**Session -1**

**1. Introduction:** **Digital Signal Processing**

Since the learners have some basic understanding about DSP, it would be a good idea to ask some basic questions to help the learners recall the concepts digital signal.

**Introduction** to **Digital Signal Processing** (**DSP**)

**Suggested Activity: Brain Storming**

**Questions:**

1. Define signal.
2. Give example for signals.
3. Tell about given signal
4. Give examples for digital system.

**Digital:** operating by the use of discrete signals to represent data in the form of numbers

**Signal**: a parameter (electrical quantity or effect) that can be varied in such a way as to convey information

**Processing**: A series operations performed according to programmed instructions

changing or analysing information which is measured as discrete sequences of numbers

**DSP applications:Communications:**

Examples

1) telephony – transmission of information in digital form via telephone lines, modem technology, mobile phones

2) encoding and decoding of the information sent over a physical channel (to optimise

transmission or to detect or correct errors in transmission)







**2. Basic elements of digital signal processing**

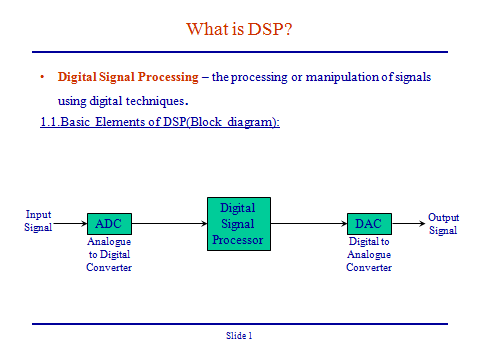
* Basic block diagram of a DSP
* Advantages of digital over analog signal processing

We can discuss about the elements of DSP through presentation

**Suggested Activity: Presentation**

Through PPT explain DSP block diagram and advantages.





**3**. **Conclusion –Mind map &Board activity**

a**.** Give components present in DSP block diagram.

b. Draw the block diagram of DSP.

c. Tell about ADC and DAC.

**Session -2**

1. **Recap : DSP**

**Suggested Activity: Quiz**

We can conduct a quiz to check the learners what things they learned in previous session.

1. **Derivation of frequency in analog signal**

**Suggested Activity: chalk and talk**

1. **Derivation of frequency in digital signal - board activity**
2. **Conclusion- Recall by words.**

**Words**: analog, digital, frequency, Euler’s identity, x (t), and x[n]

**Session-3**

1. **Introduction –Sampling**

**Suggested Activity: Introduces**

### [Nyquist–Shannon sampling theorem - Wikipedia, the free ...](http://www.google.co.in/url?sa=t&rct=j&q=what%20is%20the%20meaning%20of%20sampling%20theorem%20in%20dsp&source=web&cd=4&cad=rja&ved=0CDoQFjAD&url=http%3A%2F%2Fen.wikipedia.org%2Fwiki%2FNyquist%25E2%2580%2593Shannon_sampling_theorem&ei=4NLtUYLaEoGMrQeflICQBA&usg=AFQjCNGtVaD-A1E-x5y9vbt32Y6uCRYn9w&bvm=bv.49478099,d.bmk)

We can introduce about sampling with examples

A sufficient condition to reconstruct *x*(*t*) from its samples is \scriptstyle f_s > 2B\!  and equivalently \scriptstyle B < f_s/2.  The two thresholds, \scriptstyle 2B and \scriptstyle f_s/2, are respectively called the **[Nyquist rate](http://en.wikipedia.org/wiki/Nyquist_rate" \o "Nyquist rate)** and **[Nyquist frequency](http://en.wikipedia.org/wiki/Nyquist_frequency" \o "Nyquist frequency)**. And respectively, they are attributes of *x*(*t*) and of the sampling equipment. The condition described by these inequalities is called the **Nyquist criterion**, or sometimes the *Raabe condition.* The theorem is also applicable to functions of other domains, such as *space,* in the case of a digitized image. The only change, in the case of other domains, is the units of measure applied to *t*, *T*, *f*, *fs*, and *B*.



