

## Lab # 4

### Signals & their Classifications

#### Objective:

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#### Introduction:

Signals are the pattern of variation that contains some sort of information. Information may be stored in memory or just transient information in real time as in communication systems.

There can be many classifications of signals; some of the classifications are listed below:

1. Continuous Time vs. Discrete Time Signals
2. Analog vs. Digital Signals
3. Periodic vs. Aperiodic Signals
4. Even vs. Odd Signals
5. Deterministic vs. Random Signals:

#### **1. Continuous Time vs. Discrete Time Signals:**

##### **a) Continuous Time Signals:**

- Continuous Time Signal is the one whose domain is uncountable, we don't care about range.
- For storing the continuous time signal you need infinite memory which is not possible in any real system. So, finite no of samples of a continuous time signals are stored.
- For plotting the continuous time signals we use plot command, which simply connects the values of intermediate samples, gives us the illusion of continuous time signals.

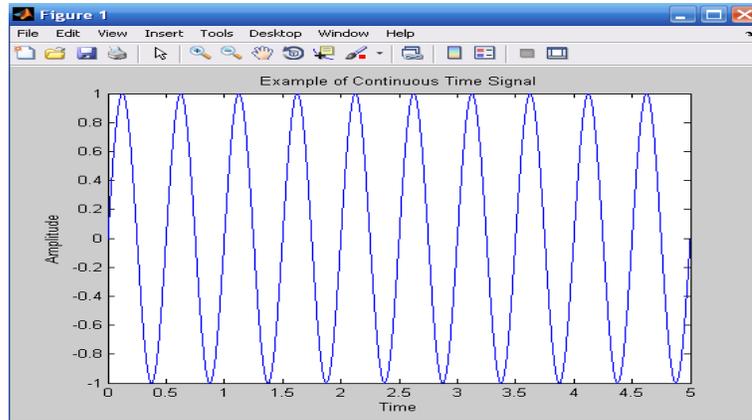
##### **%Continuous Time Signal Example**

```
f=2; %Frequency
t=(0:0.01:2*pi); %Horizontal time axis
x= sin(2*pi*f*t );
plot(t,x)
```

```

title('Example of Continuous Time Signal');
xlabel ('Time');
ylabel ('Amplitude');

```



**b) Discrete Time Signals:**

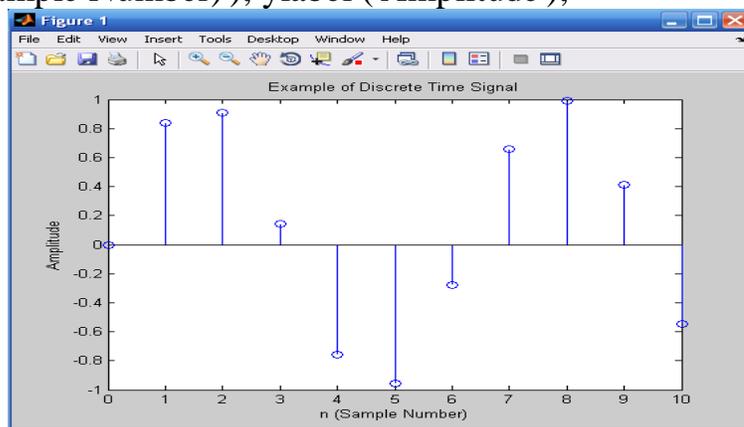
- Discrete Time Signals are those signals which are purely based upon domain, whose domain is countable. We don't care about range of the signal.
- In MATLAB we can plot any discrete time signal for example using stem command as follows:

**%Discrete Time Signal Example**

```

A=1
f=1;           % Frequency
n=0:10;       % Sample Number
y= A*sin(f*n);
stem(n,y);
title('Example of Discrete Time Signal');
xlabel ('n (Sample Number)'); ylabel ('Amplitude');

```



## 2. Analog vs. Digital Signal:

This classification of signal is purely based on range, we don't care about the domain.

