K. J. Somaiya College of Engineering, Mumbai-77

Batch:- A-4 **Roll No:-** 16010122151

Experiment No:- 2

Grade: AA / AB / BB / BC / CC / CD /DD

Signature of the Staff In-charge with date

Title: Represent discrete time signals and perform different operations on them.

Objective: To familiarize the beginner to MATLAB by introducing the basic features and commands of the program.

Expected Outcome of Experiment:

CO	Outcome
CO1	Identify various discrete time signals and systems and perform signal manipulation

Books/ Journals/ Websites referred:

1. http://www.mathworks.com/support/
2. www.math.mtu.edu/~msgocken/intro/intro.html
3. www.mccormick.northwestern.edu/docs/efirst/matlab.pdf
4. A.Nagoor Kani "Digital Signal Processing", 2nd Edition, TMH Education.

Pre Lab/ Prior Concepts:

Using MATLAB we can easily generate all basic functions such as unit step, ramp, growing and decaying exponential, etc. The various signals plotted in this program are Step signal,

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Ramp signal, Exponential signal etc

1. Unit Step Signal

The step signal is defined as

U[n] = k ; if n>=0

= 0 ; otherwise

When k=1 it is called as unit step signal.

2. Ramp Signal

The ramp signal is defined

as r[n] = n ; if n>=0

= 0 ; otherwise

3. Exponential Signal

The exponential signal is defined as

X[n] =a^n

When 'a' is greater than 1 it is **increasing** exponential

When 'a' is less than 1 it is **decaying** exponential.

4. Impulse Signal

The impulse signal is defined

as d[n] = k ; if n=0

= 0 ; otherwise

When k=1 it is called as unit impulse

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The functions used in this program are:

a. Ones

This function is used to create an array of all ones Syntax: Y=ones (m, n)

Description:

Y=ones (n) returns an n-by-n matrix of 1's.

An error message appears if n is not a scalar.

Y=ones (m, n) or Y=ones([m n]) returns an m-by-n matrix of ones.

b. Zeros

This function is used to create an array of all zeros

Syntax: Y=zeros(m,n)

Description:

Y=zeros(n) returns an n-by-n matrix of 0's.

An error message appears if n is not a scalar.

Y=zeros (m,n) or Y=ones([m n]) returns an m-by-n matrix of Zeros.

c. EXP

This function is used to plot exponential signals

Syntax: Y=exp(X)

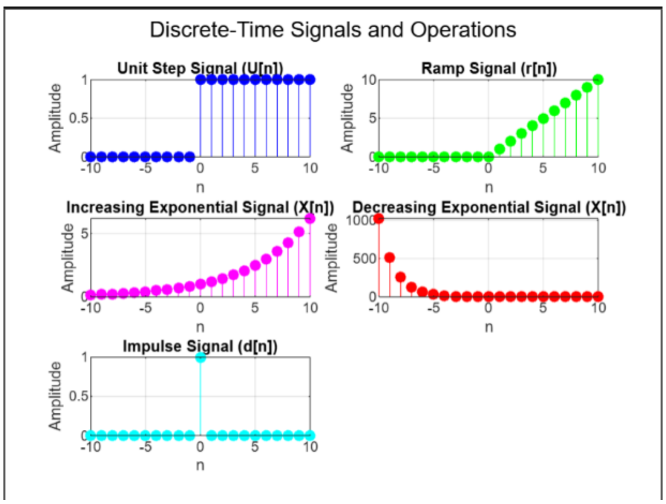
Description:

The exp function is an elementary function that operates element-wise on arrays. Its domain includes complex numbers.

