American International University- Bangladesh (AIUB)
Faculty of Engineering
Data Communications Lab

Course Name:	**Data Communications**		
Course Code:	CoE 3201	**Section:**	**E**
Semester:	Spring 2023-24	**Group No:**	**8**
Assignment Name:	**Open Ended Lab- 2**		
Assessed CO2:	Demonstrate an experiment for shift keying (ASK) and multiplexing (FDM) to communicate binary bits as analog signals; Demultiplex and convert them back into binary bits at the receiver.		
Assessed POI:	**P.d.1.P3**		
Student Name:	**MD. TAHSIN HASIB**	**Student ID:**	**22-46026-1**
Student Name:	**MD. SHOHANUR RAHMAN SHOHAN**	**Student ID:**	**22-46013-1**
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Student Name:	**A. F. M. RAFIUL HASSAN**	**Student ID:**	**22-47048-1**
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Mark distribution (to be filled by Faculty):

Objectives	Proficient [10-8]	Good [7-4]	Needs Improvement [3-1]	Secured Marks
Depth of knowledge displayed through appropriate research (P1)	Student was able to apply in-depth engineering knowledge achieved by appropriate research about digital/analog communication to design the communication model correctly and **fulfilled all design criteria**.	Design process is not completely supported by in-depth engineering knowledge achieved by appropriate research about digital/analog communication, **some but not all of the design criteria are fulfilled**.	Design process contains mistakes and does not display enough in-depth engineering knowledge achieved by appropriate research about digital/analog communication. **Most of the design criteria are not fulfilled**.	
Depth of analysis (P3)	Student defended the diversified approach taken to solve the problem with **well-justified in-depth analysis that demonstrated abstract thinking**.	Student's attempts to analyze the diversified approach taken to solve the problem **is not enough in-depth, some of design choices do not demonstrate adequate abstract thinking** and are not properly justified.	Student **did not attempt any in-depth analysis** of the designed system and **displayed no abstract thinking**.	
Level of integration of multiple sections of design for solution of high-level problem (P7)	Student correctly identified all problems and successfully integrated the interdependent parts into a high-level design using a block diagram. Block diagram was at best match with the given problem.	Student was able to identify some of the problems correctly and integrated the interdependent parts into a high-level design using a block diagram. Some parts of the block diagram were not a good match for the given problem.	Student was able to identify only one/two of the problems correctly and could not properly integrate the interdependent parts into a high-level design using a block diagram. Only one/two blocks were correct and/or block diagram was incomplete.	
Comments:			**Total Marks (Out of 10):**	

Purpose

The purpose of this OEL report is to explore and demonstrate the fundamental concepts of shift keying, specifically Amplitude Shift Keying (ASK), and multiplexing, particularly Frequency Division Multiplexing (FDM), as methods for transmitting binary information as analog signals and again demultiplexing the composite signal back to original analog signals.

Procedure

Initially three digital bit streams were created: x1, x2, and x3, representing different binary sequences. These sequences serve as the basis for the modulation process. The modulation (ASK) phase involved converting each binary bit in the sequences into an analog signal. For each digital bit sequence, a corresponding analog signal was generated using Amplitude Shift Keying (ASK) modulation. Each bit in the digital sequence was represented by a sine wave with varying amplitude. The carrier signals for each bit sequence were also created. MATLAB functions such as “sin” and “plot” were utilized for signal generation and visualization, respectively. Plots are then generated to visualize the digital bit streams, the ASK-modulated signals, and the carrier signals for each bit sequence. The frequency domain analysis of the ASK-modulated signals is performed using the Fast Fourier Transform (FFT), facilitated by functions like “fft” and “fftshift”. These functions compute the FFT and shift the zero-frequency component to the center of the spectrum, respectively. The ASK-modulated signals for all three-bit sequences were combined to form a composite signal. Then the signal was plotted in time and frequency domain. Later, the composite signal was passed through bandpass filters to extract individual signals corresponding to each bit sequence. Demodulation was accomplished by multiplying the filtered signals with their respective carrier signals. MATLAB's filter function is employed for signal filtering operations. Low-pass filtering was applied to recover the original analog signals. After demodulation, time-domain and frequency-domain analysis are conducted on the received signals. Plots were generated to visualize the received signals and their frequency domain.