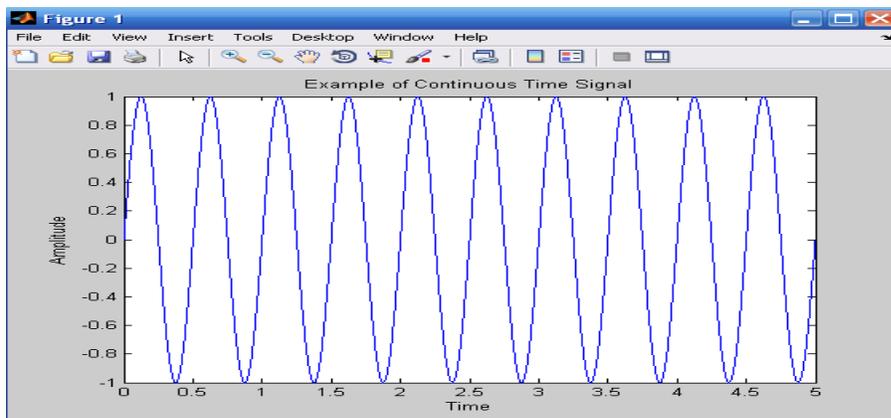
### a) Analog Signals:

Analog Signals can take infinite values in range.

In MATLAB we can plot any continuous time signal for example. using **plot** command as follows:

### %Analog Signal Example:

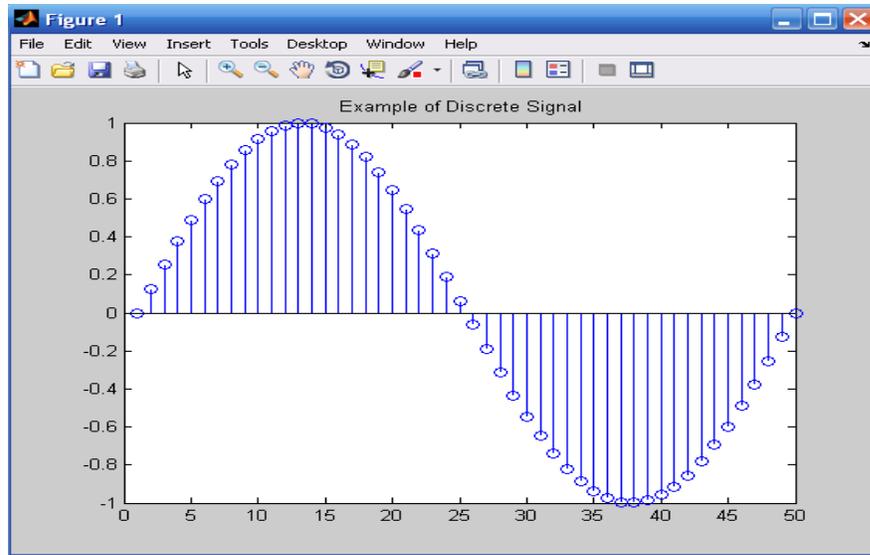
```
f=2; %Frequency
t=(0:0.01:2*pi); %Horizontal time axis
x= sin(2*pi*f*t );
plot(t,x)
title('Example of Continuous Time Signal');
xlabel ('Time');
ylabel ('Amplitude');
```



We can also plot analog signal using stem command.

### %Example of Discrete Time Analog Signal

```
x= linspace(0,2*pi,50)';
y = sin(x)
stem(y)
title(' Example of Discrete Signal')
```



**b) Digital Signal:**

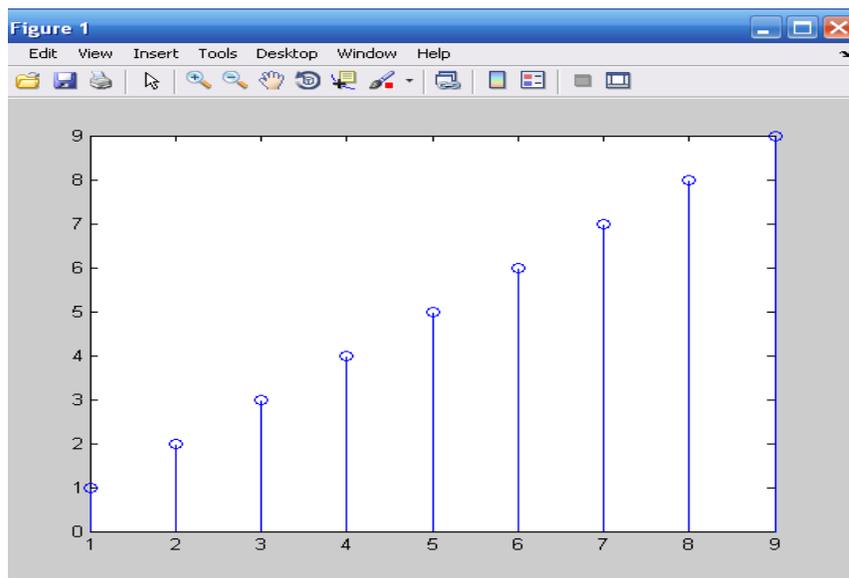
- Digital signal is the one which can take countable finite values in range.
- In MATLAB we can plot digital signal for example a random bipolar data using stem or plot commands

