KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY

Academic Year: 2021-2022

Name of the Course: SIGNALS AND SYSTEMS

Course Code: EC314PC

Year and Semester: II/I

Name of the Faculty:N.SAIRAM

Department in which subject is handled: ECE

Course Type: Basic Sciences / Humanities & Social Sciences/ Professional Core / Professional elective / Open Elective /Engineering Sciences / Mandatory courses / Project.

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KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY

Vision of the Institute

To emerge as a premier institute for high quality professional graduates who can contribute to economic and social developments of the Nation.

Mission of the Institute

Mission	Statement
IM1	To have holistic approach in curriculum and pedagogy through industry interface to meet the needs of Global Competency.
IM2	To develop students with knowledge, attitude, employability skills, entrepreneurship, research potential and professionally ethical citizens.
IM3	To contribute to advancement of Engineering & Technology that would help to satisfy the societal needs.
IM4	To preserve, promote cultural heritage, humanistic values and spiritual values thus helping in peace and harmony in the society.

Vision of the Department

To impart quality technical education in Electronics and Communication with accent on creativity, innovation and research thereby producing competent engineers who can meet global challenges with societal commitment.

Mission of the Department

Mission	Statement
DM1	To impart quality education to students in Basic Sciences, Mathematics, Electronics and Communication Engineering through innovative teaching-learning processes.
DM2	To facilitate students to define, design, and solve engineering problems in the field of Electronics and Communications Engineering using various Electronic Design Automation (EDA) tools.
DM3	To encourage research culture among faculty and students thereby facilitating them to be creative and innovative through constant interaction with R & D organizations and Industry.
DM4	To inculcate teamwork, imbibe leadership qualities, professional ethics and social responsibilities in students and faculty.

Program Educational Objectives:

PEO1: Graduates with fundamental and advanced knowledge in Sciences, Mathematics and in Engineering Subjects of Electronics, Communication and allied Engineering to become globally competent with a flair for lifelong learning.

PEO2: Graduates capable in design, develop creative and innovative technologies in the field of Electronics and Communication Engineering, enabling them to work in multi-disciplinary teams to meet the societal needs.

PEO3: Graduates with professional values, ethics, positive attitude, communication skills, latest technological awareness to ensure sustainable development and to succeed in their chosen profession.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team network: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-Long learning: Recognize the need for, and have the preparation and able to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded Systems, Digital & Analog Devices, etc.

PSO2. An ability to solve complex Electronics & Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive at cost effective and appropriate solutions.

PSO3. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

EC304PC: SIGNALS AND SYSTEMS

B.Tech. II Year I Sem.

L	T	P	C
3	1	0	4

Pre-requisite: Nil

Course Objectives:
- This gives the basics of Signals and Systems required for all Electrical Engineering related courses.
- To understand the behavior of signal in time and frequency domain
- To understand the characteristics of LTI systems
- This gives concepts of Signals and Systems and its analysis using different transform techniques.

Course Outcomes: Upon completing this course, the student will be able to
- Differentiate various signal functions.
- Represent any arbitrary signal in time and frequency domain.
- Understand the characteristics of linear time invariant systems.
- Analyze the signals with different transform technique

UNIT - I

Signal Analysis: Analogy between Vectors and Signals, Orthogonal Signal Space, Signal approximation using Orthogonal functions, Mean Square Error, Closed or complete set of Orthogonal functions, Orthogonality in Complex functions, Classification of Signals and systems, Exponential and Sinusoidal signals, Concepts of Impulse function, Unit Step function, Signum function.

UNIT – II

Fourier series: Representation of Fourier series, Continuous time periodic signals, Properties of Fourier Series, Dirichlet's conditions, Trigonometric Fourier Series and Exponential Fourier Series, Complex Fourier spectrum.

Fourier Transforms: Deriving Fourier Transform from Fourier series, Fourier Transform of arbitrary signal, Fourier Transform of standard signals, Fourier Transform of Periodic Signals, Properties of Fourier Transform, Fourier Transforms involving Impulse function and Signum function, Introduction to Hilbert Transform.

UNIT - III

Signal Transmission through Linear Systems: Linear System, Impulse response, Response of a Linear System, Linear Time Invariant(LTI) System, Linear Time Variant (LTV) System, Transfer function of a LTI System, Filter characteristic of Linear System, Distortion less transmission through a system, Signal bandwidth, System Bandwidth, Ideal LPF, HPF, and BPF characteristics, Causality and Paley-Wiener criterion for physical realization, Relationship between Bandwidth and rise time, Convolution and Correlation of Signals, Concept of convolution in Time domain and Frequency domain, Graphical representation of Convolution.

UNIT – IV

Laplace Transforms: Laplace Transforms (L.T), Inverse Laplace Transform, Concept of Region of Convergence (ROC) for Laplace Transforms, Properties of L.T, Relation between L.T and F.T of a signal, Laplace Transform of certain signals using waveform synthesis.

Z–Transforms: Concept of Z- Transform of a Discrete Sequence, Distinction between Laplace, Fourier and Z Transforms, Region of Convergence in Z-Transform, Constraints on ROC for various classes of signals, Inverse Z-transform, Properties of Z-transforms.

UNIT - V

Sampling theorem: Graphical and analytical proof for Band Limited Signals, Impulse Sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Effect of under sampling – Aliasing, Introduction to Band Pass Sampling.

Correlation: Cross Correlation and Auto Correlation of Functions, Properties of Correlation Functions, Energy Density Spectrum, Parsevals Theorem, Power Density Spectrum, Relation between Autocorrelation Function and Energy/Power Spectral Density Function, Relation between Convolution and Correlation, Detection of Periodic Signals in the presence of Noise by Correlation, Extraction of Signal from Noise by Filtering.

TEXT BOOKS:

1. Signals, Systems & Communications - B.P. Lathi, 2013, BSP.
2. Signals and Systems - A.V. Oppenheim, A.S. Willsky and S.H. Nawabi, 2 Ed.

REFERENCE BOOKS:

1. Signals and Systems – Simon Haykin and Van Veen, Wiley 2 Ed.,
2. Signals and Systems – A. Rama Krishna Rao, 2008, TMH
3. Fundamentals of Signals and Systems - Michel J. Robert, 2008, MGH International Edition.
4. Signals, Systems and Transforms - C. L. Philips, J.M.Parr and Eve A.Riskin, 3 Ed., 2004, PE.
5. Signals and Systems – K. Deergha Rao, Birkhauser, 2018.

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Outcomes

Course Name: SIGNALS AND SYSTEMS (EC314PC)

CO.1: Differentiate various signal functions [Understanding]

CO.2: Represent any arbitrary signal in time and frequency domain [Apply]

CO.3: Understand the characteristics of linear time invariant systems [Apply]

CO4: Analyze the signals with different transform technique [Apply]

CO5: Explain sampling and correlation between two signals[Apply]

CO6: Implementing the filter characteristics,auto correlation and cross correlation and it power density spectrum.[Evaluation]

Faculty

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CO- PO& PSO Mapping

Course Name: Signals and Systems (C314)

PO / CO	PO1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12	PSO 1	PSO2	PSO3
C314.1	3	1.84	-	2.1	2.5	-	-	-	-	-	-	2.5	-	1.68	-
C314.2	1.8	2.07	-	1.8	3	-	-	-	-	-	-	1.33	-	2.63	-
C314.3	3	2.53	-	2.1	2	-	-	-	-	-	-	1.33	-	1.68	-
C314.4	2.4	2.3	-	1	2	-	-	-	-	-	-	2.5	-	1.68	-
C314.5	2	1.76	-	1	2	-	-	-	-	-	-	2	-	2.63	-
C314.6	2	2	-	1.6	1	-	-	-	-	-	-	1	-	2	-
C314	2.36	2.08	-	1.6	2.5	-	-	-	-	-	-	1.7	-	2.058	-

Level of Mapping: High -3, Medium -2, Low-1

Faculty

N.SAIRAM

CO-PO mapping Justification

C314.1: Differentiate various signal functions [Understanding]

	Justification
PO1	Student can able to analyze Analogy between vectors and signals, Signal approximation using Orthogonal functions,MeanSquareError
PO2	Student can able to understand Classification of signals and Condition for orthogonality (technique)
PO4	Analysing charecteristics of a signal (Problem identification) Generate signal (Data required)
PO5	Generation of various singals using MATLAB
PO12	Context of signals and systems knowledge is required in ECE related professions

C314.2: Represent any arbitrary signal in time and frequency domain [Apply]

	Justification
PO1	Student gets the knowledge on Representation of Fourier series
PO2	Students can able to solve the complex problems
PO4	Finding Fourier Transform (FT) of a signal (Problem identification)
PO5	Finding the FT of a signal using MATLAB
PO12	Context of FS,FT knowledge is required in ECE related professions

C314.3 : Understand the characteristics of linear time invariant systems [Apply]

	Justification
PO1	Students can learn Linear System, Linear Time Invariant(LTI) System.
PO2	Student can analyze the Linear Time Variant (LTV) System, Transfer function of a LTI System
PO4	Finding Linear Time Variant(LTI) and Linear Time Variant (LTV) System (Problem identification)
PO5	Easily evaluate the relation between convolution and correlation of signals
PO12	Finding output of system is difficult, as it is difficult to solve differential equations II) Apply LTI, or LTV

C314.4: Analyze the signals with different transform technique [Apply]

	Justification
PO1	Laplace tranform of standard signals, Z-Transform of discrete signal

PO2	Student can analyze the Concept of Region of Convergence (ROC) for Laplace Transforms
PO4	Region of Convergence in Z-Transform
PO5	Laplace Transform of certain signals using waveform synthesis
PO12	Students can learn Properties of Z-transforms and Properties of L.T Region of convergence(Used in analysis of systems)

C314.5: Explain sampling and correlation between two signals[Apply]

	Justification
PO1	Student get the knowledge on Graphical and analytical proof for Band Limited Signals
PO2	Student able to learn Impulse Sampling, Natural and Flat top Sampling
PO4	Student able to draw various sampling signs
PO5	Easily evaluate the Reconstruction of signal from its samples
PO12	Sampling theorem (Context of sampling theorem knowledge is required in ECE related professions)

C314.6: Implementing the filter characteristics, auto correlation and cross correlation and it power density spectrum.[Evaluation]

	Justification
PO1	Student gets the knowledge of Cross Correlation and Auto Correlation of Functions
PO2	Students are able to design different Energy Density Spectrum and Power Spectrum
PO4	Students able to learn Relation between Convolution and Correlation
PO5	Detection of Periodic Signals in the presence of Noise by Correlation,
PO12	Student can used in real time applications related correlation concepts

CO-PSO mapping Justification

C314.1: Differentiate various signal functions [Understanding]

	Justification
PSO2	Using Matlab, write a program to perform the operations on signals (experiment)

C314.2: Represent any arbitrary signal in time and frequency domain [Apply]

	Justification
PSO2	Fourier Transform Techniques to analyze the signal in frequency domain , required for current communications field

C304.3: Understand the characteristics of linear time invariant systems [Apply]

	Justification
PSO2	Get the basic Concept of convolution in Time domain and Frequency domain

C314.4: Analyze the signals with different transform technique [Apply]

	Justification
PSO2	Usign matlab software, Processing of different singals and systems can be performed.

C314.5: Explain sampling and correlation between two signals[Apply]

	Justification
PSO2	Student can understand different types of sampling signals

C314.6: Implementing the filter characteristics,auto correlation and cross correlation and it power density spectrum.[Evaluation]

	Justification
PSO2	Students can able to design power density spectrum and correlation functions

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DEPARTMENT OF ELECTRONICS & COMMUNICATIONENGINEERING

Lesson Plan – Signals & System (EC304PC)

Faculty Name: N.SAIRAM	Year / Sem: II/I	Academic Year: 2021-22

L. No	Name of the Topic	Reference Book	Delivery Method
1	**Unit I: Signal Analysis:** Introduction to the subject	T1	Chalk & Talk
2	Classification of Signals	T1,T2	Chalk & Talk
3	Explain about Continues and discrete signals	T1	Chalk & Talk
4	Explain about deterministic and non-deterministic	T1,T2	Chalk & Talk
5	Explain about even and odd component signal	T1	Chalk & Talk
6	Explain about periodic and aperiodic signal	T1	Chalk & Talk
7	Explain about energy and power signal, real and imagery signal	T1	Chalk & Talk
8	Concept of standard signals	T1,T2	Chalk & Talk
9	Concepts of Impulse function, Unit Step function,ramp	T1	Chalk & Talk
10	Exponential , Sinusoidal signals and parabolic	T1	Chalk & Talk
11	Signum function,rect,tringular and sampling function	T1	Chalk & Talk
12	Analogy between Vectors and Signals	T1	Chalk & Talk
13	Orthogonal Signal Space and Signal approximation using Orthogonal functions	T1	Chalk & Talk
14	Mean Square Error	T1,T2	Chalk & Talk
15	Closed or complete set of Orthogonal functions	T1	Chalk & Talk
16	Orthogonality in Complex functions	T1,R1	Chalk & Talk
17	Classification of systems: linear and Non-linear Systems, Time Variant and Time Invariant	T1	Chalk & Talk
18	Static and Dynamic Systems, Causal and Non-causal Systems	T1	Chalk & Talk
19	Invertible and Non-Invertible Systems, Stable and Unstable Systems	T1	Chalk & Talk
Slip Test			
20	**UNIT-II: Fourier series & Fourier Trasforms** Introduction to Fourier series and Fourier Transforms	T1	Chalk & Talk
21	Representation of Fourier series, Continuous time periodic signals	T1	Chalk & Talk
22	Properties of Fourier Series	T1,R2	Chalk & Talk
23	Dirichlet's conditions	T1	Chalk & Talk
24	Trigonometric Fourier Series and Exponential Fourier Series	T1	Chalk & Talk
25	Complex Fourier spectrum	T1,T2	Chalk & Talk

26	Deriving Fourier Transform from Fourier series	T1	Chalk & Talk
27	Fourier Transform of arbitrary signa	T1,R1	Chalk & Talk
28	Fourier Transform of standard signals	T1	Chalk & Talk
29	Fourier Transform of Periodic Signals	T1	Chalk & Talk
30	Properties of Fourier Transform	T1,T2	Chalk & Talk
31	Fourier Transforms involving Impulse function and Signum function	T1	Chalk & Talk
32	introduction to Hilbert Transform	T1	Chalk & Talk
Slip Test			
33	**UNIT-III: Signal Transmission Through Linear Systems** Introduction to Signal Transmission through Linear Systems	T1	Chalk & Talk
34	Linear System, Impulse response	T1,T2	Chalk & Talk
35	Response of a Linear System, Linear Time Invariant(LTI) System	T1	Chalk & Talk
36	Linear Time Variant (LTV) System	T1,R2	Chalk & Talk
37	Transfer function of a LTI System	T1	Chalk & Talk
38	Filter characteristic of Linear System, Distortion less transmission through a system	T1,T2	Chalk & Talk
39	Signal bandwidth, System Bandwidth Ideal LPF, HPF, and BPF characteristics	T1	Chalk & Talk
40	Causality and Paley wiener criterion for physical realization	T1,R1	Chalk & Talk
41	Relationship between Bandwidth and rise time, Convolution and Correlation of Signals	T1	Chalk & Talk
42	Concept of convolution in Time domain and Frequency domain	T1	Chalk & Talk
43	Graphical representation of Convolution	T1	Chalk & Talk
Slip Test			
44	**UNIT-IV: Laplace Transforms & Z –Transforms** Introduction to Laplace Transforms, Inverse Laplace Transform and Z –Transforms	T1	Chalk & Talk
45	Concept of Region of Convergence (ROC) for Laplace Transforms	T1	Chalk & Talk
46	Properties of L.T, Relation between L.T and F.T	T1,R2	Chalk & Talk
47	Laplace Transform of certain signals using waveform synthesis	T1	Chalk & Talk
48	Concept of Z- Transform of a Discrete Sequence	T1	Chalk & Talk
49	Distinction between Laplace, Fourier and Z Transforms	T1	Chalk & Talk
50	Region of Convergence in Z-Transform	T1,T2	Chalk & Talk
51	Constraints on ROC for various classes of signals	T1	Chalk & Talk
52	Inverse Z-transform and Properties of Z-transforms	T1	Chalk & Talk
Slip Test			

53	**UNIT-V: Sampling Theorem & Correlation** Introduction to sampling theorem and correlation	T1	Chalk & Talk
54	Graphical and analytical proof for Band Limited Signals	T1,T2	Chalk & Talk
55	Impulse Sampling, Natural and Flat top Sampling	T1	Chalk & Talk
56	Reconstruction of signal from its samples	T1	Chalk & Talk
57	Effect of under sampling – Aliasing	T1,R2	Chalk & Talk
58	Introduction to Band Pass Sampling	T1	Chalk & Talk
59	Cross Correlation and Auto Correlation of Functions,	T1	Chalk & Talk
60	Properties of Correlation Functions	T1,T2	Chalk & Talk
61	Energy Density Spectrum	T1	Chalk & Talk
2	Parsevals Theorem, Power Density Spectrum	T1,R1	Chalk & Talk
63	Relation between Autocorrelation Function and Energy/Power Spectral Density Function	T1	Chalk & Talk
64	Relation between Convolution and and Correlation	T1	Chalk & Talk
65	Detection of Periodic Signals in the presence of Noise by Correlation	T1	Chalk & Talk
66	Extraction of Signal from Noise by Filtering	T1	Chalk & Talk
Slip Test			

EXT BOOKS:

Ref	Title	Author	Edition	Publisher
T1	Principles of Linear Systems and Signals - B.P. Lathi, 2 Ed,2009, OXFORD	B.P. Lathi	2	OXFORD
T2	Signals and Systems	A.V. Oppenheim, A.S. Willsky and S.H. Nawabi	2	Prentice Hall

REFERENCE BOOKS:

R1	Signals and Systems	Simon Haykin and Van Veen	2	Wiley
R2	Fundamentals of Signals and Systems	Michel J. Robert	1	McGraw-Hill Education

WEB REFERENCES:

W1	www.nptel.com
W2	www.electronicsforu.com
W3	www.sciencedirect.com
W4	www.intelligentedu.com
W5	www.iitd.ernet.in
W6	www.iitk.ac.in
W7	www.electronicsforu.com
W8	www.springerlink.com
W9	www.iitr.ac.in
W10	www.iitr.ac.in

(N.SAIRAM)

(HOD)

A.Y-2021-22,ECE II/I

Content beyond syllabus

s.no	Gaps Identified	CO	PO/POS
1	Discrete-time Fourier Transform	C304.2	PO1,PO2,PO4,PO5,PO12,PSO2

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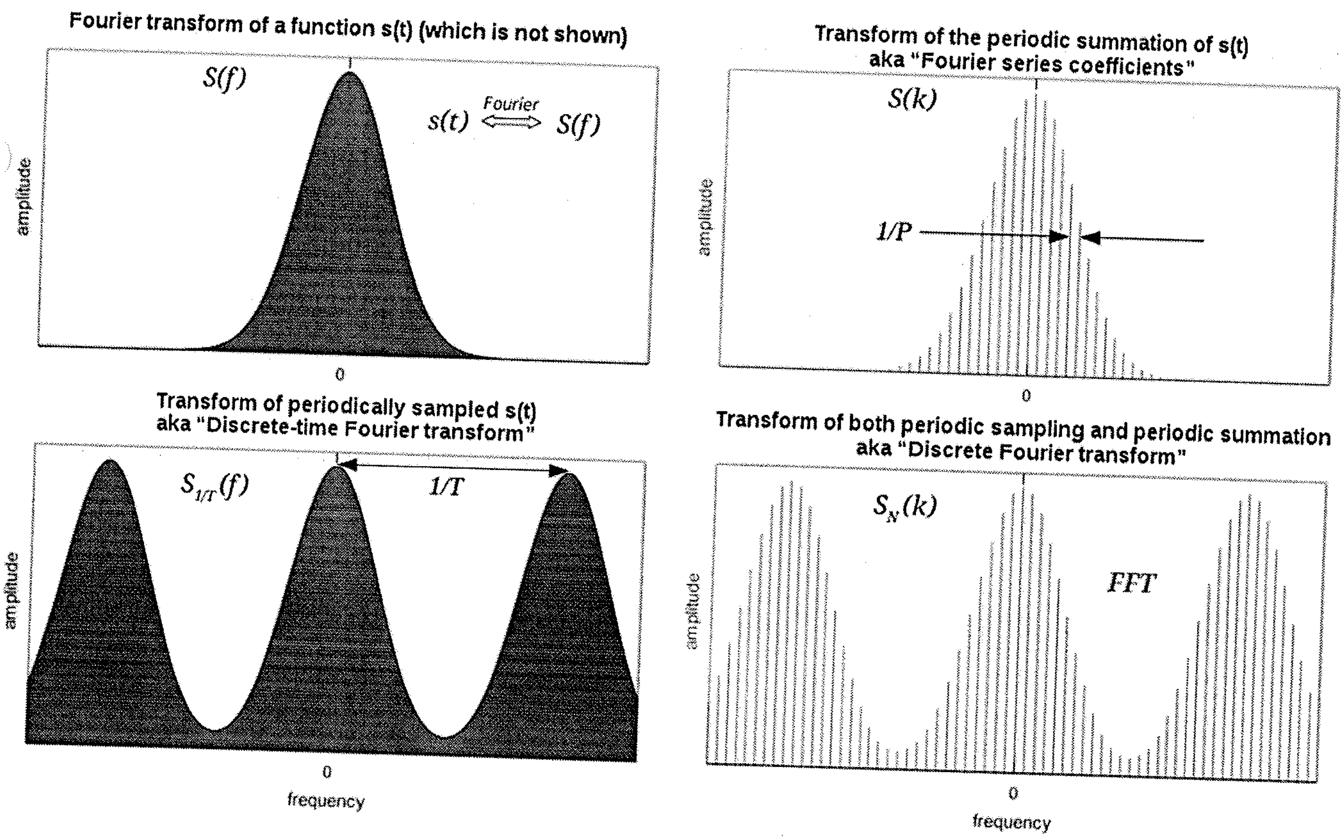
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

A.Y-2020-21,ECE II/I

Content beyond syllabus

Seminar Report on Discrete-time Fourier Transform-(DTFT)

A Seminar is conducted for II year ECE on Discrete-time Fourier Transform-(DTFT)
In mathematics, the discrete-time Fourier transform (DTFT) is a form of Fourier analysis that is applicable to a sequence of values. The DTFT is often used to analyze samples of a continuous function. The term discrete-time refers to the fact that the transform operates on discrete data, often samples whose interval has units of time. From uniformly spaced samples it produces a function of frequency that is a periodic summation of the continuous Fourier transform of the original continuous function. Under certain theoretical conditions, described by the sampling theorem, the original continuous function can be recovered perfectly from the DTFT and thus from the original discrete samples. The DTFT itself is a continuous function of frequency, but discrete samples of it can be readily calculated via the discrete Fourier transform (DFT) (see § Sampling the DTFT), which is by far the most common method of modern Fourier analysis.The students actively participated in the seminar



ASSIGNMENTS

UNIT-1

ASSIGNMENT-1(BATCH-1)

1. Sketch the following signals (i) r(t)-r(t-1)-r(t-3)+r(t-4) (ii)π $t-2$ 2 + $\pi(2t-3.5)$
2. Estimate the mean square error value of a function f(t)
3. Explain the analogy of vectors and signals in terms of orthogonality andevaluation of constant

4. A rectangular function is defined as
   $(t) =$ $1, \quad 0 < t < \pi$
   $-1, \quad \pi < t < 2\pi$
   Approximate the above function by a single sinusoid sint between theintervals(0,2π) , Apply the mean square error in this approximation

ASSIGNMENT-1(BATCH-2)

1. Prove that the functions Øm(t) and Øn(t) where Øk(t) =(1/√T)(cos kwt+sinkwt);T=2π/w are orthogonal over the period(0,T)?
2. Prove that sin nwt and cos mwt are orthogonal to each other for all integers m,n?
3. Prove that the complex exponential signals are orthogonal functions x(t)=$e^{jnwt}$and y(t)=e^{jmwt} let the interval be(t_0, t_0+T)?
4. Discuss how an unknown function f(t) can be expressed using infinite mutually orthogonal functions. Hence show the representation of a waveform f(t) using trigonometric fourier series.

ASSIGNMENT-1(BATCH-3)

1. Show that f(t) is orthogonal to signals cost, cos2t, cos3t, … cosnt for all integervalues of n, n≠0, over the interval (0,2π) if
   i. $f(t) =$ $1, \quad 0 < t < \pi$
      1. $-1, \quad \pi < t < 2\pi$
2. Find whether the signal given by x (n) = 5cos (6n) is periodic?
3. Prove that sin nwt and cos mwt are orthogonal to each other for all integers m,n?
4. Sketch the following signals (i) U(t)-U(t-1)-U(t-3)+U(t-4)

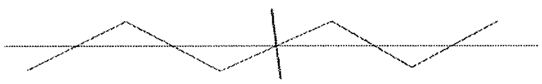
ASSIGNENT-2(Batch-1)

1. Write a short note on exponential Fourier spectrum?
2. Derive the polar Fourier series from the exponential fourier series representationand hence prove that Dn=2 |Cn|?
3. Distinguish between the exponential form of the fourier series and fourier transform. What is the nature of the 'transform pair' in the above two cases?

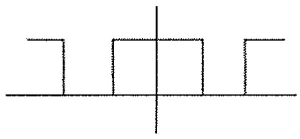
   Find the fourier transforms of
4. a)cos wt u(t) b) sin wt u(t) c) cos (wt+Ø) d) e^{jwt}

ASSIGNENT-2(Batch-2)

1. Find the fourier series expansion of the periodic triangular wave shown belowfor the interval (0,T) with amplitude of 'A'

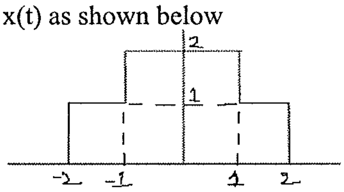


2. Obtain the trigonometric fourier series for the periodic rectangular waveform asshown below for the interval (-T/4,T/4)

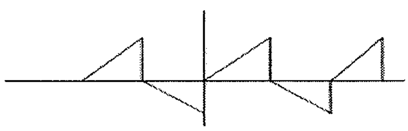
   a. 
3. Find the fourier transforms of a normalized Gaussian pulse
4. Find the fourier transforms of a Triangular pulse

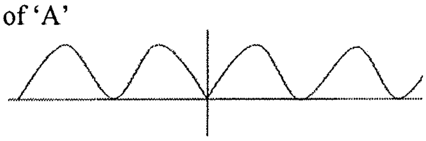
ASSIGNENT-2(Batch-3)

1. Find the fourier transforms of signal $x(t)=e^{-A|t|}$ sgn(t)
2. Find the fourier transforms of signal x(t) as shown below

   a. 

3. Assume that T=2, determine the fourier series expansion of the signal shown below with amplitude of ±1

   a. 
4. Find the exponential fourier series for the fullwave rectified sinewave as shown below for the interval (0,2π) with an amplitude of 'A'

   a. 

ASSIGNENT-3(Batch-1)

1. Determine whether the following input-output equations are linear or non linear.
   a. a)$y(t)=x^2(t)$ b) $y(t)=x(t^2)$ c) $y(t)=t^2x(t-1)$ d) $y(t)=x(t) \cos 50\pi t$

2. Find whether the following systems are causal or non-causal
   a) $y(t)=x(-t)$ b) $y(t)=x(t+10)+x(t)$ c) $y(t)=x(\sin(t))$ d) $y(t)=x(t) \sin(t+1$

3. Determine whether the following systems are time-varying or time-invariant
   a) $y(t)=tx(t)$ b) $y(t)=t^2 x(t-1)$ c) $y(t)=a[x(t)]^2+bx(t)$ d) $y(t)=x(t) \cos 50\pi t$

4. For a system excited by $x(t)=e^{-2t} u(t)$, the impulse response is $h(t)=e^{-t} u(t)+e^{2t} u(-t)$, find the output y(t) for this system

ASSIGNENT-3(Batch-2)

1. A system produces an output of $y(t)= e^{-t} u(t)$ for an input of $x(t)= e^{-2t} u(t)$.Determine the impulse response and frequency response of the system
2. Give the system impulse response h(t). State the conditions for stability andcausality
3. Write down the input-output relation of LTI system in time and frequencydomain.
4. Define impulse response of a linear time invariant system.