Results

The code for the experiment:

```
% Group - 8 OEL
% MD. TAHSIN HASIB - 22-46026-1
% MD. SHOHANUR RAHMAN SHOHAN - 22-46013-1
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% MD. ASHIKUZZAMAN ABIR - 22-47006-1
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clc
clear all
close all

% digital bit stream
x1 = [1 0 1 0 1 1];
x2 = [0 1 0 1 0 0];
x3 = [1 1 1 0 0 1];

bit1 = [];
bp1 = 1;
for n=1:1:length(x1)
    if x1(n) == 1;
        se = 3*ones(1,100);
    else
        x1(n) == 0;
        se = zeros(1,100);
    end
    bit1 = [bit1 se];
end

tb1 = bp1/100:bp1/100:100*length(x1)*(bp1/100);

figure
subplot(3,1,1);
plot(tb1, bit1,'lineWidth',2.5);
grid on;
axis([-0 6 -5 5]);
ylabel('Amplitude(volt)');
xlabel('Time(sec)');
title('Digital Bit Stream Signal - 1');


Am1 = 3;
A = 0;
brm1 = 1/bp1;
fm1 = brm1*3;
tm1 = bp1/99:bp1/99:bp1;
```

```
ask1 = [];
for i=1:1:length(x1)
    if (x1(i)==1)
        y = Am1*sin(2*pi*fm1*tm1);
    else
        y = A*sin(2*pi*fm1*tm1);
    end
    ask1 = [ask1 y];
end
% plotting ask1
tmp1 = bp1/99:bp1/99:bp1*length(x1);
subplot(3,1,2);
plot(tmp1, ask1);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('ASK of Digital Bit Stream Signal - 1');



Ac1 = 3;
brc1 = 1/bp1;
fc1 = brc1*101;
tc1 = bp1/99:bp1/99:bp1;
c1=[];
for i=1:1:length(x1)
    if (x1(i)==1)
        y = Ac1*sin(2*pi*fc1*tc1);
    else
        y = Ac1*sin(2*pi*fc1*tc1);
    end
    c1 = [c1 y];
end

tcp1 = bp1/99:bp1/99:bp1*length(x1);
subplot(3,1,3);
plot(tcp1, c1);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Carrier Signal for ASK - 1');
```

```
bit2 = [];
bp2 = 1;
for n=1:1:length(x2)
    if x2(n) == 1;
        se = 3*ones(1,100);
    else
        x2(n) == 0;
        se = zeros(1,100);
    end
    bit2 = [bit2 se];
end

tb2 = bp2/100:bp2/100:100*length(x2)*(bp2/100);

figure
subplot(3,1,1);
plot(tb2, bit2,'lineWidth',2.5);
grid on;
axis([-0 6 -5 5]);;
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Digital Bit Stream Signal - 2');

Am2 = 3;
A = 0;
brm2 = 1/bp2;
fm2 = brm2*4;
tm2 = bp2/99:bp2/99:bp2;
ask2 = [];
for i=1:1:length(x2)
    if (x2(i)==1)
        y = Am2*sin(2*pi*fm2*tm2);
    else
        y = A*sin(2*pi*fm2*tm2);
    end
    ask2 = [ask2 y];
end
% plotting ask2
tmp2 = bp2/99:bp2/99:bp2*length(x2);
subplot(3,1,2);
plot(tmp2, ask2);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('ASK of Digital Bit Stream Signal - 2');
```

```
% carrier for ask2
Ac2 = 3;
brc2 = 1/bp2;
fc2 = brc2*105;
tc2 = bp2/99:bp2/99:bp2;
c2 = [];
for i=1:1:length(x2)
    if (x2(i)==1)
        y = Ac2*sin(2*pi*fc2*tc2);
    else
        y = Ac2*sin(2*pi*fc2*tc2);
    end
    c2 = [c2 y];
end
% plotting carrier for ask - 2
tcp2 = bp2/99:bp2/99:bp2*length(x2);
subplot(3,1,3);
plot(tcp2, c2);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Carrier Signal for ASK - 2');
```

```
% third Signal
bit3 = [];
bp3 = 1;
for n=1:1:length(x3)
    if x3(n) == 1;
        se = 3*ones(1,100);
    else
        x3(n) == 0;
        se = zeros(1,100);
    end
    bit3 = [bit3 se];
end
```

```
tb3 = bp3/100:bp3/100:100*length(x1)*(bp3/100);

figure
subplot(3,1,1);
plot(tb3, bit3,'lineWidth',2.5);
grid on;
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Digital Bit Stream Signal - 3');


Am3 = 3;
A = 0;
brm3 = 1/bp3;
fm3 = brm3*5;
tm3 = bp3/99:bp3/99:bp3;
ask3 = [];
for i=1:1:length(x3)
    if (x3(i)==1)
        y = Am3*sin(2*pi*fm3*tm3);
    else
        y = A*sin(2*pi*fm3*tm3);
    end
    ask3 = [ask3 y];
end
% plotting ask - 3
tmp3 = bp3/99:bp3/99:bp3*length(x3);
subplot(3,1,2);
plot(tmp3, ask3);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('ASK of Digital Bit Stream Signal - 3');


Ac3 = 3;
brc3 = 1/bp3;
fc3 = brc3*110;
tc3 = bp3/99:bp3/99:bp3;
c3 = [];
for i=1:1:length(x3)
    if (x3(i)==1)
        y = Ac3*sin(2*pi*fc3*tc3);
    else
        y = Ac3*sin(2*pi*fc3*tc3);
    end
    c3 = [c3 y];
end
% plotting carrier for ask - 3
```

```
tcp3 = bp3/99:bp3/99:bp3*length(x3);
subplot(3,1,3);
plot(tcp3, c3);
axis([-0 6 -5 5]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Carrier Signal for ASK - 3');









% Fourier Transform of ask1
figure
fs = 594;
M_ask1 = abs(fftshift(fft(ask1)))/(fs/2);
f_bit1 = fs/2*linspace(-1,1,fs);
subplot(3,1,1)
stem(f_bit1, M_ask1)
axis([-270 270 0 2.5])
xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - ASK of Digital Bit Stream Signal - 1')
% Fourier Transform of ask2
M_ask2 = abs(fftshift(fft(ask2)))/(fs/2);
f_bit2 = fs/2*linspace(-1,1,fs);
subplot(3,1,2)
stem(f_bit2, M_ask2)
axis([-270 270 0 2.5])
xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - ASK of Digital Bit Stream Signal - 2')
% Fourier Transform of ask3
M_ask3 = abs(fftshift(fft(ask3)))/(fs/2);
f_bit3 = fs/2*linspace(-1,1,fs);
subplot(3,1,3)
stem(f_bit3, M_ask3)
axis([-270 270 0 2.5])
xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - ASK of Digital Bit Stream Signal - 3')
```