**%Digital Signal Example**

`d=[1 2 3 4 5 6 7 8 9]`

`n=1:9`

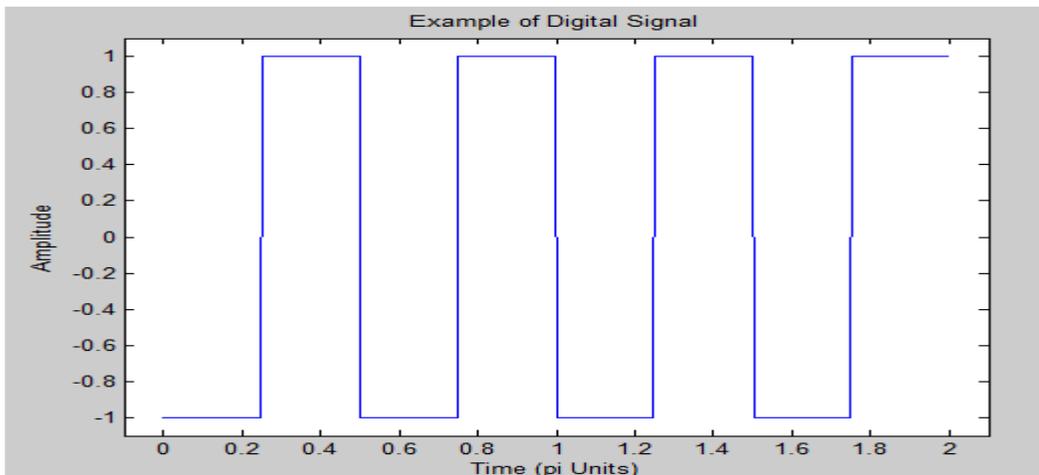
`stem(n,d)`



Square wave is another example of Digital signal.

### %Digital Signal Example

```
f=2; %Frequency
phase=pi; %Phase
t=(0:0.01:2*pi)/pi; %Horizontal time axis
plot(t, square(2*pi*f*t+phase));
axis([-0.1,2.1,-1.1,1.1]);
title('Example of Digital Signal');
xlabel ('Time (pi Units)');
ylabel ('Amplitude');
```



### 3. Periodic vs. Aperiodic Signals:

#### a) Periodic Signals:

- A signal which repeats its pattern after a specific interval of time is called periodic signal.

Where N is the fundamental time period.

In MATLAB we can generate a periodic signal using following code:

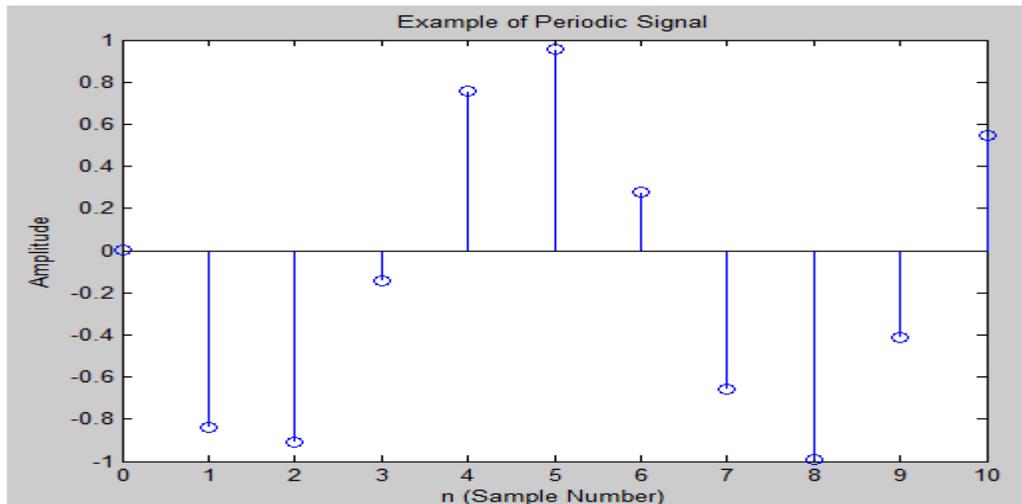
### %Periodic Signal Example

```
A=1; % Amplitude
f=1; % Frequency
phase=pi; % Phase
```

```

n=0:10;           %Sample Number
stem(n,A*sin(f*n+phase));
title('Example of Periodic Signal');
xlabel ('n (Sample Number)');
ylabel ('Amplitude');

```



**b) Aperiodic Signals:**

- The opposite of a periodic signal is an aperiodic signal
- A signal which does not repeat its pattern after a specific interval of time is called aperiodic signal.

