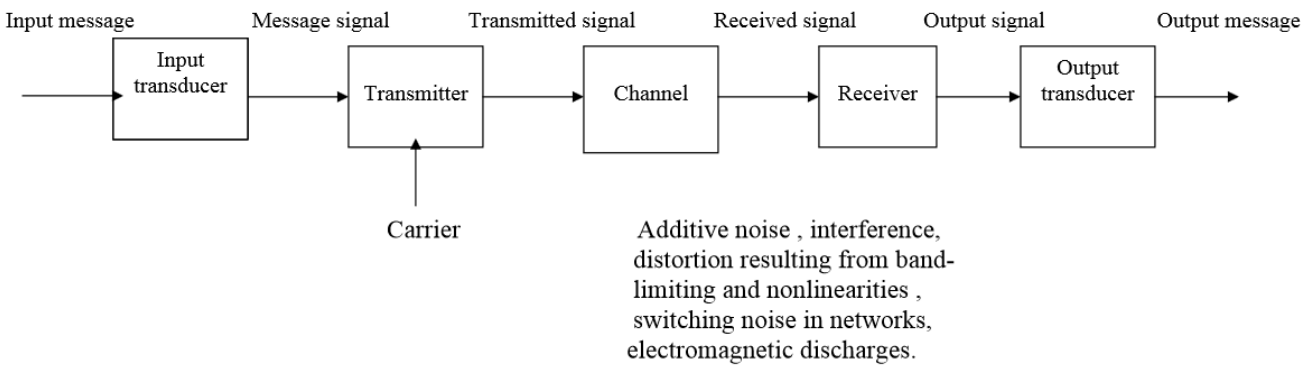
Lecture One

Introduction to Communication Engineering

The principle objective of a communication system is to transmit information signals from one point to another. The information signals may be the result of a voice message, a T.V. picture, a meter reading, or may take on a variety of other formats depending on the specific application. Communication Engineering involves the analysis, design, and fabrication of an operating system that performs the communication objective.

Functional Elements of a Communication System

Communication system between two remotely located points can be illustrated by the following diagram.



Block Diagram of a Communication System .

Usually, Systems involve three major subsystems:

1. Transmitter,
2. Channel ,
3. Receiver.

We will now discuss briefly each functional element shown in Fig. 1

1. Input Transducer

Converts source signal to electric signal

a. Microphone

b. Camera

c. Keyboard

2. Transmitter:

a. The purpose of the transmitter is to couple the message to the channel.

b. Modulate a carrier wave with the signal from the input transducer.

Modulation Reasons:

There are several reasons for using a carrier and

(1) Ease of radiation,

(2) Reduce noise and interference,

(3) Channel assignment,

(4) Multiplexing or transmission of several messages over a single channel,

(5) Overcome equipment limitations.

3. Channel:

Medium used to transfer signal from transmitter to receiver. Point to point or Broadcast and it is Often adds noise / weakens & distorts signal

All channels have one thing in common: the signal undergoes degradation from transmitter to receiver. This degradation results from noise and other undesired signals or interference but also may include other distortion effects as well, such as fading signal levels, multiple Transmission paths and filtering.

Wireline	Wireless
1. physically connect transmitter to receiver with a "wire",	1. Logical connection over a multiplexed medium,
2. more private and much less prone to interference,	2. Less,
3. Not,	3. Allowing portable transmission and reception,
4. Coaxial Cable, Fiber Optics…Etc.	4. Radio Channel.

3. Receiver:

a. The receiver's function is to extract the desired message from the received signal at the channel output and to convert it to a form suitable for the output transducer.

b. Amplification, where the received signal may be extremely weak ,

c. The main function of the receiver is to demodulate the received signal.

