جامـــــعـة المـــــستـقـبـل
AL MUSTAQBAL UNIVERSITY

# كلية العلـــــوم
# قـــســـــــــم الانــظـــمـــة الـــطـبـيـة الـــذكـــــيـــة

# المحاضرة الثانية

# Digital Signal Processing

**المادة : DSP**
**المرحلة : الثالثة**
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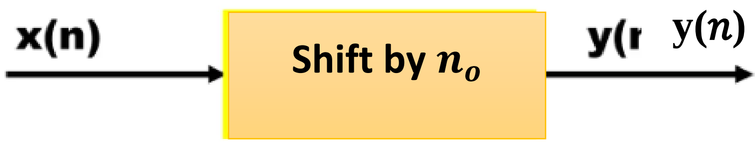
# Operations on Signals

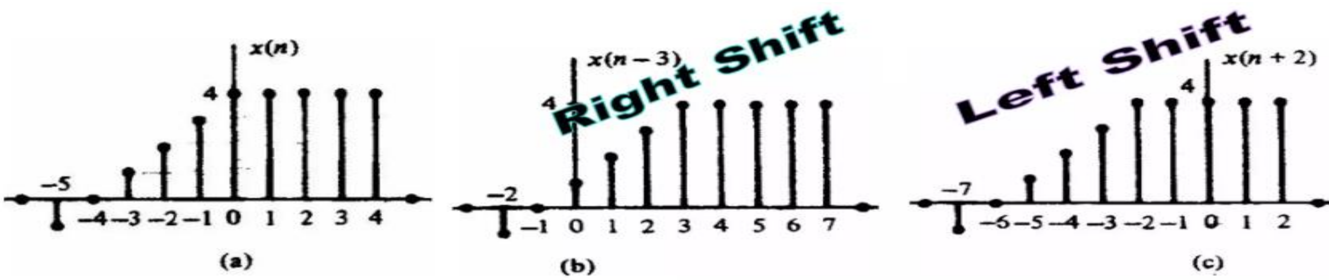
## 2.1. Shifting

Shifting means movement of the signal, either in time domain (around Y-axis) or in amplitude domain (around X-axis).




$y(n) = x(n - n_o)$

If $y(n) = x(n - n_o)$, $x(n)$ is shifted to the right by $n_o$ samples if *no* is **positive** (this is referred to as a delay), and it is shifted to the left by $n_o$ samples if $n_o$ is **negative** (referred to as an advance).




- [a] x(n) = [-1 0 1 2 3 4 4 4 4 4]
- [b] x(n-3) = [-1 0 1 2 3 4 4 4 4 4] [Delayed]
- [c] x(n+2) = [-1 0 1 2 3 4 4 4 4 4] [Advanced]

We can classify the shifting into two categories named as Time shifting and Amplitude shifting, these are subsequently discussed below.

## a- Time Shifting

Time shifting means, shifting of signals in the time domain. Mathematically, it can be written as

$$x(t) \rightarrow y(t+k)$$

This K value may be positive or it may be negative. According to the sign of k value, we have two types of shifting named as Right shifting and Left shifting.

### Case 1 (K > 0)

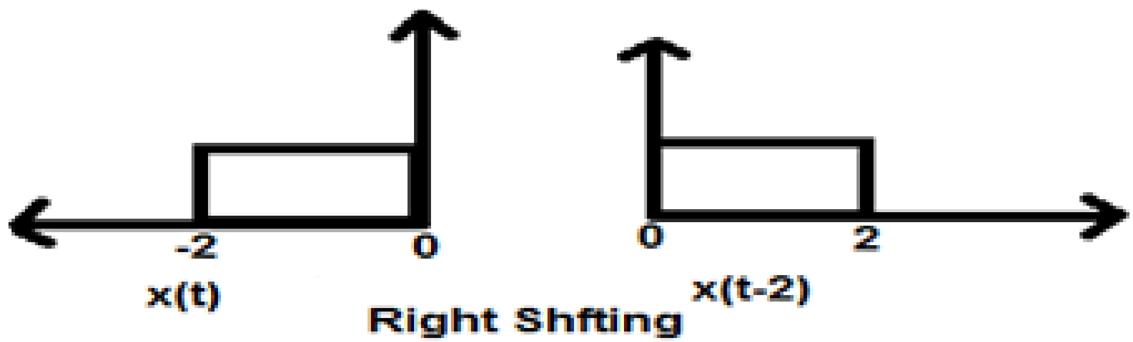
When **K** is greater than zero, the shifting of the signal takes place towards right in the time domain. Therefore, this type of shifting is known as Left Shifting of the signal.