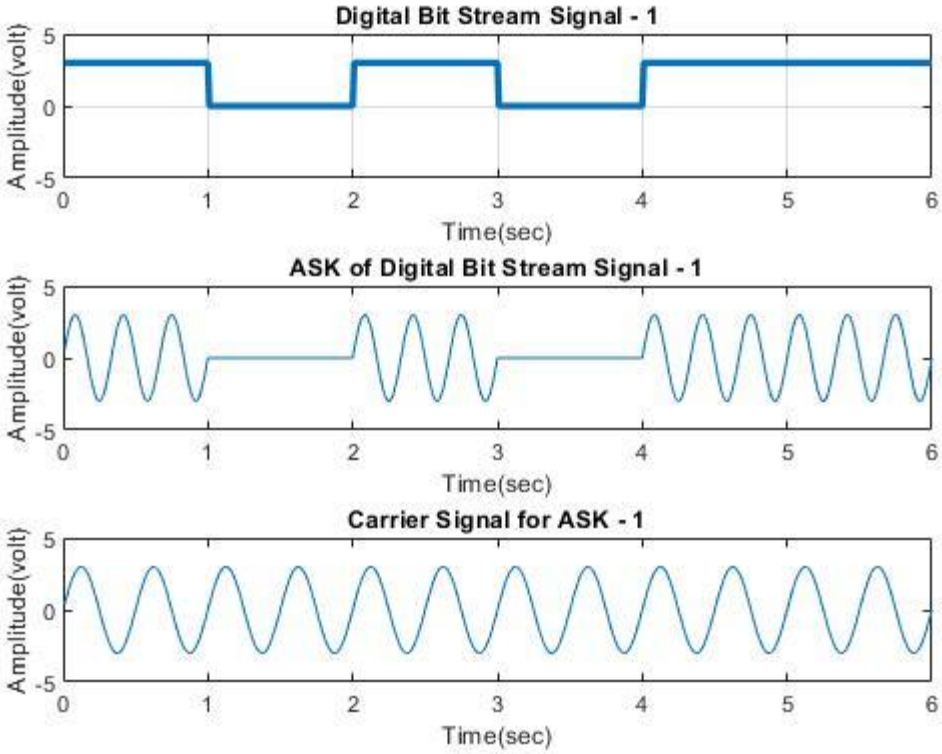
```matlab
% plotting composite signal of ask1, ask2, ask3
tcomp = bp3/99:bp3/99:bp3*length(x3);
comp_sig = (ask1).*c1+(ask2).*c2+(ask3).*c3;

figure
subplot(2,1,1)
plot(tcomp, comp_sig);
axis([0 6 -20 20]);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Composite Signal: ASK1 + ASK2 + ASK3');
% Fourier Transform of composite signal
M_comp = abs(fftshift(fft(comp_sig)))/(fs/2);
f_bitcomp = fs/2*linspace(-1,1,fs);
subplot(2,1,2)
stem(f_bitcomp, M_comp)
axis([-270 270 0 3.5])
xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - Composite Signal (ASK1 + ASK2 + ASK3)')
```