4. Output Transducer:

The device converts the electric to the original message signal at its input into the form desired by the system user.

a. Loudspeaker ,

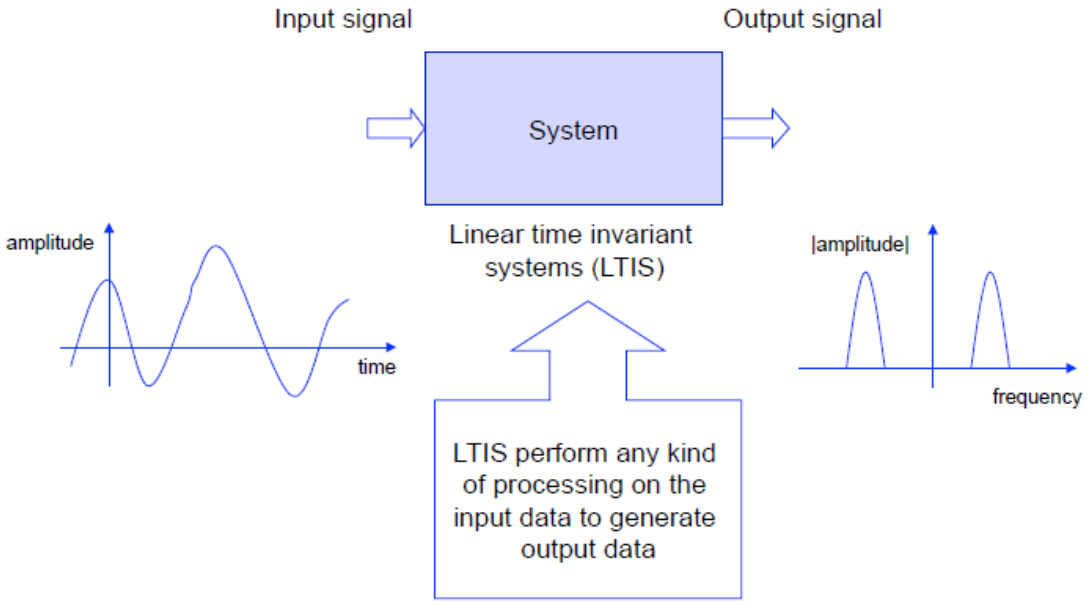
b. Recorders,

c. Personal computers,

d. Meters ,

e. Cathode – ray tubes.

Signals and Systems



Signals are a set of information or data like telephone or television signals. Signals are represented mathematically as a function of one or more independent variable. Signal may be processed using systems which may modify them or extract additional information from them.

System is an entity that processed a set of signals (inputs) to yield another set of signals (outputs). Systems may be made up of physical components as in electrical, mechanical systems (Hardware realization), or they may be an algorithms that compute the output from input signals (software realization).

Example of signals

1. Electrical signals like voltages, current and EM field intensity in Circuit,
2. Acoustic signals like audio or speech signals (analog or digital),
3. Video signals like intensity variation in an image,
4. Biological signal like sequence of bases in gene,
5. Noise which will be treated as unwanted signal.

Signal Classification

1. Continuous-time Signal

A continuous-time signal is a signal that can be defined at every instant of time. A continuous-time signal contains values for all real numbers along the X-axis. It is denoted by *x (t)*.

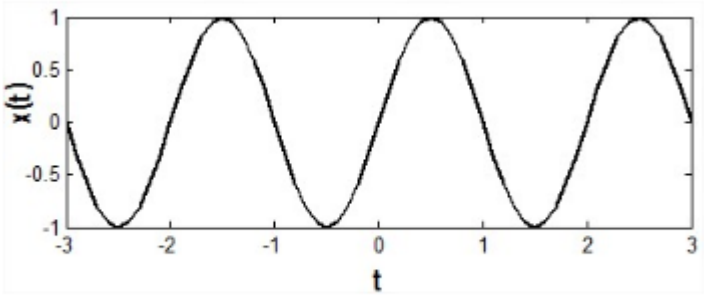


Fig.1(a) Continuous-time signal

2. Discrete-time Signal

Signals that can be defined at discrete instant of time is called discrete time signal. Basically discrete time signals can be obtained by sampling a continuous-time signal. It is denoted as *x(n)*.Figure 1(b) shows discrete-time signal.

