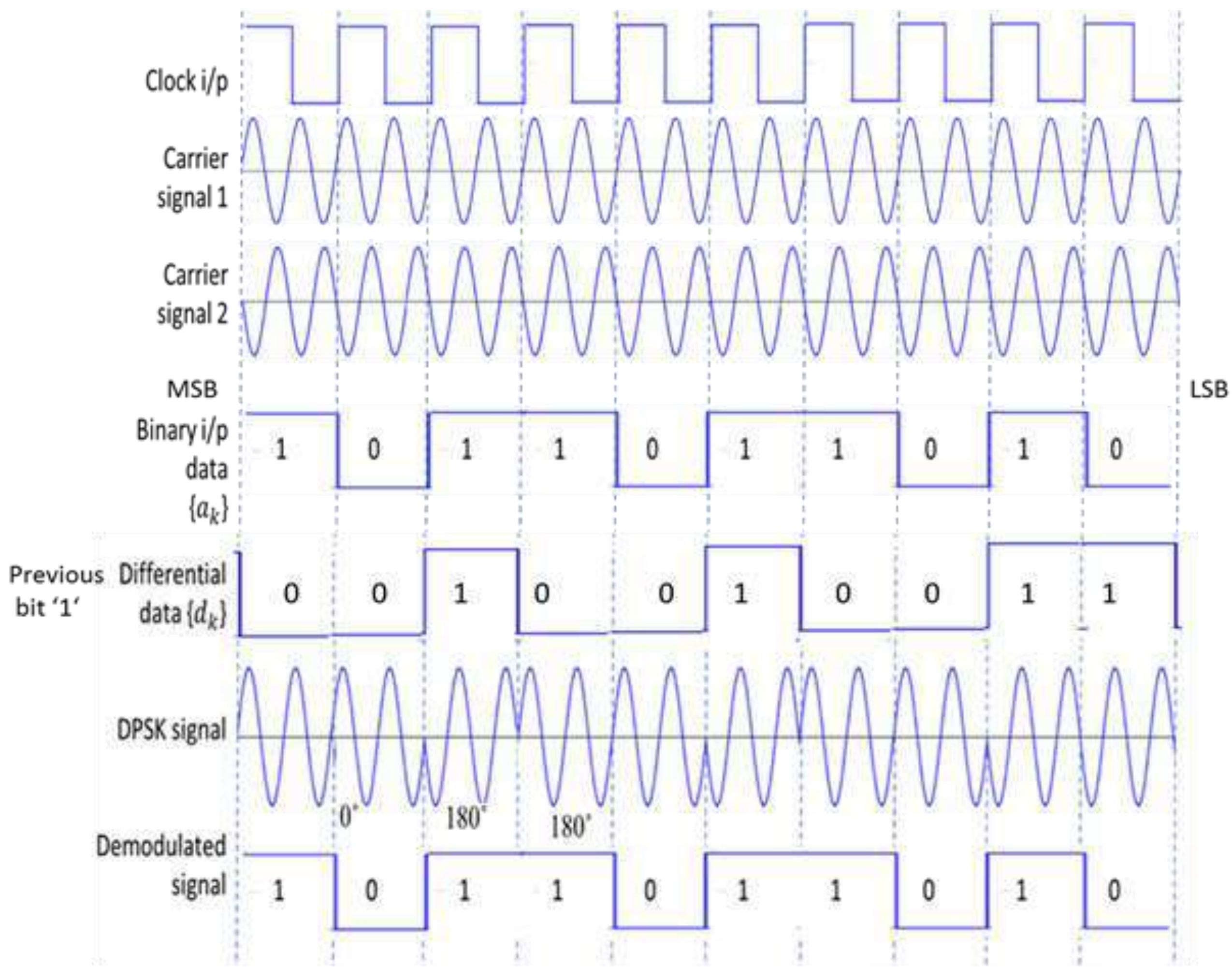
Observation Table:

SL. No.	Bit stream b(t)	$Q_1(t)$	Encoded bit stream d(t) 1 initial value	Delayed bit stream $Q_2(t)$	Detected bit stream b(t)
1	0	0	1	0	0
2	0	1	0	1	0
3	0	0	1	0	0
4	0	1	0	1	0
5	1	0	0	0	1
6	1	0	0	0	1
7	1	0	0	0	1
8	0	0	1	0	0
9	1	1	1	1	1
10	1	1	1	1	1
11	0	1	0	1	0
12	1	0	0	0	1
13	1	0	0	0	1
14	0	0	1	0	0
15	1	1	1	1	1
16	0	1	0	1	0
17	1	0	0	0	1

Procedure:

1. Connections are made as per circuit diagram.
2. The input bit stream b(t) and monopulseare applied and output of the encoder is observed and verified as per circuit diagram.
3. Now apply the output of the encoder as input to the decoder circuit and observe the message bit stream b(t) and verify the obtained bit stream with original bit stream that was transmitted.

Waveforms:



Conclusion: DPSK generation and detection has been verified for the given 8 bit binary data input.

EXPERIMENT:5
Gram-Schmidt Orthogonalization: To find orthogonal basis vectors for the given set ofvectors and plot the orthonormal vectors.

Objectives: i) To find orthogonal basis vectors for the given set of vectors

Theory: Gram-Schmidt Orthogonalization is a method for orthonormalizing a set of vectors in a vector space. Here's a step-by-step breakdown of the process:

1. Start with a set of linearly independent vectors {v1, v2, ..., vn}.
2. Set u1 = v1 (the first vector is already orthogonal to itself).
3. For each subsequent vector vi (i = 2 ton):
   - Compute the projection of vi onto ui: proj_ui(vi) = (vi ·ui) / (ui·ui) * ui
   - Subtract the projection from vi to get the orthogonal component: wi = vi - proj_ui(vi)
   - Normalize wi to get the orthonormal vector ui+1 = wi / ||wi||
4. The resulting set {u1, u2, ..., un} is an orthonormal basis.