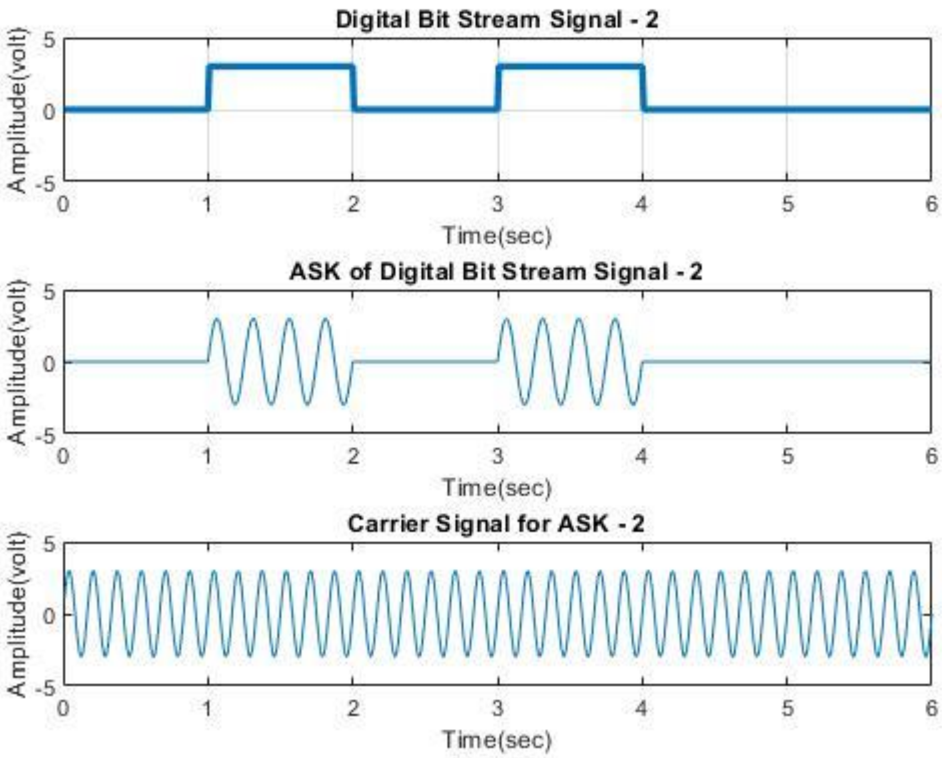
```matlab
% demultiplexing the original analog ask1, ask2, ask3 signals
fs = 300; %Sampling Frequency
trec = bp3/99:bp3/99:bp3*length(x3); %Generating Time axis

% Passing the Composite Signal Through Bandpass Filter
% Normalize cutoff frequencies
fc1_norm = (fc1 - fm1 - 6) / (fs/2);
fh1_norm = (fc1 + fm1 + 6) / (fs/2);
[num1, den1] = butter(5, [fc1_norm fh1_norm]); % Design filter for signal 1

fc2_norm = (fc2 - fm2 - 6) / (fs/2);
fh2_norm = (fc2 + fm2 + 6) / (fs/2);
[num2, den2] = butter(5, [fc2_norm fh2_norm]); % Design filter for signal 2

fc3_norm = (fc3 - fm3 - 6) / (fs/2);
fh3_norm = (fc3 + fm3 + 6) / (fs/2);
[num3, den3] = butter(5, [fc3_norm fh3_norm]); % Design filter for signal 3
```