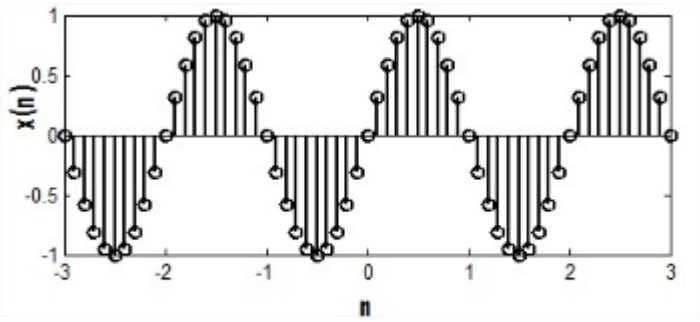


Fig.1(b) Discrete-time signal

3. Periodic and Aperiodic Signal

A signal is said to be periodic if it repeats itself after some amount of time $x(t+T)=x(t)$, for some value of T. The period of the signal is the minimum value of time for which it exactly repeats itself.

Signal which does not repeat itself after a certain period of time is called aperiodic signal. The periodic and aperiodic signals are shown in Figure 2(a) and 2(b) respectively.

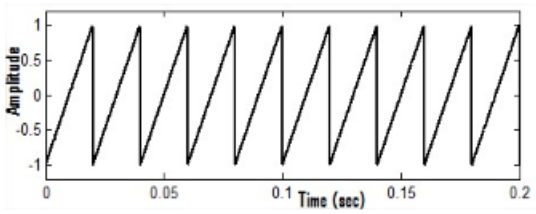


Fig.2(a) Periodic signal

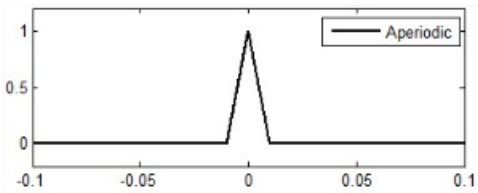


Fig.2(b) Aperiodic signal

4. Random and Deterministic Signal

A random signal cannot be described by any mathematical function, where as a deterministic signal is one that can be described mathematically. A common example of random signal is noise. Random signal and deterministic signal are shown in the Figure 3(a) and 3(b) respectively.

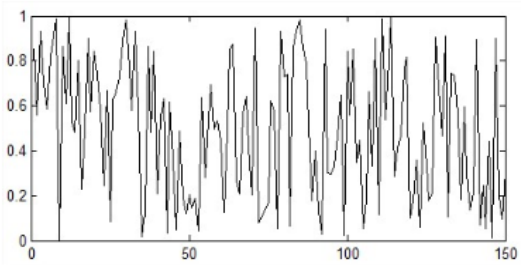


Fig.3(a) Random signal

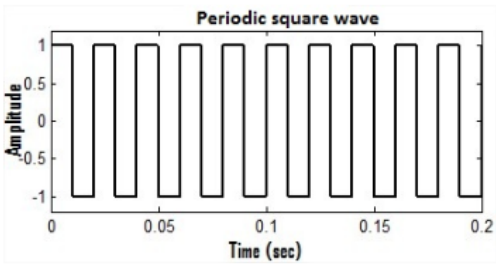


Fig.3(b) Deterministic signal

5. Causal, Non-causal and Anti-causal Signal

Signal that are zero for all negative time, that type of signals are called causal signals, while the signals that are zero for all positive value of time are called anti-causal signal.

A non-causal signal is one that has non zero values in both positive and negative time. Causal, non-causal and anti-causal signals are shown below in the Figure 4(a), 4(b) and 4(c) respectively.