Here's a simple example in 2D:

v1 = [1, 0]
v2 = [3, 4]

u1 = v1 = [1, 0]
proj_u1(v2) = (v2 · u1) / (u1 · u1) * u1 = (3/1) * [1, 0] = [3, 0]
w2 = v2 - proj_u1(v2) = [3, 4] - [3, 0] = [0, 4]
u2 = w2 / ||w2|| = [0, 4] / √(4^2) = [0, 1]

So, the orthonormal basis is {u1, u2} = {[1, 0], [0, 1]}.

Gram-Schmidt Orthogonalization has various applications in linear algebra, numerical analysis, and signal processing. It's used to:

- Find orthonormal bases for vector spaces
- Perform QR decomposition of matrices
- Solve least squares problems
- Compute eigenvalues and eigenvectors
- Analyze signals and systems

MAT LAB CODE :

```
n = 2;
A = [1 3; 4 -7; -1 -12];
Q = zeros(size(A));
QN = zeros(size(A));
for j= 1:n
   v = A (:,j) ;
   for i = 1: j-1
rij = Q(:,i).' * A(:,j) / (Q(:,i).' * Q(:,i));
       v = v - rij * Q(:,i);
   end
Q(:,j) = v;
QN(:,j) = v/norm(v);
end
sqrt(Q.'*Q)
```

OUT PUT:

```
4.2426         0
       0   13.8784
```

Conclusion: Verified orthogonal basis vectors for the given set of vectors.

EXPERIMENT: 06
Simulation of binary baseband signals using a rectangular pulse and estimate the BER for AWGN channel using matched filter receiver

Objectives: Simulation of binary baseband signals using a rectangular pulse and estimate the BER for AWGN channel

Theory: We can use a matched filter receiver to simulate binary baseband signals using a rectangular pulse and estimate the bit error rate (BER) for an additive white Gaussian noise (AWGN) channel

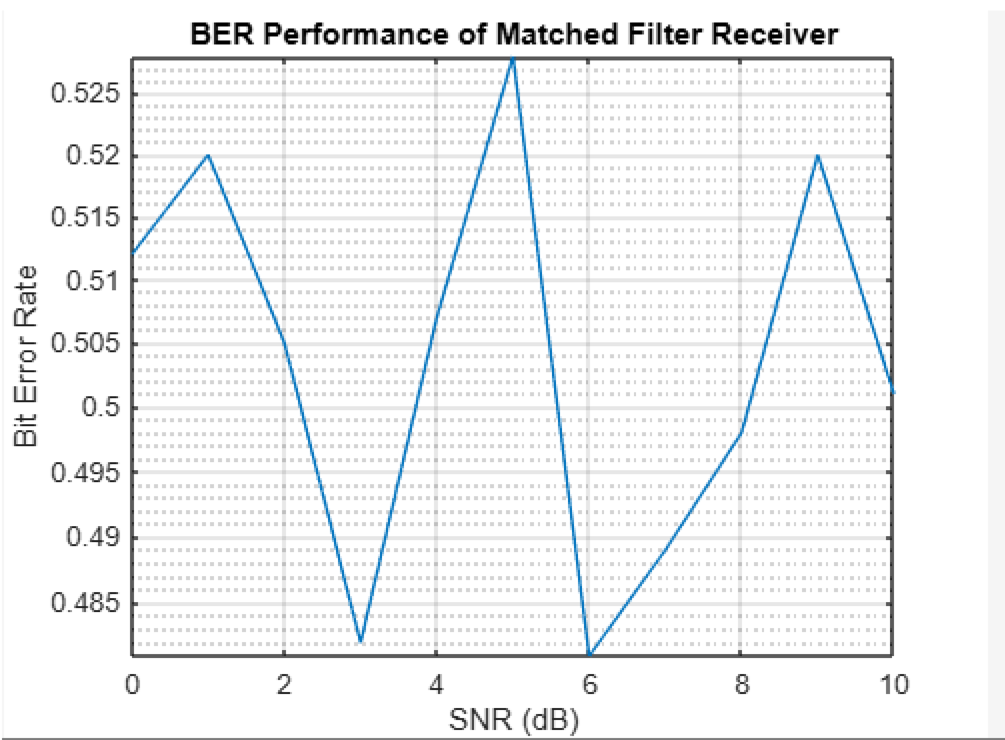
- Matched filter: matched filter is a linear filter that compares a known signal to an unknown signal to detect the presence of the known signal in the unknown signal. It's used to maximize the signal-to-noise ratio (SNR) in the presence of additive stochastic noise.
- AWGN:Additive white Gaussian noise is a noise model that mimics the effect of many random processes in nature. It's used to model the effect of noise in the baseband.
- Baseband:Baseband is the range of frequencies occupied by a signal that has not been modulated to higher frequencies.

MAT LAB CODE:

```
% Parameters
Fs = 1e5;  % Sampling frequency
Rb = 1e4;  % Bit rate
N = 1e3;   % Number of bits
SNR_range = 0:10;  % SNR range in dB
% Initialize BER vector
BER = zeros(size(SNR_range));
% Loop through SNR values
fori = 1:length(SNR_range)
    SNR = SNR_range(i);
    % Generate random binary data
data = randi([01], N, 1);

    % Rectangular pulse shaping
pulse = ones(1, Fs/Rb);
```

```
signal = repmat(data, 1, Fs/Rb) .* pulse;

    % Add AWGN
noise = sqrt(0.5 / (10^(SNR/10))) * randn(size(signal));
received_signal = signal + noise;

    % Matched filter receiver (integrator)
integrated_signal = cumsum(received_signal);
detected_symbols = integrated_signal(Fs/Rb:end) >= 0;
    % Estimate BER
errors = sum(data ~= detected_symbols);
    BER(i) = errors(i) / N;
end
% Plot BER vs SNR
figure;
semilogy(SNR_range, BER);
xlabel('SNR (dB)');
ylabel('Bit Error Rate');
title('BER Performance of Matched Filter Receiver');
grid on;
```

OUTPUT:



Conclusion: Simulation of binary baseband signals using a rectangular pulse and estimate the BER for AWGN channel is done using matched filter receiver.