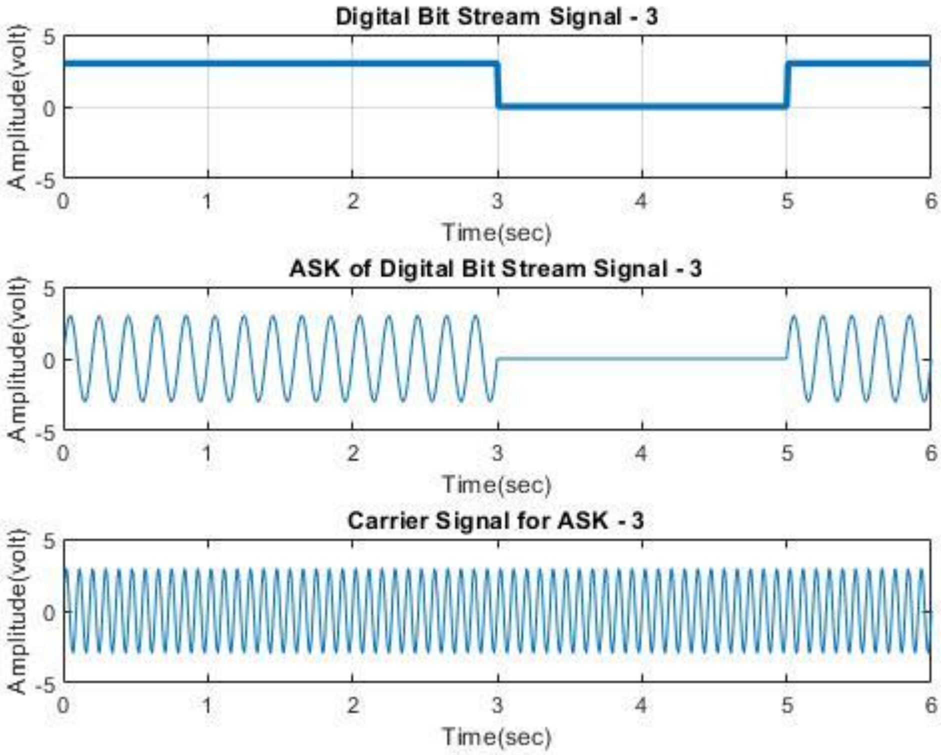
```
% Filter the composite signal (assuming comp_sig is defined)
bpf1 = filter(num1, den1, comp_sig);
bpf2 = filter(num2, den2, comp_sig);
bpf3 = filter(num3, den3, comp_sig);

% Demodulation (assuming Am1, Am2, Am3 are defined)
z1 = 2*bpf1 .* c1;
z2 = 2*bpf2 .* c2;
z3 = 2*bpf3 .* c3;

% Normalize cutoff frequencies for demodulation filters
fm1_norm = (fm1 + 6) / (fs/2);
[num5, den5] = butter(5, fm1_norm);
Rec1 = filter(num5, den5, z1);

fm2_norm = (fm2 + 6) / (fs/2);
[num6, den6] = butter(5, fm2_norm);
Rec2 = filter(num6, den6, z2);

fm3_norm = (fm3 + 6) / (fs/2);
[num7, den7] = butter(5, fm3_norm);
Rec3 = filter(num7, den7, z3);

% Plotting the Received Signals in Time-Domain and Frequency Domain
figure
subplot(3,1,1)
plot(trec, Rec1)
xlabel('time')
ylabel('amplitude')
title('received signal 1 in time domain')
subplot(3,1,2)
plot(trec,Rec2)
xlabel('time')
ylabel('amplitude')
title('received signal 2 in time domain')
subplot(3,1,3)
plot(trec,Rec3)
xlabel('time')
ylabel('amplitude')
title('received signal 3 in time domain')




% Fourier Transform of rec1
figure
fs = 594;
M_rec1 = abs(fftshift(fft(Rec1)))/(fs/2);
```