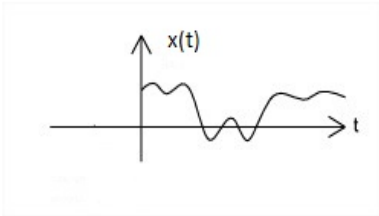


Fig.4(a) Causal signal

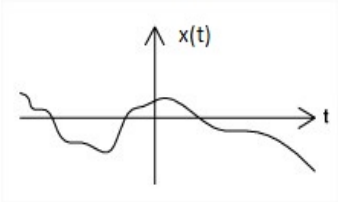


Fig.4(b) Non-caual signal

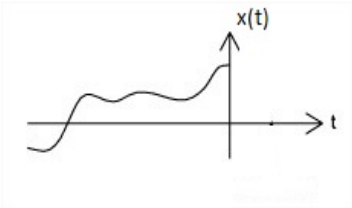


Fig.4(c) Anti-causal signal

6. Even and Odd Signal

An even signal is any signal '*x*' such that *x(t) = x(-t)*. On the other hand, an odd signal is a signal '*x*' for which *x(t) = -x(-t)*. Even signals are symmetric around the vertical axis, so that they can easily spotted.

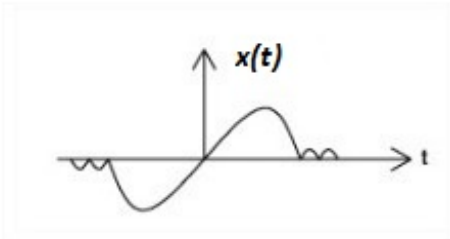


Fig.5(a) Odd signal

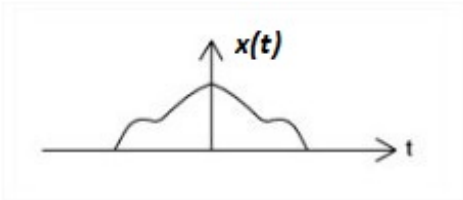


Fig.5(b) Even signal

Properties of signal

1. Amplitude-Scaling of Signal

Consider a signal *x(t)* which is multiplying by a constant *'A'* and this can be indicated by a notation $x(t) \rightarrow Ax(t)$. For any arbitrary 't' this multiplies the signal value *x(t)* by a constant *'A'*. Thus, $x(t) \rightarrow Ax(t)$ multiplies *x(t)* at every value of *'t'* by a constant *'A'*. This is called amplitude-scaling. If the amplitude-scaling factor is negative then it flips the signal with the *t*-axis as the rotation axis of the flip. If the scaling factor is -1 then only the signal will be flip. This is shown in the Figure (a), (b), (c) which is given below.

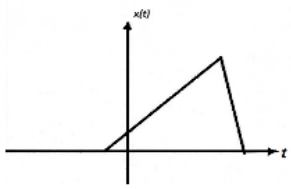


Fig.6(a) A signal x(t)

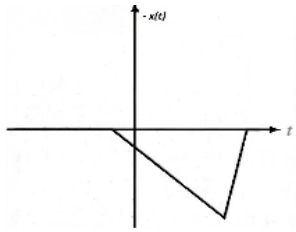


Fig.6(b) A signal x(t) scaled by *-1*

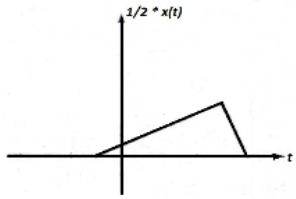


Fig.6(c) A signal x(t) scaled by *1/2*

2. Time-Shifting of Signal

In signals and system amplitude scaling, time shifting and time scaling are some important properties. If a continuous time signal is defined as $x(t) = s(t - t1)$. Then we can say that $x(t)$ is the time shifted version of $s(t)$.

Consider a simple signal $s(t)$ for $0 < t < 1$

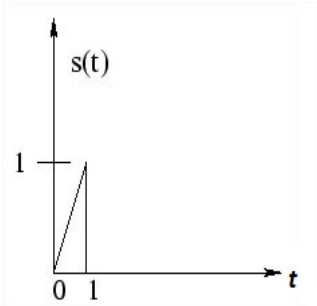


Fig.8(a) Signal within $0< t < 1$

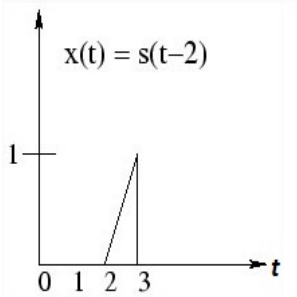


Fig.8(b) Signal shifted by 2 sec.