**Example**:


### Case 2 (K < 0)

When K is less than zero the shifting of signal takes place towards right in the time domain. Therefore, this type of shifting is known as Right shifting.

**Example:** The figure given below shows right shifting of a signal by 2.




## b- Amplitude Shifting

Amplitude shifting means shifting of signal in the amplitude domain (around
X-axis). Mathematically, it can be represented as:

$$x(t) \rightarrow x(t)+K$$

This **K** value may be positive or negative. Accordingly, we have two types of
amplitude shifting which are subsequently discussed below.

### Case 1 (K > 0)

When **K** is greater than zero, the shifting of signal takes places towards up in the
x-axis. Therefore, this type of shifting is known as upward shifting.

**Example:**

Let us consider a signal x(t) which is given as:

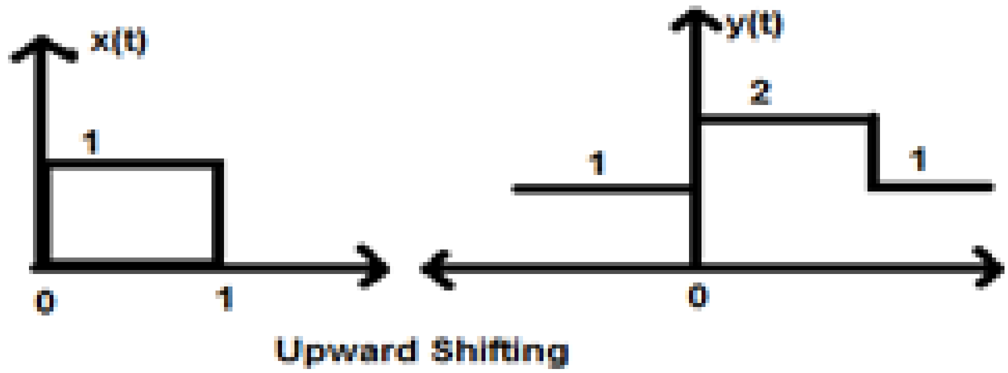
$$x(t) = \begin{cases} 0, t < 0 \\ 1, 0 \leq t \leq 2 \\ 0, t > 0 \end{cases}$$

Let we have taken **K=+1** so new signal can be written as:

$$(t) \to (t) + 1$$

So, **y(t)** can finally be written as:

$$y(t) = \begin{cases} 1, t < 0 \\ 2, 0 \leq t \leq 2 \\ 1, t > 0 \end{cases}$$




**Case 2 (K < 0)**

When **K** is less than zero shifting of signal takes place towards downward in the X- axis. Therefore, it is called downward shifting of the signal.

**Example:** Let us consider a signal x(t) which is given as:

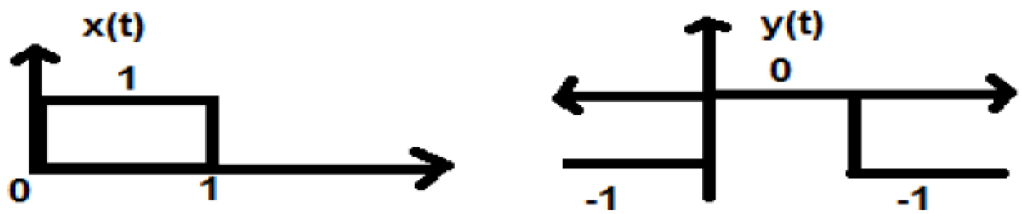
$$x(t) = \begin{cases} 0, t < 0 \\ 1, 0 \leq t \leq 2 \\ 0, t > 0 \end{cases}$$

Let we have taken K=-1 so new signal can be written as:

$$\boldsymbol{(t) \rightarrow (t) - 1}$$

So, **y(t)** can finally be written as:

$$y(t) = \begin{cases} -1, t < 0 \\ 0, 0 \leq t \leq 2 \\ -1, t > 0 \end{cases}$$