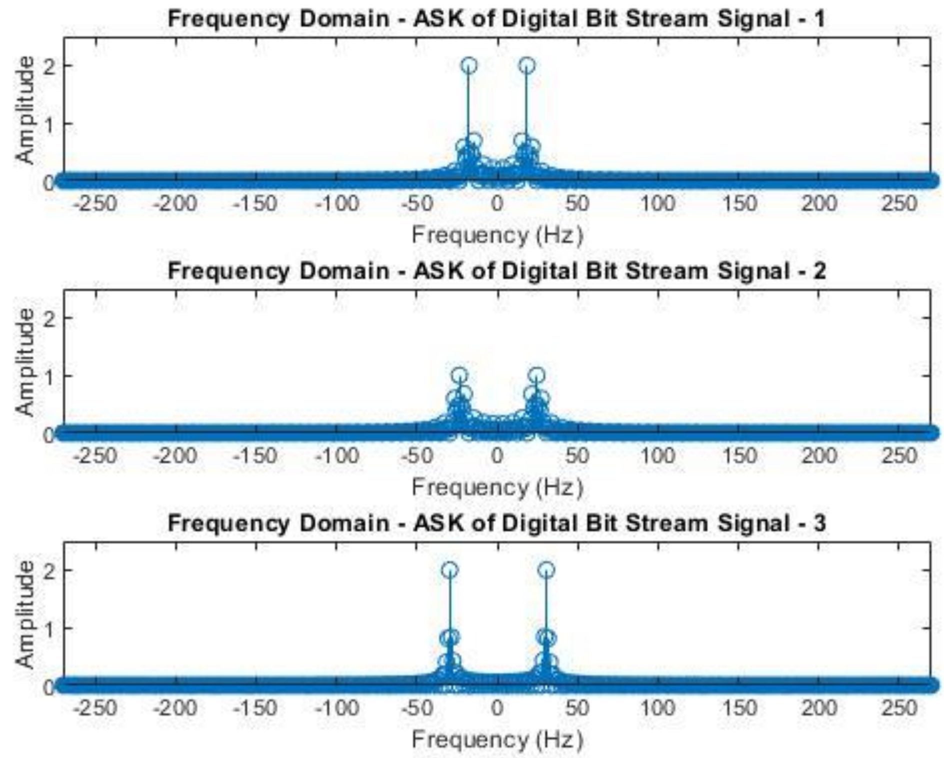
```
f_rec1 = fs/2*linspace(-1,1,fs);
subplot(3,1,1)
stem(f_bit1, M_rec1)

xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - Received ASK of Digital Bit Stream Signal - 1')
% Fourier Transform of rec2
M_rec2 = abs(fftshift(fft(Rec2)))/(fs/2);
f_rec2 = fs/2*linspace(-1,1,fs);
subplot(3,1,2)
stem(f_rec2, M_rec2)

xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - Received ASK of Digital Bit Stream Signal - 2')
% Fourier Transform of ask3
M_rec3 = abs(fftshift(fft(Rec3)))/(fs/2);
f_rec3 = fs/2*linspace(-1,1,fs);
subplot(3,1,3)
stem(f_rec3, M_rec3)

xlabel('Frequency (Hz)')
ylabel('Amplitude')
title('Frequency Domain - Received ASK of Digital Bit Stream Signal - 3')
```

The x1, x2, x3 bit streams were converted into analog signals using ASK. The figure shows all three ASK signals along with their different carrier signals both in time and frequency domain.