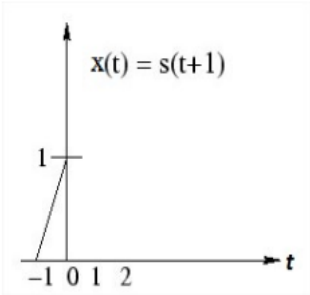


Fig.8(c) Signal shifted by -1 sec.

Now shifting the function by time $t1 = 2$ sec.

$$x(t) = s(t-2) = t-2 \quad \text{for} \quad 0 < (t-2) < 1$$
$$= t-2 \quad \text{for} \quad 2 < (t-2) < 3$$

Which is simply signal $s(t)$ with its origin delayed by 2 sec.

Now if we shift the signal by $t1 = -1$ sec.

$$\text{then } x(t) = s(t+1) = t+1 \quad \text{for} \quad 0 < (t+1)$$
$$= t+1 \quad \text{for} \quad -1 < t < 0.$$

Which is simply $s(t)$ with its origin shifted to the left or advance in time by 1 seconds. This time-shifting property of signal is shown in the Figure 8(a), 8(b) and 8(c) given above.

3. Time-Scaling of Signal

Time scaling compresses or dilates a signal by multiplying the time variable by some quantity. If that quantity is greater than one, the signal becomes narrower and the operation is called compression. If that quantity is less than one, the signal becomes wider and the operation is called dilation or (Expansion). Figure 7(a), 7(b), 7(c) shows the signal x(t), compression of signal and dilation of signal respectively.

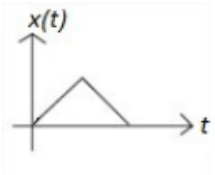


Fig.7(a) Signal x(t)

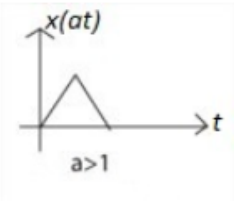


Fig.7(b) Compression of signal

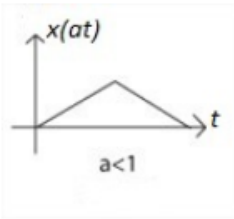
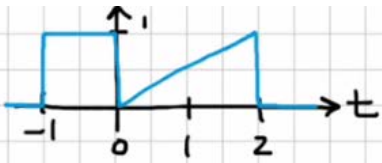


Fig.7(c) Dilation of signal

Example (1)

Consider the signal

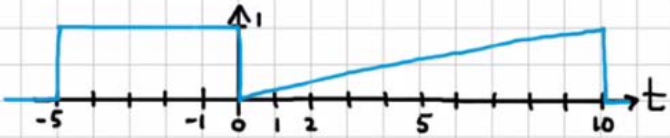


Sketch the following:

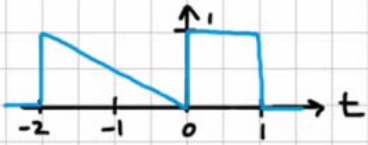
a) $x_1(t) = x(t-2) \Rightarrow$ Time shift 2s to the right (i.e. delay)

b) $x_2(t) = x(2t) \Rightarrow$ Compress in time by factor of 2.