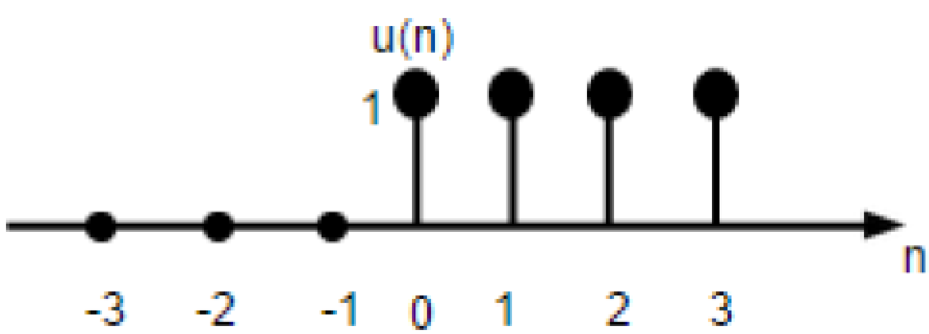



Downward Shfting

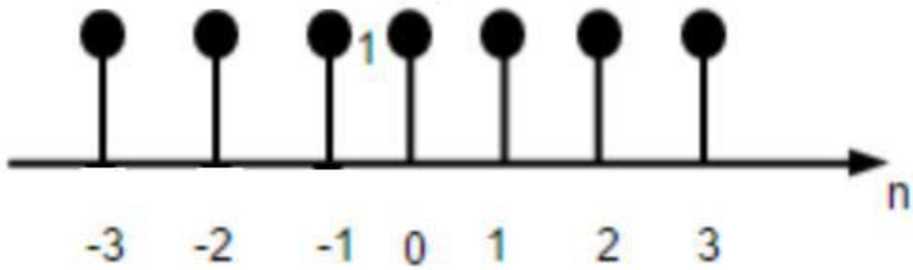
**<u>Example</u>: Find U(n+3)**

**<u>Sol</u>:**

$$\mathrm{U(n)} = \begin{cases} 1, for\ n \geq 0 \\ 0, for\ n < 0 \end{cases}$$



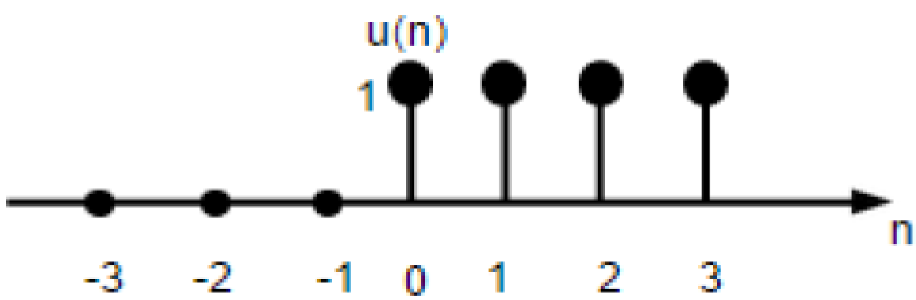

**U(n+3)**



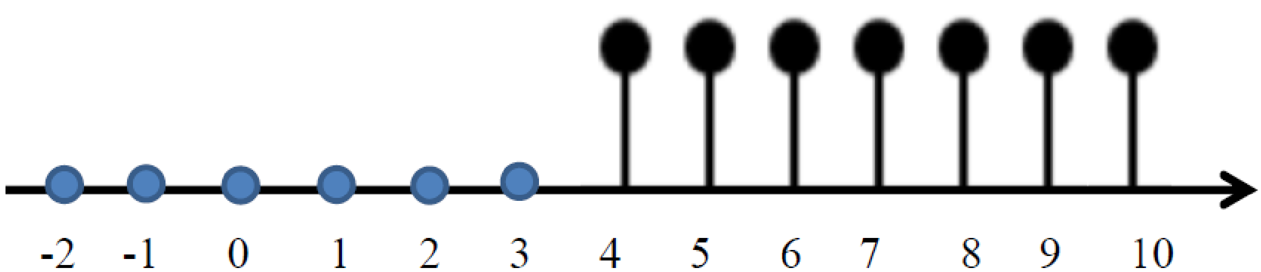

**Example**: Draw U(n-4)

**Sol**:

$$U(n) = \begin{cases} 1, for\ n \geq 0 \\ 0, for\ n < 0 \end{cases}$$




**U(n-4)**



**H.W:**

**- Draw U(n) +2**

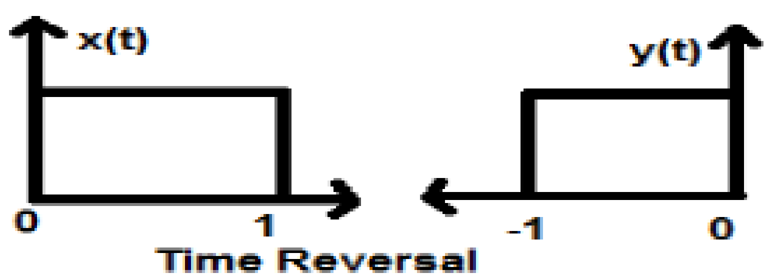
## 2.2. Reversal

### a- Time Reversal

Whenever signal's time is multiplied by -1, it is known as time reversal of the signal. In this case, the signal produces its mirror image about Y-axis. Mathematically, this can be written as;

$$x(t) \rightarrow y(t) \rightarrow x(-t)$$

This can be best understood by the following example.