ASSIGNENT-3(Batch-3)

1. What is the impulse response of the system y(t)= x(t-to)
2. Is the discrete time system describe by the equation y (n) = x(-n) causal ornon causal ?Why?
3. Is the system y(t) = y(t-1) + 2t y(t-2) time invariant ?
4. What is the period T of the signal x(t) = 2cos (n/4)?

ASSIGNENT-4(Batch-1)

1. State the properties of Laplace transform
2. Properties of ROC of Laplace transforms
3. Properties of Z-transforms?
4. Find the inverse z-transform of $X(z) = ^{(z-1)}z\ 2 - 0.1z - 0.56$

ASSIGNENT-4(Batch-2)

1. Find the z-transform and ROC of the following sequences
   i) $x[n]=[4(5n)-3(4n)]\ u(n)$ ii) $(1/3)^n\ u[-n]$ iii) $(1/3)^n\ [u[-n]-u[n-8]]$
2. Determine the Laplace transform and associated region of convergence and pole-zero plot for the following function of time.
   $x(t)= e^{-2t}\ u(t) + e^{3t}\ u(t)$
3. Find the Laplace Transform of cos wt and sin wt using frequency shiftingproperty
4. .Find the z-transform of the following sequences
   i)$x[n]= a^{-n}\ u[-n-1]$ ii) $x[n]= u[-n]$ iii) $x[n]= -a^n\ u[-n-1]$

ASSIGNENT-4(Batch-3)

1. State convolution property of Z transform.
2. What is the time shifting property of Z transform
3. State Convolution property of the Laplace transform
4. State the time shifting property for laplace transform

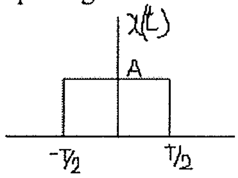
ASSIGNENT-5(Batch-1)

1. The signal $x(t)=\cos 5\pi t+0.3 \cos 10\pi t$ is instantaneously sampled. Determine themaximum interval of the sample
2. Determine the convolution of two functions $x(t)=a\, e^{-at}$; $y(t)= u(t)$
3. What is meant by sampling?
4. What is meant by aliasing?

ASSIGNENT-5(Batch-2)

1. What are the effects aliasing?

2. Suppose that the signal $x(t)= u(t+0.5)-u(t-0.5)$ and the signal $h(t)= e^{jwt}$
   Determine a value of w which ensures that $y(0)=0$, where$y(t)=x(t)*h(t)$
3. For the analog signal $x(t)=3 \cos 100\pi t$
   a.Determine the minimum sampling rate to avoid aliasing
   b.Suppose that the signal is sampled at the rate, f_s=200Hz, what is the discrete time signal obtained after sampling
4. Find the convolution of the rectangular pulse given below with itself



ASSIGNENT-5(Batch-3)

1. Determine the energy and power for the following signals and hence determinewhether the signal id energy or power signal
   i) $x(t)=e^{-3t}$ ii) $x(t)=e^{-3|t|}$ iii) $x(t)= e^{-10t}\, u(t)$ iv) $x(t)=A\, e^{j2\pi at}$

2. write about the types of sampling?

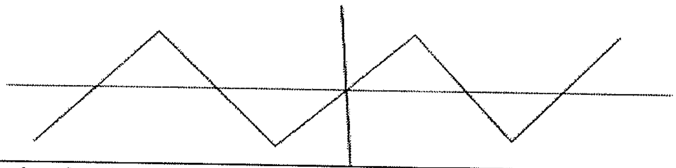
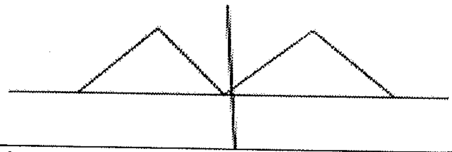
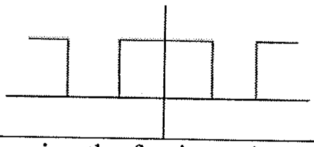
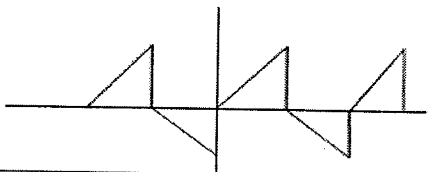
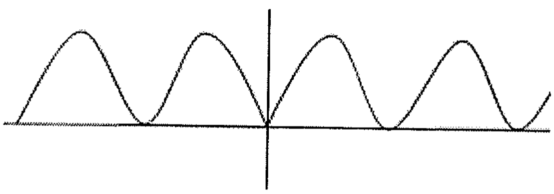
3. explain autocorrelation function and properties?

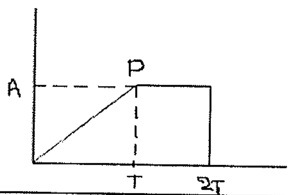
4. define cross correlation of energy signal?

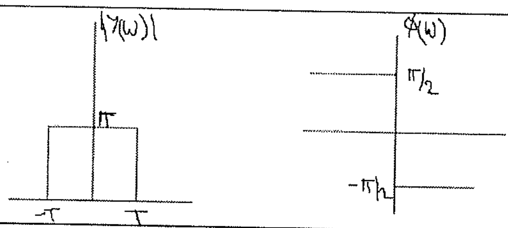
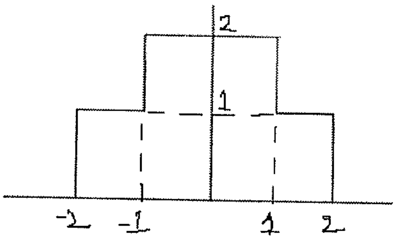
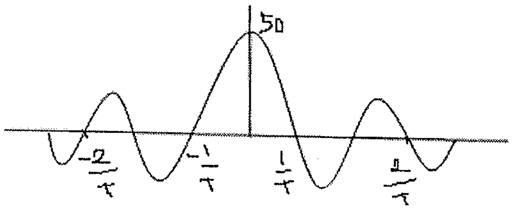
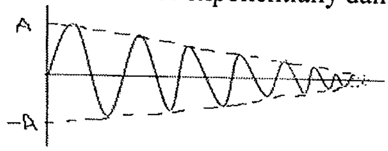
Signals & Systems Unit Wise Important Questions

S. No	QUESTION	Blooms Taxonomy Level
	UNIT-I **Signal Analysis**	
	Short Questions:	
1	Define Signal.	Remember
2	Define system.	Understand
3	What are the major classifications of the signal?	Understand
4	Define discrete time signals and classify them	Remember
5	Define continuous time signals and classify them.	Understand
6	Condition for minimum mean square error?	Remember
7	Define discrete time unit step &unit impulse.	Understand
8	Define continuous time unit step and unit impulse.	Remember
9	Define periodic signal and nonperiodic signal.	Remember
10	Define unit ramp signal.	Understand
11	Define energy and power signals?	Understand
12	Define even and odd signal?	Remember
13	Define unit ramp function?	Remember
14	Define the Parseval's Theorem?	Remember
15	Define continuous time complex exponential signal?	Remember
16	What is continuous time real exponential signal?	Understand
17	What is continuous time growing exponential signal?	Remember
18	Find whether the signal given by x (n) = 5cos (6n) is periodic	Apply
	Long Answer questions	
1	Prove that the functions Øm(t) and Øn(t) where Øk(t) =(1/√T)(cos kwt+sinkwt);T=2π/w are orthogonal over the period(0,T)	Understand
2	Prove that sin nwt and cos mwt are orthogonal to each other for all integers m,n	Apply
3	Prove that the complex exponential signals are orthogonal functions $x(t)=e^{jnwt}$ and $y(t)=e^{jmwt}$ let the interval be(t_0, t_0+T)	Apply
4	Discuss how an unknown function f(t) can be expressed using infinite mutually orthogonal functions. Hence show the representation of a waveform f(t) using trigonometric fourier series.	Apply
5	A rectangular function is defined as $f(t) = \begin{cases} A, & 0 < t < \pi/2 \\ -A, & \frac{\pi}{2} < t < 3\pi/2 \\ A, & \frac{3\pi}{2} < t < 2\pi \end{cases}$ Approximate the above function by A cos t between the intervals (0,2π) suchthat the mean square error is minimum.	Apply
6	A rectangular function is defined as $f(t) = \begin{cases} 1, & 0 < t < \pi \\ -1, & \pi < t < 2\pi \end{cases}$	Remember

	Approximate the above function by a single sinusoid sint between the intervals$(0,2\pi)$, Apply the mean square error in this approximation.	
7	Show that f(t) is orthogonal to signals cost, cos2t, cos3t, … cosnt for all integervalues of n, $n\neq0$, over the interval $(0,2\pi)$ if $f(t) = \begin{cases} 1, & 0 < t < \pi \\ -1, & \pi < t < 2\pi \end{cases}$	Apply
8	Explain the analogy of vectors and signals in terms of orthogonality and evaluation of constant.	Remember
9	Estimate the mean square error value of a function f(t)	Apply
10	Sketch the following signals (i) r(t)-r(t-1)-r(t-3)+r(t-4) (ii)$\pi\ t-2\ 2+\pi(2t-3.5)$	Apply
	UNIT-II **Fourier Series & Fourier Transforms**	
1	Write down the exponential form of the Fourier series representation of a Periodic signal?	Apply
2	Write down the trigonometric form of the fourier series representation of a Periodic signal?	Apply
3	Write short notes on Dirichlet's conditions for fourier series.	Understand
4	State Time Shifting property in relation to fourier series.	Understand
5	Obtain Fourier Series Coefficients for $x(n) = sinw_0n$	Remember
6	What are the types of Fourier series?	Remember
7	Define Fourier transform pair.	Remember
8	Find the fourier transform of x(t)=sin(wt)	Understand
9	Explain how aperiodic signals can be represented by fourier transform.	Remember
10	Explain how periodic signals can be represented by fourier transform.	Remember
11	State Convolution property of Fourier Transform.	Remember
12	Find the fourier transform of x(t)=cos(wt)	Apply
13	Find the fourier transform of sgn function	Apply
14	Find the Fourier transform of $x(t)=e^{j2\pi ft}$	Apply
15	State properties of fourier transform.	Understand
16	State Parseval's relation for continuous time fourier transforms.	Apply
17	The Fourier transform (FT) of a function x (t) is X (w). What is the FT of dx(t)/ dt	Remember
18	What is the Fourier transform of a rectangular pulse existing between $t=-T/2$ to $t=T/2$	Understand
19	What is the Fourier transform of a signal $x(t)=e^{2t}u(-t)$	Apply
20	What are the difference between Fourier series and Fourier transform?	Apply
21	Explain time shifting property of fourier transform	Apply
	Long answer questions	
1	Write a short note on exponential fourier spectrum	Apply
2	Derive the polar fourier series from the exponential fourier series representationand hence prove that Dn=2 |Cn|	Apply
3	With regard to fourier series representation, justify the following statement a) odd functions have only sine terms b) even functions have no sine terms	Remember

	c) functions with half-wave symmetry have only odd harmonics	
4	Find the fourier series expansion of the periodic triangular wave shown belowfor the interval (0,T) with amplitude of 'A' 	Apply
5	Determine the fourier series of the function shown below for the interval (0,T)with amplitude of 'A' 	Understand
6	Obtain the fourier series representation of an impulse train given by $x(t) = \sum_{n=-\alpha}^{\alpha} \delta(t - nT)$	Apply
7	Determine the fourier series expansion of the square wave function as $f(t) = \begin{cases} 1, & -1/2 < t < 1/2 \\ -1, & ½ < t < 3/2 \end{cases}$	Remember
8	Obtain the trigonometric fourier series for the periodic rectangular waveform asshown below for the interval (-T/4,T/4) 	Apply
9	Assume that T=2, determine the fourier series expansion of the signal shown below with amplitude of ±1 	Apply
10	Find the exponential fourier series for the fullwave rectified sinewave as shownbelow for the interval (0,2π) with an amplitude of 'A' 	Remember
11	Distinguish between the exponential form of the fourier series and fourier transform. What is the nature of the 'transform pair' in the above two cases	Remember

12	Find the fourier transform of the following a) real exponential, $x(t)= e^{-at} u(t), a>0$ b) rectangular pulse, $x(t) = \begin{cases} 1, & -T \le t \le T \\ 0, & \|t\| > T \end{cases}$ c) $x(t)= e^{at} u(-t), a>0$	Apply
13	a) Find the fourier transform of a gate function $(t) = \begin{cases} 1, & \|t\| < 1/2 \\ 0, & \|t\| > 1/2 \end{cases}$ b) Find the fourier transform of x(t)=1	Apply
14	Find the fourier transforms of a) cos wt u(t) b) sin wt u(t) c) cos (wt+Ø) d) e^{jwt}	Remember
15	Find the fourier transforms of a normalized Gaussian pulse	Understand
16	Find the fourier transforms of a Triangular pulse	Apply
17	Find the fourier transforms of signal $x(t)=e^{-A\|t\|} sgn(t)$	Apply
18	Find the fourier transforms of signal x(t) 	Apply
19	The magnitude |Y(w)| and phase Ø(w) of the fourier transform of a signal y(t)are shown in below, find y(t)	Remember

		
20	Find the fourier transforms of signal x(t) as shown below 	Understand
21	Determine the fourier transforms of the sinc function as shown below 	Apply
22	Find the fourier transform of square wave with period T=4, amplitude of 'A'	Apply
23	Determine the fourier transform of exponentially damped sinusoidal signal 	Apply
24	Find the fourier transform of periodic pulse train with period T=T/2, withamplitude of 'A'	Remember

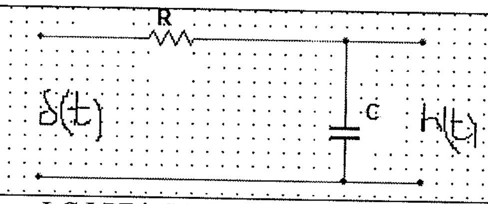
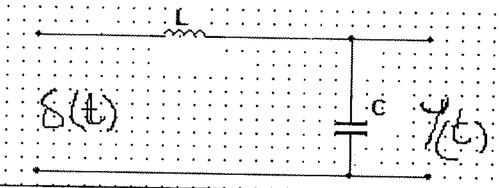
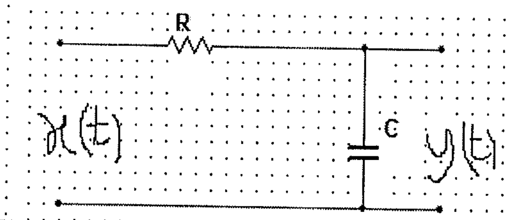
25	Find the fourier transform of $e^{-at}\sin wt\, u(t)$	Apply
26	Find the continuous magnitude and phase spectra of a single pulse $A,\ (-a, 0)$ $x(t) =\ \ 0,\ \ \forall t$ $-A,\ \ (0, a)$	Understand
27	2 Consider the signal $x(t) = \frac{\sin 50\pi t}{\pi t}$ which is to be sampled with a sampling frequency of $\omega_s=150\pi$ to obtain a signal g(t) with fourier transform G(jw). Determine the maximum value of w_0 for which it is guaranteed that G(jw)=75X(jw) for $\lvert w \rvert \le w_0$, where X(jw) is F.T of x(t)	Apply
	UNIT-III **Signal transmission through linear systems**	
1	What are the Conditions for a System to be LTI System?	Remember
2	Define time invariant and time varying systems.	Understand
3	Is the system describe by the equation y(t) = x(2t) Time invariant or not? Why?	Understand
4	What is the period T of the signal x(t) = 2cos (n/4)?	Remember

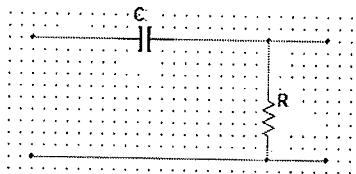
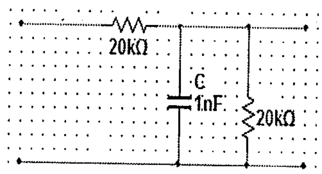
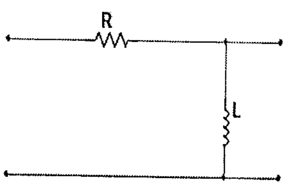
5	Is the system y(t) = y(t-1) + 2t y(t-2) time invariant ?	Understand
6	Is the discrete time system describe by the equation y (n) = x(-n) causal or non causal ?Why?	Remember
7	What is the periodicity of x(t) = $e^{j100\Pi t}$?	Understand
8	What is the impulse response of two LTI systems connected in parallel	Apply
9	Define LTI CT systems	Apply
10	What is the condition of LTI system to be stable?	Understand
11	What are the tools used for analysis of LTI CT systems?	Understand
12	When the LTICT system is said to be dynamic?	Remember

13	When the LTICT system is said to be causal?	Remember
14	When the LTICT system is said to be stable?	Remember
15	Define impulse response of continuous system	Remember
16	Find the unit step response of the system given by h (t)= 1/RC $e^{-t/RC}$ u(t)	Understand
17	What is the impulse response of the system y(t)= x(t-to)	Remember
18	Define eigenvalue and eigen function of LTI-CT system.	Understand
19	The impulse response of the LTI-CT system is given as h(t) = e^{-t} u(t). Determine transfer function and check whether the system is causal and stable series?	Remember
20	Define impulse response of a linear time invariant system.	Understand

21	Write down the input-output relation of LTI system in time and frequency domain.	Remember
22	Define transfer function in CT systems.	Understand
23	What is the relationship between input and output of an LTI system?	Apply
24	Write down the convolution integral to find the output of the CT systems	Apply
25	Give the system impulse response h(t). State the conditions for stability and causality.	Understand
26	List and draw the basic elements for the bloc diagram representation of the CT systems.	Understand
27	What are the three elementary operations in block diagram representation of CT system	Remember
	Long Answers Questions	

1	Determine whether the following input-output equations are linear or non linear. a) $y(t)=x^2(t)$ b) $y(t)=x(t^2)$ c) $y(t)=t^2x(t-1)$ d) $y(t)=x(t) \cos 50\pi t$	Understand
2	Find whether the following system are static or dynamic a) $y(t)= x(t^2)$ b) $y(t)=e^{x(t)}$ c) $y(t) = \sum_{r=0}^{\infty} x(t-r)dr$	Apply
3	Find whether the following systems are causal or non-causal a) $y(t)=x(-t)$ b) $y(t)=x(t+10)+x(t)$ c) $y(t)=x(\sin(t))$ d) $y(t)=x(t) \sin(t+1)$	Apply
4	Determine whether the following systems are time-varying or time-invariant a) $y(t)=tx(t)$ b) $y(t)=t^2 x(t-1)$ c) $y(t)=a[x(t)]^2+bx(t)$ d) $y(t)=x(t) \cos 50\pi t$	Apply
5	Show that the following systems are LTI systems a) $y(t)=x(t/4)$ b) $y(t) = \begin{cases} x(t)+x(t-4), & t \geq 0 \\ 0, & t < 0 \end{cases}$	Apply
6	Find whether the following systems are stable or unstable a) $y(t)=e^{x(t)}$; $\lvert x(t)\rvert<10$ b) $y(t)=(t+10)\,u(t)$	Apply
7	Find the impulse response of a system characterized by the differential equations a) $r\left[\frac{dy(t)}{dt}\right] + y(t) = x(t); \quad -\infty < t < \infty$ b) $r\left[\frac{d^2y(t)}{dt^2}\right] + y(t) = x(t); \quad -\infty < t < \infty$ Where x(t) is the input and y(t) is the output	Apply
8	Test whether the system described in the figure is BIBO stable or not	Understand

		
9	Test whether the given LC LPF is BIBO stable or not 	Apply
10	Find the voltage of the RC LPF shown below for an input voltage of te^{-at} 	Apply
11	The impulse response of a continuous time system is expressed as □$(t) = \frac{1}{RC} e^{-\frac{t}{RC}} u(t)$ find the frequency response and plot the magnitude and phase plots	Understand
12	A system produces an output of $y(t)= e^{-t} u(t)$ for an input of $x(t)= e^{-2t} u(t)$. Determine the impulse response and frequency response of the system	Apply
13	The input voltage to an RC circuit is given as $x(t)=te^{-t/RC} u(t)$ and the impulse response of this circuit is given as $h(t)=(1/RC)\ e^{-t/RC} u(t)$. Determine the outputy(t)	Apply
14	For a system excited by $x(t)=e^{-2t} u(t)$, the impulse response is $h(t)=e^{-t} u(t)+e^{2t} u(-t)$, find the output y(t) for this system	Apply

15	Consider a causal LTI system with frequency response $H(w) = \frac{1}{3+jw}$ For a particular input x(t), the system is observed to produce the output, $y(t)=e^{-3t}u(t)-e^{-4t}u(t)$, find the input x(t)?	Understand
16	The transfer function of the LPF is given by $$H(w) = \begin{cases} (1 + k\cos wT)e^{-jwr}; & \lvert w\rvert < 2\pi B \\ 0; & \lvert w\rvert > 2\pi B \end{cases}$$ Determine the output y(t) when a pulse x(t) band limited in B is applied at input	Understand
17	Find the impulse response of the system as shown below  Find the transfer function. What would be its frequency response? Sketch the response.	Apply
18	Determine the maximum bandwidth of signals that can be transmitted through the low pass RC filter as shown below, if over this bandwidth, the gain variationis to be within 10% and the phase variation is to be within 7% of the ideal characteristics.  	Apply
19	There are several possible ways of estimating an essential bandwidth of non-band limited signal. For a low pass signal, for example, the essential bandwidth may be chosen as a frequency where the amplitude spectrum of the signal decays to k% of its peak value. The choice of k depends on the nature of application. Choosing k=5, determine the essential bandwidth of $g(t)= e^{-at}u(t)$.	Apply
20	Find the impulse response to the RL filter as shown below  	Understand
21	Consider a stable LTI system characterized by the differential equation $$\frac{d^2y(t)}{dt^2} + 4\frac{d\,y(t)}{dt} + 3\,y(t) = \frac{d\,x(t)}{dt} + 2\,x(t)$$ Find its impulse response and transfer function	Understand

	UNIT-IV **Laplace transforms and z transforms**	
1	What is the use of Laplace transform?	Understand
2	What are the types of laplace transform?	Remember
3	Define Bilateral and unilateral laplace transform.	Understand
4	Define inverse laplace transform.	Remember
5	State the linearity property for laplace transform.	Apply
6	Region of convergence of the laplace transform	Understand
7	State the time shifting property for laplace transform	Understand

8	What is pole zero plot.	Apply
9	State initial value theorem and final value theorem for laplace transform	Apply
10	State Convolution property of the Laplace transform	Apply
11.	What is region of Convergence?	Understand
12.	What are the Properties of ROC?	Remember
13.	The unilateral Laplace transform of $f(t)$ is $1/s^2+s+1$. What is the unilateral Laplace transform of $tf(t)$	Understand
14.	Find the Laplace Transforms of the function f(t)u(t),where f(t) is periodic with period T, is A(s) times the L.T. of its first period.	Remember
15.	In what range should Re(s) remain so that the L.T. of the function $e^{(a+2)t+5}$ exists?	Apply

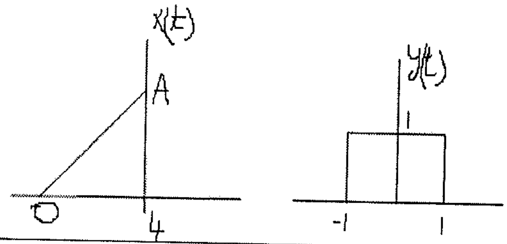
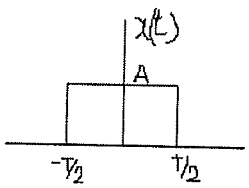
16.	Define Z transform.	Understand
17.	What are the two types of Z transform?	Understand
18.	Define unilateral Z transform.	Apply
19.	What is the time shifting property of Z transform.	Apply
20	What is the differentiation property in Z domain	Apply
21	State convolution property of Z transform.	Understand
22	State the methods to find inverse Z transform.	Remember
23	State multiplication property in relation to Z transform.	Understand

24	State parseval's relation for Z transform.	Remember
25	What is the relationship between Z transform and fourier	Apply
26	Define one sided Z transform and two sided Z transform.	Understand
27	What is the Z-transform of sequence $x(n)=a^n u(n)$?	Understand
28	What is the linearity property of Z transform	Apply
29	What is the correlation property of z transform	Apply
30	The final value of $x(t)=(2+e^{-3t})\ u(t)$ is obviously $x(\infty)=2$. Show that this final value can be found with the final value theorem.	Understand
	Long Answer Questions	

1.	Determine the function of time x(t) for each of the following Laplace transformsand their associated region of convergence i) $\frac{2(s+1)}{s^2-s+1}$ $Re\{s\} > 1/2$ ii) $\frac{s^2-s+1}{(s+1)^2}$ $Re\{s\} > -1$	Understand
2.	Consider the following signals, find Laplace transform and region of convergence for each signal a) e^{-2t} u(t) + e^{-3t} u(t) b) e^{-4t} u(t) + e^{-5t} sin 5t u(t)	Apply
3.	State the properties of Laplace transform	Understand
4.	Determine the function of time x(t) for each of the following Laplace transforms a) $\frac{1}{s^2+9}$; $Re\{s\} > 0$ b) $\frac{s}{s^2+9}$; $Re\{s\} < 0$ c) $\frac{s+1}{(s+1)^2+9}$; $Re\{s\} < -1$	Remember
5.	Determine the Laplace transform and associated region of convergence for eachof the following functions of time i) x(t) = 1; $0 \le t \le 1$ ii) x(t)= t; $2-t$; $1 \le t \le 2$ iii) x(t)= cos wt	Apply
6.	Properties of ROC of Laplace transforms	Understand
7.	Find the Laplace Transforms of the following functions a) exponential function b) unit step function c) hyperbolic sine & cosine d) damped sine function e) damped hyperbolic cosine & sine f) power 'n'	Understand
8.	Find the inverse Laplace transform of the functions i) Y(s)= $\frac{10s}{(s+2)^3(s+8)}$ ii) Y(s)= $\frac{10s}{(s+2)^2(s+8)}$	Apply

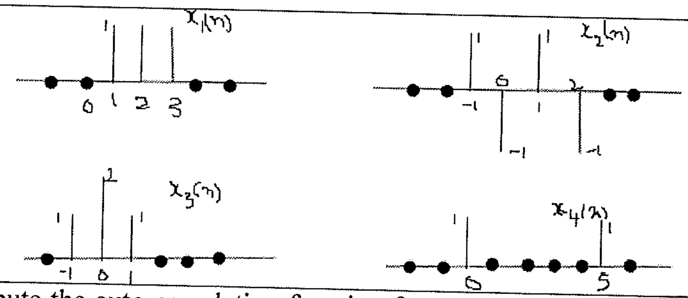
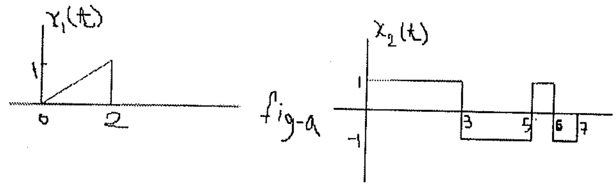
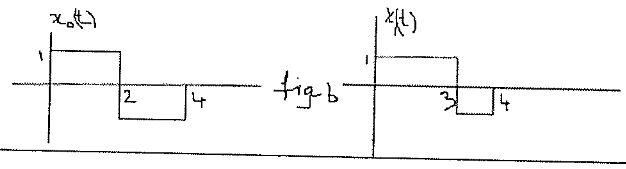
9.	Find the inverse Laplace transform of the functions i) $Y(s)= \frac{2s^2+6s+6}{(s+2)(s^2+2s+2)}$ ii) $Y(s)= \frac{s^4+5s^3+12s^2+7s+15}{(s+2)(s^2+1)^2}$	Apply
10.	A certain function f(t) is known to have a transform $F(s)= \frac{6s^2+8s+5}{s(2s^2+6s+5)}$, find f(t) find also values of f(t) at t=0 and $t=\infty$	Apply
11.	Find x(t) if $X(s)= \frac{1}{(s^2+a^2)^2}$ using convolution	Understand
12.	For an initially inert system, the impulse response is $(e^{-2t}+e^{-t})$ u(t). find the excitation to produce an output of t. e^{-2t} u(t)	Remember
13.	Find the Laplace transform of the following function , x(t)= (1/t) $\sin^2$ wt	Understand
14.	Obtain the inverse Laplace transform of the function $ln \left\{ \frac{s+a}{s+b} \right\}$	Remember
15.	Find the Laplace Transform of cos wt and sin wt using frequency shifting property	Apply
16	Determine the Laplace transform and associated region of convergence andpole-zero plot for the following function of time. $x(t)= e^{-2t} u(t) + e^{3t} u(t)$	Understand