Y=exp(X) returns the exponential for each element of X. For complex, it returns the complex exponential.

```
% Define the discrete time index
n = -10:10;  % Discrete time range from -10 to 10
% Scaling factor for Unit Step and Impulse Signals
k = 1;
%% 1. Unit Step Signal (U[n])
U = zeros(size(n));   % Initialize with 0s
U(n >= 0) = k;        % U[n] = 1 for n >= 0, else 0
%% 2. Ramp Signal (r[n])
r = zeros(size(n));   % Initialize ramp signal with 0s
r(n >= 0) = n(n >= 0);  % r[n] = n for n >= 0, else 0
%% 3. Exponential Signals
% a. Increasing Exponential Signal (a > 1)
a_increasing = 1.2;  % Exponential base > 1
X_increasing = a_increasing .^ n;  % X[n] = a^n
% b. Decreasing Exponential Signal (a < 1)
a_decreasing = 0.5;  % Exponential base < 1
X_decreasing = a_decreasing .^ n;  % X[n] = a^n
%% 4. Impulse Signal (d[n])
d = zeros(size(n));  % Initialize impulse signal with 0s
d(n == 0) = k;  % d[n] = 1 at n = 0, else 0
%% Create a Single Figure with Subplots
figure;
% Subplot 1: Unit Step Signal
subplot(3, 2, 1);  % 3 rows, 2 columns, first subplot
stem(n, U, 'filled');
title('Unit Step Signal (U[n])');
xlabel('n');
ylabel('Amplitude');
grid on;
axis tight;
% Subplot 2: Ramp Signal
subplot(3, 2, 2);  % 3 rows, 2 columns, second subplot
stem(n, r, 'filled');
title('Ramp Signal (r[n])');
xlabel('n');
ylabel('Amplitude');
grid on;
axis tight;
% Subplot 3: Increasing Exponential Signal
subplot(3, 2, 3);  % 3 rows, 2 columns, third subplot
stem(n, X_increasing, 'filled');
title('Increasing Exponential Signal (X[n])');
xlabel('n');
ylabel('Amplitude');
grid on;
axis tight;
% Subplot 4: Decreasing Exponential Signal
subplot(3, 2, 4);  % 3 rows, 2 columns, fourth subplot
stem(n, X_decreasing, 'filled');
```

```
title('Decreasing Exponential Signal (X[n])');
xlabel('n');
ylabel('Amplitude');
grid on;
axis tight;
% Subplot 5: Impulse Signal
subplot(3, 2, 5);  % 3 rows, 2 columns, fifth subplot
stem(n, d, 'filled');
title('Impulse Signal (d[n])');
xlabel('n');
ylabel('Amplitude');
grid on;
axis tight;
% Adjust layout for better presentation
sgtitle('Discrete-Time Signals and Operations'); % Add a title for the entire
figure
```



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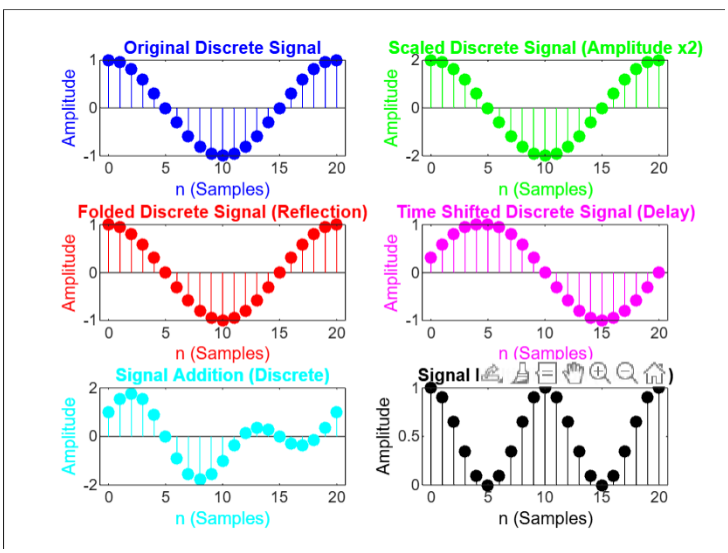
Operations on Signals:

1. Addition of signals.
2. Subtraction of signals.
3. Multiplication of two signals.
4. Scaling – Upscaling & Downscaling.
5. Shift operation – Advance/Right shift & Delay/Left shift.

```
   % DSP Lab - Discrete-Time Scaling, Folding, Shifting, Addition,
Multiplication

   % Create a discrete-time signal (e.g., a simple discrete sine wave)
   n = 0:20;  % Discrete-time index (samples)
   f = 5;      % Frequency of the sine wave (Hz)
     % Generate the discrete sine wave signal x = cos(2*pi*f*n/100);
   x = cos(2*pi*f*n/100);

   % Plot the original signal
   figure;
   subplot(3,2,1);
   stem(n, x, 'filled');
   title('Original Discrete Signal');
   xlabel('n (Samples)');
   ylabel('Amplitude');

   % 1. Scaling Function (Amplitude Modification)
   scaled_x = 2 * x;  % Scale the signal by a factor of 2
   subplot(3,2,2);
   stem(n, scaled_x, 'filled');
   title('Scaled Discrete Signal (Amplitude x2)');
   xlabel('n (Samples)');
   ylabel('Amplitude');

   % 2. Folding Function (Reflection)
   folded_x = x(end:-1:1);  % Flip the signal in time (folding)
   subplot(3,2,3);
   stem(n, folded_x, 'filled');
   title('Folded Discrete Signal (Reflection)');
   xlabel('n (Samples)');
   ylabel('Amplitude');

   % 3. Time Shifting Function (Delay)
   shift_amount = 5;
shifted_x = zeros(size(x));  % Initialize with zeros
for i = 1:length(x)
   new_index = mod(i + shift_amount - 1, length(x)) + 1;  % Handle the
circular shift manually
   shifted_x(new_index) = x(i);
end
 % Shift the signal by 5 samples
   subplot(3,2,4);
   stem(n, shifted_x, 'filled');
   title('Time Shifted Discrete Signal (Delay)');
   xlabel('n (Samples)');
   ylabel('Amplitude');
```

```
% 4. Addition Function (Signal Addition)
% Create another discrete signal to add
y = sin(2*pi*2*f*n/100);  % Another discrete sine wave with frequency 2*f
added_x = x + y;  % Add both signals together
subplot(3,2,5);
stem(n, added_x, 'filled');
title('Signal Addition (Discrete)');
xlabel('n (Samples)');
ylabel('Amplitude');

% 5. Multiplication Function (Signal Multiplication)
% Multiply the original signal by another signal (e.g., modulated by a
cosine wave)
modulated_x = x .* cos(2*pi*f*n/100);  % Multiply by a cosine wave
subplot(3,2,6);
stem(n, modulated_x, 'filled');
title('Signal Multiplication (Discrete)');
xlabel('n (Samples)');
ylabel('Amplitude');
```