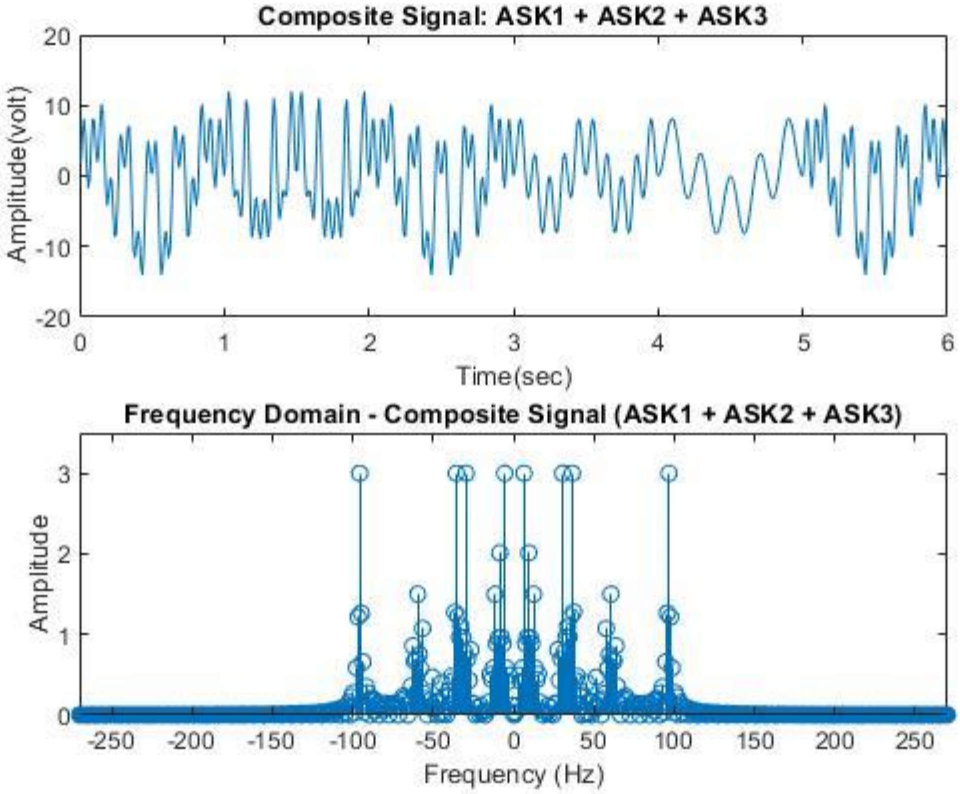




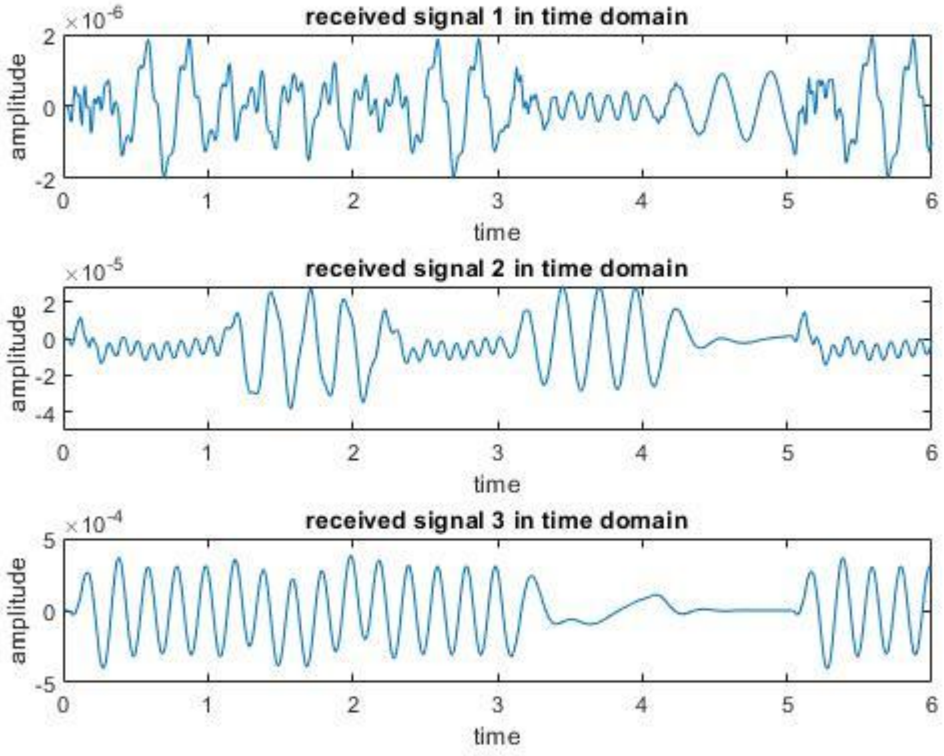

Digital Bit Stream Signal - 3
Amplitude(volt)
Time(sec)
ASK of Digital Bit Stream Signal - 3
Amplitude(volt)
Time(sec)
Carrier Signal for ASK - 3
Amplitude(volt)
Time(sec)

