INTRODUCTION

Signal: Any physical quantity which varies with time, space or any other independent variable.

Eg: i) A signal varying with time i.e. the values of the signal vary as a function of time.

$X(t) = 3*t$

ii) An equation of a plane i.e. a signal dependent on two independent variables (In this case the variables being the x and y co-ordinates).

$F(x,y) = x + 3xy + y^2$

System: Any physical device which performs some operation on a signal.

Eg: i) Filter: A filter is a system which removes all undesired information like noise,interference from the signal.

Classification of signals:

1. **Continuous time signals**: The signals are a function of a continuous variable like time, space etc. Most of the signals encountered in engineering are continuous in nature.

Eg: i) Signals produced by speech

ii) An electrical signal like voltage, current are continuous in nature.

2. **Discrete time signals**: These signals are a function of discrete integers. These signals are commonly used in signal processing.

Eg: i) A clock signal is a discrete time signal.

Advantages of discrete time signals:

1. Robustness

2. Storage capability

3. Flexibility

4. Regeneration

SAMPLING:

Discrete time signals are produced by a process called “Sampling”.

Sampling means “selecting the values of an analog/continuous time signal at discrete intervals of time “.

Eg: Uniform sampling: It is described by the equation

x(n) = x(nT) = x(n/Fs) where T = Sampling rate and Fs = sampling frequency

Sampling theorem:

The rate at which the signal should be sampled in order to reproduce it at the receiver is defined by the sampling theorem.

Theorem: If the highest frequency contained in an analog signal x(t) is Fm and the signal is sampled at a rate Fs >= 2Fm, then x(t) can be exactly recovered from its samples.

The sampling rate Fs = 2Fm is termed as the Nyquist rate.

Aliasing:

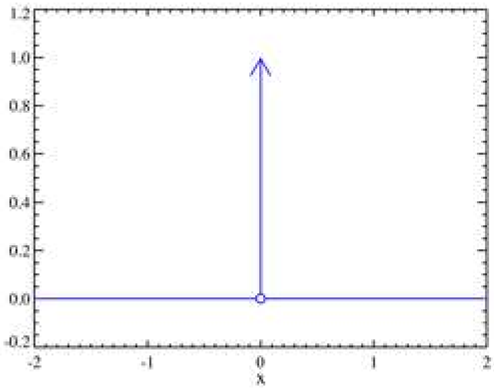
The effect of undersampling i.e. when Fs< 2Fm can be explained by a phenomenon known as “Aliasing”.

Sampling in time domain results in periodic replication of the spectrum in the frequency domain.

Elementary Discrete time signals:

1. **Unit impulse sequence**: It is denoted by δ(n) and is defined as

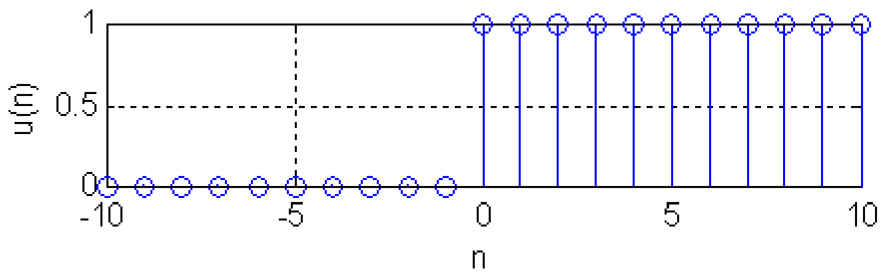
$$\delta(n) = 1, \text{ for } n=0$$
$$= 0, \text{ otherwise}$$



2. **Unit step sequence**: It is denoted by u(n) and defined as

$$u(n) = 1, \text{ for } n>=0$$

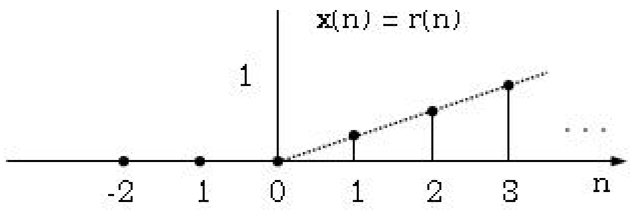
$$= 0, \text{ otherwise}$$



3. **Unit ramp signal**: It is denoted by r(n) and is defined as

$$r(n) = n, \text{ for } n>=0$$

$$= 0, \text{ otherwise}$$



4. **Exponential signal:** It is a sequence of the form

$$x(n) = a^n \text{ for all } n$$

and the parameter 'a' can be real or complex.