Conclusion:-

With help of Matlab we were able to represent discrete time signals and perform different operations on them

Post Lab Questions

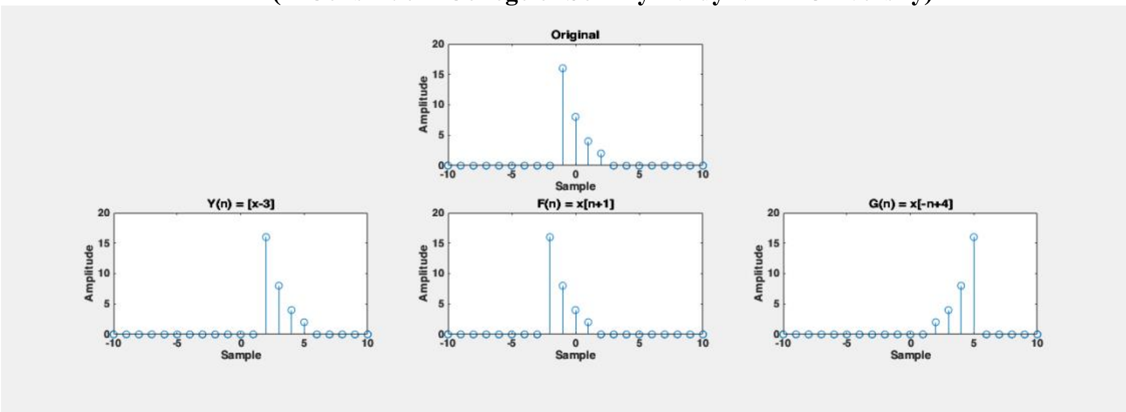
1. **Let x(n) = 8(0.5)^n (u[n+1] - u[n-3]). Sketch the following signals**

I.Y(n) = [x-3]

II.F(n) = x[n+1]

III.G(n) = x[-n+4]

```
u = @(n) 1.*(n>=0);
x = @(n) 8.*((0.5).^n).*(u(n+1) - u(n-3));

n = -10:1:10;

X = x(n);
subplot(3,3,2);
stem(n,X)
xlabel("Sample");
ylabel("Amplitude");
title("Original");

Y = x(n-3);
subplot(3,3,4);
stem(n,Y);
xlabel("Sample");
ylabel("Amplitude");
title("Y(n) = [x-3]");

F = x(n+1);
subplot(3,3,5);
stem(n,F);
xlabel("Sample");
ylabel("Amplitude");
title("F(n) = x[n+1]");

G = x(-n+4);
subplot(3,3,6);
stem(n,G);
xlabel("Sample");
ylabel("Amplitude");
title("G(n) = x[-n+4]");
```



2. The process of conversion of continuous time signal into discrete time signal is known as <u>Sampling</u>

3. Which of the following is example of deterministic signal?

a. Step
b. Ramp
c. Exponential
d. All of the above

Ans: c. Exponential

4. For energy signals the energy will be finite and the average power will be <u>0</u>

5. In a signal x(n), if ‘n’ is replaced by ‘n/3’ the it is called <u>Expansion</u>

6. The system y(n)=sin[x(n)] is

a. Stable
b. BIBO stable
c. Unstable
d. None of the above

Ans: d. None of the above