EXPERIMENT: 7
Perform the QPSK Modulation and demodulation. Display the signal and its constellation.

Objectives: To Display the QPSK Modulation and demodulation

Theory:

QPSK Modulation:

1. Data Encoding: The data is first encoded into a sequence of bits (0s and 1s).
2. Dibit Mapping: The bits are grouped into pairs (dibits) and mapped to a QPSK symbol using the following constellation:
   - 00 → -1 - 1j
   - 01 → -1 + 1j
   - 10 → +1 - 1j
   - 11 → +1 + 1j
3. Carrier Modulation: The QPSK symbols are then modulated onto a carrier wave using the following equation:
   - $s(t) = Ac \cos(2\pi ft + \theta)$
   - where Ac is the amplitude, f is the frequency, t is time, and θ is the phase angle.

QPSK Demodulation:

1. Coherent Detection: The received signal is multiplied by a local carrier wave (coherent detection) to extract the QPSK symbols.
2. Sampling: The received signal is sampled at the symbol rate.
3. Phase Detection: The phase angle of each sample is determined using the following equation:
   - $\theta = \arctan(Q/I)$
   - where Q and I are the quadrature components of the received signal.
4. Symbol Mapping: The phase angle is mapped to the corresponding dibit using the QPSK constellation.
5. Data Decoding: The dibits are converted back to the original data bits.

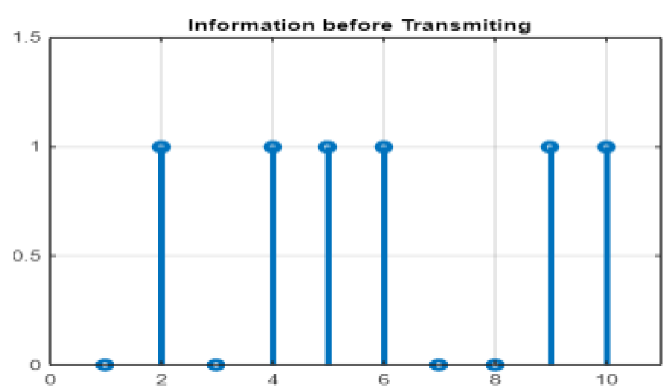
MAT LAB CODE:

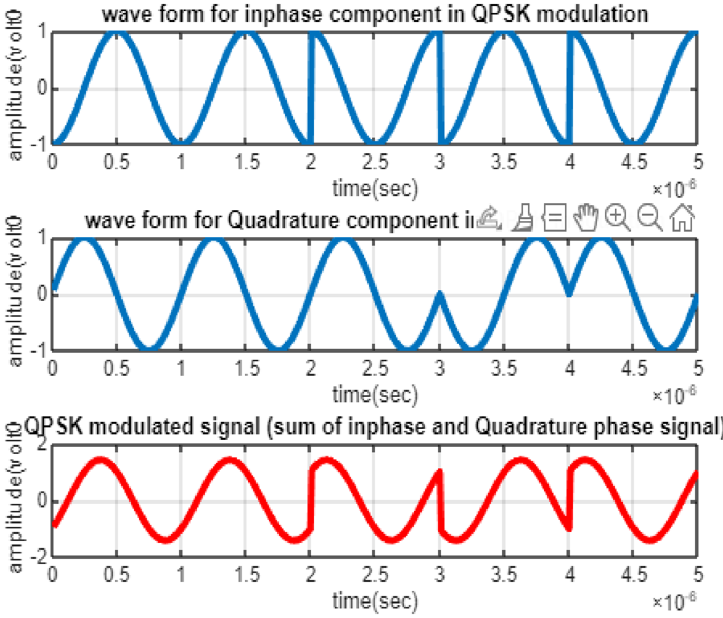
```
clc;
clear all;
close all;
data=[0  1 0 1 1 1 0 0 1 1]; % information
%Number_of_bit=1024;
```

