Al-Mustaqbal University

College of Engineering and Technology

Department of Biomedical Engineering

Stage: three

Signal Processing

2023-2024

Lecture (2): Representation of discrete time signal

Signal Processing: Anything that carries information can be called as signal. It can also be defined as a physical quantity that varies with time, temperature, pressure or with any independent variables such as speech signal or video signal. The process of operation in which the characteristics of a signal Amplitude, Shape, Phase, Frequency, etc. undergoes a change is known as signal processing.

Signals may have to be transformed in order to:

- Amplify or filter out embedded information.
- Detect patterns.
- Prepare the signal to survive a transmission channel.
- Undo distortions contributed by a transmission channel.

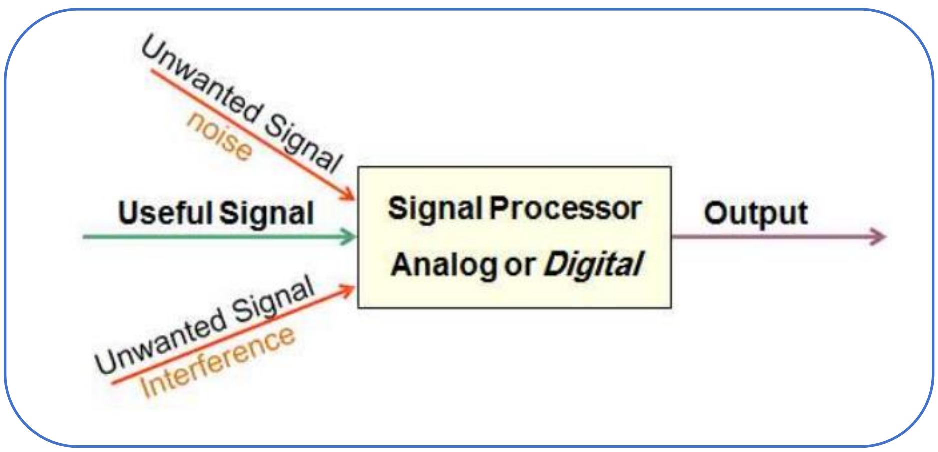


Figure (1): Explain the main idea of signal processing

Digital signal processing (DSP) system: Digital signal processing (DSP) is one of the most powerful technologies that will shape science and engineering in the twenty-first century. Revolutionary changes have already been made in aboard range of fields: communications, radar and sensor. DSP converts signals that naturally accrue in analog form (such as sound, video and information from sensors) to digital form and uses digital techniques to enhance and modify analog signal data for various applicati

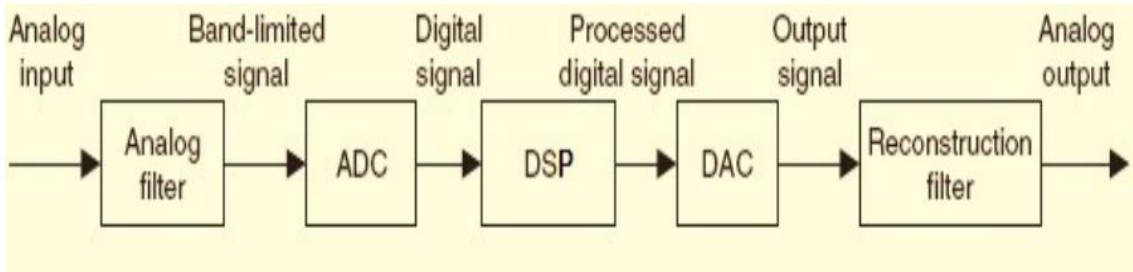


Figure (2): A typical digital signal processing (DSP) system

The system consists of an analog filter, an analog-to-digital conversion (ADC) unit, a digital signal processor (DSP), a digital-to-analog conversion (DAC) unit, and a reconstruction (anti-image) filter.

As shown in the figure (2), the analog input signal, which is continuous in time and amplitude, is generally encountered in our real life. Examples of such analog signals include current, voltage, temperature, pressure, and light intensity. Usually a transducer (sensor) is used to convert the non-electrical signal to the analog electrical signal (voltage). This analog signal is fed to an analog filter, which is applied to limit the frequency range of analog signals prior to the sampling process. The purpose of filtering is to significantly attenuate aliasing distortion.