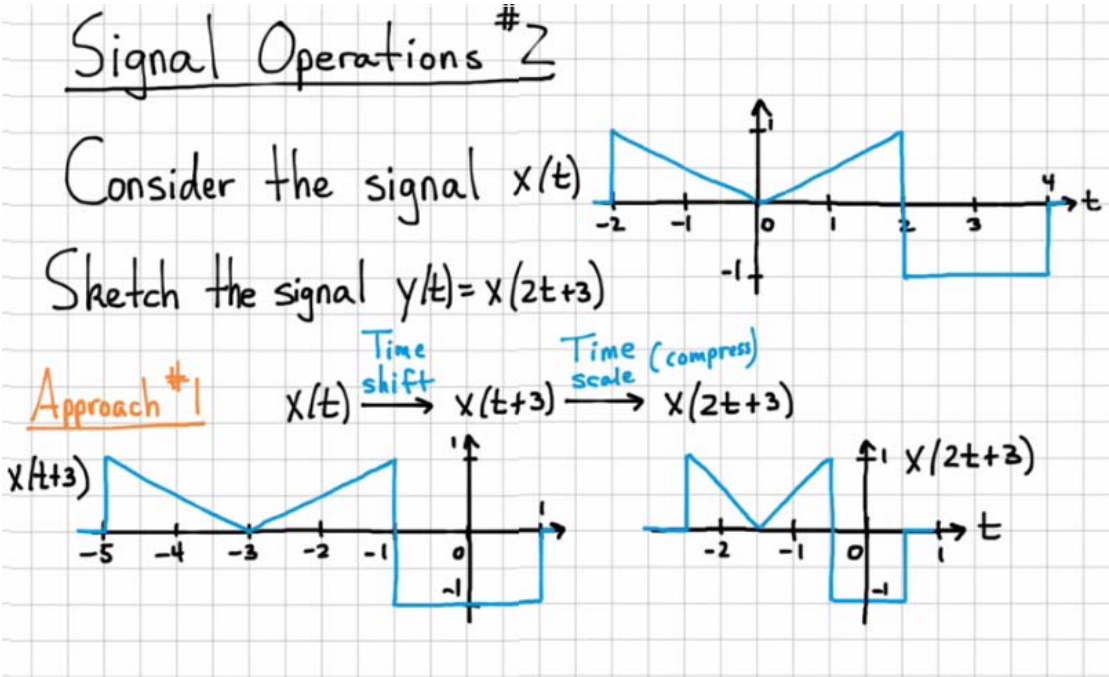
c) $x_3(t) = x(0.2t) \Rightarrow$ Expand in time by factor of $\frac{1}{0.2} = 5$



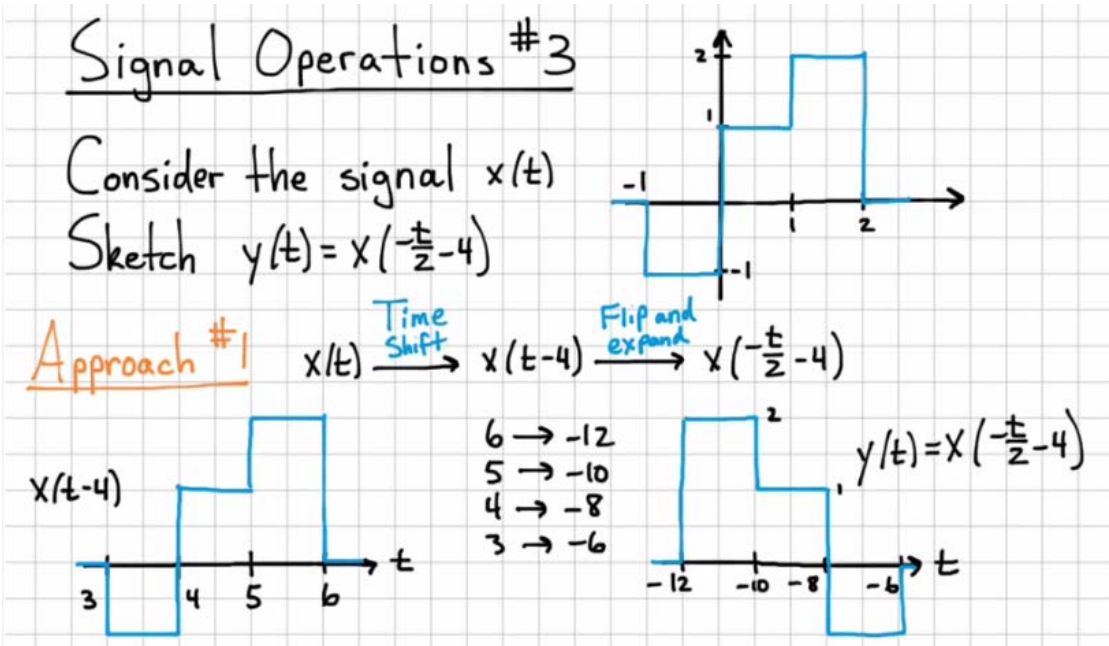
d) $x_4(t) = x(-t) \Rightarrow$ Reverse in time