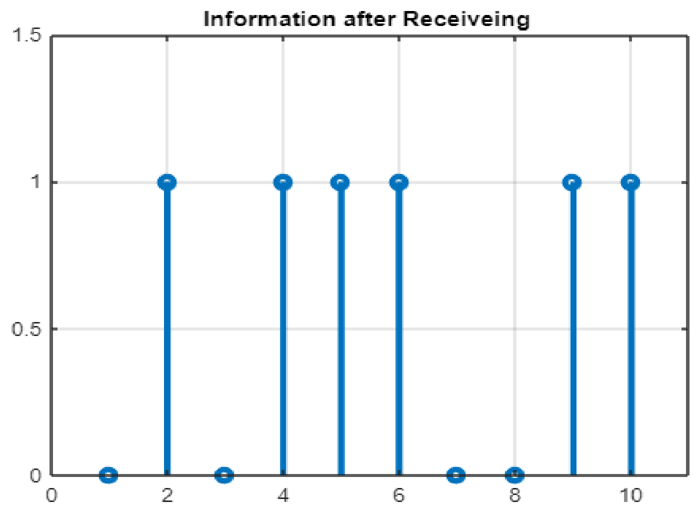
```
%data=randint(Number_of_bit,1);
figure(1)
stem(data, 'linewidth',3), grid on;
title('  Information before Transmiting ');
axis([ 0 11 0 1.5]);
data_NZR=2*data-1; % Data Represented at NZR form for QPSK modulation
s_p_data=reshape(data_NZR,2,length(data)/2);  % S/P convertion of data
br=10.^6; %Let us transmission bit rate  1000000
f=br; % minimum carrier frequency
T=1/br; % bit duration
t=T/99:T/99:T; % Time vector for one bit information
% XXXXXXXXXXXXXXXXXXXXXXX QPSK modulatio
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
y=[];
y_in=[];
y_qd=[];
for(i=1:length(data)/2)
   y1=s_p_data(1,i)*cos(2*pi*f*t); % inphase component
   y2=s_p_data(2,i)*sin(2*pi*f*t) ;% Quadrature component
y_in=[y_in y1]; % inphase signal vector
y_qd=[y_qd y2]; %quadrature signal vector
   y=[y y1+y2]; % modulated signal vector
end
Tx_sig=y; % transmitting signal after modulation
tt=T/99:T/99:(T*length(data))/2;
figure(2)
subplot(3,1,1);
plot(tt,y_in,'linewidth',3), grid on;
title(' wave form for inphase component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
subplot(3,1,2);
plot(tt,y_qd,'linewidth',3), grid on;
title(' wave form for Quadrature component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
subplot(3,1,3);
plot(tt,Tx_sig,'r','linewidth',3), grid on;
title('QPSK modulated signal (sum of inphase and Quadrature phase signal)');
xlabel('time(sec)');
ylabel(' amplitude(volt0');

% QPSK demodulation
Rx_data=[];
Rx_sig=Tx_sig; % Received signal
for(i=1:1:length(data)/2)
```

```
%%XXXXXX inphase coherent dector XXXXXXX
Z_in=Rx_sig((i-1)*length(t)+1:i*length(t)).*cos(2*pi*f*t);
% above line indicat multiplication of received &inphasecarred signal
Z_in_intg=(trapz(t,Z_in))*(2/T);% integration using trapizodialrull
if(Z_in_intg>0) % Decession Maker
Rx_in_data=1;
else
Rx_in_data=0;
end
%%XXXXXX Quadrature coherent dector XXXXXX
Z_qd=Rx_sig((i-1)*length(t)+1:i*length(t)).*sin(2*pi*f*t);
%above line indicat multiplication ofreceived&Quadphasecarred signal
Z_qd_intg=(trapz(t,Z_qd))*(2/T);%integration using trapizodialrull
if (Z_qd_intg>0)% Decession Maker
Rx_qd_data=1;
else
Rx_qd_data=0;
end
Rx_data=[Rx_dataRx_in_dataRx_qd_data]; % Received Data vector
end
figure(3)
stem(Rx_data,'linewidth',3)
title('Information after Receiveing ');
axis([ 0 11 0 1.5]), grid on;
% XXXXXXXXXXXXXXXXXXXXXXXXX    end of program
```

OUTPUT:







Conclusion: Performed the QPSK Modulation and Demodulation.

EXPERIMENT: 8
Generate 16-QAM Modulation and obtain the QAM constellation.

Objectives: Generation of 16-QAM Modulation and QAM constellation

Theory: QAM (Quadrature Amplitude Modulation) is a digital modulation technique that conveys data by changing the amplitude and phase of a carrier wave. Here's an overview of QAM modulation:

Key aspects:

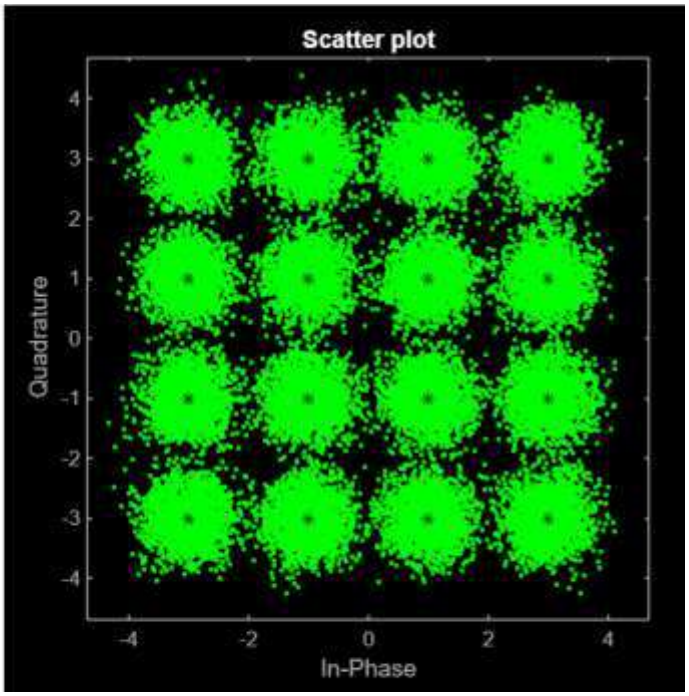
1. Constellation: QAM uses a constellation diagram to represent the possible states of the modulated wave.
2. Amplitude and Phase: QAM modulates both the amplitude and phase of the carrier wave.
3. Symbol Rate: QAM transmits multiple bits per symbol, increasing the symbol rate.
4. Bandwidth Efficiency: QAM achieves high bandwidth efficiency due to its ability to transmit multiple bits per symbol.

MAT LAB CODE:

```
% Parameters
M = 16; % 16-QAM
k = log2(M); % Bits per symbol
nSymbols = 1000; % Number of symbols

% Generate random binary data
data = randi([0 1], nSymbols * k, 1);

% Map bits to symbols
dataSymbolsInDecimal = bi2de(reshape(data, k, []).', 'left-msb');

% Generate 16-QAM symbol mapping (Gray coding)
realPart = 2 * mod(dataSymbolsInDecimal, sqrt(M)) - sqrt(M) + 1;
imagPart = 2 * floor(dataSymbolsInDecimal / sqrt(M)) - sqrt(M) + 1;
symbols = realPart + 1i * imagPart;

% Normalize power
symbols = symbols / sqrt(mean(abs(symbols).^2));

% Plot QAM constellation
figure;
scatter(real(symbols), imag(symbols), 'filled');
grid on;
```

```
title('16-QAM Constellation Diagram');
xlabel('In-Phase');
ylabel('Quadrature');
axis([-1.5 1.5 -1.5 1.5]);
```

OUTPUT:



Conclusion: Generated 16-QAM Modulation and obtained the QAM constellation

EXPERIMENT: 09
Encoding and Decoding of Huffman code.

Objectives: To understand Encoding and Decoding of Huffman code.