Basic operations on signals:

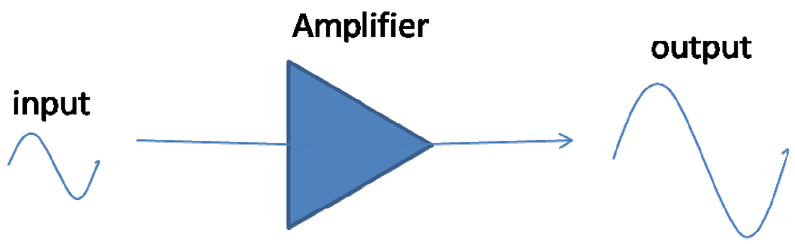
1. **Amplitude scaling**: It is defined by the equation

$$y[n] = c*x[n]$$

Where x(t) is the input signal and c is the amplification factor.

This implies that the value of the signal is multiplied by c at every point n.

Eg: An amplifier is a physical device which performs amplification of the signal.



2. **Addition:** It is defined by the equation

$$y[n] = x1[n] + x2[n]$$

The values of x1[n] and x2[n] are added at every instant n.

Eg: An audio mixer is an example of an adder. It adds the voice and music signals.

3. **Multiplication**: It is defined by the equation

$$y[n] = x1[n] * x2[n]$$

Eg: A DSBSC modulation scheme is an example for multiplication of signals. In DSBSC, the carrier signal is multiplied with the message signal before transmission..

Operations on independent variable:

1. **Time scaling**: It is defined as

$$y[n] = x[an]$$

where ‘a’ is an integer

2. **Reflection**: It is defined by the equation

$$y[n] = x[-n]$$

It is a signal which is a reflected version of the input signal about the amplitude axis.

3. **Time shifting**: It is defined by the equation

$$y[n] = x[n - n_0]$$

where n_0 is an integer.

Precedence rule for time shifting and time scaling:

In case of a system function, $y[n] = x[an - n_0]$, priority should first be given to time shifting followed by time scaling.

Eg: $y[n] = x[2n + 3]$

Step 1: Perform time shifting.

Let $z[n] = x[n+3]$

Step 2: Perform time scaling on the signal z[n]

$y[n] = z[2n]$

SYSTEMS

A system is any physical device which performs some operation on a signal.

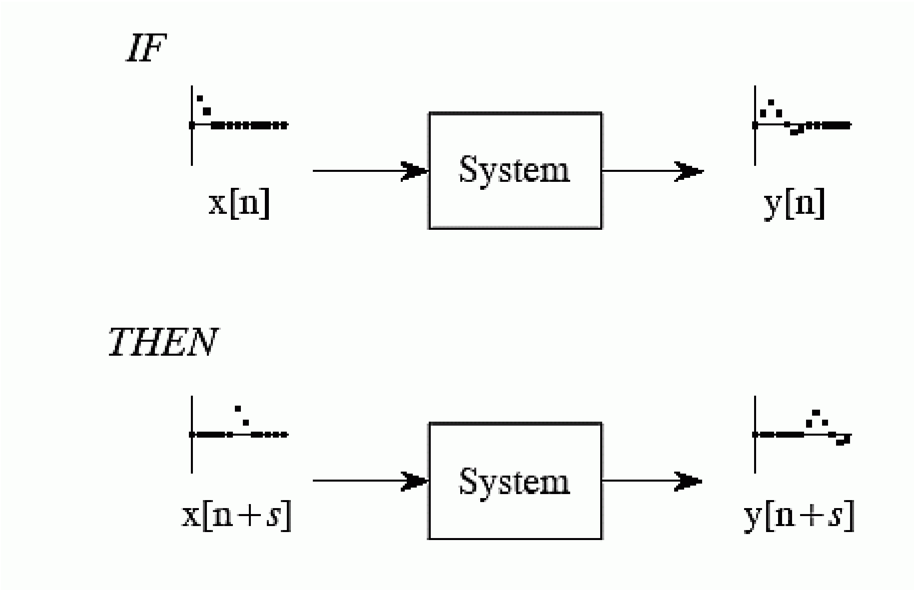
Properties of systems:

1. **Stability**: A system is said to be stable if every bounded input produces a bounded output.

A sequence x[n] is bounded if and only if there exists $M>=0$ such that $|x[n]| <=M$ for all n.

Eg: $y[n] = (0.5)^n\ u(n)$ is an example of a stable system.

2. **Shift Invariance**: A system is said to be shift invariance if a time delay or time advance in input signal produces an identical shift in the output signal.



3. **Causality**: A system is said to be causal if the present value of the output signal depends only or the present or the past values of the input signal.

Eg: y[n] = x[n] + x[n-1]

4. **Linearity**: A system is said to be linear if it satisfies the principle of superposition i.e. it obeys the principles of additivity and homogeneity.