204181 Signals and Systems

Teaching Scheme:

Lectures: 4 Hrs/ Week

Tutorial : 1 Hr/Week

Examination Scheme:

Theory Online : 50 Marks

Theory Paper : 50 Marks

Term work: 25

Course Objectives and Outcomes:

The concept and theory of signals and systems are needed in almost all electronics and telecommunication engineering fields and in many other engineering and scientific disciplines as well. The main objective of this course is to lay the foundation for further studies in areas such as communication, signal processing, and control systems etc. This course will explore the basic concepts of signals and systems.

Having successfully completed this course, the student will be able to:

1. Understand the basic signals and their classification, perform operations on signals.
2. Understand and identify the systems based on their properties
3. Understand, identify the system based on their properties in terms impulse response and also solve the convolution integral and sum.
4. Understand, and resolve the signals in frequency domain using Fourier series and Fourier transform. Find the amplitude spectrum, phase spectrum of the various signals and also systems. Analyze the system in frequency domain.
5. Understand, and resolve the signals in complex frequency domain using Laplace Transform. Analyze the system in s – domain. Characterize the system in s- domain. Apply Laplace transforms to analyze electrical circuits.
6. Understand, apply and determine the correllogram, auto correlation, cross correlation, energy spectral density, and power spectral density of discrete and continuous signals. Carry out the system analysis and inter play between frequency and time domain.
7. Understand the basic concept of probability, random variables and random signals. Calculate the CDF, PDF and probability of a given event. Calculate the mean, mean square, variance and standard deviation for given random variables using pdf.

Unit I : Introduction to Signals and Systems **10L**

Definition of signals and systems, communication and control systems as examples, Classification of signals: Continuous time and discrete time, even, odd, periodic and non periodic, deterministic and non deterministic, energy and power.

Operations on signals: Amplitude scaling, addition, multiplication, differentiation, integration (Accumulator for DT), time scaling, time shifting and folding, precedence rule.

Elementary signals: exponential, sine, step, impulse and its properties, ramp, rectangular, triangular, signum, sinc.

Systems: Definition, Classification: linear and non linear, time variant and invariant, causal and non-causal, static and dynamic, stable and unstable, invertible.

Unit II : System Analysis **8L**

System modeling: Input output relation, impulse response, block diagram, integro-differential equation. Definition of impulse response, convolution integral, convolution sum, computation of convolution integral using graphical method for unit step to unit step, unit step to exponential, exponential to exponential and unit step to rectangular, rectangular to rectangular only. Computation of convolution sum. Properties of convolution, system interconnection, system properties in terms of impulse response, step response in terms of impulse response.

Unit III : System Analysis in Frequency Domain using Fourier Transform **6L**

Definition and necessity of CT and DT Fourier series and Fourier transforms. Analogy between CTFS, DTFS and CTFT, DTFT. CT Fourier series, CT Fourier transform and its properties, problem solving using properties, amplitude spectrum, phase spectrum of the signal and system. Interplay between time and frequency domain using sinc and rectangular signals. Limitations of FT and need of LT and ZT.

Unit IV : System Analysis in Frequency Domain using Laplace Transform **6L**

Definition and its properties, ROC and pole zero concept. Application of Laplace transforms to the LTI system analysis. Inversion using duality, numerical based on properties. Signal analysis

using LT.

Unit V : Correlation and Spectral Density 6L

Definition of Correlation and Spectral Density, correllogram, analogy between correlation, covariance and convolution, conceptual basis, auto-correlation, cross correlation, energy/power spectral density, properties of correlation and spectral density, inter relation between correlation and spectral density.

Unit VI : Probability, Random Variables and Random Signals 6L

Experiment, sample space, event, probability, conditional probability and statistical independence. Random variables: Continuous and Discrete random variables, cumulative distributive function, Probability density function, properties of CDF and PDF. Statistical averages, mean, moments and expectations, standard deviation and variance. Probability models: Uniform, Gaussian, Binomial. Evolution and definition of random signal through probability via random variable.

Text Books :

1. Simon Haykins and Barry Van Veen, "Signals and Systems", 2nd Edition, Wiley India.
2. Simon Haykins, " An Introduction to Analog and Digital Communications", Wiley India

Reference Books :

1. Mrinal Mandal and Amir Asif, Continuous and Discrete Time Signals and Systems, Cambridge University Press, 2007
2. Charles Phillips, "Signals , Systems and Transforms" , 3rd Edition, Pearson Education.
3. Peyton Peebles, "Probability, Random Variable, Random Processes", 4 th Edition, Tata Mc Graw Hill.
4. Luis F. Chaparro, Signals and Systems using MATLAB, Academic Press an imprint of Elsevier Inc, 2011
5. M.J.Roberts and Govind Sharma, "Fundamentals of Signals and Systems",2nd edition,Mc Graw Hill,2010

Signals and Systems

(Tutorial Assignments)

Tutorials must be conducted batch wise. Batch size should not be more than 20 students.

The main objective of this tutorial is to focus on the outcomes defined in the theory syllabus by solving the following assignments based on paper work.

1 A) Sketch and write defining mathematical expression for the following signals in CT and DT

a) Unit Step.
b) Rectangular
c) Exponential
d) Signum
e) Sine
f) Sinc
g) Triangular
h) Unit Impulse.
i) Unit Ramp

B) Classify and find the respective value for the above signals

a) Periodic / Non Periodic
b) Energy / Power /Neither

2 Take any two CT and DT signals and perform the following operation Amplitude scaling, addition, multiplication, differentiation, integration (accumulator for DT), time scaling, time shifting and folding

3 Express any two system mathematical expressions in input output relation form and determine whether each one of them is, Memory less, Causal, Linear, Stable, Time in variant, Invertible

4 Express any two system mathematical expressions in impulse response form and determine whether each one of them is, Memory less, Causal, Linear, Stable, Time in variant, Invertible

5 State and prove the properties of CT Fourier Transform. Take rectangular and sinc signal as examples and demonstrate the applications of CTFT properties. And also demonstrate the interplay between the time and frequency domain

6 State and prove the properties of CT Laplace Transform. Take any example of a system in time domain and demonstrate the application of LT in system analysis

7 A) Find the following for the given energy signal

a) Autocorrelation
b) Energy from Autocorrelation
c) Energy from definition
d) Energy Spectral Density directly
e) ESD from Autocorrelation

B) Find the following for the given power signal

a) Autocorrelation
b) Power from Autocorrelation
c) Power from definition
d) Power Spectral Density directly
e) PSD from Autocorrelation

8 A) List and Explain the properties of CDF & PDF, Suppose a certain random variable has the CDF

$$F_X(x)=\begin{cases} 0 & x\le 0 \\ kx^2 & 0<x\le 10 \\ 100k & x>10 \end{cases}$$

Evaluate k, Write the corresponding PDF and find the values of $P(X\le 5)$ and $P(5 < X \le 7)$

(This is only an example. Various Probability functions may be given)

B) Find mean ,mean square , standard deviation , variance of X

when $f_X(x)=ae^{-ax}u(x)$ with a>0

(This is only an example. Various Probability functions may be given)