Theory:

Huffman Coding is a technique of compressing data to reduce its size without losing any of the details. It was first developed by David Huffman.

Huffman Coding is generally useful to compress the data in which there are frequently occurring characters.

Huffman coding is a lossless data compression algorithm. It assigns variable-length codes to input characters based on how frequently they are used. The most frequent characters have the smallest codes, and the least frequent characters have longer codes. Huffman coding is useful for compressing data with frequently occurring characters. It's independent of the data type, so it can be used for images, audio, or spreadsheets. It's used in JPEG and MPEG-2.

MAT LAB CODE:

```
clc;
clear all;
close all;
p=input('Enter the probabilities:');
n=length(p);
symbols=[1:n];
[dict,avglen]=huffmandict(symbols,p)
temp=dict;
t=dict(:,2);
fori=1:length(temp) temp{i,2}=num2str(temp{i,2});
end
disp('The huffman code dict:');
disp(temp)
fprintf('Enter the symbols between 1 to %d in []',n);
sym=input(':')
encode=huffmanenco(sym,dict);
disp('The encoded output:');
disp(encode);
bits= input('Enter the bit stream in []);');
decode=huffmandeco(bits,dict);
disp('The symbols are:');
```

```
disp(decode);
```

OUTPUT:

```
Enter the probabilities:[0.1 0.3 0.2 0.15 0.25]
The huffman code dict:
    {[1]}    {'1  0  1'}
    {[2]}    {'0  0'   }
    {[3]}    {'1  1'   }
    {[4]}    {'1  0  0'}
    {[5]}    {'0  1'   }
Enter the symbols between 1 to 5 in []:[4]
The encoded output:
     1
     0
     0
Enter the bit stream in []);[1 0 0]
The decoded output:
     4
```

Conclusion: Huffman coding and decoding is verified through the example.

EXPERIMENT:10
Encoding and Decoding of binary data using a Hamming code.

Objectives: To understand Hamming code encoding algorithm and analyzing its performance.

Theory:

Hamming codes have a minimum distance of 3, which means that the decoder can detect and correct a single error, but it cannot distinguish a double bit error of some codeword from a single bit error of a different codeword. The four data bits — assembled as a vector p — is pre-multiplied by G (i.e.Gp) and taken modulo 2 to yield the encoded value that is transmitted. The original 4 data bits are converted to seven bits (hence the name "Hamming(7,4)") with three parity bits added to ensure even parity using the above data bit coverage.

MATLAB CODE:

```
clc;
n=7; % no of code word bits per block
k=4;% no of message bits per block
A=[1 1 1; 1 1 0; 1 0 1; 0 1 1 ];
% parity submatrix need binary (decimal combination of 7,6,5,3)%
G= [eye(k) A]; % Generator matrix
H=[A' eye(n-k)]; % parity check matrix
%encode
msg=[1 1 1 1]; % message block vector-change to any 4bit sequence
code=mod(msg*G,2); %encode message
% Channel error (add on error to code)%
%code(1)=~code(1);
code(2)=~code(2);
%code(3)=~code(3);
%code(4)=~code(4);
%code(5)=~code(5);
%code(6)=~code(6);
%code(7)=~code(7);
recd=code; %received codeword with error
%decode%
syndrome=mod(recd*H',2);

%find position of error in codeword(index) %
```

```
find= 0;
for ii=1:n
 if ~find
        errvect=zeros(1,n);
        errvect(ii)=1;
        search=mod(errvect*H',2);
        if search==syndrome
                find=1;
                index=ii;
        end
 end
end

disp('Generator Matrix (G):');
disp(G);
disp('Parity Check Matrix (H):');
disp(H);
disp('Original Message:');
disp(msg);
disp('Encoded Codeword:');
disp(code);
disp('Received Codeword with Error:');
disp(recd);
disp('Syndrome:');
disp(syndrome);
disp(['position of error in codeword=',num2str(index)]);
correctedcode=recd;

correctedcode(index)=mod(recd(index)+1,2); %corrected codeword

% Strip off parity bits%
msg_decoded=correctedcode;
msg_decoded=msg_decoded(1:4);

% Display the Output%
disp('Corrected Codeword:');
disp(correctedcode);
disp('Decoded Message:');
disp(msg_decoded);
```

OUTPUT:

Generator Matrix (G):

```
1 0 0 0 1 1 1
0 1 0 0 1 1 0
0 0 1 0 1 0 1
0 0 0 1 0 1 1
```

Parity Check Matrix (H):

```
1 1 1 0 1 0 0
1 1 0 1 0 1 0
1 0 1 1 0 0 1
```

Original Message:

```
1 1 1 1
```

Encoded Codeword:

```
1 0 1 1 1 1 1
```

Received Codeword with Error:

```
1 0 1 1 1 1 1
```

Syndrome:

```
1 1 0
```

position of error in codeword=2
Corrected Codeword:

```
1 1 1 1 1 1 1
```

Decoded Message:

```
1 1 1 1
```

Conclusion: The Hamming code is effective in detecting and correcting single-bit errors in transmitted data.

EXPERIMENT:11
For a given data, use CRC-CCITT polynomial to obtain the CRC code. Verify for the cases, a) Without error b) With error

Objectives: i) To understand the calculation of CRC polynomial
ii) To obtain CRC code for with and without error cases.

Theory:

The cyclic redundancy checks or CRC is a technique for detecting errors in digital data, but not for making corrections when errors are detected. It is used primarily in data transmission. In the CRC method, a certain number of check bits, are appended to the message being transmitted. The receiver can determine whether or not the check bits agree with the data,to ascertain with a certain degree of probability whether or not an error occurred in transmission. In this method, the message is divided by an agreed upon polynomial called generator polynomial. The obtained reminder is called CRC and is appended with the message bits and transmitted. If: x div y gives remainder c that means: x = n y + c
Hence (x-c) = n y, (x-c) div y gives remainder 0.For e.g.: 14%3=2, therefore (14-2) =12 ,12%3=0.