Example (2)



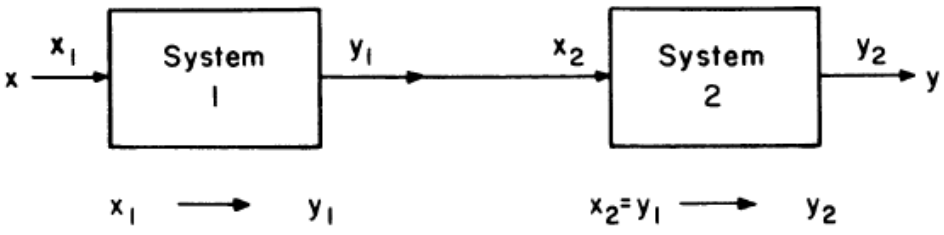
Example (3)



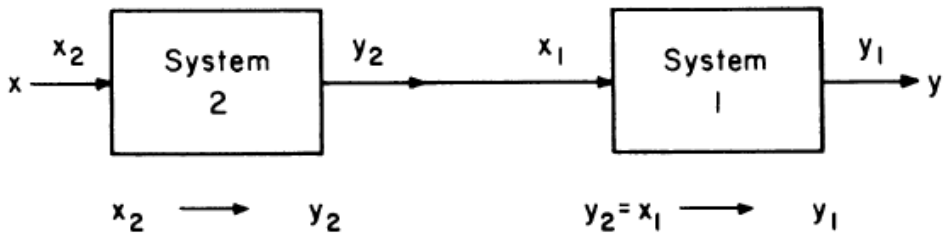
Interconnections of Two Systems:

1. Cascade Interconnection

Cascade



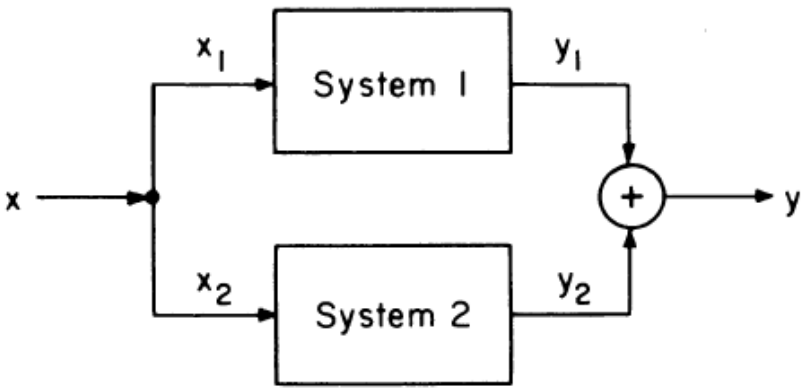
$x_1 \longrightarrow y_1$ $\qquad$ $x_2 = y_1 \longrightarrow y_2$