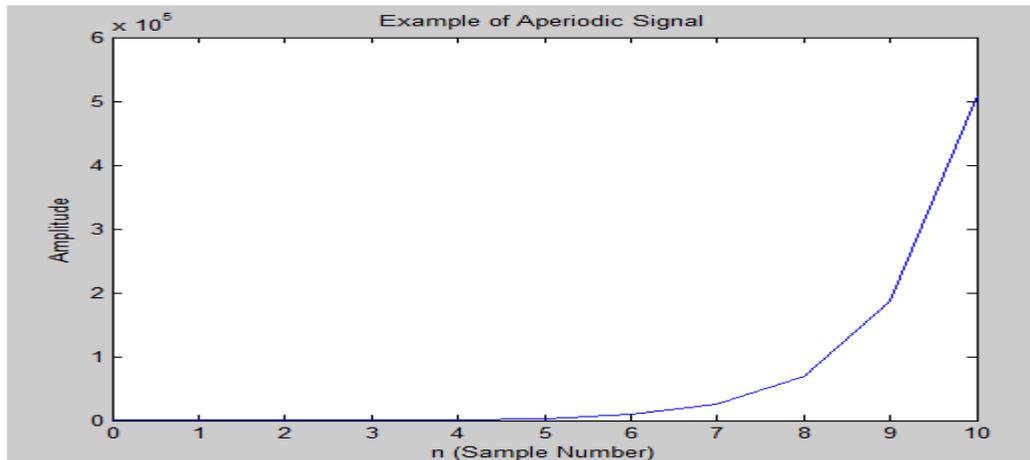
In MATLAB we can generate an Aperiodic signal using following code:

**%Aperiodic Signal Example**

```

A=1;           %Amplitude
f=1;           %Frequency
phase=pi;      %Phase
n=0:10;        %Sample Number
plot(n,A*exp(f*n+phase));
title('Example of Aperiodic Signal');
xlabel ('n (Sample Number)');
ylabel ('Amplitude');

```



## **4. Even vs. Odd Signals**

### **a) Even Signals:**

- If  $x(-n) = x(n)$  then signal is called even signal.
- Cosine function is an example of even signal.

### **%Even Signal Example**

```
t=0:0.1:10;
even_s=cos(-t);
plot(even_s)
title(' Example of Even Signal')
```

### **b) Odd Signals:**

- If  $x(-n) = -x(n)$  then signal is called odd signal.
- Sine function is an example of odd signal.

### **%Odd Signal Example**

```
t=0:0.1:10;
odd_s=sin(-t);
plot(odd_s)
title(' Example of Odd Signal')
```

## **4. Deterministic vs. Random Signals:**

**a) Deterministic Signal:**

- A deterministic signal is one which can be completely represented by Mathematical equation at any time.
- In a deterministic signal there is no uncertainty with respect to its value at any time.

**All the examples given above are of deterministic signals.**

**b) Random Signal:**

- Stochastic signals, or random signals, are not so nice.
- Random signals cannot be characterized by a simple, well-defined mathematical equation and their future values cannot be predicted. Rather, we must use probability and statistics to analyze their behavior.
- Also, because of their randomness, average values from a collection of signals are usually studied rather than analyzing one individual signal.

## Post Lab Questions

a) What is a periodic signal? Give example.

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b) What is 'stem' command used for?

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c) Give an example of Deterministic and Random Signal each , other than those mentioned in lab.

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d) Differentiate between Continuous Time Signal and Discrete time Signal.

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## Lab Tasks

### Task 1

a) The general form of a sine wave is

$$y = A\sin(2\pi f t + \varphi)$$

Generate a continuous sine wave given the following specifications:

- $A = 5$
- $f = 2 \text{ Hz}$
- $\varphi = \pi/8$  radians

b) Plot 4 different discrete signals in same graph.

### Task 2

a) Verify the following statements

- $x(-n) = x(n)$ , for even signal.
- $x(-n) = -x(n)$ , for odd signal.

**HINT:** Cos function is an example of Even signal and Sine function is an example of Odd signal.

b) Generate a digital signal containing number of samples equal to sum of your Student ID.

### Task 3

a) Give an example for Periodic and Aperiodic each (other than those mentioned in the lab) and plot them in MATLAB.

b) Plot any deterministic and random signal and plot them in the same graph window.