17	Find the z-transform of the following sequences i) $x[n]= a^{-n} u[-n-1]$ ii) $x[n]= u[-n]$ iii) $x[n]= -a^{n} u[-n-1]$	Understand
18	A finite series sequence x[n] is defined as x[n]={5,3,-2,0,4,-3}.find X[z] and itsROC.	Apply
19	Find the z-transform of the following i) x[n]= cos nw. u[n] ii) $x[n]= a^{n}$ sin nw. u[n] iii) $x[n]= a^{n}$ u [n]	Apply
20	Find the z-transform and ROC of the following sequences i) x[n]=[4(5n)-3(4n)] u(n) ii) $(1/3)^{n}$ u[-n] iii) $(1/3)^{n}$ [u[-n]-u[n-8]]	Apply
21	Constraints on ROC for various classes of signals?	Understand
22	Using the power series expansion technique, find the inverse z-transform of thefollowing X(z): i) $X(z)= \frac{z}{2z^2-3z+1}$; $\|z\|<1/2$ ii) $X(z)= \frac{z}{2z^2-3z+1}$; $\|z\|>1$	Remember
23	Find the inverse Z-transform of $X(z)= \frac{z}{z(z-1)(z-2)^2}$; $\|z\|>2$ using partial fraction	Understand
24	Find inverse z-transform of X(z) using long division method −1 X(z)= 2+3z $1+z^{-1})(1+0.25z^{-1}$ (z−2)) − 8	Remember

25	Properties of Z-transforms?	Apply
26	Find the inverse z-transform of $X(z)=\frac{2\,(z^{-1})}{z^{2}-0.1z-0.56}$	Understand
	UNIT-V **sampling theorem and correlation**	
1	Determine the convolution of two functions $x(t)=a\,e^{-at}$; $y(t)=u(t)$	Apply
2	Find the convolution of the functions x(t) and y(t) as shown below 	Apply
3	Find the convolution of the rectangular pulse given below with itself 	
4	Determine the energy and power for the following signals and hence determine whether the signal id energy or power signal i) $x(t)=e^{-3t}$ ii) $x(t)=e^{-3\|t\|}$ iii) $x(t)=e^{-10t}u(t)$ iv) $x(t)=A\,e^{j2\pi at}$	

5	Verify Parseval's theorem for the energy signal $x(t)= e^{-at} u(t), a>0$	
6	What is meant by sampling?	Apply
7	State Sampling theorem.	Understand
8	What is meant by aliasing?	Apply
9	What are the effects aliasing?	Apply
	Long answer questions	
1	The signal $x(t)=\cos 5\pi t+0.3 \cos 10\pi t$ is instantaneously sampled. Determine themaximum interval of the sample	Remember
2	The signal $x(t)=\cos 5\pi t+0.3 \cos 10\pi t$ is instantaneously sampled. The interval between the samples is T_s a) Find the maximum allowable value for T_s b) If the sampling signal is $S(t) = \sum_{k=-\alpha}^{\alpha} \delta(t-0.1k)$, the sampled signal $v_s(t)= v(t).S(t)$ consists of a train of impulses, each with a different strength $v_s(t) = \sum_{k=-\alpha}^{\alpha} I_k \delta(t-0.1k)$, find I_0, I_1, I_2 c) To reconstruct the signal $v_s(t)$ is passed through a rectangular LPF. Findthe minimum filter bandwidth to reconstruct the signal without	Apply

	distortion	
3	For the analog signal $x(t)=3 \cos 100\pi t$ a) Determine the minimum sampling rate to avoid aliasing b) Suppose that the signal is sampled at the rate, f_s=200Hz, what is thediscrete time signal obtained after sampling c) Suppose that the signal is sampled at the rate, f_s=75Hz, what is thediscrete time signal obtained after sampling d) What is the frequency $0<f< f_s/2$ of a sinusoid that yields samplesidentical to those obtained in (c) above	Understand
4	Show that a band limited signal of finite energy which has no frequency components higher than f_m Hz is completely described by specifying values of the signals at instants of time separated by $1/2\ f_m$ seconds. Also show that if theinstantaneous values of the signal are separated at intervals larger than $1/2\ f_m$ seconds, they fail to describe the signal. A band pass signal has spectral range extending from 20kHz to 80kHz; find the acceptable range of sampling frequency f_s.	Apply
5	A flat-top sampling system samples s signal of maximum frequency 1kHz with 2.5 Hz sampling frequency. The duration of the pulse is 0.2s. Compute the amplitude distortion due to aperture effect at the highest signal frequency. Also determine the equalization characteristic.	Apply
6	Suppose that the signal $x(t)= u(t+0.5)-u(t-0.5)$ and the signal $h(t)= e^{jwt}$ a) Determine a value of w which ensures that $y(0)=0$, where$y(t)=x(t)*h(t)$ b) Is your answer to the previous part unique?	Apply
7	a) If $x(t)=0,\ \|t\|>T_1$ and $h(t)=0,\ \|t\|>T_2$ then $x(t)*h(t)=0,\ \|t\|>T_3$ for some positive number T_3. Express T_3 in terms of T_1 and T_2 b) Consider a discrete-time LTI system with the property that if the input	Remember
8	a) compute the auto correlation sequences for the signals $x_1[n]$, $x_2[n]$, $x_3[n]$,$x_4[n]$ as shown below b) compute the cross-correlation sequences $\emptyset_{x_i x_j}[n]$, $i\neq j$, $i,j=1,2,3,4$	Apply

		
9	a) compute the auto correlation function for each of the two signals $x_1(t)$ and $x_2(t)$ as shown in fig-a b) let x(t) be a given signal, and assume that x(t) is of finite duration—i.e., that x(t)=0 for t<0 and t>T. Find the impulse response of an LTI system so that $Ø_{xx}(t-T)$ is the output if x(t) is the input c) The system determined in fig-b is a matched filter for the signal x(t). Let x(t) be as in fig-b, and let y(t) denote the response to x(t) of an LTI system with real impulse response h(t). Assume that h(t)=0 for t<0 and for t>T. show that the choice for h(t) that maximizes y(T), subject to the constraint that $\int_0^T \square^2(t)dt = M$; *a fixed positive number*  	Apply

Code No: 153BT

R18

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B.Tech II Year I Semester Examinations, October - 2020

SIGNALS AND SYSTEMS

(Common to ECE, EIE)

Time: 2 hours **Max. Marks: 75**

Answer any five questions

All questions carry equal marks

\- - -

1.a) Show that f(t) is orthogonal to signals cost, cos2t, cos3t, … cos nt for all integer values of n, n≠0, over the interval (0,2π) if $x(t) = \begin{cases} 1, & for\ 0 < t < \pi \\ -1, & for\ \pi < t < 2\pi \end{cases}$ C214.1 understand

b) Discover the analogy of vectors and signals in terms of orthogonality. Understand C214.1

2.a) Estimate the mean square error value of a function f(t). Evaluate C214.1

b) Sketch the following signals (i) r(t)-r(t-1)-r(t-3)+r(t-4) (ii)$\pi\left(\frac{t-2}{2}\right) + \pi(2t - 3.5)$[7+8]

3.a) Assume that T=2, determine the Fourier series expansion of the signal shown below figure 1 with amplitude of ±1. Evaluate C214.4

Figure: 1

b) Prove the following properties of the Fourier transform: (i) duality (ii) modulation.[8+7] understand C214.4

4.a) Determine the exponential Fourier series from trigonometric Fourier series. Evaluate C214.4

b) Solve the Fourier transform of the rectangular pulse. Evaluate [6+9]

5.a) Find the convolution of the rectangular pulse given below figure 2 with itself. Evaluate C214.4

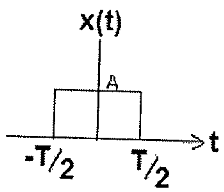


Figure: 2

b) Explain causality and physical relizability of a system and give Paley wiener criterion. Analyze C214.3 [8+7]

6.a) A system produces an output of $y(t)= e^{-t}\,u(t)$ for an input of $x(t)= e^{-2t}\,u(t)$. Determine the impulse response and frequency response of the system. Evaluate C214.3

b) Compare the signals and system bandwidth. understand C214.3 [9+6]

7. Evaluate the Laplace Transforms of the following functions: Evaluate C214.4
a) Exponential function b) Unit step function c) Damped sine function. [15]

8.a) Prove that for a signal, auto correlation and PSD form a Fourier transform pair. Analyze C214.4

b) A function f(t) has a PSD of S(w). Find the PSD of i) integral of f(t) and ii) time derivative of f(t). [7+8]

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Code No: R1621043 **R16** SET - 1

II B. Tech I Semester Supplementary Examinations, May - 2019
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) Define continuous time unit step and unit impulse C214.1 understand
   b) State the condition for convergence of Fourier series. C214.2 understand (2M)
   c) Define System and signal bandwidth. C214.3 Remember (3M)
   d) List and state the properties of convolution Integral C214.3 Remember (2M)
   e) Define ROC of the Laplace Transform C214.4 Remember (2M)
   f) Find the Z-transform and its ROC of $\delta(n+k)$ C214.4 Evaluate (3M)

PART -B

2. a) Test Whether the signal x(n) = (½) ^{n} u(n) energy or power signal C214.1 Evaluate (7M)
   b) Explain about analogy between vectors and signals C214.1 understand (7M)
3. a) State and prove the properties of Hilbert's transform C214. understand (7M)
   b) State and prove any four properties of Fourier Transform C214.4 understand (7M)
4. a) State and prove sampling theorem for band limited signals. C214.6 understand (7M)
   b) Determine the Nyquist sampling rate and Nyquist sampling interval for C214.6 (7M) Evaluate
   i) $x(t) = 2sinc(100\Pi t)$ ii) $x(t) = sinc(80\Pi t)sinc(120\Pi t)$
5. a) Obtain the relationship between the bandwidth and rise time of ideal low pass filter. (7M) C214.3 Evaluate
   b) Prove that autocorrelation function and energy spectral density function forms a Fourier transform pair. (7M) C214.6 Remember
6. a) State and prove initial value and final value theorems of Laplace transform. (7M) C214.4 understand
   b) Find the inverse Laplace transform of x(s) = 5(s+5)/ s(s+3) (s+7); Re(s) > -3 (7M) C214.4 Evaluate
7. a) State and prove time shifting and time convolution properties of z- transform. (7M) Evaluate
   b) Find the inverse Z-transform of $X(z) = \frac{z+2}{4z^2-2z+3}$ C214.4 (7M)

C214.4 Evaluate
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Code No: R1621043 **R16** SET - 1

II B. Tech I Semester Regular/Supplementary Examinations, October/November - 2018
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) Determine whether the sequence is periodic or not. $x_2(n) = \sin(n/8)$. (2M)
b) Obtain the Fourier transform of the impulse function δ(t) (2M)
c) Define aliasing. (2M)
d) State the properties of power spectral density. (2M)
e) Determine the function of time x(t) of the Laplace Transform and the ROC $\frac{s}{s^2+9}$ (3M)
f) Find the Z-transform of the sequence u[n] (3M)

PART –B

2. a) Define orthogonal signal space and bring out clearly its application in representing a signal. (5M)
b) Obtain the condition under which two signals f1(t) and f2(t) are said to be orthogonal to each other. Hence prove that Sin nw_0t and Cos mw_0t are orthogonal to each other for all integer values of m,n (9M)

3. a) Derive the necessary expression to represent the function f(t) using Trigonometric Fourier Series. (7M)
b) Bring out the relationship between Trigonometric and Exponential Fourier series. (7M)

4. a) Explain briefly impulse sampling. (7M)
b) Define sampling theorem for time limited signal and find the Nyquist rate for the following signals. (7M)
i. rect300t
ii. -10 sin 40πt cos 300πt

5. a) Explain how input and output signals are related to impulse response of a LTI system. (7M)
b) Explain the characteristics of an ideal LPF. Explain why it can't be realized. (7M)
c) Differentiate between signal bandwidth and system bandwidth. (7M)
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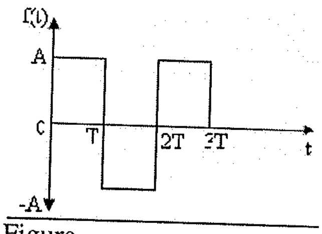
6. a) State and Prove Initial value and Final value theorem with respect to Laplace transform. (7M)
   b) Find the Laplace transform of the periodic rectangular wave shown in Figure. (7M)



Figure

7. a) State and prove the convolution and scale change properties in Z transform (6M)
   b) Prove that the final value of x(n) for $X(z) = z^2/[z-1][z-0.2]$ is 1.25 and its initial value is unity. (8M)

Code No: R1621043

R16

SET - 2

II B. Tech I Semester Regular/Supplementary Examinations, October/November - 2018

SIGNALS & SYSTEMS

(Com to ECE, EIE and ECC)

Time: 3 hours

Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) Determine the continuous time version of a sinusoidal signal and bring out the relation between sinusoidal and complex exponential signals. (2M)
   b) State and represent the time differentiation property of Fourier transform. (2M)
   c) Define flat top sampling. (2M)
   d) State the relations between convolution and correlation. (2M)
   e) Determine the function of time x(t) of the Laplace Transform and the ROC $\frac{1}{s^2+9}$ (3M)
   f) Find the Z-transform of the sequence u[-n] (3M)

PART –B

2. a) Derive the expression for component vector of approximating the function $f_1(t)$over $f_2(t)$ and also prove that the component vector becomes zero if the $f_1(t)$ and $f_2(t)$ are orthogonal. (7M)
   b) A rectangular function f(t) is defined by (7M)
   f(t) = 1 for $0<t<\pi$
   = -1 for $\pi<t<2\pi$
   Approximate this function by a waveform *sin*t over the interval (0, 2π) such that the mean square error is minimum

3. a) Define Hilbert Transform. What is its significance. (7M)
   b) Determine the Hilbert Transform of the signal x(t) = cost3t. (7M)

4. a) State and Prove the sampling theorem for Band limited signals. (7M)
   b) Discuss the effect of aliasing due to under sampling (7M)

5. a) Determine an expression for the correlation function of a square wave having the values 1 or 0 and a period T. (6M)
   b) The signal $V(t) = \cos \omega_o t + 2\sin 3\omega_o t + 0.5 \sin 4\omega_o t$ is filtered by an RC low pass filter with a 3 dB frequency, $f_c = 2f_o$. Find the output power S_o. (6M)
   c) State Parseval's theorem for energy / power signals. (2M)
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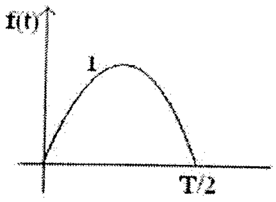
6. a) Derive the relation between Laplace Transform and Fourier Transform. (7M)
   b) Determine the Laplace transform of signal shown in figure (7M)



7. a) Using scaling property determine the Z-transform of $a^n \cos\omega n$ and find its ROC. (6M)
   b) Using differentiation property find the Z-transform of $x(n) = n^2u(n)$. (4M)
   c) Obtain the Z-transform of $x(n) = -a^nu(-n-1)$ (4M)

Code No: R1621043 **R16** SET - 3

II B. Tech I Semester Regular/Supplementary Examinations, October/November - 2018
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) Write short notes on orthogonal functions. (2M)
   b) Obtain the Fourier transform of the DC signal (2M)
   c) What is the effect of under sampling. How can it be reduced. (2M)
   d) Differentiate between causal and non causal systems. (2M)
   e) State the initial value theorem of Laplace Transform. (3M)
   f) Distinguish between one sided and two sided z transforms. (3M)

PART –B

2. a) Define and sketch the following signals (8M)
   i) Truncated Exponential signal
   ii) Delayed Unit impulse function
   iii) Unit parabolic function
   iv) Sinc function.
   b) Define and sketch the unit step function and signum function. Bring out the relation between these two functions (6M)

3. a) Compute the Fourier Transform of (7M)
   i) $f(t) = (1/2)^{-n}u(-n-1)$
   ii) $f(t) = \sin(n\pi/2)+\cos(n)$
   b) State all the properties of Fourier Transform. (7M)

4. a) The signal x(t) with Fourier transform $X(j\omega) = u(\omega + \omega_0) - u(\omega - \omega_0)$ can undergo impulse train sampling without aliasing, provided that the sampling period $T < \pi/\omega_0$. Justify. (7M)
   b) A signal $x(t)= 2\cos400\pi t + 6\cos640\pi t$ is ideally sampled at $f_s = 500$Hz. If the sampled signal is passed through an ideal low pass filter with a cut off frequency of 400 Hz, what frequency components will appear in the output. (7M)

5. a) Explain the process of detection of periodic signals by the process of correlation. (7M)
   b) Determine the cross correlation between the two sequences x(n) = {1,0,01} and h(n) = { 4,3,2,1} (7M)

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6. a) State the properties of the ROC of LT (6M)

b) Determine the function of time x(t) for each of the following Laplace Transforms and their associated regions of convergence (8M)

i) $\frac{(s+1)^2}{s^2-s+1}$ Re{S} > ½

ii) $\frac{s^2-s+1}{(s+1)^2}$ Re{S} > -1

7. a) Determine inverse Z Transform of x(z) = $\frac{1}{2-4z^{-1}+2z^2}$ by long division method when i) ROC : $|Z| > 1$ ii) ROC : $|Z| < 1$ (7M)

b) Determine Z Transform of the following (7M)

i) $(1/4)^4\, u(n) - cos(n\pi/4)\, u(n)$

ii) $2^n\, u(n-2)$

Code No: R1621043 **R16** SET - 4

II B. Tech I Semester Regular/Supplementary Examinations, October/November - 2018
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) Determine whether the sequence is periodic or not. $x_1(n) = \sin(6\pi\, n/7)$. (2M)
   b) Obtain the Fourier transform of the unit step function. (2M)
   c) Define impulse sampling. (2M)
   d) What are the characteristics of an ideal LPF. (2M)
   e) State the properties of Laplace transforms (3M)
   f) Find the Z-transform of the sequence $\delta[n]$. (3M)

PART –B

2. a) Define and sketch the following signals (6M)
   i) Unit Step function
   ii) Unit impulse function
   iii) Signum function
   b) Explain the analogy of vectors and signals in terms of orthogonality and evaluation of constant. (9M)

3. a) Determine the Fourier transform of a two sided exponential pulse $x(t) = e^{-|t|}$ (7M)
   b) Find the Fourier transforms of an even function $x_e(t)$ and odd function $x_o(t)$ of $x(t)$. (7M)

4. Determine the Nyquist sampling rate and Nyquist interval for the given signals.
   a) Sin $c(100\Pi t)$ (3M)
   b) Sin τ $(100\Pi t)$ (3M)
   c) Sin $c(100\Pi t)$ + Sin $c(50\Pi t)$ (4M)
   d) Sin $c(100\Pi t)$ + 3Sin $c^2(60\Pi t)$ (4M)

5. a) What are the requirements to be satisfied by an LTI system to provide distortionless transmission of a signal? (7M)
   b) Bring out the relation between bandwidth and rise time? (7M)
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6. a) Find inverse Laplace Transforms of the following (8M)
   i) $\frac{s^2+6s+7}{s^2+3s+2}$ $Re\{S\} > -1$
   ii) $\frac{s^3+2s^2+6}{s^2+3s}$ $Re\{S\} > 0$
   b) Find the Laplace transform of cos ωt (6M)

7. a) State and prove the properties of the Z-transform (7M)
   b) Find the Z-transform of the following sequence (7M)
   $x[u] = a^n\ u[n]$

Code No: R1621043 **R16** SET - 1

II B. Tech I Semester Regular Examinations, October/November - 2017
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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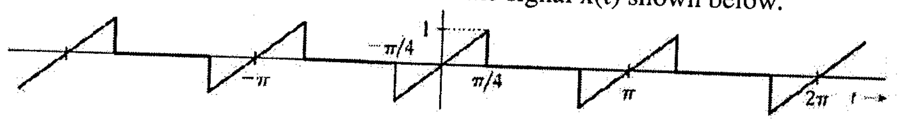
PART –A

1. a) Define an impulse function and plot $\delta(t+2) - \delta(t-3)$. (2M)
 b) Define Hilbert transform of a signal x(t). (2M)
 c) Write short notes on band pass sampling. (3M)
 d) Write the conditions for distortion less transmission. (3M)
 e) Write time scaling property of Laplace transform. (2M)
 f) Find the Z transform of $\delta(n-2)$ (2M)

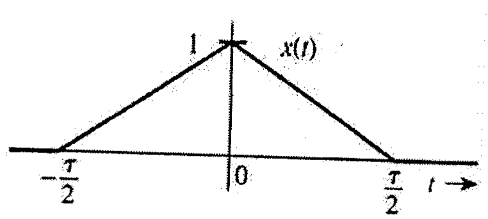
PART –B

2. a) Find the even and odd components of the signal $x(t) = \cos(\omega_0 t + \pi/3)$. (7M)
 b) A function $f(t) = \begin{cases} 1 & 0 < t \le 0.5 \\ -1 & 0.5 < t \le 1 \end{cases}$ using $f(t) = c_1 \sin t + c_2 \sin 3t$. Compute the coefficients c_1, c_2. (5M)
 c) Discuss orthogonality in complex functions. (2M)

3. a) Find the trigonometric Fourier series for the signal x(t) shown below. (7M)



 b) Compute the Fourier transform of the signal x(t) applying differentiation in time property of Fourier transform. (7M)



4. State and prove sampling theorem for band limited signals. (14M)

5. a) A system represented by $y(t) = 2x(t-2) + 2x(t+2)$. (7M)
 i) Is the system time invariant? Justify your answer.
 ii) Is the system causal? Justify your answer.
 b) Explain detection of signal in the presence of noise using correlation. (7M)
~~~~~~

6. a) Find the inverse Laplace transform of (7M)
$G(s)=\dfrac{4s}{(s+3)(s+8)},\ \sigma>-3$

b) Find the Laplace transform of $e^{-\alpha|t|}$ (7M)

7. a) Using the z-domain differentiation property find the Z transform of (7M)
$x[n]=n(5/8)^{n}\,u[n]$

b) Find the inverse of (7M)
$X(z)=\dfrac{z-1}{3z^{2}-2z+2},\ |z|<0.8165$

Code No: R1621043

R16

SET - 2

II B. Tech I Semester Regular Examinations, October/November - 2017
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours

Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

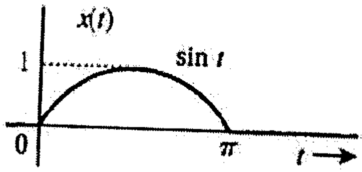
~~~~~~

PART –A

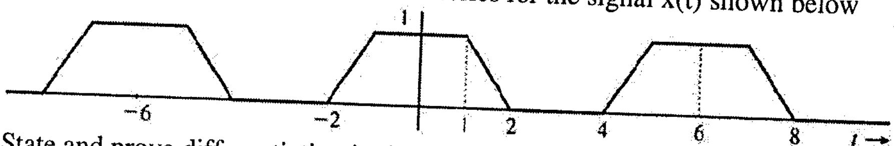
1. a) Define a unit step function and plot u(t-2) (2M)
b) Write Direchlet's conditions. (3M)
c) Discuss the effects of under sampling on recovery of signal. (2M)
d) Explain the characteristics of ideal LPF. (2M)
e) Write the constraints on ROC for different signals. (3M)
f) Find the Z transform of δ(n+2) (2M)

PART –B

2. a) Find the even and odd components of the signal x(t) =sin2t + sin2t.cos2t + cos2t (7M)
b) Discuss orthogonality in signals using relevant expressions. Explain the term complete set. Give examples of complete sets. (4M)
c) Compute the energy of the signal x(t) shown below (3M)



3. a) Find the complex exponential Fourier series for the signal x(t) shown below (10M)



b) State and prove differentiation in time domain property of Fourier transform. (4M)

4. a) Explain natural sampling with relevant waveforms and expressions. (7M)
b) Explain reconstruction of signals from samples using relevant expressions. (7M)

5. a) A system is given by y(t) = $\frac{d}{dt}x(t-1)$, (7M)
i) Check whether the system is BIBO stable. (Let x(t) be a square wave.)
ii) Is the system causal? Justify your answer.
b) Write the properties of autocorrelation function and prove two of them. (7M)

|''|'''||''||'''||||
~~~~~~

6. a) Find the inverse Laplace transform of (7M)

$G(s) = \frac{4}{(s+3)(s+8)}, \sigma > -3$

b) Find the Laplace transform of $e^{-\sigma t}\sin(\omega_0 t)u(t)$ (7M)

7. a) Using convolution property find the Z transform of (7M)

$x[n] = (0.9)^n u[n] * (0.6)^n u[n]$

b) Find the inverse Z transform of (7M)

$X(z) = \frac{z^2}{(z-1/2)(z-3/4)}, \ |z| < 1/2$

Code No: R1621043 **R16** SET - 3

II B. Tech I Semester Regular Examinations, October/November - 2017
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

~~~~~~

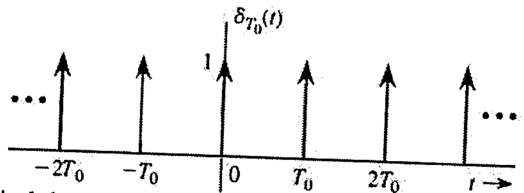
PART –A

1. a) Explain time reversal and draw time reversed unit step function. (2M)
   b) Express complex exponential Fourier coefficients in terms of trigonometric Fourier coefficients. (2M)
   c) State sampling theorem for band pass signals. (3M)
   d) Explain the characteristics of ideal HPF. (2M)
   e) Define region of convergence of Laplace transform. (2M)
   f) Compare Laplace, Fourier and z- transforms. (3M)

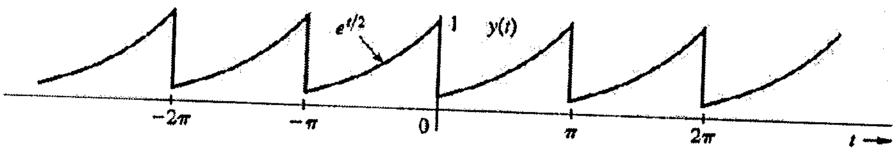
PART -B

2. a) Derive the expression for mean square error when a function is approximated by a set of orthogonal signals. (10M)
   b) Find the even and odd components of the signal x(t) = tu(t) (4M)

3. a) Compute the Fourier transform of the signal represented below (7M)



   b) Find the trigonometric Fourier series for the signal y(t) shown below (7M)



4. a) Explain flat top sampling with relevant expressions and waveforms. (7M)
   b) What is Nyquist rate of sampling? A signal x(t) = 10sinc(500t), find its Nyquist rate. Where sinc(x) = $\frac{\sin(\pi x)}{\pi x}$ (7M)

5. a) Derive the relationship between autocorrelation function and energy spectral density of an energy signal. (7M)
   b) Stating the properties and relevant mathematical expressions check whether the following systems are LTI or not? (7M)
   i) y(t) = 2x(t) + 3x(3t)
   ii) $z(t) = (dw(t)/dt)^2$
~~~~~~

6. a) Find the inverse Laplace transform of (7M)
$G(s) = \frac{s}{s^2+2s+2}, \sigma > -1$
b) Find the Laplace transform of $-te^{-\alpha t}u(-t)$ (7M)

7. a) Find the inverse Z transform of $X(z) = \ln(1+az^{-1})$; ROC $|z|>a$ (7M)
b) Find the Z transform and ROC of (7M)
$x[n] = (0.8)^n u[n] + (0.6)^n u[-(n+1)]$

Code No: R1621043

R16

SET - 4

II B. Tech I Semester Regular Examinations, October/November - 2017
SIGNALS & SYSTEMS
(Com to ECE, EIE and ECC)

Time: 3 hours

Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