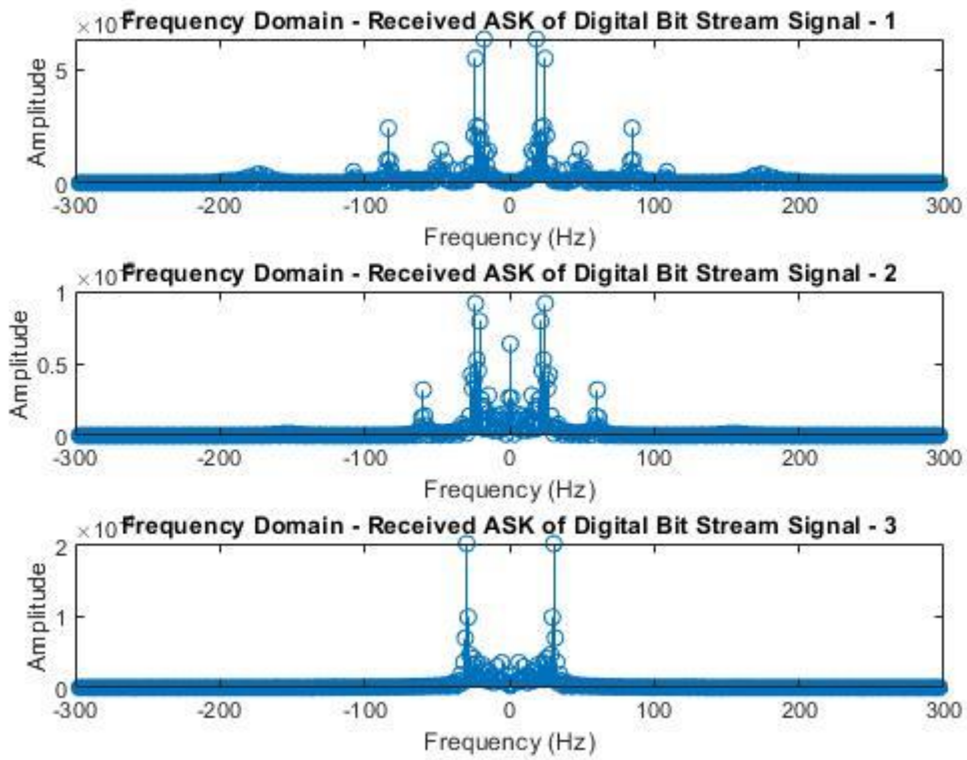

Frequency Domain - ASK of Digital Bit Stream Signal - 1
Amplitude
Frequency (Hz)
Frequency Domain - ASK of Digital Bit Stream Signal - 2
Amplitude
Frequency (Hz)
Frequency Domain - ASK of Digital Bit Stream Signal - 3
Amplitude
Frequency (Hz)

Analog ASK signals were added together for creating a composite signal. The figure shows the composite signal in time and frequency domain.



The composite signal was filtered, and the individual analog signals were extracted back to their original form. The received signal is slightly different from the original analog signal because of the noise that affected them while modulation. Figure below shows all three received signals in time and frequency domain.


received signal 1 in time domain
amplitude
time
received signal 2 in time domain
amplitude
time
received signal 3 in time domain
amplitude
time


Frequency Domain - Received ASK of Digital Bit Stream Signal - 1
Amplitude
Frequency (Hz)
Frequency Domain - Received ASK of Digital Bit Stream Signal - 2
Amplitude
Frequency (Hz)
Frequency Domain - Received ASK of Digital Bit Stream Signal - 3
Amplitude
Frequency (Hz)

Impacts on Society, Health, and Safety

Two essential methods in modern communication systems are ASK and FDM. They make it possible to transmit enormous volumes of data across a variety of mediums, which encourages the growth of telecommunications networks. This promotes worldwide connectedness by revolutionizing the ways in which people exchange information, interact, and conduct business. While ASK and FDM contribute to global connectivity, they also exacerbate the digital divide. Societies with limited access to advanced communication technologies may face marginalization, hindering their socio-economic development and access to vital services like education and healthcare.

Telemedicine services are made possible by the transmission of medical data made easier via ASK and FDM. Patients in remote or underdeveloped locations might benefit greatly from the ability to consult healthcare providers online, receive diagnoses, and obtain medical advice. FDM is essential to medical monitoring systems because it enables real-time vital sign monitoring, including blood pressure and heart rate. This ongoing observation can lead to better health outcomes, early intervention, and improved patient care.

For emergency communication systems to transmit distress signals, position information, and other key information quickly and reliably, ASK and FDM are essential. When there is an emergency, such a natural disaster or an accident, first responders need to be able to coordinate rescue operations and deliver help. Many transportation systems, such as those in aviation and maritime communication, use FDM. It raises operational efficiency and safety standards by ensuring secure and effective communication between control centers, aircraft, ships, and ground staff.

ASK and FDM contribute to the globalization of media, enabling the distribution of diverse cultural content worldwide. People can access entertainment, news, and information from different cultures, fostering cultural exchange and understanding. ASK and FDM promote cultural exchange, they also raise concerns about cultural homogenization and the erosion of local traditions. The digital divide exacerbates disparities in access to digital content, potentially marginalizing cultural expressions from underserved communities.

Discussion & Conclusion

In conclusion, the principles of Amplitude Shift Keying (ASK) modulation and demodulation for digital communication were explored. The experiment was conducted successfully by generating digital bit streams, modulation of these streams into analog signals using ASK, and subsequent demodulation to recover the original digital information. Throughout the experiment, various MATLAB functions were employed to facilitate signal generation, manipulation, visualization, and analysis. Functions such as “sin”, “plot”, “filter”, and “fft” were used in implementing the modulation and demodulation processes, as well as in analyzing the frequency domain of the signals. The results of the experiment demonstrated the successful modulation of digital information into analog signals using ASK modulation, composite signal generation using FDM (Frequency Division Multiplexing). Furthermore, the demodulation process effectively recovered the original digital information from the modulated signals. By passing the composite signal through bandpass filters and performing demodulation using carrier signals, the individual bit streams were successfully extracted. Time-domain and frequency-domain analysis of the demodulated signals further validated the effectiveness of the demodulation process.

References

- Lab Report 6: Study of Digital to Analog Conversion using MATLAB
- Lab Report 9: Frequency Division Multiplexing using MATLAB