# 2. Sampling theorem

**Suggested Activity: chalk and talk**

We can discuss the sampling theorem

1. **Proof of sampling theorem, aliasing and nyquist theorem**

**Suggested Activity: chalk and talk**

****

1. **Conclusion& summary**

**Suggested Activity: Match word puzzle**

|  |  |
| --- | --- |
| **Fs >= 2W** | **Sampling** |
| **Analog to digital conversion** | **Nyquist rate** |
| **Fs = 2W** | **Sampling theorem** |
| **Fs < 2W** | **Aliasing** |

**Session-4**

1. **Introduction-Signals**

**Suggested Activity: Questions and answers**

**Sample questions:**

|  |
| --- |
| 1. What is a signal?  2. What are the different types of signals?  3. What are the signals that we encounter in daily life?  4. What are different ways in which the signals can be classified?  5. What are the mathematical tools used to represent a signal in frequency domain? |

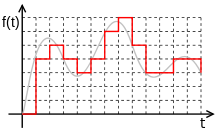
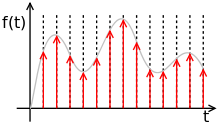
###### Discrete time signals

### [Discrete signal - Wikipedia, the free encyclopedia](http://www.google.co.in/url?sa=t&rct=j&q=discrete%20time%20signal%20&source=web&cd=1&cad=rja&ved=0CCkQFjAA&url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FDiscrete_signal&ei=5tTtUeP4KIHwrQf7uIGgDw&usg=AFQjCNF92pT3vIdskXqv10-vnKltpjJKlA)

###### Suggested Activity: -chalk and talk

A **discrete signal** or **discrete-time signal** is a [time series](https://en.wikipedia.org/wiki/Time_series) consisting of a [sequence](https://en.wikipedia.org/wiki/Sequence) of qualities. In other words, it is a type series that is a function over a [domain](https://en.wikipedia.org/wiki/Domain_(mathematics)) of discrete integral.

Unlike a [continuous-time signal](https://en.wikipedia.org/wiki/Continuous_signal), a discrete-time signal is not a function of a continuous argument; however, it may have been obtained by [sampling](https://en.wikipedia.org/wiki/Sampling_(information_theory)) from a continuous-time signal, and then each value in the sequence is called a [sample](https://en.wikipedia.org/wiki/Sample_(signal)). When a discrete-time signal obtained by sampling a sequence corresponding to uniformly spaced times, it has an associated [sampling rate](https://en.wikipedia.org/wiki/Sampling_rate); the sampling rate is not apparent in the data sequence, and so needs to be associated as a separate data item.



Discrete sampled signal digital signal

**3. Classification**

###### Suggested Activity: - Odd man out



**4. Conclusion**

**Suggested Activity: Problems**

1. Draw x(n)={2,5,4,7,1}
2. Find x(n-1) for x(n) = {2,9,8,3,4}

**Session-5**

**1. Introduction – System**

**Suggested Activity: Quiz**

1. What is system?
2. Give examples for system.
3. Differentiate analog and digital system.

###### 2. Discrete time systems

**Suggested Activity: Chalk and talk**

**3.** Classification

**Suggested Activity: Odd man out**

**4. Conclusion-Match the following**

|  |  |
| --- | --- |
| Superposition principle | Causal |
| Stability | Dynamic |
| Output depends present input | Linear |
| Need memory | Invariant |
| Shifting | Stable |

**Session -6**

**1. Recap: DT System**

**Suggested Activity: Recall by words**

1. x (n)
2. defined specific time
3. summation
4. ‘n’ integer
5. **Analysis of LTIS**

### [LTI system theory - Wikipedia, the free encyclopedia](http://www.google.co.in/url?sa=t&rct=j&q=lti%20system&source=web&cd=1&cad=rja&sqi=2&ved=0CCkQFjAA&url=http%3A%2F%2Fen.wikipedia.org%2Fwiki%2FLTI_system_theory&ei=pvvtUf36B4WMrgfHt4H4Ag&usg=AFQjCNEOl_JFIKVoJIrpooNjd44WoeRrHg)

en.wikipedia.org/wiki/**LTI**\_**system**\_theory‎

**Suggested Activity: Writing board**

Derive causality and stability condition for LTIS on board and finally ask condition for the causality and stability to the learners for knowing the understanding of learners.