~~~~~~

PART –A

1. a) Define an even signal and check whether signum function is even or not?. (2M)
   b) Write duality property of Fourier transform. (2M)
   c) A signal x(t) = 5sin(250t) + 6 sin(200πt), find the sampling rate to avoid aliasing. (3M)
   d) Explain the characteristics of ideal BPF. (2M)
   e) Write the relationship between Laplace transform and Fourier transform of a signal. (2M)
   f) Find the Z transform of nδ(n). (3M)

PART -B

2. a) Find the even and odd components of the signal $x(t) = (1+t^2+t^3)\cos^2 10t$. (7M)
   b) Present the analogy between vectors and signals. (7M)

3. a) Find the Fourier transform of the signum function. (5M)
   b) Write the properties of Fourier series. (5M)
   c) Find the Fourier transform of $x(t) = e^{-a|t|}$ (4M)

4. a) Compare impulse sampling, natural sampling and flat top sampling with relevant diagrams. (7M)
   b) What is aliasing effect? Explain using relevant diagrams. Suggest the remedies to avoid aliasing. (7M)

5. a) Define cross correlation function, write its properties and prove any two of them. (7M)
   b) Derive the relationship between bandwidth and rise time. (7M)

6. a) Find the inverse Laplace transform of (7M)
   $$G(s) = \frac{e^{-2s}}{s^2+2s+2}, \ \sigma > -1$$
   b) Find the Laplace transform of $-e^{-\alpha t}\sin(\omega_0 t)\,u(-t)$ (7M)

7. a) Find the inverse Z transform of $X[z] = \frac{-z(z+0.4)}{(z-0.8)(z-2)}$ ROC $0.8 < |z| < 2$ (7M)
   b) Find the Z transform and ROC of $x[n] = (1.2)^n u[n] + (3)^n u[-n-1]$ (7M)