$x_2 \longrightarrow y_2$ $\qquad$ $y_2 = x_1 \longrightarrow y_1$

2. Parallel interconnection

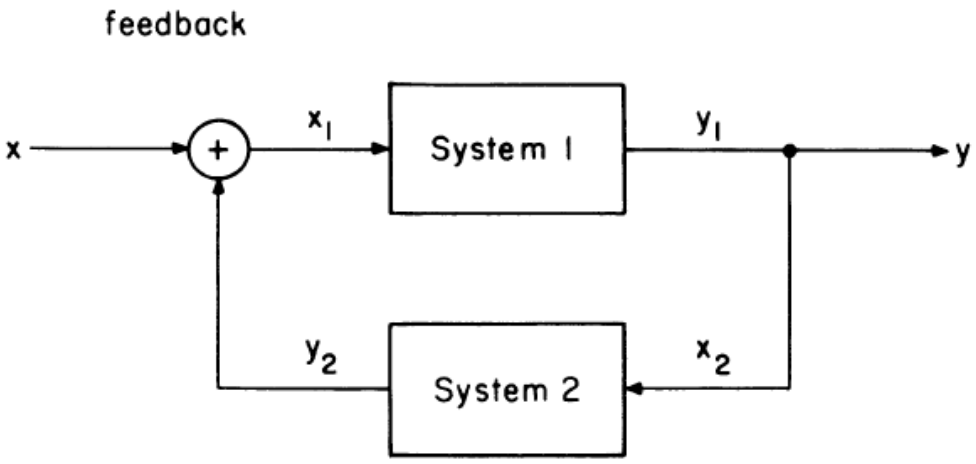
parallel



$x_1 = x_2 = x$

$y = y_1 + y_2$

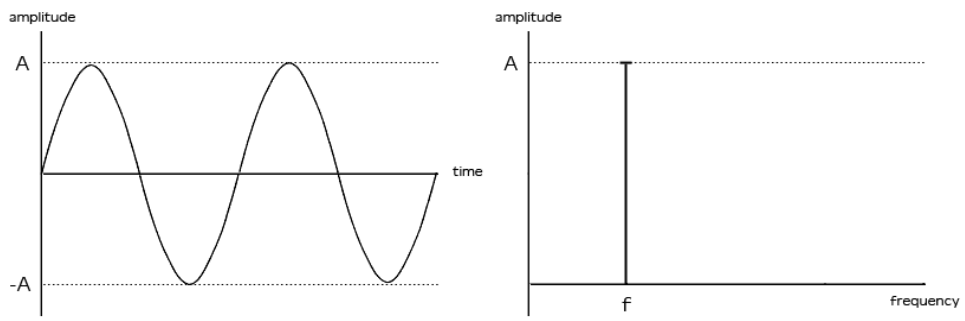
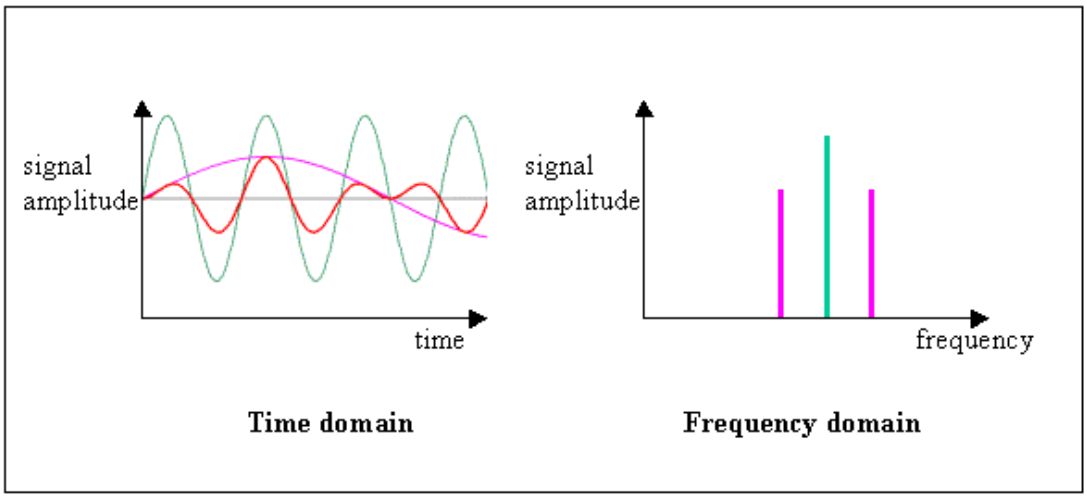
3. Feedback interconnection



$x_1 = x + y_2$

$y = y_1$

$x_2 = y_1$

Signal Domain Analysis

In time-domain we can see a shape of the signal in a certain amount of time (depends on how large the graph is horizontally), in frequency-domain we can see the position of the same signal on the frequency axis and it looks like a vertical line where the height of this line represents the amplitude. In this case we have depictured a single sine frequency and that is the most explicit case – it is simple to view in both graphs.