**Linear time-invariant theory**, commonly known as **LTI system theory,** comes from [applied mathematics](http://en.wikipedia.org/wiki/Applied_mathematics) and has direct applications in [NMR spectroscopy](http://en.wikipedia.org/wiki/NMR_spectroscopy), [seismology](http://en.wikipedia.org/wiki/Seismology), [circuits](http://en.wikipedia.org/wiki/Electrical_network), [signal processing](http://en.wikipedia.org/wiki/Signal_processing), [control theory](http://en.wikipedia.org/wiki/Control_theory), and other technical areas. It investigates the response of a [linear](http://en.wikipedia.org/wiki/Linear_system) and [time-invariant system](http://en.wikipedia.org/wiki/Time-invariant_system) to an arbitrary input signal. Trajectories of these systems are commonly measured and tracked as they move through time (e.g., an acoustic waveform), but in applications like [image processing](http://en.wikipedia.org/wiki/Image_processing) and [field theory](http://en.wikipedia.org/wiki/Classical_field_theory), the LTI systems also have trajectories in spatial dimensions. Thus, these systems are also called *linear translation-invariant* to give the theory the most general reach. In the case of generic [discrete-time](http://en.wikipedia.org/wiki/Discrete-time) (i.e., [sampled](http://en.wikipedia.org/wiki/Sample_(signal))) systems, *linear shift-invariant* is the corresponding term. A good example of LTI systems are electrical circuits that can be made up of resistors, capacitors, and inductors.

1. **Conclusion & summary**

**Suggested Activity: Brain storming**

1. Define LTIS.
2. Draw block diagram
3. What is convolution?
4. What are the properties of convolution?
5. Give condition for causality.
6. Give condition for stability.

**Session -7**

**1.** **Recap: Z-transform**

**Suggested Activity: Discuss & questions**

Learners have basic idea about z-transform studied in mathematics. Discuss the topic with asking questions.

1. Define z-transform.
2. Give the formula for z-transform.
3. Find z-transform for x(n) =an u(n).
4. Give any two properties of z-transform.
5. **Z-transform and ROC:**

**Suggested Activity: Chalk and talk**

Explain z-transform, ROC and inverse z-transform on the board and also solving problems.

**3. Conclusion:**

**Suggested Activity: Tit for tat**

**Session -8**

**1. Recap: Z-transform**

**Suggested Activity: Problem solving**

1. x(n) = 2n u(n) X(z) =?
2. x(n)={2,3,1,4}.Determine z-transform.
3. x(n)={7,5,9,1}Find ROC.

* Z transform is the powerful tool for analyzing Linear –time invariant discrete time systems in the frequency domain.
* The frequency response of discrete time systems can be determined by evaluating the transfer function on the unit circle of Z plane

**2. Properties of z-transform**

**Suggested Activity: PPT and board**

Through PPT explain the properties of z-transform and proof of properties on the board.

**3. Conclusion**

**Suggested Activity: Rapid fire**

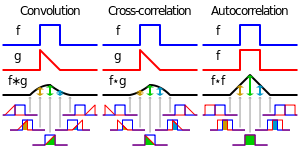
**Session -9**

1. **Introduction –Convolution**

**Suggested Activity: Introduces**

### [Convolution - Wikipedia, the free encyclopedia](http://www.google.co.in/url?sa=t&rct=j&q=convolution&source=web&cd=1&cad=rja&sqi=2&ved=0CCkQFjAA&url=http%3A%2F%2Fen.wikipedia.org%2Fwiki%2FConvolution&ei=DAHuUYTHOMnUrQer24HIBA&usg=AFQjCNF72hWxml1-uOtl3iWzcTrWhjayqw)

*For the usage in formal language theory, see*[*Convolution (computer science)*](http://en.wikipedia.org/wiki/Convolution_(computer_science))*.*

[](http://en.wikipedia.org/wiki/File:Comparison_convolution_correlation.svg)

[http://bits.wikimedia.org/static-1.22wmf9/skins/common/images/magnify-clip.png](http://en.wikipedia.org/wiki/File:Comparison_convolution_correlation.svg)Visual comparison of convolution, [cross-correlation](http://en.wikipedia.org/wiki/Cross-correlation) and[autocorrelation](http://en.wikipedia.org/wiki/Autocorrelation).