|''|'''||''||'''||||
~~~~~~

F.S → period

F.T → Aperiod

UNIT-5

$x(t) \to x(s)$ $x(n)$

LAPLACE TRANSFORMS AND Z-TRANSFORMS

Discrete

LAPLACE TRANSFORMS:

x/10   1, 2, 6, 10, 11, 12, 14, 20, 21, 23, 25, 26, 38, 33, 35, 38, 41, 42, 48, 50, 55

→ Laplace transform represents continuous time signals in terms of complex exponentials i.e e^{-st}. It is used to analyze the signals or functions which are not absolutely integrable.

→ More effectively continuous time signals can be analyzed using laplace transform.

→ Laplace transform provides broader characterization compared to Fourier Transform.

DEFINITION:

→ To transform a time domain signal x(t) to S-domain, multiply the signal by e^{-st} and then integrate from $-\infty$ to ∞.

→ The transformed signal is represented as X(s) and transformation is denoted by letter $\mathcal{L}$

Laplace transform is given as for continuous time signal x(t)

i.e

$$\boxed{X(s) = \int_{-\infty}^{\infty} x(t) e^{-st}\, dt} \to ①$$

where 'S' is complex in nature and given as $s = \sigma + j\omega$.

(σ → realpart / attenuation constant; $j\omega$ → imaginary / complex frequency)

→ If x(t) is defined for $t \geq 0$ (i.e x(t) is causal) then

$$\boxed{\mathcal{L}\{x(t)\} = X(s) = \int_{0}^{\infty} x(t) e^{-st}\, dt} \to ②$$

TYPES OF LAPLACE TRANSFORM:

(i) Bilateral or two sided Laplace transform: If the integration is taken from $-\infty$ to ∞ as shown in eq(1) then it is called Bilateral L.T

(ii) Unilateral or one sided Laplace transform: If the integration is taken from 0 to ∞ as shown in eq(2) then it is called Unilateral L.T

→ Useful in analysis of networks and solving differential equations.

INVERSE LAPLACE TRANSFORM:

→ The s-domain signal X(s) can be transformed to time domain signal x(t) by using inverse laplace transform and is defined as

$$L^{-1}[X(s)] = x(t) = \frac{1}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty} X(s)e^{st}\,ds$$

→ The signal x(t) and X(s) are called Laplace transform pair

$$x(t) \underset{L^{-1}}{\overset{L}{\rightleftharpoons}} X(s)$$

RELATION BETWEEN FOURIER TRANSFORM AND LAPLACE TRANSFORM:

Fourier transform is given as

$$X(j\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}\,dt \quad \rightarrow (1)$$

→ FT can be calculated only if x(t) is absolutely integrable i.e

$$\int_{-\infty}^{\infty} |x(t)|\,dt < \infty \quad \rightarrow (2)$$

→ Laplace transform is written as $x(t)e^{-st}$

$$X(s) = \int_{-\infty}^{\infty} x(t)e^{-(\sigma+j\omega)t}\,dt \quad \text{putting } s=\sigma+j\omega$$

$$= \int_{-\infty}^{\infty} x(t)e^{-\sigma t}\cdot e^{-j\omega t}\,dt \qquad e^{a+b} = e^a\cdot e^b$$

$$L(x(t)) = X(s) = \int_{-\infty}^{\infty}\{x(t)e^{-\sigma t}\}e^{-j\omega t}\,dt \quad \rightarrow (3) \qquad \sigma = \text{Real}$$

comparing eq(3) with eq(1), laplace transform of x(t) is basically fourier transform of $x(t)e^{-\sigma t}$.

→ If $\sigma=0$, then above equation i.e $s=j\omega$ the above eqn

$$X(s) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}\,dt = X(j\omega) \text{ when } s=j\omega.$$

→ It is basically fourier transform on imaginary ($j\omega$) axis in s-plane.

CONVERGENCE / REGION OF CONVERGENCE (ROC):

→ From eqn $\left\{ \int_{-\infty}^{\infty} (x(t)e^{-\sigma t})\, e^{-j\omega t} dt \right\}$ we know that Laplace transform is basically the fourier transform of $x(t)e^{-\sigma t}$. If fourier transform of $x(t)e^{-\sigma t}$ exists then laplace transform of $x(t)$ exists.

→ $\int_{-\infty}^{\infty} |x(t)e^{-\sigma t}|\, dt < \infty$ must be absolutely integrable for fourier transform to exists.

→ Laplace transform of $x(t)$ will exist, if above condition is satisfied.

→ The range of values of 'σ' for which laplace transform converges is called ROC or region of convergence.

(or)

→ The Laplace transform of a signal given by $\int_{-\infty}^{\infty} x(t)e^{-st}\, dt$. The values of '$s$' for which the integral $\int_{-\infty}^{\infty} x(t)e^{-st}\, dt$ converges is called ROC.

PROBLEMS:

(1) Calculate the Laplace transform and ROC for $x(t) = e^{-at}u(t)$ (Right sided causal sgl)

Sol

$x(t) = e^{-at}u(t)$ where $a > 0$

$= e^{-at}$ for $t \geq 0$

$$L[x(t)] = X(s) = \int_{-\infty}^{\infty} x(t)e^{-st} dt = \int_{-\infty}^{\infty} e^{-at}u(t)\, e^{-st} dt$$

$$= \int_{0}^{\infty} e^{-at} e^{-st} dt = \int_{0}^{\infty} e^{-(s+a)t} dt$$

$$= \frac{1}{-(s+a)} \left[e^{-(s+a)t} \right]_0^{\infty} = \frac{-1}{s+a} [0 - 1]$$

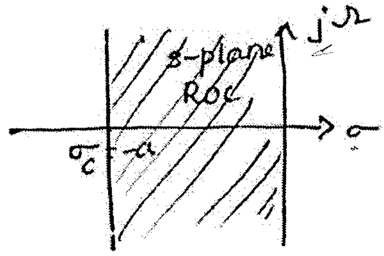
$$= \frac{1}{s+a}$$

ROC: $s > -a$

$$= -\left[\frac{e^{-(s+a)t}}{s+a}\right]_0^{\infty}$$

$$= -\left\{\lim_{t\to\infty}\left[\frac{e^{-(s+a)t}}{s+a}\right] - \lim_{t\to 0}\left[\frac{e^{-(s+a)t}}{s+a}\right]\right\}$$

$$X(s) = +\left[\frac{e^{-(s+a)\infty}}{-(s+a)} - \frac{e^{-(s+a)0}}{-(s+a)}\right]$$



$s = j\omega + \sigma$

$$L\{x(t)\} = \frac{e^{-k\times\infty}e^{-j\Omega\times\infty}}{s+a} + \frac{1}{s+a}$$

where $k = \sigma + a = \sigma - (-a)$.

when $\sigma > -a$, $k = \sigma - (-a)$ = positive $\therefore e^{-k\infty} = e^{-\infty} = 0$

When $\sigma < -a$, $k = \sigma - (-a)$ = Negative $\therefore e^{-k\infty} = e^{+\infty} = \infty$

$\therefore$ $X(s)$ converges when $\sigma > -a$ and does not converge for $\sigma < -a$.

$\therefore$ When $\sigma > -a$, the $X(s)$ is given by

$$L\{x(t)\} = X(s) = \frac{-e^{-k\times\infty}e^{-j\Omega\times\infty}}{s+a} + \frac{1}{s+a} = \frac{-0\times e^{-j\Omega\times\infty}}{s+a} + \frac{1}{s+a} = \frac{1}{s+a}$$

Properties of L.T :

(1) Amplitude Scaling

If $L[x(t)] = X(s)$ then $L[A\,x(t)] = A\,X(s)$

Proof:

$$X(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t)\cdot e^{-st}\,dt$$

$$L\{A\,x(t)\} = \int_{-\infty}^{\infty} A\cdot x(t)e^{-st}\,dt = A\int_{-\infty}^{\infty} x(t)e^{-st}\,dt$$

$$= A\,X(s).$$

(2) Linearity:

If $L\{x_1(t)\} = X_1(s)$ and $L\{x_2(t)\} = X_2(s)$ then $L\{a_1x_1(t) + a_2x_2(t)\} = a_1X(s) + a_2X_2(s)$

Proof

$$X_1(s) = L\{x_1(t)\} = \int_{-\infty}^{\infty} x_1(t)e^{-st}\,dt$$

$$X_2(s) = L\{x_2(t)\} = \int_{-\infty}^{\infty} x_2(t)e^{-st}\,dt$$

$$L\{a_1x_1(t) + a_2x_2(t)\} = \int_{-\infty}^{\infty}[a_1x_1(t) + a_2x_2(t)]e^{-st}\,dt$$

$$= a_1\int_{-\infty}^{\infty} x_1(t)e^{-st}\,dt + a_2\int_{-\infty}^{\infty} x_2(t)e^{-st}\,dt$$

$$= a_1X_1(s) + a_2X_2(s)$$

3) Time differentiation:

If $L\{x(t)\} = X(s)$ then $L\left\{\frac{d}{dt}x(t)\right\} = sX(s) - x(0)$; where $x(0)$ is value of $x(t)$ at $t=0$

Proof

$$X(s) = L\{x(t)\} = \int_0^{\infty} x(t)e^{-st}\,dt$$

$$\therefore L\left\{\frac{d}{dt}x(t)\right\} = \int_0^{\infty}\frac{dx(t)}{dt}\,e^{-st} = \int_0^{\infty} e^{-st}\frac{dx(t)}{dt}\,dt$$

$\left\{\because \int uv = u\int v - \int\left[du\int v\right]\right.$

$u = e^{-st} \mid v = \frac{dx(t)}{dt}$

$$= \left[e^{-st}\cdot x(t)\right]_0^{\infty} - \int_0^{\infty} -s\,e^{-st}x(t)\,dt$$

$$= e^{-\infty}x(\infty) - e^{0}x(0) + s\int_0^{\infty} x(t)e^{-st}\,dt$$

$$= s\int_0^{\infty} x(t)e^{-st}\,dt - x(0) = sX(s) - x(0)$$

(4) Time Integration:

If $L[x(t)] = X(s)$ then $L\{\int x(t)\,dt\} = \frac{X(s)}{s} + \frac{[\int x(t)\,dt]_{t=0}}{s}$

Proof

$$X(s) = L\{x(t)\} = \int_0^{\infty} x(t) e^{-st} dt$$

$$L\{\int x(t)\,dt\} = \int_0^{\infty} \left[\int x(t)\,dt\right] e^{-st} dt$$

$$= \left[\left[\int x(t)\,dt\right] \frac{e^{-st}}{-s}\right]_0^{\infty} - \int_0^{\infty} x(t) \cdot \frac{e^{-st}}{-s}\, dt$$

$$= \left[\int x(t)\,dt\right]\Big|_{t=\infty} \frac{e^{-\infty}}{-s} - \left[\int x(t)\,dt\right]\Big|_{t=0} \frac{e^{0}}{-s} + \frac{1}{s}\int_0^{\infty} x(t) e^{-st} dt$$

$$= \frac{1}{s}\left[\int x(t)\,dt\right]\Big|_{t=0} + \frac{1}{s}\int_0^{\infty} x(t)\, e^{-st} dt$$

$$= \frac{X(s)}{s} + \frac{\left[\int x(t)\,dt\right]\big|_{t=0}}{s}$$

5) Frequency shifting:

If $L[x(t)] = X(s)$ then $L\{e^{\pm at} x(t)\} = X(s \mp a)$

Proof

$$X(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t) e^{-st} dt$$

$$\therefore L\{e^{\pm at} x(t)\} = \int_{-\infty}^{\infty} e^{\pm at} x(t) \cdot e^{-st} dt$$

$$= \int_{-\infty}^{\infty} x(t) \cdot e^{-(s \mp a)t} dt$$

$$= X(s \mp a).$$

6) Time shifting

If $L\{x(t)\} = X(s)$ then $L\{x(t \pm a)\} = e^{\pm as} X(s)$

Proof:

$$x(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t)e^{-st}dt$$

$$L\{x(t\pm a)\} = \int_{-\infty}^{\infty} x(t\pm a)e^{-st}dt = \int_{-\infty}^{\infty} x(\tau)e^{-s(\tau\mp a)}d\tau$$

put $t\pm a=\tau$
$\therefore t=\tau\mp a$
$dt=d\tau$

$$= \int_{-\infty}^{\infty} x(\tau)e^{-s\tau}\times e^{\pm as}d\tau = e^{\pm as}\int_{-\infty}^{\infty} x(\tau)e^{-s\tau}d\tau$$

$$= e^{\pm as}\int_{-\infty}^{\infty} x(t)e^{-st}dt = e^{\pm as}(x(s))$$

(7) Frequency differentiation:

If $L\{x(t)\} = x(s)$ then $L\{t\,x(t)\} = -\frac{d}{ds}x(s)$

proof

$$x(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t)e^{-st}dt$$

$$\frac{d}{ds}x(s) = \frac{d}{ds}\int_{-\infty}^{\infty} x(t)e^{-st}dt$$

$$= \int_{-\infty}^{\infty} x(t)\left(\frac{d}{ds}e^{-st}\right)dt = \int_{-\infty}^{\infty} x(t)(-te^{-st})dt$$

$$= \int_{-\infty}^{\infty}(-t\,x(t))\,e^{-st}dt = L\{-t\,x(t)\} = -L\{t\,x(t)\}$$

$$\therefore L\{t\times x(t)\} = -\frac{d}{ds}x(s).$$

(8) Frequency Integration:

If $L\{x(t)\} = x(s)$ then $L\left\{\frac{1}{t}x(t)\right\} = \int_s^{\infty} x(s)\,ds.$

Proof

$$x(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t)e^{-st}dt$$

On integrating above eqn w.r.to s b/w limits s to ∞

$$\int_s^{\infty} x(s)\,ds = \int_s^{\infty}\left[\int_{-\infty}^{\infty} x(t)e^{-st}dt\right]ds = \int_{-\infty}^{\infty} x(t)\left[\int_s^{\infty} e^{-st}ds\right]dt$$

$$= \int_{-\infty}^{\infty} x(t)\left[\frac{e^{-st}}{-t}\right]_s^{\infty}dt = \int_{-\infty}^{\infty} x(t)\left[\frac{e^{\infty}}{-t} - \frac{e^{-st}}{-t}\right]dt$$

$$= \int_{-\infty}^{\infty} x(t)\left[0+\frac{e^{-st}}{t}\right]dt = \int_{-\infty}^{\infty}\left[\frac{1}{t}x(t)\right]e^{-st}dt = L\left\{\frac{1}{t}x(t)\right\}.$$

9) Time Scaling:

If $L[x(t)] = X(s)$ then $L\{x(at)\} = \frac{1}{|a|} X\left(\frac{s}{a}\right)$

Proof

$$X(s) = L\{x(t)\} = \int_{-\infty}^{\infty} x(t) e^{-st} dt$$

$$\therefore L\{x(at)\} = \int_{-\infty}^{\infty} x(at) e^{-st} dt = \int_{-\infty}^{\infty} x(\tau) e^{-s\left(\frac{\tau}{a}\right)} \frac{d\tau}{a} \quad \left\} \begin{array}{l} \text{put } at = \tau \\ \therefore dt = \frac{d\tau}{a} \end{array} \right.$$

$$= \frac{1}{a} \int_{-\infty}^{\infty} x(\tau) e^{-\left(\frac{s}{a}\right)\tau} d\tau$$

$$= \frac{1}{a} X\left(\frac{s}{a}\right)$$

The above transform is applicable for positive values of 'a'.

If 'a' happens to be negative

$$L\{x(at)\} = \frac{-1}{a} X\left(\frac{s}{a}\right)$$

In general, $L\{x(at)\} = \frac{1}{|a|} X\left(\frac{s}{a}\right)$.

(10) Periodicity:

If $x(t) = x(t+nT)$ and $x_1(t)$ be one period of $x(t)$ and $L\{x_1(t)\} = \int_0^T x_1(t) e^{-st} dt$

then $L\{x(t+nT)\} = \frac{1}{1-e^{-sT}} \int_0^T x_1(t) e^{-st} dt$

Proof

$$L\{x(t+nT)\} = \int_0^{\infty} x(t+nT) e^{-st} dt$$

$$= \int_0^T x_1(t) e^{-st} dt + \int_T^{2T} x_1(t-T) e^{-s(t+T)} dt + \int_{2T}^{3T} x_1(t-2T) e^{-s(t+2T)} dt + \cdots$$

$$+ \cdots + \int_{PT}^{(P+1)T} x_1(t-PT) e^{-s(t+PT)} dt + \cdots$$

$$= \sum_{P=0}^{\infty} \int_{PT}^{(P+1)T} x_1(t-PT) e^{-s(t+PT)} dt$$

$$= \sum_{P=0}^{\infty} \int_0^T x_1(t) e^{-st} \cdot e^{-PsT} dt = \int_0^T x_1(t) e^{-st} \left(\sum_{P=0}^{\infty} e^{-PsT}\right) dt$$

$$= \int_0^T x_1(t) e^{-st} \left(\sum_{P=0}^{\infty} e^{-sT}\right)^P dt$$

$$= \int_0^T x_1(t) e^{-st} \left(\frac{1}{1-e^{-sT}}\right) dt = \frac{1}{1-e^{-sT}} \int_0^T x_1(t) e^{-st} dt.$$

Initial Value Theorem:

The initial value theorem states that, if x(t) and its derivative are Laplace transformable then $\underset{t\to 0}{Lt}\, x(t) = \underset{s\to\infty}{Lt}\, sX(s)$.

i.e $x(0) = \underset{t\to 0}{Lt}\, x(t) = \underset{s\to\infty}{Lt}\, sX(s)$.

Proof

We know that

$$L\left\{\frac{dx(t)}{dt}\right\} = sX(s) - x(0)$$

On taking limits $s\to\infty$ on both sides of equation.

$$\underset{s\to\infty}{Lt}\, L\left\{\frac{dx(t)}{dt}\right\} = \underset{s\to\infty}{Lt}\left[sX(s) - x(0)\right]$$

$$\Rightarrow \underset{s\to\infty}{Lt}\int_0^\infty \frac{dx(t)}{dt} e^{-st}\, dt = \underset{s\to\infty}{Lt}\left[sX(s) - x(0)\right]$$

$$\Rightarrow \int_0^\infty \frac{dx(t)}{dt}\left(\underset{s\to\infty}{Lt}\, e^{-st}\right) dt = \underset{s\to\infty}{Lt}\, sX(s) - x(0)$$

$$\Rightarrow 0 = \underset{s\to\infty}{Lt}\, sX(s) - x(0)$$

$$\therefore x(0) = \underset{s\to\infty}{Lt}\, sX(s).$$

$$\boxed{\therefore \underset{t\to 0}{Lt}\, x(t) = \underset{s\to\infty}{Lt}\, sX(s)}$$

Final Value theorem:

The final value theorem states that if x(t) and its deriative are laplace transformable then $\underset{t\to\infty}{Lt}\, x(t) = \underset{s\to 0}{Lt}\, sX(s)$.

i.e Final value of signal $x(\infty) = \underset{t\to\infty}{Lt}\, x(t) = \underset{s\to 0}{Lt}\, sX(s)$.

proof

$$L\left\{\frac{dx(t)}{dt}\right\} = sX(s) - x(0)$$

By taking limits $s\to 0$ on both sides of above eqn we get

$$\underset{s\to 0}{Lt}\, L\left\{\frac{dx(t)}{dt}\right\} = \underset{s\to 0}{Lt}\left\{sX(s) - x(0)\right\}$$

$$\lim_{s\to 0}\int_0^{\infty}\frac{dx(t)}{dt}e^{-st}dt = \lim_{s\to 0}\left[sX(s)-x(0)\right]$$

$$\int_0^{\infty}\frac{dx(t)}{dt}\left(\lim_{s\to 0}e^{-st}\right)dt = \lim_{s\to 0}sX(s) - x(0)$$

Not fn of 's'

Z - TRANSFORMS :

FUNDAMENTAL DIFFERENCES BETWEEN CONTINUOUS & DISCRETE TIME SIGNAL
(Ref Unit - I page No: 9)

→ DISCRETE TIME SIGNAL REPRESENTATION USING COMPLEX EXPOENTIAL AND SINUSDIOAL COMPONENTS. (Ref Unit - I - page No: 10, 11, 12)

→ PERIODICITY PROPERTIES OF DT COMPLEX FUNCTIONS :

→ A DT complex exponential is periodic if it repeats after certain 'N' number of samples.

consider $x(n) = e^{j\omega_0 n}$

$$\therefore x(n+N) = e^{j\omega_0 (n+N)}$$

$$= e^{j\omega_0 n} \cdot e^{j\omega_0 N}$$

For periodicity $x(n) = x(n+N)$

$$\text{i.e. } e^{j\omega_0 n} = e^{j\omega_0 n} \cdot e^{j\omega_0 N} \Rightarrow e^{j\omega_0 N} = 1.$$

Expressing $e^{j\omega_0 N}$ in terms of sinusoidal functions

$$e^{j\omega_0 N} = \cos\omega_0 N + j\sin\omega_0 N \quad \text{by Euler's identity } e^{j\theta} = \cos\theta + j\sin\theta$$

→ For periodicity $e^{j\omega_0 N} = 1$ gives $\cos\omega_0 N + j\sin\omega_0 N = 1$. This eqn is satisfied for

$$\omega_0 N = 2\pi, 4\pi, 6\pi, 8\pi \ldots$$

$$= 2\pi K \quad \text{where } K = \text{integer}.$$

$$\text{(or)} \quad \frac{\omega_0}{2\pi} = \frac{K}{N} \quad \rightarrow (1)$$

$$\text{but } \omega_0 = 2\pi f \Rightarrow \frac{\omega_0}{2\pi} = f \quad \rightarrow (2)$$

Substitute (2) in (1)

$$f = \frac{K}{N}.$$

∴ For complex exponential to be periodic, $\frac{\omega_0}{2\pi} = \frac{K}{N}$ (i.e rational)

Z-TRANFORM (CONCEPT):

The z-transform of $x(n)$ is denoted by $X(z)$ and defined as

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

→ where z is complex variable.

→ $x(n)$ & $X(z)$ is called z-transform pair represented as

$$x(n) \xleftrightarrow{z} X(z).$$

→ Purpose of learning z-transform is to analyse the DT signals and systems, digital filter design and for synthesis of digital filter / systems.

→ For any input sequence, the z-transform is complex. It has real & imaginary parts.

$x(n)$ ⟶ [z-transform] ⟶ $X(z)$
Real & Imaginary parts.

DISTINCTION BETWEEN LAPLACE, FOURIER AND Z TRANSFORM:

z-transform given as

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n} \quad \text{ROC}: r_2 < |z| < r_1$$

where 'z' is defined as $z = re^{j\Omega}$ in which 'r' is magnitude of z i.e $|z|$, and Ω = angle of z i.e $\angle z$

→ putting for $z = re^{j\Omega}$ in $X(z)$ we get

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) (re^{j\Omega})^{-n}$$

$$= \sum_{n=-\infty}^{\infty} [x(n) r^{-n}] e^{-j\Omega n}. \quad \to (1)$$

→ Fourier transform is given by $X(\Omega) = \sum_{n=-\infty}^{\infty} x(n) e^{-j\Omega n}$ →(2) comparing $X(\Omega)$ with $X(z)$ we find that $X(z)$ indicates fourier transform of $x(n) r^{-n}$.

→ Let X(z) of eq ① is evaluated on unit circle. Then $|z| = r = 1$ i.e $r^{-n} = 1$

$$\therefore X(z)\Big|_{z=e^{j\Omega}} = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j\Omega n}.$$

→ Fourier transform by definition

$$\boxed{X(z)\Big|_{z=e^{j\Omega}} = X(\Omega)}$$ → R/Betn FT & Z-T

→ Laplace Transform of i/p sgl x(t) defined as

$$L\{x(t)\} = X(s) = \int_{0}^{\infty} x(t)\, e^{-st}\, dt \rightarrow ①$$

On substituting $s = \sigma + j\Omega$ in above eqn ①

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\, e^{-(\sigma + j\Omega)t}\, dt \rightarrow ②$$

but definition of fourier transform of x(t) is

$$F\{x(t)\} = X(j\Omega) = \int_{-\infty}^{\infty} x(t) \cdot e^{-j\Omega t}\, dt \rightarrow ③$$

By comparing equations ② & (3) we can say that

By putting $\sigma = 0$ in laplace transform we get fourier transform of continuous time signal.

$$\therefore X(j\Omega) = X(s)\Big|_{s=j\Omega}.$$

REGION OF CONVERGENCE IN Z-TRANSFORM :

→ Since z-transform is an infinite power series, it exists only for those values of z for which the series converges.

→ The ROC of X(z) is the set of all values of z, for which X(z) attains a finite value.

CONSTRAINTS ON ROC FOR VARIOUS CLASSES OF SIGNALS: (OR)

PROPERTIES OF ROC with proofs:

(1) The ROC is a ring or disk in the z-plane centered at the origin.

(2) The ROC cannot contain any poles.

(3) If x(n) is a finite duration, causal sequence then the ROC is the entire z-plane except at z=0.

(4) If x(n) is a finite duration, anti-causal sequence then the ROC is the entire z-plane except at $z=\infty$

(5) If x(n) is a finite duration, two sided sequence then the ROC is entire z-plane except at $z=0$ & $z=\infty$.

(6) If x(n) is an infinite duration, two sided sequence the ROC will consist of a ring in z-plane, bounded on interior and exterior by a pole not containing any poles.

(7) The ROC of an LTI stable system contains unit circle.

(8) The ROC must be connected region.

Case i) Finite duration, right sided (causal) signal:

Let x(n) be finite duration signal with N-samples, defined in range $0 \leq n \leq (N-1)$

$$\therefore x(n) = \{x(0), x(1), x(2) \dots x(N-1)\}$$

$$X(z) = \sum_{n=0}^{N-1} x(n) z^{-n}$$

$$= x(0) + x(1) z^{-1} + \dots + x(N-1) z^{-(N-1)}$$

$$= x(0) + \frac{x(1)}{z} + \frac{x(2)}{z^2} + \dots + \frac{x(N-1)}{z^{N-1}}$$

When z=0, all the terms except the first term become infinite. Hence the X(z) exists for all values of z except z=0.

$\therefore$ ROC for finite duration right sided is entire z-plane except z=0

Case ii) finite duration, left sided (anticausal) signal:

Let x(n) be finite duration signal with N-samples, defined in the range $-(N-1) \leq n < 0$

$$\therefore x(n) = \{x(-N-1)), \ldots x(-2), x(-1), x(0)\}$$

z-transform of x(n) is

$$X(z) = \sum_{n=-(N-1)}^{0} x(n) z^{-n}$$

$$x(z) = x(-(N-1)) z^{(N-1)} + \ldots + (x(-2)) z^2 + x(-1) z + x(0)$$

when $z = \infty$, all terms expept the last term become infinite. Hence the x(z) exists for all values of z, except $z = \infty$.

$\therefore$ ROC of x(z) is entire z-plane except $z = \infty$.

Case iii) Finite duration, two sided (non-causal) signal:

Let x(n) be a finite duration signal with N-samples, defined in the range $-M \leq n \leq M$ where $M = \frac{N-1}{2}$.

$$\therefore x(n) = \{x(-M), \ldots, x(-2), x(-1), x(0), x(1), x(2) \ldots x(M)\}$$

z-transform of x(n) is

$$x(z) = \sum_{n=-M}^{M} x(n) z^{-n}$$

$$= x(-M) z^M + \ldots + x(-2) z^2 + x(-1) z + x(0) + x(1) z^{-1} + x(2) z^{-2} + \cdots + x(M) z^{-M}$$

$$= x(-M) z^M + \ldots + x(-2) z^2 + x(-1) z + x(0) + \frac{x(1)}{z} + \frac{x(2)}{z^2} + \cdots + \frac{x(M)}{z^M}.$$

when $z = 0$, the terms with negative power of z attain infinity and when $z = \infty$, the terms with positive power of z attain infinity. Hence x(z) converges for all values of z, except at $z = 0$ & $z = \infty$.

ROC is entire z-plane except $z = 0$ & $z = \infty$.

Case iv) Infinite duration, right sided (causal) signal :

Let $x(n) = r_1^n$; $n \geq 0$

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n} = \sum_{n=0}^{\infty} r_1^n z^{-n} = \sum_{n=0}^{\infty} (r_1 z^{-1})^n$$

If $0 < |r_1 z^{-1}| < 1$, then $\sum_{n=0}^{\infty} |r_1 z^{-1}|^n = \frac{1}{1 - r_1 z^{-1}}$

{ Using infinite geometric series sum formula

$$\sum_{n=0}^{\infty} c^n = \frac{1}{1-c}$$

if $0 < |c| < 1$

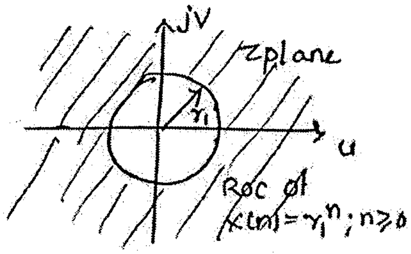
$$\therefore X(z) = \frac{1}{1 - \frac{r_1}{z}} = \frac{z}{z - r_1}$$

Condition to be satisfied for convergence of $X(z)$ is

$0 < |r_1 z^{-1}| < 1$

$\therefore |r_1 z^{-1}| < 1$

$\frac{|r_1|}{|z|} < 1 \Rightarrow |z| > |r_1|$ → represent a circle of radius r_1 in z-plane.



→ $X(z)$ converges for all points external to the circle of radius r_1 in z-plane.

$\therefore$ ROC of $X(z)$ is exterior of the circle of radius r_1 in z-plane.

Case v) : Infinite duration, left sided (anticausal) signal :

Let $x(n) = r_2^n$; $n \leq 0$

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n} = \sum_{n=-\infty}^{0} r_2^n z^{-n} = \sum_{n=0}^{\infty} (r_2^{-1} z)^n$$

If $0 < |r_2^{-1} z| < 1$ then $\sum_{n=0}^{\infty} (r_2^{-1} z)^n = \frac{1}{1 - r_2^{-1} z}$.

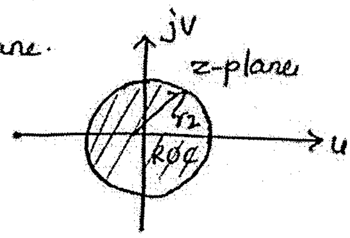
$$\therefore X(z) = \frac{1}{1 - r_2^{-1} z} = \frac{1}{1 - \frac{z}{r_2}} = \frac{r_2}{r_2 - z}$$

$$= \frac{-r_2}{z - r_2}$$

Condition to be satisfied for convergence of $X(z)$ is

$0 < |r_2^{-1} z^{-1}| < 1 \Rightarrow \therefore |r_2^{-1} z| < 1 \Rightarrow \frac{|z|}{|r_2|} < 1 \Rightarrow |z| < |r_2|$