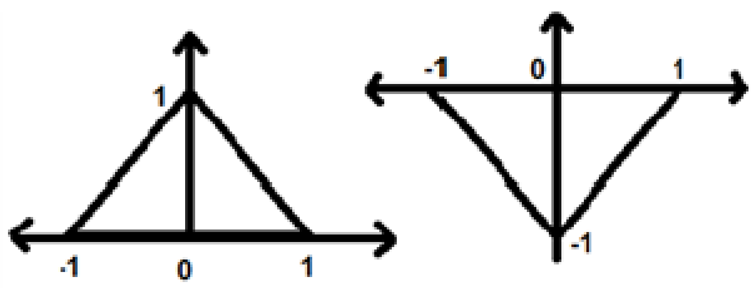

In the above example, we can clearly see that the signal has been reversed about its Y-axis. So, it is one kind of time scaling also, but here the scaling quantity is −1 always.

### b. Amplitude Reversal

Whenever the amplitude of a signal is multiplied by -1, then it is known as amplitude reversal. In this case, the signal produces its mirror image about X-axis. Mathematically, this can be written as:

**x(t)→y(t)→−x(t)**

Consider the following example. Amplitude reversal can be seen clearly.



Amplitude Reversal

## 2.3. Scaling

Scaling of a signal means, a constant is multiplied with the time or amplitude of the signal.

### a. Time Scaling

If a constant is multiplied to the time axis, then it is known as Time scaling. This can be mathematically represented as:

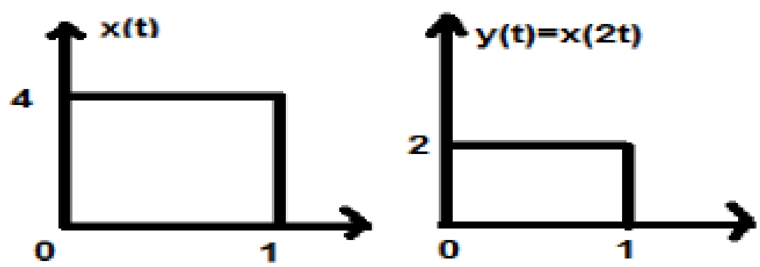
$$x(t) \rightarrow y(t) = x(\alpha t) \;\; or \;\; x\left(\frac{t}{\alpha}\right); \;\; \textbf{where } \alpha \neq 0$$

So the y-axis being same, the x- axis magnitude decreases or increases according to the sign of the constant (whether positive or negative). Therefore, scaling can also be divided into two categories as discussed below.

## Time Compression

Whenever alpha is greater than zero, the signal's amplitude gets divided by alpha whereas the value of the Y-axis remains the same. This is known as Time Compression.

**Example**: Let us consider a signal **x(t)**, which is shown as in figure below. Let us take the value of alpha as 2. So, **y(t)** will be **x(2t)**, which is illustrated in the given figure.




Time Compression

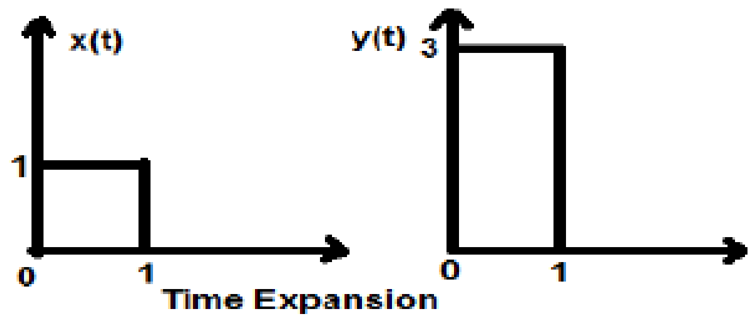
Clearly, we can see from the above figures that the time magnitude in y-axis remains the same but the amplitude in x-axis reduces from **4** to **2**. Therefore, it is a case of Time Compression.