When the transmitted message is received by the receiver, the received message is divided by generator polynomial. If the remainder is zero, the received data is error free else the received data has errors.

MAT LAB CODE:

```
clc;
close all;
clear all;
n=input('enter the lenth of the code');
k=input('enter the message lenth');
m=input('enter the massage bits');
disp('Generate the Generator Sequence');
G=cyclpoly(n,k,'max')
disp('Generate the generator polynomial');
g=poly2sym(G)
disp('Encoded bits');
C=encode(m,n,k,'cyclic',G)
disp('Decoded bits')
D=decode(C,n,k,'cyclic',G)
ch=biterr(m,D)
if(ch==0)
```

```
disp('Messsage is error free')
else
disp('message contains error')
end
```

OUTPUT:

Enter the length of the code word 07
Enter the message length 04
Enter the message bits [1011]
Generate the Generator Sequence
G=1101
x^3+x^2+1
Encoded bits
C=1001011
Decoded bits
D=1011
ch = 0
Message is error free

Conclusion: CRC code is verified for cases with and without error.

EXPERIMENT: 12
Encoding and Decoding of Convolution code

Objectives: i) To understand difference between Block codes and Convolution codes
ii) To analyze the performance of convolution codes

Theory: Theory of convolution codes involves understanding the structure of encoder, constraint length, generator polynomials, the Viterbi decoding algorithm and performance matrix. This code plays crucial role in enhancing the reliability of digital communication systems by providing error detection and correction capabilities.

In convolutional coding, the coder input and output are continuous streams of digits. The coder outputs n output digits for every k digit input, and the code is described as 'a rate k/n code'. If the input digits are included unmodified in the coder output the code is described as systematic. The convolutional coding technique is used to encode and decode a continuous stream of bits. The basic concept behind the convolution is the overlapping of two signals to form the other one. A convolutional code can be used to detect or correct infinite sequences of errors or to correct infinite sequences of erasures. First, erasure correction is shown to be related to error detection, as well as error detection to error correction. A binary convolutional code of rate 1/v bits per symbol can be generated by a linear finite-state machine consisting of an L-stage shift register, v modulo-2 adders connected to some of the shift registers, and a commutator that scans the output of the modulo-2 adders

MAT LAB CODE:

```
clc;
close all;
k=3;
G1=7;% First sequence polynomial
G2=5;% Second sequence polynominal
msg=[1 0 1 1 0];
trel=poly2trellis(k,[G1 G2]);
disp('message sequence:');
disp(msg);
coded=convenc(msg,trel);
disp('encoder output:');
disp(coded);
tblen=length(msg);
```

```
decoded=vitdec(coded,trel,tblen,'trunc','hard');
disp('decoder output:');
disp(decoded);
```

OUTPUT:

```
message sequence:
    1     0     1     1     0
encoder output:
    1     1     1     0     0     0     0     1     0     1
encoder output:
    1     0     1     1     0
```

Conclusion: Convolutional codes are effective for error correction in digital communication systems. The ((3, 1, 2)/ suitably designed) indicates a convolutional code with constraint length 3, one input bit at a time, and two output bits.

EXPERIMENT: 13

To Generation and Detection of the Amplitude Shift Keying signal using Virtual lab

Link: https://kcgcollege.ac.in/Virtual-Lab/Electronics-and-Communication-Engineering/Exp-3/index.html

Objectives: To study Generation and Detection of ASK Signal.

Theory:

Introduction

One of the older type of digital modulation technique is in which the binary data are represented as amplitude variations in the waveform. This technique is called Amplitude Shift Keying (ASK) or ON-OFF shift keying(OOK). In this case, the amplitude of the carrier is modulated by the digital data.

Concept

In this technique, the binary data is represented as message waveform and the carrier waveform is a sinusoidal signal. Swiching between the states in the carrier wave will take place with respect to the binary data given. If the message data is in state-1, the signal increases the carrier level(i.e. ON state) and if the message data is in state-0 the carrier level is decreased(i.e. OFF state). Hence this technique is called ON-OFF shift keying. This technique is used widely used in home automation devices, low RF applications etc, Amplitude Shift Keying (ASK) is a digital modulation scheme where the binary data is transmitted using a carrier signal with two different amplitude levels. For binary 0 and 1, the carrier switches between these two levels. In its simplest form, a carrier is sent during one input and no carrier is sent during the other. This kind of modulation scheme is called on-off keying. A simple ASK modulator circuit is shown in figure. Here a sinusoidal high frequency carrier signal is sent for logic '0' (-5V) and no carrier is sent for logic '1' (+5V). The transistor works as a switch closes when the input (base) voltage is +5V (logic '1') and shorts the output. When the input voltage is -5V (logic '0'), the switch opens and the carrier signal is directly connected to the output.

Amplitude Shift Keying Wave Forms:

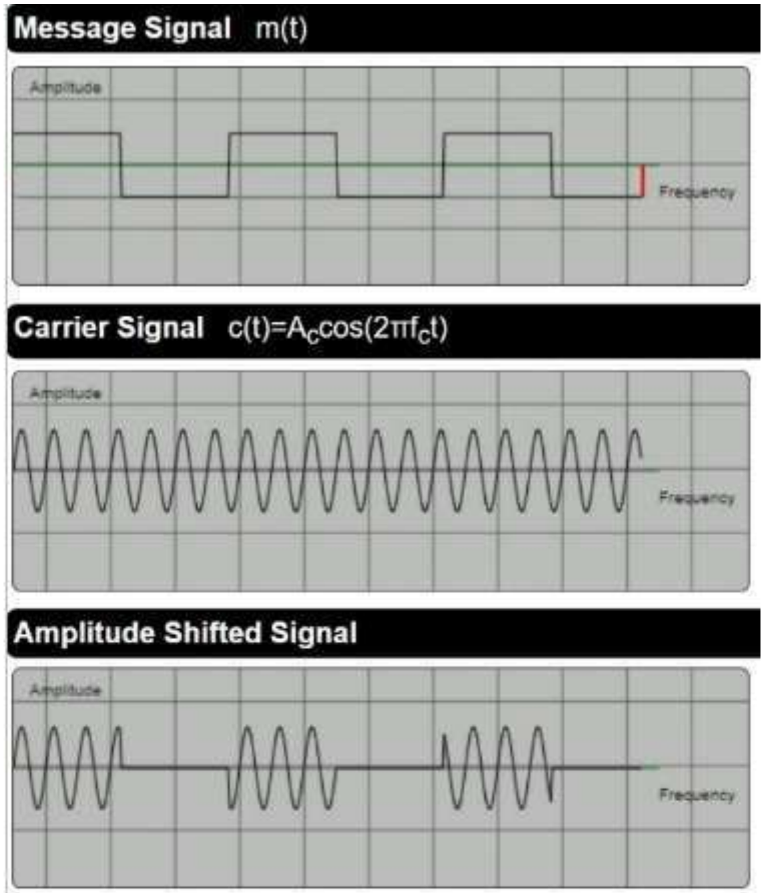


Figure 9: Amplitude Shifted Signal

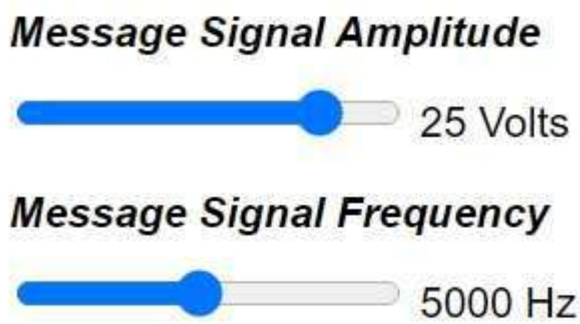
The demodulator circuit consists of an envelope detector and a comparator. The diode D selects the positive half cycle of the ASK input. The envelop detector formed by 2.2K resistor and 0.01uF capacitor detects the data out of the ASK input. The Op Amp comparator and the zener diode amplitude limiter convert this detected signal to its original logic levels. The 10K potentiometer may be varied to set suitable reference voltage for the comparator.

Procedure:

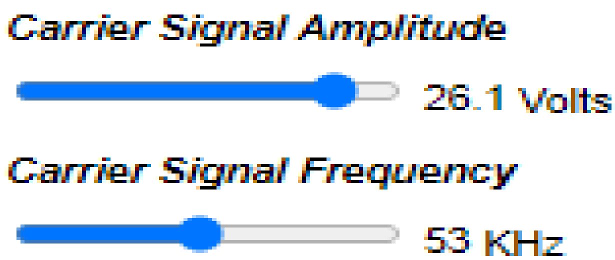
These procedure steps will be followed on the simulator

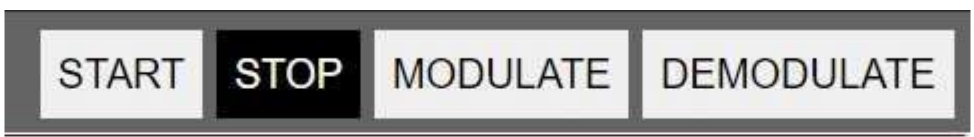
1. After going through the theory and pretest, click the "Simulation" tab
2. The simulator will display the interactive Simulator
3. The simulator will display the interactive Simulator
4. The simulator will display the interactive Simulator