The band-limited signal at the output of the analog filter is then sampled and converted via the ADC unit into the digital signal, which is discrete both in time and in amplitude.

The DSP then accepts the digital signal and processes the digital data according to DSP rules such as lowpass, highpass, and bandpass digital filtering, or other algorithms for different applications. Notice that the DSP unit is a special type of digital computer and can be a general-purpose digital computer, a microprocessor, or an advanced microcontroller; furthermore, DSP rules can be implemented using software in general. With the DSP and corresponding software, a processed digital output signal is generated. This signal behaves in a manner according to the specific algorithm used.

The DAC unit converts the processed digital signal to an analog output signal. The signal is continuous in time and discrete in amplitude (usually a sample-and-hold signal).

The final stage in Figure (2) is often another analog filter designated as a function to smooth the DAC output voltage levels back to the analog signal.

In contrast to the above, a direct analog processing of analog signals is much simpler since it involves only a signal processor. It is therefore natural to ask why we go to use the DSP systems. There are several good reasons:

- Digital processing is inherently stable and reliable.
- Good processing techniques are available for digital signals, such as Data compression (or source coding), Error Correction (or channel coding), Equalization and Security.
- Easy to mix signals and data using digital techniques known as Time Division Multiplexing (TDM).
- Sensitivity to electrical noise is minimal.
- Digital information can be encrypted for security.

Application of DSP

The field of DSP has matured considerably over the last several decades and now is at the core of many diverse application and products. These include

- Speech /audio (speech recognition /synthesis, digital audio , equalization)
- Image/video (enhancement, coding for storge and transmission , robotic vision, animation)
- Military /space (radar processing, secure communication, missile guidance, sonar processing)
- Biomedical/ health care (scanners, ECG analysis, X-ray analysis, EEG brain mappers)

Representation of Discrete Time Signals

A discrete time signal may be represented by any one of the following four ways :

- Graphical Representation
- Functional Representation
- Tabular Representation
- Sequence Representation

1) Graphical Representation

- Consider a discrete time signal x(n) with the values, $x(-3) = -2$,

$x(-2) = 3$,

$x(-1) = 0$,

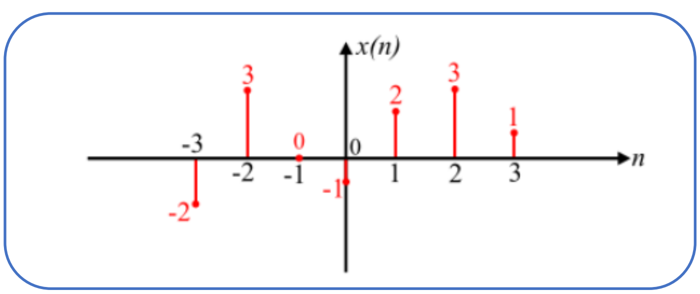
$x(0) = -1$,

$x(1) = 2$,

$x(2) = 3$,

$x(3) = 1$

This discrete time signal can be represented graphically as shown in the figure below.



2) Functional Representation

The magnitude of the signal will be written against the values of (n) in case of the functional representation of a discrete-time signal. Therefore, in the following way, we can represent the above discrete time signal x(n) with the help of functional representation like this:

$$x(n) = \begin{cases} -2 & when\, n = -3 \\ 3 & when\, n = -2 \\ 0 & when\, n = -1 \end{cases}$$

3) Tabular representation

In case of a tabular representation of discrete-time signal, we use the table to represent the sampling instant n and the magnitude of discrete-time signal at the corresponding sampling instant. In the following way, we can represent the above discrete time signal x(n) with the help of a tabular form like this:

n	-3	-2	-1	0	1	2	3
X(n)	-2	3	0	-1	2	3	1

4) Sequence Representation

The discrete time signal x(n) can be represented in the sequence representation as follows ;

X(n)={-2, 3, 0, -1, 2, 3, 1}
↑

Here, the arrow mark (↑) denotes the term corresponding to n = 0. When no arrow is indicated in the sequence representation of a discrete time signal, then the first term of the sequence corresponds to n = 0.