The term $|r_2|$ represent a ck of radius of r_2 in z-plane. $X(z)$ converges for all pts internal to the ck of radius r_2 in z-plane. ∴ ROC of $X(z)$ is interior of the circle of radius r_2.



Case vi) Infinite duration, two sided (anticausal) signal:

Let $x(n) = r_1^n u(n) + r_2^n u(-n)$

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n} = \sum_{n=-\infty}^{\infty} r_2^n z^{-n} + \sum_{n=0}^{\infty} r_1^n z^{-n}$$

$$= \sum_{n=0}^{\infty} r_2^{-n} z^n + \sum_{n=0}^{\infty} r_1^n z^{-n}$$

$$= \sum_{n=0}^{\infty} (r_2^{-1} z)^n + \sum_{n=0}^{\infty} (r_1 z^{-1})^n$$

$$= \frac{1}{1-r_2^{-1}z} + \frac{1}{1-r_1 z^{-1}}$$

{ Using infinite geometric series sum formula if $0<|r_2^{-1}z|<1$ & $0<|r_1 z^{-1}|<1$

The term $\sum_{n=0}^{\infty} (r_2^{-1} z)^n$ converges if

$0<|r_2^{-1}z|<1$

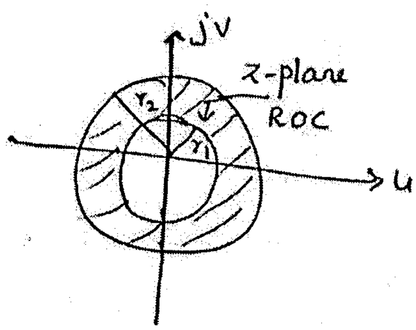
$\therefore |r_2^{-1}z|<1 \Rightarrow |r_2^{-1}z| \Rightarrow \frac{|z|}{|r_2|}<1 \Rightarrow |z|<|r_2|$.

The term $\sum_{n=0}^{\infty} (r_1 z^{-1})^n$ converges if

$0<|r_1^{-1}z|<1$

$\therefore |r_1 z^{-1}|<1$

$\frac{|r_1|}{|z|}<1 \Rightarrow |z|>|r_1|$.



∴ ROC is the region between two circles of radius r_1 & r_2.

PROPERTIES OF Z-TRANSFORM:

Linearity Property:

→ States that z-transform of linear weighted combination of discrete time signals is equal to similar linear weighted combination of z transform of individual discrete time signals.

Let $z[x_1(n)] = X_1(z)$ and $z[x_2(n)] = X_2(z)$ then by linearity property

$$z[a_1 x_1(n) + a_2 x_2(n)] = a_1 X_1(z) + a_2 X_2(z) \quad (a_1, a_2 \text{ are constants}).$$

proof:

z-transform definition

$$X_1(z) = z\{x_1(n)\} = \sum_{n=-\infty}^{\infty} x_1(n) z^{-n}$$

$$X_2(z) = z\{x_2(n)\} = \sum_{n=-\infty}^{\infty} x_2(n) z^{-n}$$

$$z[a_1 x_1(n) + a_2 x_2(n)] = \sum_{n=-\infty}^{\infty} [a_1 x_1(n) + a_2 x_2(n)] z^{-n}$$

$$= \sum_{n=-\infty}^{\infty} [a_1 x_1(n) z^{-n} + a_2 x_2(n) z^{-n}]$$

$$= \sum_{n=-\infty}^{\infty} a_1 x_1(n) z^{-n} + \sum_{n=-\infty}^{\infty} a_2 x_2(n) z^{-n}$$

$$= a_1 \sum_{n=-\infty}^{\infty} x_1(n) z^{-n} + a_2 \sum_{n=-\infty}^{\infty} x_2(n) z^{-n}$$

$$= a_1 X_1(z) + a_2 X_2(z).$$

Shifting property:

case i) Two sided z-transform

The shifting property of z-transform states that z-transform of a shifted signal shifted by 'm' units of time is obtained by multiplying z^m to z-transform of unshifted signal.

Let $z\{x(n)\} = X(z)$ then $z\{x(n-m)\} = z^{-m} X(z)$ & $z\{x(n+m)\} = z^m X(z)$

Proof:

$$X(z) = z\{x(n)\} = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z\{x(n-m)\} = \sum_{n=-\infty}^{\infty} x(n-m) z^{-n}$$

Let $n-m=p \therefore n=p+m$

when $n \to -\infty, p \to -\infty$

$n \to \infty, \ p \to \infty$

$$= \sum_{p=-\infty}^{\infty} x(p) z^{-(m+p)}$$

$$= \sum_{p=-\infty}^{\infty} x(p) z^{-p} \cdot z^{-m}$$

$$= z^{-m} \sum_{p=-\infty}^{\infty} x(p) z^{-p} = z^{-m} X(z)$$

$$z\{x(n+m)\} = \sum_{n=-\infty}^{\infty} x(n+m) z^{-n}$$

$$= \sum_{p=-\infty}^{\infty} x(p) z^{-(p-m)}$$

$$= \sum_{p=-\infty}^{\infty} x(p) z^{-p} \cdot z^{m}$$

$$= z^{m} \sum_{p=-\infty}^{\infty} x(p) z^{-p} \qquad (\because \text{if } p \to n)$$

$$= z^{m} \cdot X(z).$$

Case ii) One sided z-transform:

Let $x(n)$ be discrete time signal defined in range $0<n<\infty$

$$z[x(n)] = X(z)$$

By shifting property

$$z[x(n-m)] = z^{-m} X(z) + \sum_{i=1}^{m} x(-i) z^{-(m-i)}$$

$$z[x(n+m)] = z^{m} X(z) - \sum_{i=0}^{m-1} x(i) z^{(m-i)}$$

Proof

$$X(z) = z\{x(n)\} = \sum_{n=0}^{\infty} x(n) z^{-n}$$

$$z\{x(n-m)\} = \sum_{n=0}^{\infty} x(n-m) z^{-n}$$

multiply by z^m & z^{-m}

$$= \sum_{n=0}^{\infty} x(n-m) z^{-n} z^{m} . z^{-m}$$

$$= z^{-m} \sum_{n=0}^{\infty} x(n-m) z^{-(n-m)}$$

$$= z^{-m} \sum_{p=-m}^{\infty} x(p) z^{-p} \quad \left\{ \text{Let } n-m=p \right.$$

$$= z^{-m} \sum_{p=0}^{\infty} x(p) z^{-p} + \sum_{p=-m}^{-1} x(p) z^{-p} . z^{-m}$$

$$= z^{-m} \sum_{p=0}^{\infty} x(p) z^{-p} + z^{-m} \sum_{p=1}^{m} x(-p) z^{p}$$

Let $p=n$, in 1st summation, $p=i$ in 2nd "

$$= z^{-m} \sum_{n=0}^{\infty} x(n) z^{-n} + z^{-m} \sum_{i=1}^{m} x(-i) z^{i}$$

$$= z^{m} X(z) + \sum_{i=1}^{m} x(-i) z^{-(m-i)}$$

$$z\{x(n+m)\} = \sum_{n=0}^{\infty} x(n+m) z^{-n} = \sum_{n=0}^{\infty} x(n+m) z^{-n} z^{m} z^{-m} \quad (\text{multiply by } z^m \,\&\, z^{-m})$$

$$= z^{m} \sum_{n=0}^{\infty} x(n+m) z^{-(n+m)}$$

$$= z^{m} \sum_{p=m}^{\infty} x(p) z^{-p}$$

Let $n+m=p$
when $n \to 0$, $p \to m$
$n \to \infty$, $p \to \infty$

$$= z^{m} \sum_{p=0}^{\infty} x(p) z^{-p} - z^{m} \sum_{p=0}^{m-1} x(p) z^{-p}$$

$$= z^{m} \sum_{n=0}^{\infty} x(n) z^{-n} - z^{m} \sum_{i=0}^{m-1} x(i) z^{-i}$$

$$= z^{m} X(z) - \sum_{i=0}^{m-1} x(i) z^{m-i} \quad \left\{ \because \text{ Let } p=n \text{ in 1st}, \; p=i \text{ in 2nd.} \right.$$

(3) Multiplication by 'n' (or Differentiation in z-domain)

If $z[x(n)] = X(n)$ then $z[n x(n)] = -z \frac{d}{dz} X(z)$

In general $z[n^m x(n)] = \left(-z \frac{d}{dz}\right)^m X(z)$

Proof

$$X(z) = z[x(n)] = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z[n x(n)] = \sum_{n=-\infty}^{\infty} n x(n) z^{-n} = \sum_{n=-\infty}^{\infty} n x(n) z^{-n} z z^{-1}$$

$$= -z \sum_{n=-\infty}^{\infty} x(n) [-n z^{-n-1}]$$

$$= -z \sum_{n=-\infty}^{\infty} x(n) \left[\frac{d}{dz} z^{-n}\right] \qquad \left\{ \because \frac{d}{dz} z^{-n} = -n z^{-n-1} \right.$$

$$= -z \frac{d}{dz} \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z[n x(n)] = -z \frac{d}{dz} X(z). \qquad \{\text{Interchanging summation \& differentiation}$$

(4) Multiplication by an exponential sequence, a^n (scaling in z-domain)

If $z\{x(n)\} = X(z)$ then $z\{a^n x(n)\} = X(a^{-1} z)$

Proof

$$z\{x(n)\} = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z[a^n x(n)] = \sum_{n=-\infty}^{\infty} a^n x(n) z^{-n}$$

$$= \sum_{n=-\infty}^{\infty} x(n) (a^{-1} z)^{-n}$$

$$= \sum_{n=-\infty}^{\infty} x(n) (a^{-1} z)^{-n}$$

$$= X(a^{-1} z).$$

(5) Time Reversal :

If $z\{x(n)\} = x(z)$ then $z\{x(-n)\} = x(z^{-1})$

proof

$$z[x(n)] = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z[x(-n)] = \sum_{n=-\infty}^{\infty} x(-n) z^{-n}$$

{ Let $p = -n$
when $n \to -\infty$, $p \to \infty$
$n \to \infty$, $p \to -\infty$

$$= \sum_{p=-\infty}^{\infty} x(p) z^{p}$$

$$= \sum_{p=-\infty}^{\infty} x(p) (z^{-1})^{-p}$$

$$= x(z^{-1})$$

(6) Conjugation :

If $z\{x(n)\} = x(z)$ then $z\{x^*(n)\} = x^*(z^*)$

proof

$$x(z) = z\{x(n)\} = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$z\{x^*(n)\} = \sum_{n=-\infty}^{\infty} x^*(n) z^{-n}$$

$$= \left[\sum_{n=-\infty}^{\infty} x(n) (z^*)^{-n}\right]^*$$

$$= [x(z^*)]^*$$

$$= x^*(z^*)$$

INVERSE Z-TRANSFORM:

Let $X(z)$ be z-transform of discrete time signal $x(n)$. The inverse z-transform is the process of recovering the discrete time sgl $x(n)$ from its z-transform $X(z)$.

→ The signal $x(n)$ can be uniquely determined from $X(z)$ & its ROC.

It can be determined by three methods

(i) Direct evaluation by contour integration (or residue method)

(ii) partial fraction expansion method

(iii) power series expansion method.

① Determine the inverse z-transform of fn $X(z) = \frac{3+2z^{-1}+z^{-2}}{1-3z^{-1}+2z^{-2}}$ by following three methods and prove that it is unique.

Sol (i) Residue Method:

$$X(z) = \frac{3+2z^{-1}+z^{-2}}{1-3z^{-1}+2z^{-2}} = \frac{z^{-2}(3z^2+2z+1)}{z^{-2}(z^2-3z+2)}$$

$$\therefore X(z) = \frac{3z^2+2z+1}{z^2-3z+2}$$

$$z^2-3z+2 \,\big)\, 3z^2+2z+1 \,\big(\, 3$$
$$\underline{\pm 3z^2 \mp 9z \pm 6}$$
$$11z-5$$

$$= 3 + \frac{11z-5}{z^2-3z+2}$$

$$= 3 + \frac{11z-5}{(z-1)(z-2)}$$

Let $X_1(z) = 3$, $X_2(z) = \frac{11z-5}{(z-1)(z-2)}$; i.e $X(z) = X_1(z) + X_2(z)$

$$x(n) = Z^{-1}\{X(z)\} = Z^{-1}\{X_1(z)\} + Z^{-1}\{X_2(z)\}$$

$$= Z^{-1}\{3\} + Z^{-1}\left\{\frac{11z-5}{(z-1)(z-2)}\right\}$$

$$= 3\delta(n) + \sum_{i=1}^{N}\left[(z-p_i)X_2(z)z^{n-1}\right]_{z=p_i}$$ Using residue theorem.

$$= 3\delta(n) + (z-1)\frac{11z-5}{(z-1)(z-2)} \cdot z^{n-1}\Big|_{z=1} + (z-2)\cdot\frac{11z-5}{(z-1)(z-2)} \cdot z^{n-1}\Big|_{z=2}$$

$$= 3\delta(n) + \frac{11-5}{1-2}(1)^{n-1} + \frac{11\times 2-5}{2-1}2^{n-1}$$

$$\therefore x(n) = 3\delta(n) - 6u(n-1) + 17(2)^{n-1}u(n-1)$$

$$= 3\delta(n) + [-6+17(2)^{n-1}]u(n-1).$$

when $n=0$, $x(0) = 3-0+0 = 3$

when $n=1$, $x(1) = 0-6+17\times 2^0 = 11$

when $n=2$, $x(2) = 0-6+17\times 2^1 = 28$

when $n=3$ $x(3) = 0-6+17\times 2^2 = 62$

$$\therefore x(n) = \{3, 11, 28, 62, 130 \cdots\}$$

Method 2:

$$X(z) = \frac{3+2z^{-1}+z^{-2}}{1-3z^{-1}+2z^{-2}} = \frac{3z^2+2z+1}{z^2-3z+2}$$

$$\therefore \frac{X(z)}{z} = \frac{3z^2+2z+1}{z(z-1)(z-2)}$$

Let $\frac{X(z)}{z} = \frac{3z^2+2z+1}{z(z-1)(z-2)} = \frac{A_1}{z} + \frac{A_2}{z-1} + \frac{A_3}{z-2}$

$$A_1 = z.\frac{X(z)}{z}\Big|_{z=0} = z\cdot\frac{3z^2+2z+1}{z(z-1)(z-2)}\Big|_{z=0} = 0.5$$

$$A_2 = (z-1)\frac{X(z)}{z}\Big|_{z=1} = (z-1)\frac{3z^2+2z+1}{z(z-1)(z-2)}\Big|_{z=1} = -6$$

$$A_3 = (z-2)\frac{X(z)}{z}\Big|_{z=2} = (z-2)\cdot\frac{3z^2+2z+1}{z(z-1)(z-2)}\Big|_{z=2} = 8.5$$

$$\frac{X(z)}{z} = \frac{0.5}{z} - \frac{6}{z-1} + \frac{8.5}{z-2}.$$

$$\therefore X(z) = 0.5 - 6 \cdot \frac{z}{z-1} + 8.5 \frac{z}{z-2}$$

On taking inverse z-transform

$$x(n) = 0.5\,\delta(n) - 6.\,u(n) + 8.5\,(2)^n u(n)$$

$$= 0.5\delta(n) + \left[-6 + 8.5(2)^n\right] u(n)$$

When $n=0$, $x(0) = 0.5 - 6 + 8.5 \times 2^0 = 3$

$n=1$, $x(1) = 0 - 6 + 8.5 \times 2^1 = 11$

$n=2$ $x(2) = 0 - 6 + 8.5 \times 2^2 = 28$

$n=3$, $x(3) = 0 - 6 + 8.5 \times 2^3 = 62$

$$\therefore x(n) = \{\underset{\uparrow}{3}, 11, 28, 62 \ldots\}$$

Method 3: Power Series Expansion method.

Divisor: $1 - 3z^{-1} + 2z^{-2}$

Quotient: $3 + 11z^{-1} + 28z^{-2} + 62z^{-3} + 130z^{-4} + \ldots$

$3 + 2z^{-1} + z^{-2}$
$\underline{3 - 9z^{-1} + 6z^{-2}}$ (signs changed: $-$, $+$, $-$)

$11z^{-1} - 5z^{-2}$
$\underline{11z^{-1} - 33z^{-2} + 22z^{-3}}$ (signs changed: $-$, $+$, $-$)

$28z^{-2} - 22z^{-3}$
$\underline{28z^{-2} - 84z^{-3} + 56z^{-4}}$

$62z^{-3} - 56z^{-4}$
$\underline{62z^{-3} - 186z^{-4} + 124z^{-5}}$

$130z^{-4} - 124z^{-5}$

$\vdots$

$$\therefore X(z) = 3 + 11z^{-1} + 28z^{-2} + 62z^{-3} + 130z^{-4} + \ldots \quad \to (1)$$

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n} = \ldots + x(0) + x(1) z^{-1} + x(2) z^{-2} + \ldots \quad \to (2)$$

On comparing (1) & (2),

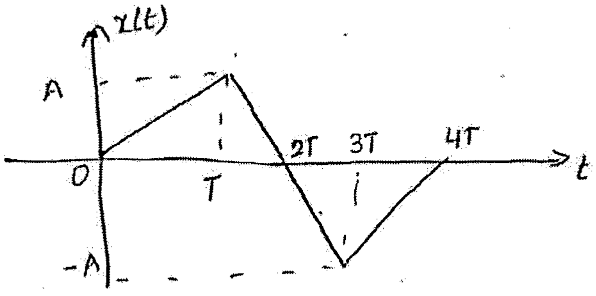
$x(0) = 3$, $x(1) = 11$, $x(2) = 28$, $x(3) = 62$

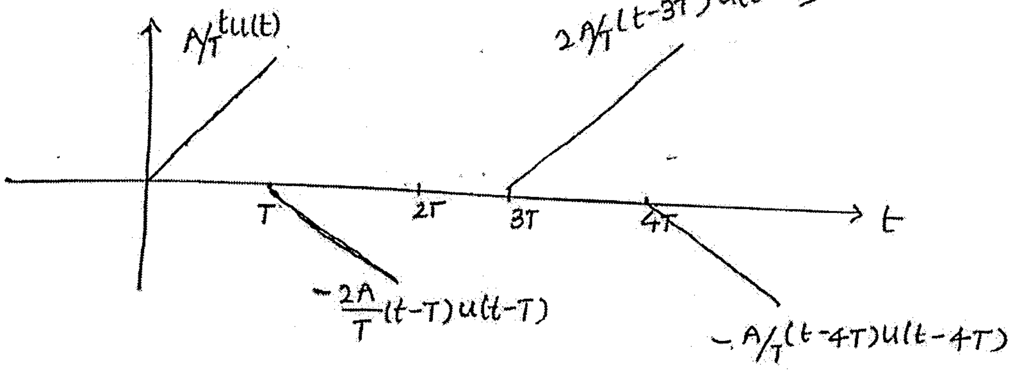
$$\therefore x(n) = \{3, 11, 28, 62 \ldots\}$$

Wave synthesis Using Laplace transform:

To express the function into singular functions and express it in synthesis

① Find the Laplace transform of the waveform.





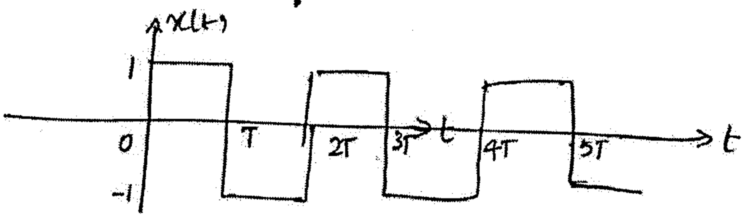
$$x(t) = \frac{A}{T} t\, u(t) - \frac{2A}{T}(t-T)\,u(t-T) + \frac{2A}{T}(t-3T)\,u(t-3T) - \frac{A}{T}(t-4T)\,u(t-4T)$$

Taking Laplace transform on both sides

$$X(s) = \frac{A}{T}\frac{1}{s^2} - \frac{2A}{T}\frac{e^{-Ts}}{s^2} + \frac{2A}{T}\frac{e^{-3Ts}}{s^2} - \frac{A}{T}\frac{e^{-4Ts}}{s^2}$$

$$= \frac{A}{Ts^2}\left[1 - 2e^{-Ts} + 2e^{-3Ts} - e^{-4Ts}\right]$$

② Find the laplace transform



$$x(t) = u(t) - 2u(t-T) + 2u(t-2T) - 2u(t-3T) + 2u(t-4T) - 2u(t-5T) + \dots$$

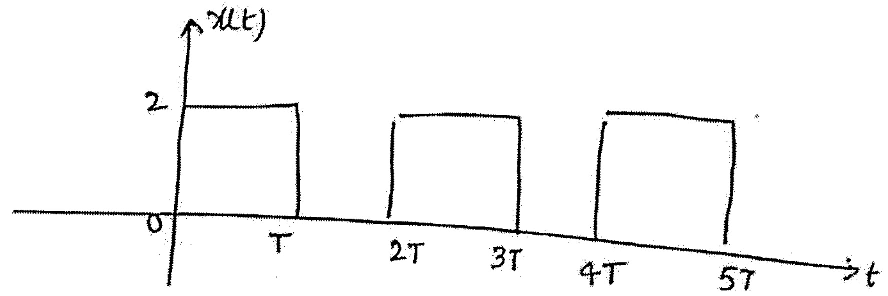
$$X(s) = \frac{1}{s} - 2\frac{e^{-Ts}}{s} + \frac{2e^{-2Ts}}{s} - \frac{2e^{-3Ts}}{s} + \frac{2e^{-4Ts}}{s} - \frac{2e^{-5Ts}}{s} + \dots$$

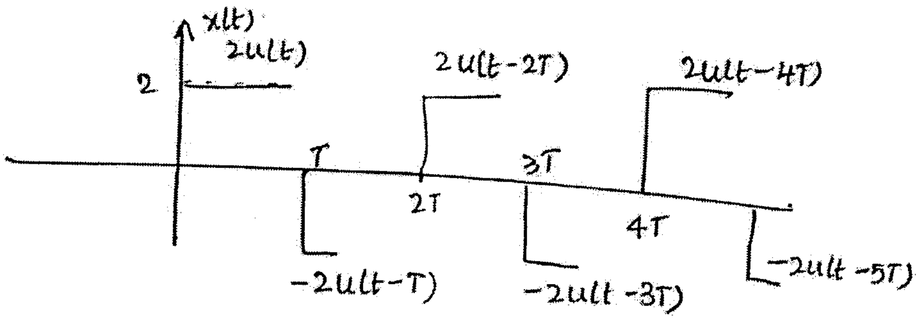
$$= \frac{1}{s}\left[1 - 2e^{-Ts}\left(1 - e^{-Ts} + e^{-2Ts} - e^{-3Ts} + e^{-4Ts} + \cdots\right)\right]$$

$$= \frac{1}{s}\left[1 - 2e^{-Ts}(1+e^{-Ts})^{-1}\right] = \frac{1}{s}\left(1 - \frac{2e^{-Ts}}{1+e^{-Ts}}\right) = \frac{1}{s}\left(\frac{1+e^{-Ts}-2e^{-Ts}}{1+e^{-Ts}}\right)$$

$$= \frac{1}{s}\left(\frac{1-e^{-Ts}}{1+e^{-Ts}}\right)$$

(3) Find the Laplace transform of waveform





$$x(t) = 2u(t) - 2u(t-T) + 2u(t-2T) - 2u(t-3T) + 2u(t-4T) - 2u(t-5T) \cdots$$

Taking Laplace transform

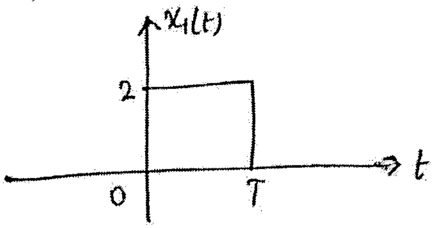
$$X(s) = \frac{2}{s} - \frac{2e^{-Ts}}{s} + \frac{2e^{-2Ts}}{s} - \frac{2e^{-3Ts}}{s} + \frac{2e^{-4Ts}}{s} - \frac{2e^{-5Ts}}{s} \cdots$$

$$= \frac{2}{s}\left[1 - e^{-Ts} + e^{-2Ts} - e^{-3Ts} + e^{-4Ts} - e^{-5Ts} \cdots\right]$$

$$= \frac{2}{s}\left[1 + e^{-Ts}\right]^{-1} = \frac{2}{s}\left(\frac{1}{1+e^{-Ts}}\right)$$

Another method

The given waveform is periodic with period 2T.



periodicity property

$$X(s) = \frac{1}{1-e^{-2Ts}} X_1(s)$$

$$x_1(t) = 2[u(t) - u(t-T)]$$

$$X_1(s) = 2\left(\frac{1}{s} - \frac{e^{-Ts}}{s}\right) = \frac{2}{s}\left(1-e^{-Ts}\right)$$

$$X(s) = \frac{1}{1-e^{-2Ts}}\left(\frac{2}{s}\right)(1-e^{-Ts})$$

$$= \frac{2}{s} \cdot \frac{1-e^{-Ts}}{(1+e^{-Ts})(1-e^{-Ts})} = \frac{2}{s}\left(\frac{1}{1+e^{-Ts}}\right)$$

periodicity property:

Used in determining the transform of periodic time functions.

$x(t) = x(t+nT)$. where T is period, $n=0,1,2\ldots$

$$X(s) = \int_0^\infty x(t)e^{-st}\,dt.$$

$$X(s) = \int_0^T x(t)\,e^{-st} + \int_T^{2T} x(t)\,e^{-st} + \int_{2T}^{3T} x(t)e^{-st}dt + \cdots + \int_{nT}^{(n+1)T} x(t)e^{-st}dt + \cdots$$

$$= \int_0^T x(t)\,e^{-st}dt + e^{-sT}\int_0^T x(t+T)\,e^{-st}dt + \cdot + e^{-nsT}\int_0^T x(t+nT)\,e^{-st}dt$$

$$x(t) = x(t+T) = x(t+2T)\ldots$$

$$X(s) = \int_0^T x(t)\, e^{-st} dt + e^{-sT}\int_0^T x(t)\, e^{-st} dt + \cdots + e^{-nsT}\int_0^T x(t)\, e^{-st} dt + \cdots$$

$$= \left[1 + e^{-sT} + e^{-2sT} + \cdots + e^{-nsT}\right] \int_0^T x(t) e^{-st} dt$$

$$= \left[1 - e^{-sT}\right]^{-1} \int_0^T x(t)\, e^{-st} dt = \frac{1}{1 - e^{-sT}}\, X_1(s).$$

where $X_1(s) = \int_0^T x(t)\, e^{-st}\, dt$

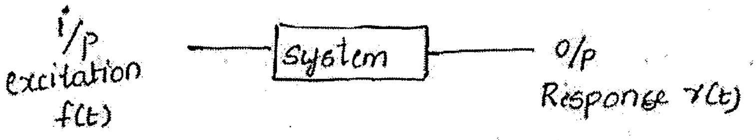
UNIT-3

SIGNAL TRANSMISSION THROUGH LINEAR SYSTEMS

System: A system is defined as set of rules that associates an o/p time function to every i/p time function.

(or)

A system is an interconnection of elements which produces expected o/p for available i/p.



$f(t) \longrightarrow r(t)$

→ System is an mathematical operator which maps i/p into o/p

Classification of system

↓

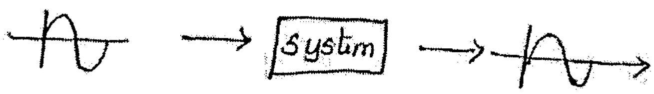
- continuous time system
- Discrete time system

continuous time system ↓

1. Static & Dynamic systems
2. Linear & Non-Linear
3. Time invariant & Time variant
4. Linear TIV or LTIV
5. Stable system
6. casual & non-causal systems.

(i) continuous time systems

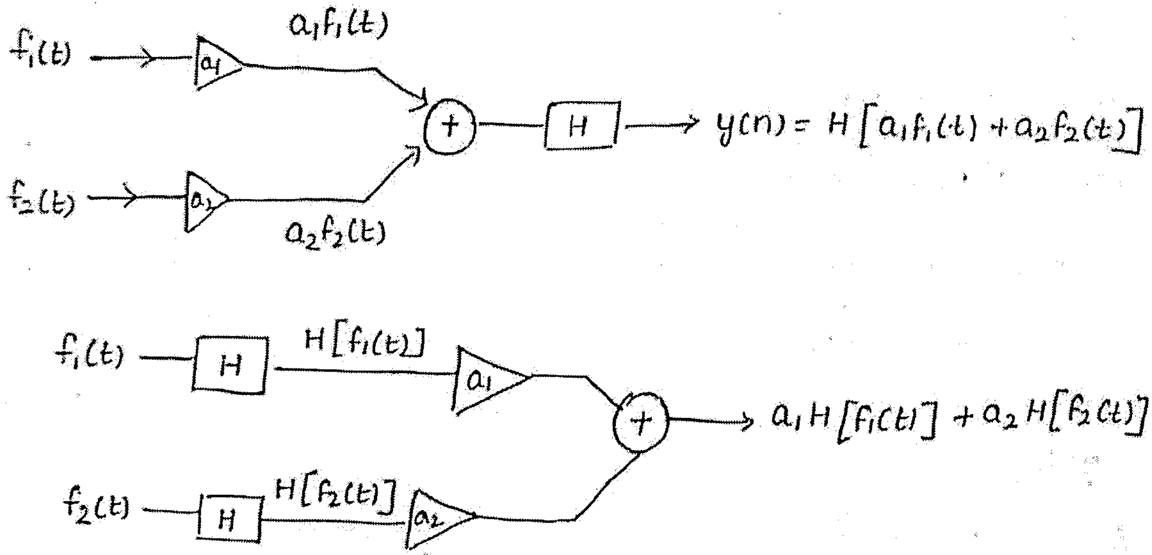
→ A continuous time system operates on a continuous time i/p signal to produce a continuous time o/p signal



(ii) Discrete time systems:

A discrete time system operates on a discrete time i/p signal to produce a discrete time o/p signal.

$$H[a_1 f_1(t) + a_2 f_2(t)] \longrightarrow a_1 H[f_1(t)] + a_2 H[f_2(t)]$$



Block diagram.

→ Any system which does not obey the above principle is called as non-linear systems.

Check for Linearity:

Procedure:

1. Apply different i/p's separately and get the o/p.
2. Apply different i/p's simultaneously and get the output.
3. If both outputs are same it is linear otherwise non-linear.

Ex:

(i) $y(t) = 4\sin t\, x(t)$

step 1: $y_1(t) = 4\sin t\; x_1(t)$

$y_2(t) = 4\sin t\; x_2(t)$

$y_1(t) + y_2(t) = 4\sin t\,[x_1(t) + x_2(t)]$

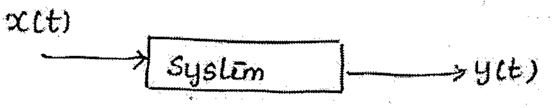
step 2: $y(t) = 4\sin t\,[x_1(t) + x_2(t)]$

$S_1 = S_2$

Time Variant And Time Invariant Systems

→ A system is said to be time invariant if the system does not depend on time i.e system delay is not function of time.

Ex:



$$x(t) \longrightarrow y(t)$$
$$x(t-t_0) \longrightarrow y(t-t_0)$$

→ A time shift t_0 in the input results in the same amount of time shift in the o/p but the waveshape does not change.

i.e the i/p and/ to o/p characteristics does not change with time.

→ Any system which doesnot obey the above principle is called as time varying system.

→ An electrical system is said to be time invariant if its component values (R, L, C) does not change with time.

Check for time Invariant:

1. Shift the i/p only and get the o/p.
2. Shift the entire system and get the o/p.
3. If both steps are identical for o/p then it is time invariant system.

Ex!

(1) $y(t) = 4x(t)$

Sol $S_1: y(t) = 4x(t-1)$
$S_2: y(t-1) = 4x(t-1)$] → $S_1 = S_2$ (TIV)

(2) $y(t) = 4t\,x(t)$

Sol $S_1: y(t) = 4t\,x(t-1)$
$S_2: y(t-1) = 4(t-1)(x(t-1))$] → $S_1 \neq S_2$ (TV)

(3) $y(t) = a\,x(t)$

Sol $S_1: y(t) = a\,x(t-1)$
S_2 $y(t-1) = a\,x(t-1)$] → $S_1 = S_2$ (TIV)

(4) $y(t) = a\,x(t) + b$

Sol $S_1: y(t) = a\,x(t-1) + b$
$S_2: y(t-1) = a\,x(t-1) + b$] $S_1 = S_2$ (TIV)

(5) $y(t) = 5t\,[x(t)]^2$

Sol $S_1: y(t) = 5t\,[x(t-1)]^2$
$S_2: y(t-1) = 5(t-1)[x(t-1)]^2$] $S_1 \neq S_2$ (TV)

(6) $y(t) = x(t+1)e^{-t}$

Sol $S_1: y(t) = x(t+1-1)e^{-t} = x(t)e^{-t}$
$S_2: y(t-1) = x(t+1-1)e^{-(t-1)}$
$= x(t) \cdot e^{-t}\,e^{1}$ → constant
$S_1 = S_2$ (TIV)

Stable System:

→ System is absolutely integrable

$$\int_{-\infty}^{\infty} |f(t)|\, dt < \infty$$

Causal And Non Causal Systems:

→ A system is said to be causal if o/p $y(t_0)$ depends only on the values of i/p $x(t)$ at $t < t_0$ {present, i/p, past i/ps, past o/ps} { $x(t) = 0$, for $t<0$; noncausal $t \leq 0$, or $t \leq 0$ and $t > 0$; $x(t) \neq 0$ for $t<0$

Ex: $y(t) = 4x(t-1)$

$y(2) = 4x(2-1) \Rightarrow 4x(2)$

$y(t) = 4x(t-1) + x(t)$

$y(2) = 4x(1) + x(2)$

→ A system is said to be non-causal if the o/p depends on future values of i/p i.e future i/ps & o/ps.

Ex: $y(t) = 4x(t+1)$

$y(2) = 4x(3)$

Examples whether it is causal & Non causal:

(1) $y(t) = K[x(t+1) - x(t)]$

$y(0) = K[x(1) - x(0)]$ → Noncausal

(2) $y(t) = 3x(t+3)$

$y(0) = 3x(3)$ → Non causal

(3) $y(t) = (t+3)x(t-3)$

$y(0) = (0+3)x(0-3)$

$= 3x(-3)$ → causal

(6) $y(t) = x(2t)$ → Non causal

(7) $y(t) = x(t) - x(t-1)$ → causal

(8) $y(t) = x(t) + \int_0^t x(\lambda)\, d\lambda$

$= x(t) + z(\lambda)]_0^t \Rightarrow$ Causal.

At $t=0, t=1, t=2$

(4) $y(t) = x(t) + 3x(t+4)$

when $t=0$, $y(0) = x(0) + 3x(4)$

when $t=1$, $y(1) = x(1) + 3x(5)$

So here response at $t=0$, $y(0)$ depends on the present i/p & future i/p

hence system is noncausal.

(5) $y(t) = x(t^2)$

$t=-1$, $y(-1) = x(1)$ → future

$t=0$, $y(0) = x(0)$ → present

$t=1$, $y(1) = x(1)$ → present

$t=2$, $y(2) = x(4)$ → future

Noncausal.

Except at $t=0$, $t=1$, the response of any value of t depends on future i/p.

$$f(t) = \underset{\Delta t \to 0}{Lt} \sum_{n=-\infty}^{\infty} f(n\Delta t)\, \Delta t\, \delta(t - n\Delta t)$$

The rectangular of width Δt & height $f(n\Delta t)$ and area under the rectangles is $\Delta t \cdot f(n\Delta t)$ and this n^{th} element approached a delta function of strength $f(n\Delta t)\Delta t$ located at $t = n\Delta t$. and this delta function is represented as $f(n\Delta t)\Delta t\, \delta(t - n\Delta t)$

$$\boxed{f(t) = \underset{\Delta t \to 0}{Lt} \sum_{n=-\infty}^{\infty} f(n\Delta t) \cdot \Delta t \cdot \delta(t - n\Delta t)}$$

As $\Delta t \to 0$, the n^{th} element may be considered.

2) Determination of $r(t)$ for the input $f(t)$:

Let $h(t)$ be the impulse response of the system.

$\delta(t) \longrightarrow$ [system] $\longrightarrow h(t)$

then $\delta(t) \longrightarrow h(t)$

$\delta(t - n\Delta t) \longrightarrow h(t - n\Delta t)$

$f(n\Delta t)\, \delta(t - n\Delta t) \longrightarrow f(n\Delta t) \cdot h(t - n\Delta t)$

$f(n\Delta t) \cdot \Delta t\, \delta(t - n\Delta t) \longrightarrow f(n\Delta t) \cdot \Delta t\, h(t - n\Delta t)$

$$\underset{\Delta t \to 0}{Lt} \sum_{n=-\infty}^{\infty} f(n\Delta t) \cdot \Delta t\, \delta(t - n\Delta t) \longrightarrow \underset{\Delta t \to 0}{Lt} \sum_{n=-\infty}^{\infty} f(n\Delta t) \cdot \Delta t\, h(t - n\Delta t).$$

$f(t) \longrightarrow$ [system] $\longrightarrow r(t)$

$$r(t) = \underset{\Delta t \to 0}{Lt} \sum_{n=-\infty}^{\infty} f(n\Delta t) \cdot \Delta t\, h(t - n\Delta t)$$

$\Delta t \to 0$ means summation becomes integration.

$$r(t) = \int_{-\infty}^{\infty} f(\tau) \cdot h(t - \tau)\, d\tau$$

$$r(t) = f(t) \otimes h(t)$$

$f(t)$ —— [$h(t)$] —— $r(t) \rightarrow f(t) \otimes h(t)$.

FILTER CHARACT ISTICS OF LINEAR SYSTEMS :

IDEAL LOW PASS FILTERS :

→ It transmits all the signals below certain frequency 'B' Hz without any distortion.

→ The range of frequencies from 0Hz to 'B' Hz is called passband of lowpass filter.

→ The frequency 'B' Hz is called cut-off frequency of the ideal lowpass filter.

→ The transfer function of ideal low pass filter can be written as

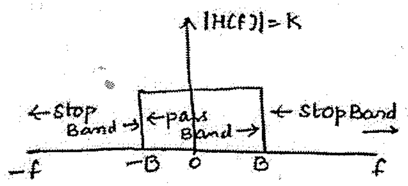
$$H(f) = K e^{-j2\pi f t_0} \quad ; \quad -B \le f < B$$
$$= 0 \quad ; \quad |f| > B.$$

K = amplitude is assumed to be unity.

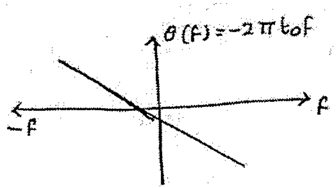
→ By K=1 in above eqn

$$H(f) = e^{-j2\pi f t_0} \quad ; \quad -B \le f < B$$
$$= 0 \quad ; \quad |f| > B$$

→ By inverse fourier transform, h(t) can be obtained for ideal LPF



a) magnitude response.



(b) phase response

$$h(t) = \int_{-B}^{B} e^{-j2\pi f t_0} \cdot e^{j2\pi f t}\, df$$

$$= \int_{-B}^{B} \left[e^{j2\pi f (t-t_0)} \right] df = \frac{1}{j2\pi(t-t_0)} \left[e^{j2\pi f (t-t_0)} \right]_{-B}^{B}$$

$$= \frac{1}{j2\pi(t-t_0)} \left[e^{j2\pi B(t-t_0)} - e^{-j2\pi B(t-t_0)} \right]$$

INTRODUCTION FOR FILTER CHARACTERISTICS:

$f(t) \longrightarrow$ [$h(t)$] $\longrightarrow r(t)$

$F(\omega)$ $\quad$ $H(\omega)$ $\quad$ $R(\omega)$

$$R(\omega) = F(\omega) \cdot H(\omega)$$

→ The spectrum of o/p is $F(\omega) \cdot H(\omega)$ i.e the system acts as a kind of filter to various frequency components.

→ Some frequency components are boosted in strength and some are attenuated and some remain unaffected.

→ $\|^{ly}$ each freq. component undergoes a different amount of phase shift i.e the modification is carried out according to $H(\omega)$.
↳ acts as waiting fn for two different frequencies.

DISTORTIONLESS TRANSMISSION THROUGH SYSTEM:

→ It means output signal is an exact replica of the i/p signal.

i/p → [System] → o/p

→ The difference between i/p and o/p of such system is that

1. Amplitude of the o/p signal may increase or decrease by some factor w.r. to i/p.
2. The o/p sgl may be delayed in time w.r to i/p sgl because of system delay.

→ o/p sgl $y(t)$ can be written in terms of i/p $x(t)$ as

$$y(t) = k\,x(t - t_0)$$

k ↓ constant Represents change in amplitude

t_0 ↳ time delay in transmission of signal through a system.

By taking fourier transform

$$Y(f) = F[y(t)] = F\{k\,x(t - t_0)\}$$

From time shifting property of FT

$$Y(f) = k\,X(f)\,e^{-j2\pi f t_0}$$

AMPLITUDE DISTORTION

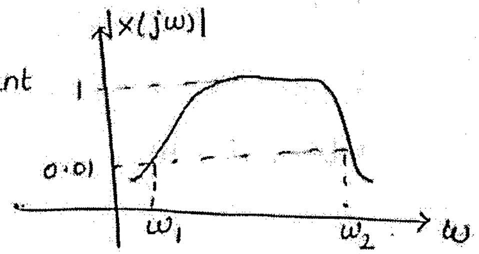
→ This distortion occurs when $|H(\omega)|$ is not constant over frequency band of interest and the frequency components present in I/p sgl are transmitted with different gain and attenuation.

PHASE DISTORTION:

→ This distortion occurs when phase of $H(\omega)$ is not linearly changing with time and different frequency components in I/p are subjected to different time delays during transmission.

SIGNAL BANDWIDTH: The band of frequencies that contains most of signal energy is called B.W of signal denoted by fm.

→ It is the range of significant signal frequencies which are present in the signal.

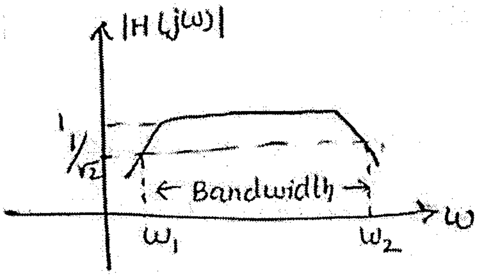


→ observe in the waveform $x(t)$ has significant frequencies from ω_1 to ω_2.

→ The B.W of this signal is $\omega_2 - \omega_1$

→ All the physically obtained signals have limited bandwidth.

SYSTEM BANDWIDTH



→ The B.W of a system is defined as range of frequencies over which $|H(\omega)|$ remains within $1/\sqrt{2}$ times of its mid-band value. for distortionless transmission the system must have infinite B.W but physical system are limited to finite BW.

→ So a system with finite BW can provide distortionless transmission for a band limited signal if $|H(\omega)|$ remains constant over BW of the signal.

→ The range of frequencies for which magnitude $|H(j\Omega)|$ of the systems remains within $\frac{1}{\sqrt{2}}$ of its maximum value.

→ The frequency domain statements can be interpreted as $|H(\omega)|$ if a physically realizable system may be zero for some discrete frequency but it can never be zero for a finite band of frequencies.

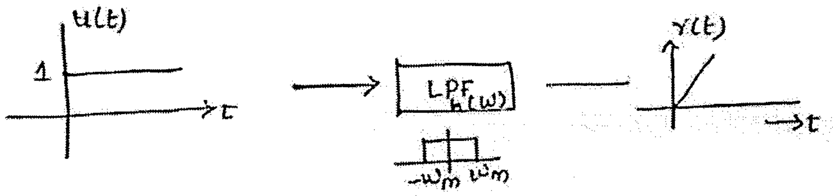
→ $H(\omega)$ for a realisable system cannot decay faster than a function of exponential order.

Ex: A system with T.F $e^{-\omega}$ is realisable whereas $e^{-\omega^2}$ is not as it decay faster.

RELATIONSHIP BETWEEN RISETIME AND BANDWIDTH:

→ If a unit step fn $u(t)$ is applied to an ideal LPF, the o/p will show a gradual rise instead of a sharp rise in the i/p.

→ The rise time (t_r) is the time required by the response to reach its final value from initial value.



Transfer function of ideal low pass filter is

$$H(\omega) = |H(\omega)| e^{j\theta(\omega)}$$

$$= G(\omega) e^{-j\omega t_0}$$

↓ Rectangular pulse with magnitude K. for $-B < f \leq B$ i.e $-\omega_m \leq \omega \leq \omega_m$ where $\omega_m = 2\pi B$.

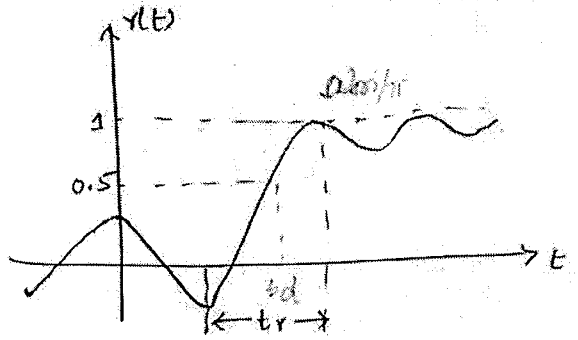
and $\theta(\omega) = -2\pi f t_0 = -\omega t_0$.

→ Fourier transform of unit step fn $u(t)$

$$FT\{u(t)\} \Rightarrow U(\omega) = \pi\delta(\omega) + \frac{1}{j\omega}$$

→ Fourier transform of response $R(\omega)$, input and $H(\omega)$ related as

$$R(\omega) = \left[\pi\delta(\omega) + \frac{1}{j\omega}\right] H(\omega) = \pi\delta(\omega).H(\omega) + \frac{1}{j\omega} H(\omega).$$



$w_c \to \infty$

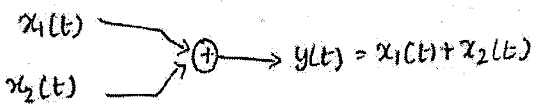
$y(t) = 1$

$w_c \to -\infty$

$y(t) = 0$

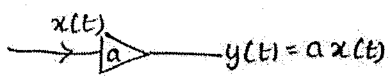
Note : { Elements of block diagram }

① Adder :



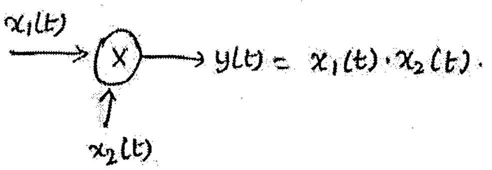
which performs the addition of two signal sequences to form sum

② constant multiplier :



It represents applying a scale factor on i/p $x(t)$.

③ Signal multiplier :



The multiplication of two signal to form product sequence.

PROBLEMS :

① The impulse response of continuous time system is given as

$$h(t) = \frac{1}{RC}\, e^{-t/RC} \cdot u(t)$$

Determine the frequency response & plot the magnitude phase plots.

Sol Take FT

$$H(\omega) = \int_{-\infty}^{\infty} h(t) \cdot e^{-j\omega t} dt$$

$$= \int_{-\infty}^{\infty} \frac{1}{RC} \cdot e^{-t/RC} \cdot u(t)\, e^{-j\omega t} dt$$

$$= \frac{1}{RC} \int_{0}^{\infty} e^{-t/RC} \cdot e^{-j\omega t} dt \quad \left(\because u(t) = 1 \text{ for } t \geq 0,\ 0 \text{ otherwise} \right)$$

step

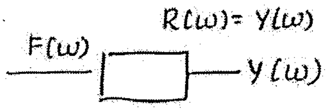
(2) For the system shown find the F.T & impulse response of the system.

$f(t) = e^{-at} \quad t>0$

$\quad 0 \quad$ elsewhere $\quad ; \quad Y(\omega) = \frac{1}{\alpha + j\omega}$

Sol

$H(\omega) = \frac{R(\omega)}{F(\omega)}$



$F(t) = e^{-at}$

$F(\omega) = \frac{1}{a+j\omega} \quad ; \quad Y(\omega) = \frac{1}{\alpha + j\omega}$

$H(\omega) = \frac{1/\alpha+j\omega}{1/a+j\omega} = \frac{a+j\omega}{\alpha+j\omega}$

$F^{-1}\left[\frac{a+j\omega}{\alpha+j\omega}\right] \Rightarrow \frac{a+\alpha-\alpha+j\omega}{\alpha+j\omega} = \frac{a-\alpha}{\alpha+j\omega} + \frac{\alpha+j\omega}{\alpha+j\omega}$

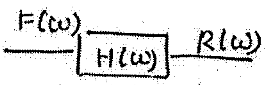
$= \frac{a-\alpha}{\alpha+j\omega} + 1$

$$h(t) = (a-\alpha)\, e^{-\alpha t} u(t) + \delta(t)$$

(3) The linear system impulse response is $[e^{-2t} + e^{-3t}]\, u(t)$ find the excitation to produce an o/p of $t \cdot e^{-2t} u(t)$?

Sol

$h(t) = [e^{-2t} + e^{-3t}]\, u(t)$



$r(t) = t \cdot e^{-2t} u(t)$

$H(\omega) = \frac{R(\omega)}{F(\omega)}$

$F(\omega) = \frac{R(\omega)}{H(\omega)}$

$r(t) = t \cdot e^{-2t} u(t) \overset{F.T}{\longleftrightarrow} \frac{1}{(2+j\omega)^2} \qquad \left(\because\ t \cdot e^{-at} u(t) \longleftrightarrow \frac{1}{(a+j\omega)^2}\right)$

$R(\omega) = \frac{1}{(2+j\omega)^2}$

$$\sum_{K=0}^{N} a_K (j\omega)^K Y(\omega) = \sum_{K=0}^{M} b_K (j\omega)^K X(j\omega)$$

$$H(\omega) = \frac{Y(\omega)}{X(\omega)} = \frac{\sum_{K=0}^{M} b_K (j\omega)^K}{\sum_{K=0}^{N} a_K (j\omega)^K}$$

↙ system transfer fn.

PROBLEMS:

① The differential equation of system is given as $\frac{d^2y(t)}{dt^2} + 5\frac{dy(t)}{dt} + 6y(t) = -\frac{dx(t)}{dt}$

Determine the frequency response & impulse response.

Sol

$$\frac{d^2y(t)}{dt^2} + 5\frac{dy(t)}{dt} + 6y(t) = -\frac{dx(t)}{dt}$$

Taking F.T

$$(j\omega)^2 Y(\omega) + 5(j\omega)Y(\omega) + 6Y(\omega) = -j\omega X(\omega)$$

$$Y(\omega)\left[(j\omega)^2 + 5j\omega + 6\right] = -j\omega X(\omega)$$

$$H(\omega) = \frac{Y(\omega)}{X(\omega)} = \frac{-j\omega}{(j\omega)^2 + 5j\omega + 6}$$

$$H(\omega) = \frac{-j\omega}{(j\omega+2)(j\omega+3)} = \frac{A}{j\omega+2} + \frac{B}{j\omega+3}$$

$$= \frac{2}{j\omega+2} - \frac{3}{j\omega+3}$$

$$h(t) = \left[2 \cdot e^{-2t} - 3e^{-3t}\right] u(t)$$

↙ impulse response of the system.

$$\left\{ \because e^{-at}u(t) \xleftrightarrow{FT} \frac{1}{a+j\omega} \right\}$$

1) $h(t) = e^{-5|t|}$

For stability $\int_{-\infty}^{\infty} |h(t)|\, dt < \infty$

$\therefore \int_{-\infty}^{\infty} |h(t)|\, dt = \int_{-\infty}^{\infty} |e^{-5|t|}|\, dt = \int_{-\infty}^{\infty} e^{-5|t|}\, dt$

$= \int_{-\infty}^{0} e^{5t} dt + \int_{0}^{\infty} e^{-5t} dt = \left[\frac{e^{5t}}{5}\right]_{-\infty}^{0} + \left[\frac{e^{-5t}}{-5}\right]_{0}^{\infty}$

$= \frac{2}{5}$ = constant / so system is stable.

2) $h(t) = e^{4t} u(t)$

$= \int_{-\infty}^{\infty} |e^{4t} u(t)|\, dt = \int_{-\infty}^{\infty} e^{4t} u(t)\, dt$

$= \int_{0}^{\infty} e^{4t} dt = \frac{e^{\infty}}{4} - \frac{e^{0}}{4} = \infty - \frac{1}{4} = \infty$ (Unstable.

3) $h(t) = e^{-4t} u(t)$ (stable)

4) $h(t) = t \cos t\, u(t)$ (unstable.

$\int_{0}^{\infty} t \cos t\, dt$

5) $h(t) = e^{-t} \sin t\, u(t)$ (stable.

$= \int_{0}^{\infty} e^{-t} \sin t\, dt$

(1) The transfer function of LPF is given by

$$H(\omega) = \begin{cases} (1+k\cos\omega T)e^{-j\omega T} & ; |\omega| < 2\pi B \\ 0 & ; |\omega| > 2\pi B. \end{cases}$$

Determine the output y(t) when a pulse x(t) bandlimited in B is applied at the input.

Sol)

$$Y(\omega) = X(\omega)H(\omega)$$

$$= X(\omega)[1+k\cos\omega T]e^{-j\omega T}$$

$$= X(\omega)e^{-j\omega T} + k X(\omega)\cos\omega T\, e^{-j\omega T}$$

we know

$$x(t-T) + x(t+T) \longleftrightarrow 2X(\omega)\cos\omega T$$

$$x(t-T) \longleftrightarrow X(\omega)e^{-j\omega T}$$

$$y(t) = F^{-1}[Y(\omega)]$$

$$= F^{-1}\left[X(\omega)e^{-j\omega T} + kX(\omega)e^{-j\omega T}\cos\omega T\right]$$

$$= x(t-T) + \frac{k}{2}\left[x(t-T-T) + x(t-T+T)\right]$$

$$y(t) = x(t) + \frac{k}{2}\left[x(t-T) + x(t+T)\right]$$

delayed by T.

2) Determine the maximum bandwidth of signals that can be transmitted through low pass RC filter as shown in figure , if over this bandwidth, the gain variation is to be 10% and the phase variation is to be within 7% of ideal characteristics.

$$H(\omega) = \frac{5000}{j\omega + 10000}$$

$$|H(\omega)| = \frac{5000}{\sqrt{\omega^2 + 10000}}$$

$$\phi(\omega) = -\tan^{-1}\left(\frac{\omega}{10000}\right).$$

At $\omega = 0$, $|H(\omega)|_{\omega=0} = \frac{5000}{10000} = 0.5$.

But there is 10% variation in gain over bandwidth B.

$$H(\omega) = 0.5 - 0.5 \times 10\% = 0.45$$

$$|H(\omega)| = \frac{5000}{\sqrt{B^2 + 10^8}}$$

$$B^2 + 10^8 = \left(\frac{5000}{0.45}\right)^2 \Rightarrow B^2 = 23.46 \times 10^6$$

$$B = 4.84\, KHz$$

But $B = 2\pi f$

$$f = \frac{B}{2\pi} = \frac{4.84 \times 10^3}{2\pi} = 770.8\, HZ$$

phase at frequency, $f = 770.8\, HZ$

$$\phi(\omega) = -\tan^{-1}\left(\frac{4.84}{10}\right) = -25.83\%.$$

(2) There are several possible ways of estimating an essential bandwidth of non-bandlimited signal. For a low pass signal, for example, the essential b.w may

INVERSE LAPLACE TRANSFORM: (PARTIAL FRACTION EXPANSION)

The universe laplace transform by partial fraction method of all three cases.

Case i) when s-domain signal $X(s)$ has distinct poles

Let $X(s) = \dfrac{k}{s(s+P_1)(s+P_2)}$

By partial fraction

$$X(s) = \frac{k_1}{s} + \frac{k_2}{s+P_1} + \frac{k_3}{s+P_2}$$

The residues k_1, k_2, k_3 are given by

$$k_1 = X(s) \times s \Big|_{s=0}, \quad k_2 = X(s) \times (s+P_1) \Big|_{s=-P_1}$$

$$k_3 = X(s) \times (s+P_2) \Big|_{s=-P_2}.$$

$$L^{-1}\{X(s)\} = L^{-1}\left\{\frac{k_1}{s} + \frac{k_2}{s+P_1} + \frac{k_3}{s+P_2}\right\}$$

$$x(t) = k_1 L^{-1}\left\{\frac{1}{s}\right\} + k_2 L^{-1}\left\{\frac{1}{s+P_1}\right\} + k_3 L^{-1}\left\{\frac{1}{s+P_2}\right\}$$

$$= k_1 u(t) + k_2 e^{-P_1(t)} u(t) + k_3 e^{-P_2 t} u(t).$$

Case ii) when s-domain signal $X(s)$ has multiple poles

$$X(s) = \frac{k}{s(s+P_1)(s+P_2)^2}$$

$$X(s) = \frac{k_1}{s} + \frac{k_2}{s+P_1} + \frac{k_3}{(s+P_2)^2} + \frac{k_4}{s+P_2}$$

The residues k_1, k_2, k_3, k_4 are given by

$$k_1 = X(s) \times s \Big|_{s=0} \qquad k_2 = X(s) \times (s+P_1) \Big|_{s=-P_1}$$

$$k_3 = X(s) \times (s+P_2)^2 \Big|_{s=-P^2} \qquad k_4 = \frac{d}{ds}\left[X(s) \times (s+P_2)^2\right]_{s=-P_2}$$

$$L^{-1}\{X(s)\} = L^{-1}\left\{\frac{k_1}{s} + \frac{k_2}{s+P_1} + \frac{k_3}{(s+P_2)^2} + \frac{k_4}{s+P_2}\right\}$$

$$= k_1 u(t) + k_2 e^{-P_1 t} u(t) + k_3 t\, e^{-P_2 t} u(t) + k_4 e^{-P_2 t} u(t)$$

In general

$$X(s) = \frac{k}{s(s+P_1)(s+P_2)^q} \quad \text{then}$$

$$X(s) = \frac{k_1}{s} + \frac{k_2}{s+P_1} + \frac{k_3}{(s+P_2)^q} + \frac{k_{12}}{(s+P_2)^{q-1}} + \cdots + \frac{k_{(q-1)2}}{s+P_2}.$$

$$k_{r2} = \frac{1}{r!} \frac{d^r}{dq^r}\left[X(s) \times (s+2)^q \right] \; ; \; r = 1, 2 \ldots q-1.$$

Case iii) When s-domain signal X(s) has complex conjugate poles

Let $$X(s) = \frac{k}{(s+P_1)(s^2+bs+c)}$$

$$X(s) = \frac{k_1}{s+P_1} + \frac{k_2 s + k_3}{s^2+bs+c}$$

$$k_1 = X(s) \times (s+P_1)_{s=-P_1}$$

$$X(s) = \frac{k_1}{s+P_1} + \frac{k_2 s + k_3}{s^2 + 2\times\frac{b}{2}\cdot s + \left(\frac{b}{2}\right)^2 + c - \left(\frac{b}{2}\right)^2}$$

Arranging s^2+bs in $(x+y)^2$.

$$= \frac{k_1}{s+P_1} + \frac{k_2 s + k_3}{\left(s+\frac{b}{2}\right)^2 + \left(c - \frac{b^2}{4}\right)^2}$$

put $\frac{b}{2} = a$, $c - \frac{b^2}{4} = \Omega_0^2$

$$X(s) = \frac{k_1}{s+P_1} + k_2 \cdot \frac{s + a + \frac{k_3}{k_2} - a}{(s+a)^2 + \Omega_0^2}$$

$$= \frac{k_1}{s+P_1} + k_2 \cdot \frac{s+a+k_4}{(s+a)^2+\Omega_0}$$

$\left(\because \text{put } \frac{k_3}{k_2} - a = k_4\right)$

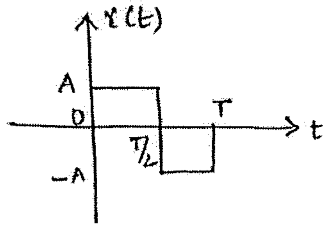
$$\therefore X(s) = \frac{k_1}{s+P_1} + k_2 \cdot \frac{s+a}{(s+a)^2+\Omega_0^2} + k_5 \frac{\Omega_0}{(s+a)^2+\Omega_0^2}$$

$\left(\frac{k_2 k_4}{\Omega_0} = k_5\right).$

$$x(t) = k_1 e^{-P_1 t} u(t) + k_2 e^{-at} \cos\Omega_0 t\, u(t) + k_5 e^{-at} \sin\Omega_0 t\, u(t).$$

LAPLACE TRANSFORM OF CERTAIN SIGNALS USING WAVEFORM SYNTHESIS:

(a)



proof

$x(t) = A$ for $0 < t < T/2$

$= -A$ for $T/2 < t < T$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\, e^{-st}\, dt = \int_0^T x(t)\, e^{-st}\, dt$$

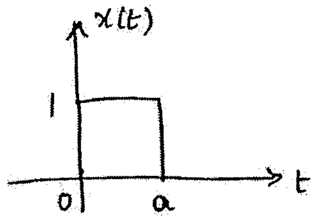
$$= \int_0^{T/2} A e^{-st}\, dt + \int_{T/2}^{T} (-A) e^{-st}\, dt = \left[\frac{Ae^{-st}}{-s}\right]_0^{T/2} + \left[\frac{-Ae^{-st}}{-s}\right]_{T/2}^{T}$$

$$= \left[\frac{Ae^{-sT/2}}{-s} - \frac{Ae^{0}}{-s}\right] + \left[\frac{Ae^{-sT}}{s} - \frac{Ae^{-sT/2}}{s}\right]$$

$$= -\frac{Ae^{-\frac{sT}{2}}}{s} + \frac{A}{s} + \frac{Ae^{-sT}}{s} - \frac{Ae^{-sT/2}}{s}$$

$$= \frac{A}{s}\left[1 - e^{-sT/2}\right]$$

(b)



proof

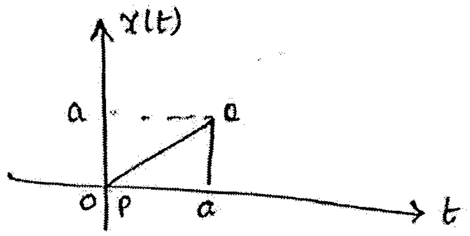
$x(t) = 1$ for $0 < t \le a$

$= 0$ for $t > a$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\, e^{-st}\, dt = \int_0^a 1 \times e^{-st}\, dt = \int_0^a e^{-st}\, dt$$

$$= \left[\frac{e^{-st}}{-s}\right]_0^a = \frac{e^{-as}}{-s} - \frac{e^{0}}{-s} = \frac{-e^{-as}}{s} + \frac{1}{s} = \frac{1}{s}(1 - e^{-as})$$

(c)



Consider the eqn of straight line $\frac{y-y_1}{y_1-y_2} = \frac{x-x_1}{x_1-x_2}$.

Here $y = x(t)$, $x = t$

Consider points P and Q as shown in figure

$P = [0, 0]$, $Q[a, a]$
$t_1, x_1(t)$ $\quad$ $t_2, x_2(t)$

$\therefore \frac{x(t)-0}{0-a} = \frac{t-0}{0-a} \Rightarrow x(t) = t$

$\therefore x(t) = t$ for $t = 0$ to a

$= 0$ for $t > a$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\, e^{-st} dt = \int_0^a e^{-st} \cdot t\, dt$$

$$= \left[t \times \frac{e^{-st}}{-s} - \int 1 \cdot \frac{e^{-st}}{-s} dt \right]_0^a$$

$$= \left[-\frac{te^{-st}}{s} - \frac{e^{-st}}{s^2} \right]_0^a$$

$$= \left[-\frac{ae^{-sa}}{s} - \frac{e^{-sa}}{s^2} + 0 + \frac{e^0}{s^2} \right]$$

$$= \frac{1}{s^2} - \frac{e^{-as}}{s^2} - \frac{ae^{-as}}{s}$$

$$= \frac{1}{s^2}\left[1 - e^{-as}(1+as)\right]$$

Problems on Laplace transforms:

1) Determine the laplace transform of continuous time signals and their ROC

(a) $x(t) = A\,u(t)$

$x(t) = A$ for $t \geq 0$ bcoz $u(t) = 1$ for $t \geq 0$

$= 0$ for $t < 0$

Laplace transform:

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\, e^{-st}\, dt = \int_{0}^{\infty} A\, e^{-st}\, dt = A\left[\frac{e^{-st}}{-s}\right]_{0}^{\infty}$$

$$= A\left[\frac{e^{-(\sigma+j\omega)t}}{-s}\right]_{0}^{\infty}$$

$$= A\left[\frac{e^{-(\sigma+j\omega)\times\infty}}{-s} + \frac{e^{0}}{s}\right] = A\left[\frac{e^{-\sigma\times\infty}\cdot e^{-j\omega\times\infty}}{-s} + \frac{e^{0}}{s}\right]$$

when $\sigma > 0$; $e^{-\sigma\times\infty} = e^{-\sigma\infty} = e^{-\infty} = 0$

when $\sigma < 0$; $e^{-\sigma\times\infty} = e^{\infty} = \infty$

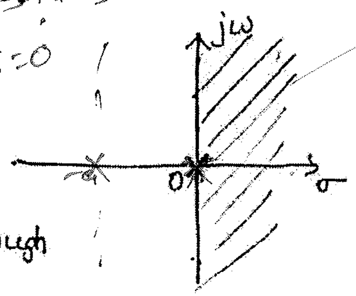
$\therefore$ we can say that $X(s)$ converges when $\sigma > 0$

When $\sigma > 0$, the $X(s)$ is given by

$$X(s) = A\left[\frac{0 \times e^{-j\omega\times\infty}}{-s} + \frac{1}{s}\right] = \frac{A}{s}$$

$\therefore L\{A\,u(t)\} = \frac{A}{s}$; with ROC as all point is s-plane to the right of line passing through $\sigma = 0$

(or ROC is right half of s-plane).



(2) $x(t) = t\,u(t)$

Sol

$$x(t) = t \quad \begin{cases} u(t) = 1 & \text{for } t \geq 0 \\ \quad\;\; = 0 & \text{otherwise} \end{cases}$$

$\frac{d}{dt}t \qquad \frac{d}{dx}x = 1$

$\int uv = u\int v - \int[du \int v]$

$$L\{x(t)\} = X(s) = \int_0^{\infty} x(t)\, e^{-st}\, dt$$

$$= \int_0^{\infty} t \cdot e^{-st}\, dt = t\left[\frac{e^{-st}}{-s}\right]_0^{\infty} - \int\left[\frac{e^{-st}}{-s}\right]_0^{\infty}$$

$(\sigma + j\omega)$

$$= t\left[\frac{e^{-st}}{-s}\right]_0^{\infty} - \left[\frac{e^{-st}}{s^2}\right]_0^{\infty}$$

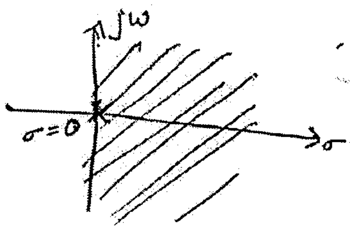
$$= t\left[\frac{e^{-(\sigma+j\omega)t}}{-s}\right]_0^{\infty} - \left[\frac{e^{-(\sigma+j\omega)t}}{s^2}\right]_0^{\infty}$$

$$= \left[\infty \times \frac{e^{-(\sigma+j\omega)\infty}}{-s} - 0 - \frac{e^{-(\sigma+j\omega)\infty}}{s^2} + \frac{e^0}{s^2}\right]$$

$$= \left[\infty \times \frac{e^{-\sigma\times\infty} \times e^{-j\omega\times\infty}}{-s} - \frac{e^{-\sigma\times\infty} \cdot e^{-j\omega\times\infty}}{s^2} + \frac{1}{s^2}\right]$$

when $\sigma > 0$, positive i.e $e^{-\sigma\times\infty} = e^{-\sigma\infty} = 0$

when $\sigma < 0$, negative i.e $e^{-\sigma\times\infty} = e^{\sigma\infty} = \infty$



It converges when $\sigma > 0$

$$= \left[\frac{\infty \times 0 \times e^{-j\omega\times\infty}}{-s} - \frac{0 \times e^{-j\omega\times\infty}}{s^2} + \frac{1}{s^2}\right] = \frac{1}{s^2}$$

$\therefore$ ROC is right half of s-plane.

$s=0;\ s=0$

3) Given that $x(t) = e^{-3t}u(t)$

$e^{at}u(t) \quad \frac{1}{s+a}$

$\frac{1}{s+3} \Rightarrow s = -3$

Sol $x(t) = e^{-3t}$ for $t \geq 0$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t) \cdot e^{-st}\, dt$$

$$= \int_0^\infty x(t)\cdot e^{-st}\,dt = \int_0^\infty e^{-3t}\cdot e^{-st}\,dt = \int_0^\infty e^{-(s+3)t}\,dt.$$

$$= \left[\frac{e^{-(s+3)t}}{-(s+3)}\right]_0^\infty$$

$$= \left[\frac{e^{-(s+3)\infty}}{-(s+3)} + \frac{e^{-(s+3)\cdot 0}}{s+3}\right] \Rightarrow \frac{e^{-(\sigma+j\omega+3)\times\infty}}{-(s+3)} + \frac{1}{s+3}$$

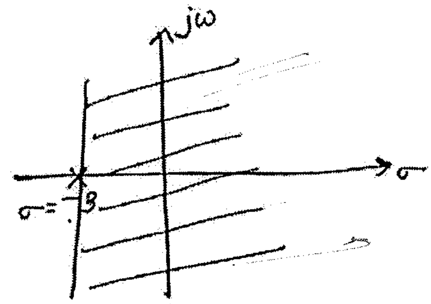
$$= \left[\frac{e^{-(\sigma+3)\infty}\cdot e^{-j\omega\times\infty}}{-(s+3)} + \frac{1}{s+3}\right]$$

$\sigma+3 = \sigma-(-3)$

if $\sigma > -3$ = positive $\therefore e^{-k\times\infty} = e^{-k\infty} = 0$

if $\sigma < -3$ = negative $\therefore e^{-k\times\infty} = e^{k\infty} = \infty$

$\therefore$ It converges at $\sigma > -3$.



$$X(s) = \left[\frac{0\times e^{-j\omega\times\infty}}{-(s+3)} + \frac{1}{s+3}\right] = \frac{1}{s+3}$$

$L\{e^{-3t}u(t)\} = \frac{1}{s+3}$; with ROC as all pts in s-plane to right of line passing through $\sigma=-3$

(4) $x(t) = e^{-3t}u(-t)$

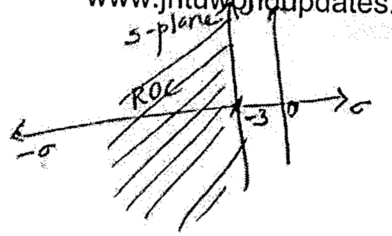
Sol: $x(t) = e^{-3t}$ for $t \leq 0$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)e^{-st}\,dt = \int_{-\infty}^{0} e^{-st}\cdot e^{-3t}\,dt$$

$$= \int_{-\infty}^{0} e^{-(s+3)t}\,dt$$

$$= \left.\frac{e^{-(s+3)t}}{-(s+3)}\right]_{-\infty}^{0} = \frac{e^0}{-(s+3)} + \frac{e^{+(s+3)\times\infty}}{+(s+3)}$$

$$= \frac{-1}{s+3} + \frac{e^{+(\sigma+j\omega+3)\times\infty}}{s+3}$$



$$= \frac{-1}{s+3} + \frac{e^{+(\sigma+3)\times\infty} \cdot e^{-j\omega\times\infty}}{s+3}$$

$k = \sigma+3 = \sigma-(-3)$

when $\sigma > -3$; positive $e^{(\sigma+3)\times\infty} = \infty$

when $\sigma < -3$; negative $e^{-k\infty} = e^{k\infty} = 0$

$\therefore$ ROC it converges when $\sigma < -3$ $\Rightarrow \frac{-1}{s+3} + \frac{0 \times e^{-j\omega\times\infty}}{s+3}$

$L\{x(t)\} = L\{e^{-3t}u(-t)\} = \frac{-1}{s+3}$ { ROC as all pts in s plane to the left passing through $\sigma = -3$

---

(5) $x(t) = e^{-4|t|}$

$= e^{-4t}$ for $t \geq 0$

$= e^{+4t}$ for $t \leq 0$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t) \cdot e^{-st} dt = \int_{-\infty}^{0} e^{4t} \cdot e^{-st} dt + \int_{0}^{\infty} e^{-4t} \cdot e^{-st} dt$$

$$= \int_{-\infty}^{0} e^{-(s-4)t} dt + \int_{0}^{\infty} e^{-(s+4)t} dt$$

$$= \left[\frac{e^{-(s-4)t}}{-(s-4)}\right]_{-\infty}^{0} + \left[\frac{e^{-(s+4)t}}{-(s+4)}\right]_{0}^{\infty}$$

$$= \left[\frac{1}{-(s-4)} + \frac{e^{+(s-4)\times\infty}}{s-4} - \frac{e^{-(s+4)\times\infty}}{s+4} + \frac{1}{s+4}\right]$$

$$= \left[\frac{-1}{s-4} + \frac{e^{(\sigma+j\omega-4)\times\infty}}{s-4} - \frac{e^{-(\sigma+j\omega+4)\times\infty}}{s+4} + \frac{1}{s+4}\right]$$

$$= \left[\frac{-1}{s-4} + \frac{e^{(\sigma-4)\times\infty} \cdot e^{j\omega\times\infty}}{s-4} - \frac{e^{-(\sigma+4)\times\infty} \cdot e^{-j\omega\times\infty}}{s+4} + \frac{1}{s+4}\right]$$

$\sigma - 4 \Rightarrow \sigma - (+4)$

when $\sigma > 4$ positive $e^{k\times\infty} = \infty$

when $\sigma < 4$ negative $e^{-k\infty} = 0$

It converges when $\sigma < +4$

$\sigma + 4 \Rightarrow \sigma - (-4)$

when $\sigma > -4$ positive $e^{-k\infty} = 0$

when $\sigma < -4$ negative $e^{+k\infty} = \infty$

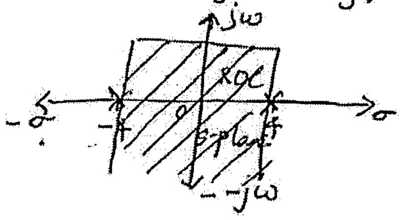
It converges when $\sigma > -4$

when σ lies between -4 and $+4$, the $x(s)$ is given by

$$X(s) = \left[\frac{-1}{s-4} + \frac{e^{(\sigma-4)\times\infty} e^{j\omega\times\infty}}{s-4} - \frac{e^{-(\sigma+4)\times\infty} \cdot e^{-j\omega\times\infty}}{s+4} + \frac{1}{s+4} \right]$$

$$= \frac{-1}{s-4} + \frac{1}{s+4} \Rightarrow \frac{-s-4+s-4}{s^2-16} = \frac{-8}{s^2-16}.$$

with ROC as all points in splane in between the lines passing through $\sigma=-4$ and $\sigma=4$.



(6) Determine the laplace transform of following signals.

$x(t) = \sin\omega_0 t \, u(t)$

Sol

$x(t) = \sin\omega_0 t$ for $t \geq 0$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t) e^{-st} dt$$

$$\because \sin\theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$$

$$= \int_{+0}^{\infty} \sin\omega_0 t \cdot e^{-st} dt$$

$$= \int_{0}^{\infty} \frac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} \cdot e^{-st} dt$$

$$= \frac{1}{2j} \left[\int_0^{\infty} e^{-(s-j\omega_0)t} dt - \int_0^{\infty} e^{-(s+j\omega_0)t} dt \right]$$