In [mathematics](http://en.wikipedia.org/wiki/Mathematics) and, in particular, [functional analysis](http://en.wikipedia.org/wiki/Functional_analysis), **convolution** is a[mathematical operation](http://en.wikipedia.org/wiki/Operation_(mathematics)) on two [functions](http://en.wikipedia.org/wiki/Function_(mathematics)) *f* and *g*, producing a third function that is typically viewed as a modified version of one of the original functions, giving the area overlap between the two functions as a function of the amount that one of the original functions is [translated](http://en.wikipedia.org/wiki/Translation_(geometry)). Convolution is similar to [cross-correlation](http://en.wikipedia.org/wiki/Cross-correlation). It has applications that include [probability](http://en.wikipedia.org/wiki/Probability), [statistics](http://en.wikipedia.org/wiki/Statistics" \o "Statistics),[computer vision](http://en.wikipedia.org/wiki/Computer_vision), [image](http://en.wikipedia.org/wiki/Image_processing) and [signal processing](http://en.wikipedia.org/wiki/Signal_processing), [electrical engineering](http://en.wikipedia.org/wiki/Electrical_engineering), and[differential equations](http://en.wikipedia.org/wiki/Differential_equations).

The convolution can be defined for functions on [groups](http://en.wikipedia.org/wiki/Group_(mathematics)) other than [Euclidean space](http://en.wikipedia.org/wiki/Euclidean_space). For example, [periodic functions](http://en.wikipedia.org/wiki/Periodic_function), such as the [discrete-time Fourier transform](http://en.wikipedia.org/wiki/Discrete-time_Fourier_transform), can be defined on a [circle](http://en.wikipedia.org/wiki/Circle) and convolved by *periodic convolution*.   And *discrete convolution* can be defined for functions on the set of [integers](http://en.wikipedia.org/wiki/Integers). Generalizations of convolution have applications in the field of [numerical analysis](http://en.wikipedia.org/wiki/Numerical_analysis) and [numerical linear algebra](http://en.wikipedia.org/wiki/Numerical_linear_algebra), and in the design and implementation of [finite impulse response](http://en.wikipedia.org/wiki/Finite_impulse_response) filters in signal processing.

Computing the inverse of the convolution operation is known as [deconvolution](http://en.wikipedia.org/wiki/Deconvolution" \o "Deconvolution).

**Linear and circular convolution Suggested Activity: writing board**

Linear and circular convolution are fundamentally different operations. However, there are conditions under which linear and circular convolution are equivalent. Establishing this equivalence has important implications. For two vectors, *x* and *y*, the circular convolution is equal to the inverse discrete Fourier transform (DFT) of the product of the vectors' DFTs. Knowing the conditions under which linear and circular convolution are equivalent allows you to use the DFT to efficiently compute linear convolutions.

The linear convolution of an N-point vector, *x*, and a L-point vector, *y*, has length N+L-1.

For the circular convolution of *x* and *y* to be equivalent, you must pad the vectors with zeros to length at least N+L-1 before you take the DFT. After you invert the product of the DFTs, retain only the first N+L-1 elements.

Create two vectors, *x* and *y*, and compute the linear convolution of the two vectors.

### [Linear and Circular Convolution - MATLAB & Simulink - MathWorks ...](http://www.google.co.in/url?sa=t&rct=j&q=linear%20convolution&source=web&cd=3&ved=0CDsQFjAC&url=http%3A%2F%2Fwww.mathworks.in%2Fhelp%2Fsignal%2Fug%2Flinear-and-circular-convolution.html&ei=tQHuUdHgC8nUrQer24HIBA&usg=AFQjCNG-ppCrK_tSjXefDyqiVl5ztvOMQg)

**3. Conclusion**

**Suggested Activity: formulas and problem solving**

Convolution topic is revised by using formulas and problem solving

x(n)={1,2,3,4}

h(n)={4,3,2,1} determine y(n).