## Time Expansion

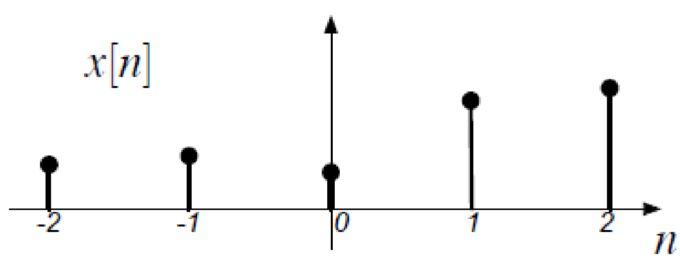
When the time is divided by the constant alpha, the Y-axis magnitude of the signal get multiplied alpha times, keeping X-axis magnitude as it is. Therefore, this is called Time expansion type signal.

**<u>Example</u>**

Let us consider a square signal xtt, of magnitude 1. When we time scaled it by a constant 3, such that x(t)→y(t)→x(t3), then the signal's amplitude gets modified by 3 times which is shown in the figure below.

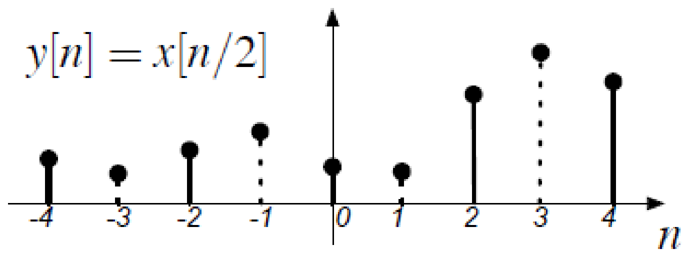



**<u>Example</u>: For x[n] shown below, Find x[n/2].**




**<u>Sol/</u>**

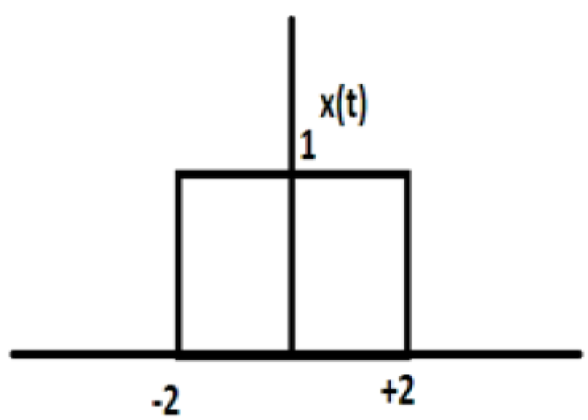
| n | x[n] | y[n]=x[n/2] |
|---|---|---|
| -2 | x[-2] | y[-2]=x[-2/2)]=x[-1] |
| -1 | x[-1] | y[-1]=x[-1/2]=0 |
| 0 | x[0] | y[0]=x[0/2]=x[0] |
| 1 | x[1] | y[1]=x[1/2]=0 |
| 2 | x[2] | y[2]=x[2/2]=x[1] |



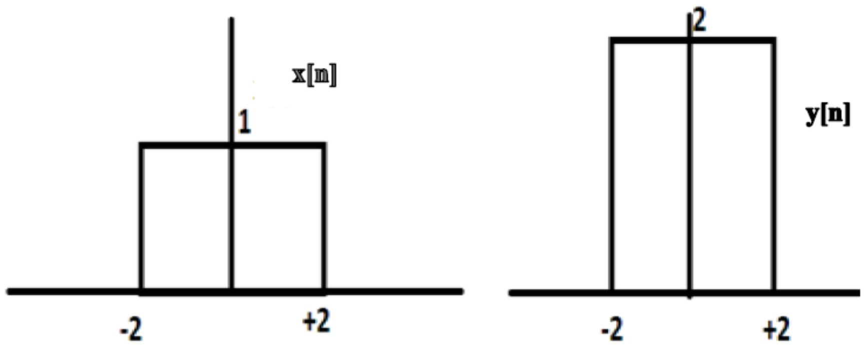

## b- Amplitude Scaling

Multiplication of a constant with the amplitude of the signal causes amplitude scaling. Depending upon the sign of the constant, it may be either amplitude scaling or attenuation.

**<u>Example:</u> For x[n] that shown below, Find 2x[n].**




**<u>Sol/</u>**




Amplitude Scalling

| n | x[n] | y[n]=2x[n] |
|---|---|---|
| -2 | x[-2] | y[-2]=2x[-2]=2*1=2 |
| 2 | x[2] | y[2]= 2x[2]=2*1=2 |