$$= \frac{1}{2j} \left\{ \left[\frac{e^{-(s-j\omega_0)t}}{-(s-j\omega_0)} \right]_0^{\infty} - \left[\frac{e^{-(s+j\omega_0)t}}{-(s+j\omega_0)} \right]_0^{\infty} \right]$$

$$= \frac{1}{2j} \left[\frac{e^{-\infty}}{-(s-j\omega_0)} + \frac{e^0}{s-j\omega_0} + \frac{e^{-\infty}}{s+j\omega_0} - \frac{e^0}{s+j\omega_0} \right]$$

$$= \frac{1}{2j} \left[\frac{1}{s-j\omega_0} - \frac{1}{s+j\omega_0} \right] = \frac{1}{2j} \left[\frac{s+j\omega_0 - s + j\omega_0}{s^2 - j^2\omega_0^2} \right] \Rightarrow \frac{1}{2j} \cdot \frac{2j\omega_0}{s^2+\omega_0^2}.$$

$$= \omega_0 / s^2 + \omega_0^2.$$

(7) $x(t) = \cos\omega_0 t\, u(t)$

Sol

$x(t) = \cos\omega_0 t \quad ; t \geq 0$

$$L\{x(t)\} = X(s) = \int_0^\infty x(t) \cdot e^{-st} dt = \int_0^\infty \frac{e^{j\omega_0 t} + e^{-j\omega_0 t}}{2} \cdot e^{-st} dt$$

$$= \frac{1}{2}\int_0^\infty \left[e^{-(s-j\omega_0)t} + e^{-(s+j\omega_0)t}\right] dt$$

$$= \frac{1}{2}\left[\frac{e^{-(s-j\omega_0)t}}{-(s-j\omega_0)} + \frac{e^{-(s+j\omega_0)t}}{-(s+j\omega_0)}\right]_0^\infty$$

$$= \frac{1}{2}\left[\frac{e^{-\infty}}{-(s-j\omega_0)} + \frac{e^0}{s-j\omega_0} - \frac{e^{-\infty}}{s+j\omega_0} + \frac{e^0}{s+j\omega_0}\right]$$

$$= \frac{1}{2}\left[\frac{1}{s-j\omega_0} + \frac{1}{s+j\omega_0}\right] = \frac{1}{2}\left[\frac{s+j\omega_0 + s - j\omega_0}{s^2 - j^2\omega_0^2}\right] = \frac{1}{2} \cdot \frac{2s}{s^2+\omega_0^2}$$

$$L\{\cos\omega_0 t\, u(t)\} = \frac{s}{s^2+\omega_0^2}$$

8) $x(t) = \cosh\omega_0 t \; u(t)$

Sol

$x(t) = \cosh\omega_0 t$ for $t \geq 0$

$\because \cosh\theta = \frac{e^\theta + e^{-\theta}}{2}$

$$L\{x(t)\} = X(s) = \int_{-\infty}^\infty x(t) \cdot e^{-st} dt$$

$$= \int_0^\infty \left(\frac{e^{\omega_0 t} + e^{-\omega_0 t}}{2}\right) e^{-st} dt$$

$$= \frac{1}{2}\int_0^\infty e^{\omega_0 t} \cdot e^{-st} dt + \frac{1}{2}\int_0^\infty e^{-\omega_0 t} \cdot e^{-st} dt$$

$$= \frac{1}{2}\left[\int_0^\infty e^{-(s-\omega_0)t} dt + \int_0^\infty e^{-(s+\omega_0)t} dt\right]$$

$$= \frac{1}{2}\left\{\left[\frac{e^{-(s-\omega_0)t}}{-(s-\omega_0)}\right]_0^\infty + \left[\frac{e^{-(s+\omega_0)t}}{-(s+\omega_0)}\right]_0^\infty\right.$$

$$= \frac{1}{2}\left[\frac{e^{-\infty}}{-(s-\omega_0)} + \frac{1}{s-\omega_0} + \frac{e^{-\infty}}{-(s+\omega_0)} + \frac{1}{s+\omega_0}\right]$$

$$= \frac{1}{2}\left[\frac{1}{s-\omega_0} + \frac{1}{s+\omega_0}\right]$$

$$= \frac{1}{2}\left[\frac{s+\omega_0+s-\omega_0}{s^2-\omega_0^2}\right] = \frac{s}{s^2-\omega_0^2}.$$

9) $x(t) = e^{-at}\sin\omega_0 t\, u(t)$

Sol) $x(t) = e^{-at}\sin\omega_0 t$ for $t \geq 0$

$$L\{x(t)\} = X(s) = \int_0^\infty x(t)\cdot e^{-st}\,dt = \int_0^\infty e^{-at}\sin\omega_0 t\, e^{-st}\,dt = \int_0^\infty e^{-at}\left(\frac{e^{j\omega_0 t}-e^{-j\omega_0 t}}{2j}\right)e^{-st}\,dt$$

$$= \frac{1}{2j}\left[\int_0^\infty e^{-(s+a-j\omega_0)t} - e^{-(s+a+j\omega_0)t}\right]dt$$

$$= \frac{1}{2j}\left[\frac{e^{-(s+a-j\omega_0)t}}{-(s+a-j\omega_0)}\right]_0^\infty - \left[\frac{e^{-(s+a+j\omega_0)t}}{-(s+a+j\omega_0)}\right]_0^\infty$$

$$= \frac{1}{2j}\left[\frac{e^{-\infty}}{-(s+a-j\omega)} + \frac{e^0}{s+a-j\omega_0} + \frac{e^{-\infty}}{s+a+j\omega} - \frac{e^0}{s+a+j\omega_0}\right]$$

$$= \frac{1}{2j}\left[\frac{1}{s+a-j\omega_0} - \frac{1}{s+a+j\omega_0}\right] = \frac{1}{2j}\left[\frac{s+a+j\omega_0-s-a+j\omega_0}{(s+a)^2+\omega_0^2}\right]$$

$$= \frac{2j\omega_0}{2j\cdot(s+a)^2+\omega_0^2}$$

$$= \frac{\omega_0}{(s+a)^2+\omega_0^2}.$$

(10) $x(t) = e^{-at}\cos\omega_0 t\; u(t)$

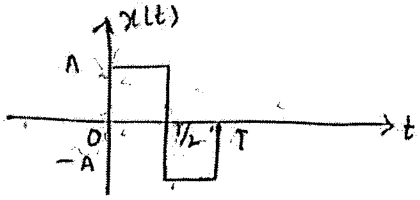
Sol) $x(t) = e^{-at}\cos\omega_0 t$ for $t \geq 0$.

||ly

$$= \frac{s+a}{(s+a)^2+\omega_0^2}$$

(11) Determine the Laplace transform of following signals.

Sol)



$x(t) = A$ for $0<t\leq T/2$

$= -A$ for $T/2<t<T$

x(t) = A·u(t)

x(t) = −A·u(t−t)

$$L\{x(t)\} = X(s) = \int_0^{T/2} A\cdot e^{-st}dt + \int_{T/2}^{T} -A\cdot e^{-st}dt$$

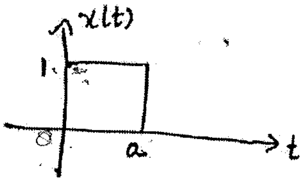
$$= A\left[\frac{e^{-st}}{-s}\right]_0^{T/2} - A\left[\frac{e^{-st}}{-s}\right]_{T/2}^{T}$$

$$= A\left[\frac{e^{-sT/2}}{-s} + \frac{1}{s}\right] - A\left[\frac{e^{-sT}}{-s} + \frac{e^{-sT/2}}{s}\right]$$

$$= -\frac{Ae^{-sT/2}}{s} + \frac{A}{s} + \frac{Ae^{-sT}}{s} - \frac{Ae^{-sT/2}}{s}$$

$$= \frac{A}{s}\left[1 + e^{-sT} - 2e^{-sT/2}\right] = \frac{A}{s}\left[1 - e^{-sT/2}\right]^2$$

(12)



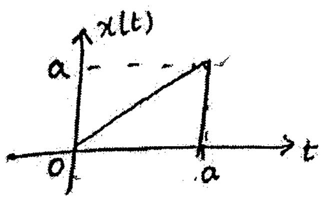
$x(t) = 1$ for $0<t<a$

$= 0$ otherwise

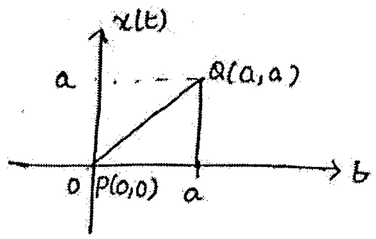
$$L\{x(t)\} = X(s) = \int_0^{a} e^{-st}dt = \left.\frac{e^{-st}}{-s}\right]_0^{a}$$

$$= \frac{e^{-as}}{-s} + \frac{1}{s} \Rightarrow \frac{1}{s}\left[1 - e^{-as}\right]$$

(13)



$$\frac{y-y_1}{y_1-y_2} = \frac{x-x_1}{x_1-x_2}.$$



here $(x_1,y_1) = (0,0)$, $(x_2,y_2) = (a,a)$

$x = t$, $y = x(t)$.

$$\Rightarrow \frac{x(t)-0}{0-a} = \frac{t-0}{0-a} \Rightarrow \frac{x(t)}{-a} = \frac{t}{-a} \Rightarrow x(t) = t \quad \text{for } 0<t<a$$
$$= 0 \quad \text{otherwise}$$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t).e^{-st}\,dt$$

$$= \int_0^a t e^{-st}\,dt = \left\{ t\left[\frac{e^{-st}}{-s}\right]_0^a - \int \frac{e^{-st}}{-s}\Big]_0^a \right\}$$

$$= t.\frac{e^{-st}}{-s}\Big]_0^a - \frac{e^{-st}}{s^2}\Big]_0^a$$

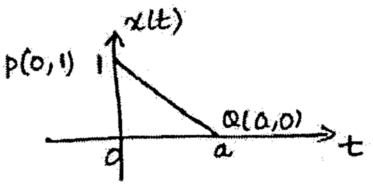
$$= a.\frac{e^{-sa}}{-s} - \frac{e^{-as}}{s^2} + \frac{1}{s^2}$$

$$= \frac{1}{s^2}\left[1 - e^{-as} - s.e^{-as}.a\right]$$

$$= \frac{1}{s^2}\left[1 - e^{-as} - as.e^{-as}\right]$$

$$= \frac{1}{s^2}\left[1 - e^{-as}(1+as)\right]$$

14)



$(x_1,y_1) = (0,1)$, $(x_2,y_2) = (a,0)$, $x = t$, $y = x(t)$.

$$\frac{y-y_1}{y_1-y_2} = \frac{x-x_1}{x_1-x_2} \Rightarrow \frac{x(t)-1}{1-0} = \frac{t-0}{0-a} \Rightarrow x(t)-1 = \frac{-t}{a}$$

$$x(t) = 1 - t/a \quad \text{for } 0 \text{ to } a$$
$$= 0 \quad \text{for } t>a$$

$$L\{x(t)\} = X(s) = \int_{-\infty}^{\infty} x(t)\cdot e^{-st}dt$$

$$= \int_0^a \left(1-\frac{t}{a}\right) e^{-st}dt = \int_0^a e^{-st}dt - \int_0^a \frac{t}{a} e^{-st}dt$$

$$= \left.\frac{e^{-st}}{-s}\right]_0^a - \frac{1}{a}\left[\int_0^a t\cdot e^{-st}dt\right]$$

$$= \frac{e^{-as}}{-s} + \frac{1}{s} - \frac{1}{a}\left[t\cdot\frac{e^{-st}}{-s} - \frac{e^{-st}}{s^2}\right]_0^a$$

$$= \frac{e^{-as}}{-s} + \frac{1}{s} - \frac{1}{a}\cdot a\cdot\frac{e^{-as}}{-s} + \frac{1e^{-sa}}{as^2} - \frac{1}{as^2}\Big]$$

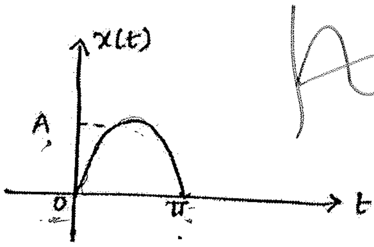
$$= \frac{e^{-as}}{-s} + \frac{1}{s} + \frac{e^{-as}}{s} + \frac{e^{-as}}{as^2} - \frac{1}{as^2}$$

$$= \frac{1}{s} + \frac{e^{-as}}{as^2} - \frac{1}{as^2} = \frac{1}{as^2}\left[e^{-as} + as - 1\right]$$

(15) Determine the laplace transform of sine pulse

Sol $x(t) = A\sin t$ for $0<t<\pi$

$= 0$ for $t>\pi$



$$L\{x(t)\} = X(s) = \int_0^{\pi} A\sin t\, e^{-st}dt$$

$$= A\left[\frac{e^{jt}-e^{-jt}}{2j} e^{-st}\right]dt = \frac{A}{2j}\left[\int_0^{\pi} e^{-(s-j)t}dt - \int_0^{\pi} e^{-(s+j)t}dt\right]_0$$

$$= \frac{A}{2j}\left[\frac{e^{-(s-j)t}}{-(s-j)}\right]_0^{\pi} - \frac{A}{2j}\left[\frac{e^{-(s+j)t}}{-(s+j)}\right]_0^{\pi}$$

$$= \frac{A}{2j}\left[\frac{e^{-(s+j)t}}{s+j} - \frac{e^{-(s-j)t}}{s-j}\right]_0^{\pi} = \frac{A}{2j}\left[\frac{(s-j)e^{-st}\cdot e^{-jt} - (s+j)e^{-st}e^{jt}}{s^2-j^2}\right]_0^{\pi}$$

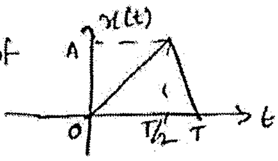
$$= \frac{A}{2j(s^2+1)}\left[(s-j)e^{-st}e^{-jt} - (s+j)e^{-st}e^{jt}\right]_0^{\pi}$$

$$= \frac{A}{2j(s^2+1)}\left[(s-j)e^{-s\pi}e^{-j\pi} - (s+j)e^{-s\pi}e^{j\pi} - (s-j)e^{-0} + (s+j)e^{0}\right]$$

$$= \frac{A}{2j(s^2+1)}\left[-(s-j)e^{-s\pi} + (s+j)e^{-s\pi} - (s-j) + (s+j)\right] = \frac{A}{2j(s^2+1)}(2je^{-\pi s} + 2j)$$

$$\Rightarrow \frac{A}{s^2+1}(e^{-\pi s}+1)$$

(16) Determine laplace transform of



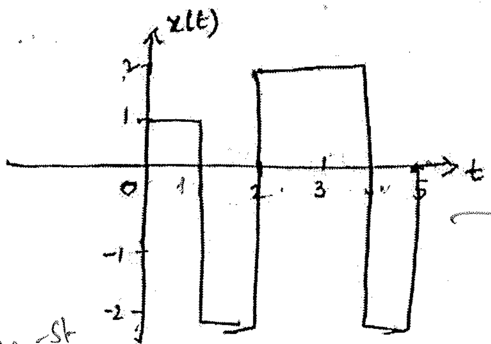
Sol

$$x(t) = \frac{2At}{T} \; ; \; 0<t<T/2$$

$$= 2A - \frac{2At}{T} \quad T/2<t<T.$$

$$L\{x(t)\} = X(s) = \frac{2A}{Ts^2}\left(1 - e^{-sT/2}\right)^2.$$

(17) Determine laplace transform of



Sol

$$x(t) = \begin{cases} 1 & \text{for } 0<t<1 \\ -2 & \text{for } 1<t<2 \\ 2 & \text{for } 2<t<4 \\ -2 & \text{for } 4<t<5 \\ 0 & \text{for } t>5 \end{cases}$$

$$X(s) = \int_0^{\infty} x(t)\, e^{-st}\, dt$$

$$L\{x(t)\} = X(s) = \int_0^1 e^{-st}\, dt + \int_1^2 -2e^{-st}\, dt + \int_2^4 2e^{-st}\, dt + \int_4^5 -2e^{-st}\, dt$$

$$= \left.\frac{e^{-st}}{-s}\right]_0^1 - 2\left[\frac{e^{-st}}{-s}\right]_1^2 + 2\left[\frac{e^{-st}}{-s}\right]_2^4 - 2\left[\frac{e^{-st}}{-s}\right]_4^5$$

$$= \frac{e^{-s}}{-s} + \frac{1}{s} + \frac{2e^{-2s}}{s} - \frac{e^{-s}}{s} - \frac{2e^{-4s}}{s} + \frac{2e^{-2s}}{s} + \frac{2e^{-5s}}{s} - \frac{2e^{-4s}}{s}$$

$$= \frac{1}{s}\left[1 - 2e^{-s} + 4e^{-2s} - 4e^{-4s} + 2e^{-5s}\right]$$

$$X(s) = \int_{-\infty}^{\infty} x(t) \cdot e^{-st}\, dt$$

$$\int_0^1 1 \cdot e^{-st}\, dt + \int_1^2 -2e^{-st}\, dt$$

(18) Determine the Laplace transform of $\delta(t)$.

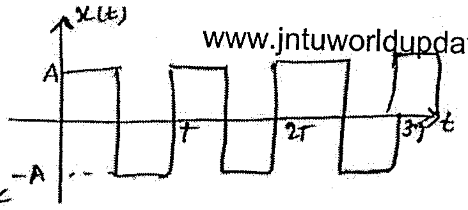
Sol

$$\delta(t) = 1 \quad \text{for } t=0$$

$$= 0 \quad \text{otherwise.}$$

$$L\{x(t)\} = X(s) = \left.\frac{e^{-st}}{-s}\right|_{t=0} =$$

• Determine the laplace transform of periodic square wave



Q) The given waveform satisfy the condition

$x(t+nT) = x(t)$ and so it is periodic

$x_1(t) = A$ for $t = 0$ to $T/2$

$= -A$ for $t = T/2$ to T

From periodicity property of laplace transform

If $X(S) = L\{x(t)\}$ and if $x(t) = x(t+nT)$ then $X(S) = \frac{1}{1-e^{-ST}} \int_0^T x_1(t) e^{-St} dt$

$$\therefore L\{x(t)\} = X(S) = \frac{1}{1-e^{-ST}} \int_0^T x_1(t) e^{-St} dt$$

we know $x_1(t)$ = laplace transform $= \frac{A}{S}\left[1 - e^{-ST/2}\right]^2$

$$X(S) = \frac{1}{1-e^{-ST}} \left[\frac{A}{S}\left(1 - e^{-ST/2}\right)\right]^2$$

$$= \frac{1}{\left(1-e^{-ST/2}\right)\left(1+e^{-ST/2}\right)} \left[\frac{A}{S}\left(1-e^{-ST/2}\right)^2\right]$$

$$= \frac{A}{S}\left[\frac{1-e^{-ST/2}}{1+e^{-ST/2}}\right]$$

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II B.Tech - I Sem(**R18**) DESCRIPTIVE TEST – I A.Y.: 2021 - 2022

Branch: ECE	Subject Name: Signals &System
Class: **B.Tech**	Date of Exam. 14-12-2021
Max. Marks: 10M	Time:01:40 PM to 03:00PM

0Answer any TWO of the following questions: 2x 5 = 10

1) Sketch the following signals: ....5Marks(Understand)

    (i). z(t) = r(t+2)-r(t+1)-r(t-1)+r(t-2)

    (ii).x(t) = -u(t+3)+2u(t+1)-2u(t-1)+u(t-3)

    (iii).y(t) = r(t+1)-r(t)+r(t-2)

2) a. Estimate the mean square error value of a function f(t)? ....5Marks(Evaluate)

   b.show that the function sinω_0t and cosω_0t are orthogonal over an interval t_0 t0 to $t_0 + 2\pi/\ \omega_0$ for integral values of n and m

3) Explain about Dirichlet's conditions and Hilbert Transform?. ....5Marks(Remember)

4) State all the properties of Fourier Series. ....5Marks(Understand)

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KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY

(COLLEGE OF ENGINEERING)

Ghanpuram(V), Ghatkesar (M), Hyderabad. - 501301

Accredited by NBA CSE ECE, NAAC

II B.Tech - I Sem(**R18**) DESCRIPTIVE TEST – I A.Y.: 2021- 2022

Branch: ECE	Subject Name: Signals &System
Class: **B.Tech**	Date of Exam. 14-12-2020
Max. Marks: 10M	Time:01:40 PM to 03:00PM

0Answer any TWO of the following questions: 2x 5 = 10

1) Sketch the following signals: ....5Marks(Understand)

    (i). z(t) = r(t+2)-r(t+1)-r(t-1)+r(t-2)

    (ii).x(t) = -u(t+3)+2u(t+1)-2u(t-1)+u(t-3)

    (iii).y(t) = r(t+1)-r(t)+r(t-2)

2) a. Estimate the mean square error value of a function f(t)? ....5Marks(Evaluate)

   b.show that the function sinω_0t and cosω_0t are orthogonal over an interval t_0 to $t_0 + 2\pi/\ \omega_0$ for integral values of n and m

3) Explain about Dirichlet's conditions and Hilbert Transform?. ....5Marks(Remember)

4) State all the properties of Fourier Series. ....5Marks(Understand)

KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY-GHATKESAR

II B.Tech. I Sem., I Mid-Term Examinations, December-2021

Subject Name: Signals &System **(Branch: ECE)**

Objective Exam

Name: ______________________________ **Hall Ticket No.**

		R	A		A	0			

Answer All Questions. All Questions Carry Equal Marks. Time: 20 Min. Marks: 10.

I. Choose the correct alternative:

1. Which one most appropriate dynamic system? [ ]
   A) y(n) + y(n - 1) + y(n + 1)
   B) y(n) + y(n - 1)
   C) y(n) = x(n)
   D) y(n) + y(n - 1) + y(n + 3) = 0

2. δ(t) is a [ ]
   A) energy signal B) power signal C) neither energy nor power D) none

3. Signal is a _________ [ ]
   A). Time variant B). It is a physical phenomenon C). It is a physical phenomenon D). All of the above

4. Which one is a causal system? [ ]
   A) y(n) = 3x[n] - 2x[n - 1] B) y(n) = 3x[n] + 2x[n + 1] C) y(n) = 3x[n + 1] + 2x[n - 1] D) y(n) = 3x[n + 1] 2x[n - 1] + x[n]

5. All non-causal systems are _________ [ ]
   A). Dynamic B).Static C).Either static or dynamic D). None of the above

6. All static systems are _____________ [ ]
   A).Causal B). Non-causal C). Either causal or non-causal D). None of the above

7. How many dirichlet's conditions are there? [ ]
   A) One B) Two C) Three D) Four

8. Who discovered Fourier series? [ ]
   A) Jean Baptiste de Fourier
   B) Jean Baptiste Joseph Fourier
   C) Fourier Joseph
   D) Jean Fourier

9. Find the Fourier transform of $e^{j\omega_0 t}$. [ ]
   A) $\delta(\omega + \omega_0)$ B) $2\pi\delta(\omega + \omega_0)$ C) $\delta(\omega - \omega_0)$ D) $2\pi\delta(\omega - \omega_0)$

10. What are the two types of Fourier series? [ ]
    A) Trigonometric and exponential
    B) Trigonometric and logarithmic
    C) Exponential and logarithmic
    D) Trigonometric only

Cont.....2

II Fill in the Blanks:

11. The impulse function is _______ when t=0

12. When t≥0, the unit signal amplitude must be ________

13. If x (-t) = -x (t) then the signal is said to be _____________

14. Linearity property in Fourier Transform_____________

15. All periodic signals are ______________--signals

16. Energy of x(t)_________________

17. ______________ system is a memory system

18. Fourier Series Equation__________________

19. Fourier Transform Equation ____________________

20. ______________are the conditions called which are required for a signal to fulfill to be represented as Fourier series

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II B.Tech - I Sem(**R18**) DESCRIPTIVE TEST – II A.Y.: 2021 - 2022

Branch: ECE
Class: **B.Tech**
Max. Marks: 10M

Subject Name: Signals &System
Date of Exam. 15-02-2022
Time:01:40 PM to 03:00PM

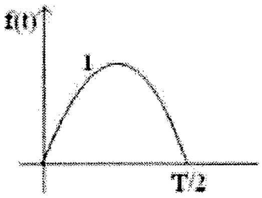
Answer any TWO of the following questions: **2x 5 = 10**

1) a).Derive the relationship between bandwidth and rise time ....**2.5Marks(Evaluate)**

b).Differentiate between signal bandwidth and system bandwidth ....**2.5Marks**(Understand)

2) a).Derive the relation between Laplace Transform and Fourier Transform ..**2.5Marks(Evaluate)**

b). Determine the Laplace transform of signal shown in figure. ....**2.5Marks(Apply)**



Figure

3) a).Explain natural sampling with relevant waveforms and expressions.?. ...**2.5Marks(Understand)**

b).Derive the relationship between autocorrelation function and energy spectral density of an energy signal ....**2.5Marks(Evaluate)**

4) a).Determine the Laplace Transform of continuous time signals and their ROC

(i) $x(t)=Au(t)$ ii)$x(t)=e^{-3t}u(t)$ ....**2.5Marks(Apply)**

b).Explain properties of ROC in Z-Transform....................................**2.5Marks(Understand)**

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II B.Tech - I Sem(**R18**) DESCRIPTIVE TEST – II A.Y.: 2021- 2022

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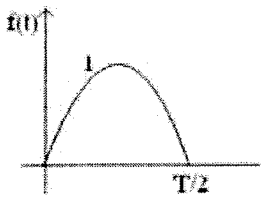
b).Differentiate between signal bandwidth and system bandwidth ....**2.5Marks**(Understand)

2) a).Derive the relation between Laplace Transform and Fourier Transform ..**2.5Marks(Evaluate)**

b). Determine the Laplace transform of signal shown in figure. ....**2.5Marks(Apply)**



Figure

3) a).Explain natural sampling with relevant waveforms and expressions.?. ...**2.5Marks(Understand)**

b).Derive the relationship between autocorrelation function and energy spectral density of an energy signal ....**2.5Marks(Evaluate)**

4) a).Determine the Laplace Transform of continuous time signals and their ROC

(i) $x(t)=Au(t)$ ii)$x(t)=e^{-3t}u(t)$ ....**2.5Marks(Apply)**

b).Explain properties of ROC in Z-Transform....................................**2.5Marks(Understand)**

11. The significance of PSD is ____________.

12. The Laplace transform is more general than the fourier transform because _______.

13. Bandpass signals can be sampled at the minimum rate of __________.

14. A band limited signal has no frequency components by on WHz may be completerly recovered from the knowledge of its samples taken at a rate of samples ________________.

15. The PSD of a random process is a measure of _________

16. Aliasing occurs when the signal is _________

17. In region of convergence the part of S is greater than α ____________.

18. Laplace transform of -U(-n-1) _______________

19. Correlation of two signals is measure of ______ between those signals

20 The phenomenon of a high frequency component taking the identity of a low frequency in the sampling version is called _______________

-oOo-

KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY-GHATKESAR
II B.Tech. I Sem., II Mid-Term Examinations, February-2022

Subject Name: Signals &System **(Branch: ECE)**

Objective Exam

Name: ____________________________ **Hall Ticket No.**

		R	A		A	0			

Answer All Questions. All Questions Carry Equal Marks. Time: 20 Min. Marks: 10.

I. Choose the correct alternative:

1. The initial value of $L^{-1}[\frac{5}{s(s+2)}]$ is [ ]
   A) 0 B) 5 C)2 D) 5/2
2. If the laplace transform of x(t) is X(S), then $\lim_{t\to\infty} x(t)$ is given by [ ]
   A) $\lim_{s\to\infty} sX(s)$ B) $\lim_{s\to 0} sX(s)$ C) $\lim_{s\to\infty} X(s)/s$ D) $\lim_{s\to 0} X(s)/s$
3. The laplace transform can be implemented easily than fourier transforms if the signal is [ ]
   A). Simple B). Complex C). Discontinuous D). Periodic
4. The laplace transform of cosωt is [ ]
   A) $\frac{\omega}{s^2+\omega^2}$ B) $\frac{s}{s^2+\omega^2}$ C) $\frac{1}{s^2+\omega^2}$ D) $\frac{2}{s^2+\omega^2}$
5. The reciprocal seconds is called [ ]
   A). Nyquist Interval B). Modulation C). Demodulation D). Sampling
6. Sampling theorem series as the basis for conversion of analog signal to signals and vice versa
   A). Continuous Time B). Discrete Time C) distortion D) distortion [ ]
7. The convolution theorem states that F[x1(t) * x2(t)] = [ ]
   A). $X1(\omega)X2(\omega)$ B). $X1(\omega) * X2(\omega)$
   C). $\frac{1}{2\pi}[X1(\omega)X2(\omega)]$ D). $\frac{1}{2\pi}[X1(\omega) * X2(\omega)]$
8. Covarianceof two independent random variable I [ ]
   A). Unity B). Zero C) Greater than Unity D). Less than Unit
9. The process of converting a continuous signal in to a discrete signal is called [ ]
   A). Analog to digital conversion B). digital to analog conversion
   C). Sampling D). all the above
10. The Z-transform of a discrete signal x(n) = a^nu(n) is [ ]
   A). $\frac{z}{z-a^n}$ B). $\frac{z}{z-a}$
   C). $\frac{z}{z+a^n}$ D). $\frac{z}{z+a}$

Cont…..2

II Fill in the Blanks:

KOMMURI PRATAP REDDY INSTITUTE OF TECHNOLOGY

Department of Electronics and Communication Engineering

Course Outcome Attainment (Internal Examination-1)

Name of the faculty N.SAIRAM — Academic Year 2021-22

Branch & Section: ECE — Examination: I Internal

Course Name: **Signals and Systems** — Year: II Semester: I

S.No	HT No.	Question No.												Obj1	A1
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12		
Max. Marks ==>		5	5	5	5									10	5
1	20RA1A0401		3	2										7.5	4.5
2	20RA1A0402	3			3									9	5
3	20RA1A0403		3	3										9	5
4	20RA1A0404	3			1.5									7.5	4
5	20RA1A0405		1	3										9.5	5
6	20RA1A0406	3			3									7.5	4
7	20RA1A0407		2		2									9.5	5
8	20RA1A0408		3	3										9	4
9	20RA1A0409	3		3										9	5
10	20RA1A0410		3		3									9	5
11	20RA1A0411	2		4										6	3.5
12	20RA1A0412	1		2										6	4
13	20RA1A0413	3			3									7	3.5
14	20RA1A0414		3	2										8	3
15	20RA1A0415	2			3									6	5
16	20RA1A0416		3		3									7	5
17	20RA1A0417	3		3										8.5	5
18	20RA1A0418	3			3									9	5
19	20RA1A0419	2.5		3										8	5
20	20RA1A0420		3	3										8	5
21	20RA5A0401	2			3									6	3
22	20RA5A0402	3		3										8	5
23	20RA5A0403		2.5		3									7	3.5
24	20RA5A0404		3		3									9	5
25	20RA5A0405	2		2										7	3
26	20RA5A0406		3		3									8.5	3.5
27	20RA5A0407	3		3										9	5
28	20RA5A0408	2			1.5									7	3
29	20RA5A0409		2	3										6	5
30	20RA5A0410	3			3									6	3
Performance Target set by the faculty / HoD		50%	50%	50%	50%					###	50%	50%	50%	50%	50%
Number of students performed above the target		10	9	11	12					0	0	0	0	30	30
Number of students attempted		17	13	15	15					0	0	0	0	30	30
Percentage of students scored more than target		59%	69%	73%	80%									100%	100%

CO Mapping with Exam Questions:

CO - 1	Y	Y											y	y
CO - 2			Y	Y									y	y
CO - 3				Y									y	y
CO - 4														
CO - 5														
CO - 6														

CO Attainment based on Exam Questions:

CO - 1	59%	69%											100%	100%
CO - 2			73%	80%									100%	100%
CO - 3				80%									100%	100%
CO - 4														
CO - 5														
CO - 6														

CO	Subj	obj	Asgn	Overall	Level
CO-1	64%	100%	100%	88%	3
CO-2	77%	100%	100%	92%	3
CO-3	80%	100%	100%	93%	3
CO-4					
CO-5					
CO-6					

Attainment Leve	
1	50%
2	75%
3	>75%

Overall Course Attainment = 3.00

Faculty
N.SAIRAM