5. Set the Message Signal Amplitude and Frequency

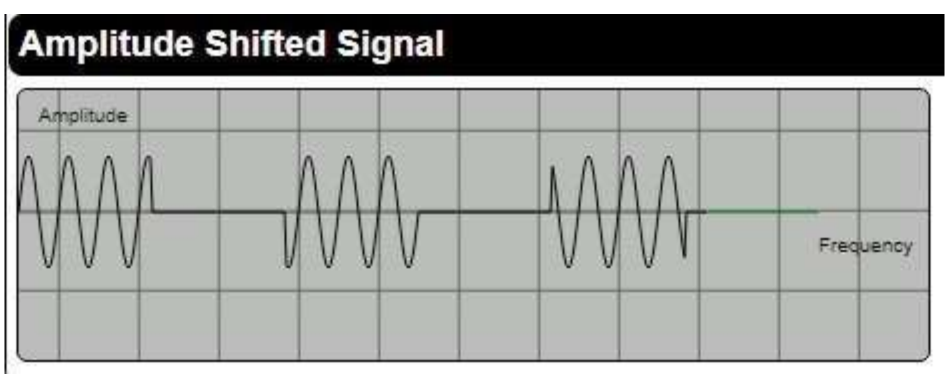


6. Set the Carrier Signal Amplitude and Frequency

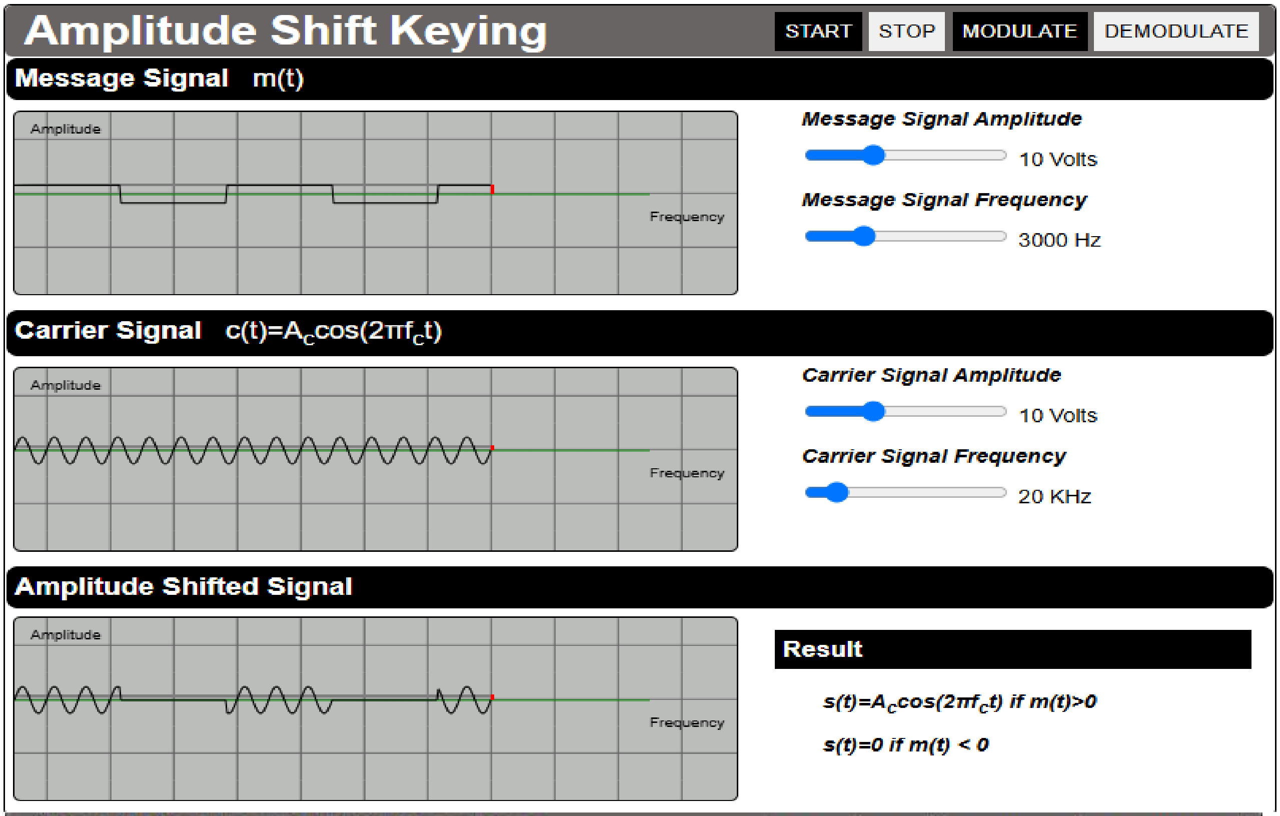


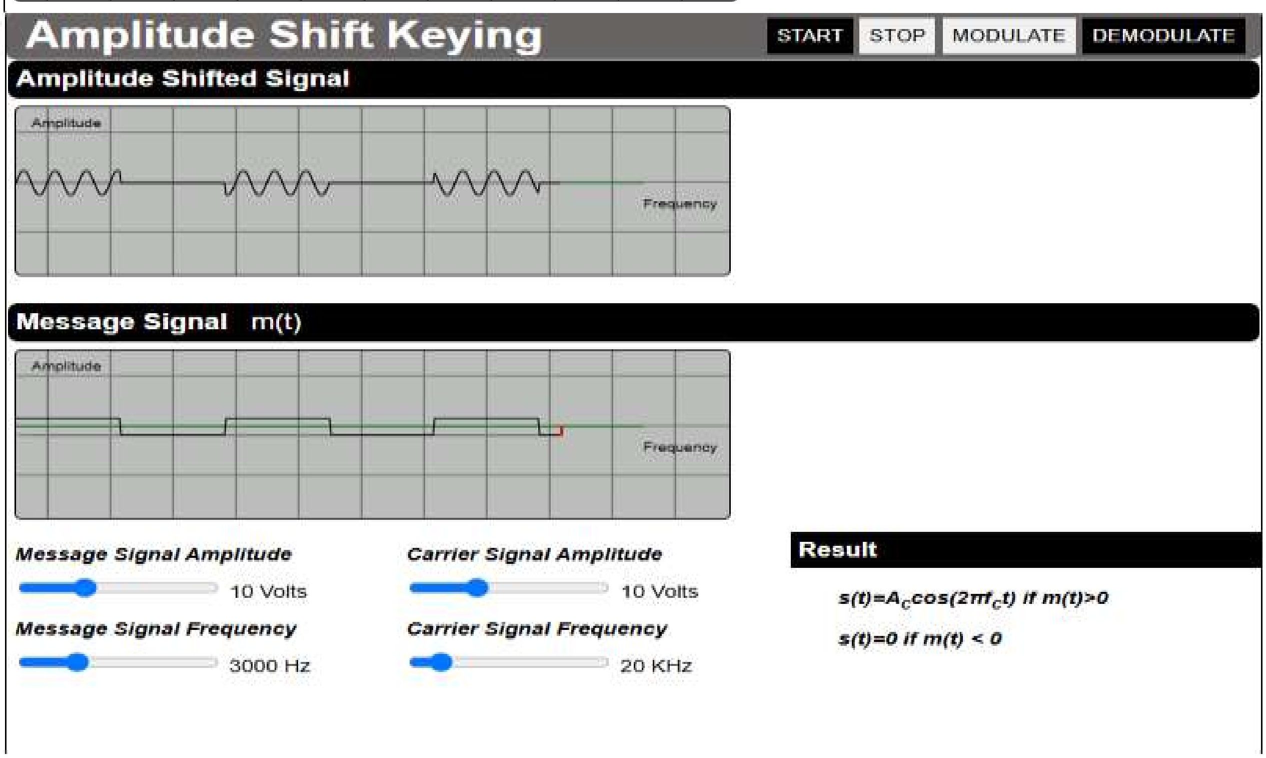


7. Click on "Modulate" button. This will Show the Modulated Message Signal.
8. Click on "Start" button. This will Start the Simulation.
9. Click on "Demodulate" button. This will Show the Demodulated Message Signal.
10. Click on "Stop" button to view the graph in a Statis state
11. In the Results Section you can view the modulation Index and type of modulation The simulator will display the interactive questions, attempt the questions.
12. Note the conclusions from the experiment performed.



Simulation:





Conclusion: ASK Modulation and Demodulation waveform is plotted using virtual lab.