

**Module 1****Chapter 1 : Introduction to Signals 1-1 to 1-61**

**Syllabus :** Definitions of signal and system. Standard signals : Step, Ramp, Pulse, impulse, Real and Complex Exponentials and Sinusoids, Classification of signals : Continuous Time (CT) and Discrete Time (DT) signals, Periodic and Aperiodic signals, Deterministic and Random signals, Even and Odd, Energy and Power signals, Basic operations on signals : Folding, Scaling and Time shifting). Convolution in DT domain (Matrix method only).

1.1	Signal .....	1-2	1.6	Operations on Independent Variable .....	1-15
1.2	CT and DT Signals .....	1-2	1.6.1	Time Shifting .....	1-15
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1.2.2	Discrete Time (DT) Signal .....	1-2	1.6.3	Time Reversal (Time Inversion) or Folding .....	1-20
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1.3.3	Sinusoidal Signals .....	1-4	1.7	Classification of Signals .....	1-27
1.3.4	Unit Step Signal .....	1-4	1.8	Periodic and Non-periodic Signals .....	1-28
1.3.5	Signum Function .....	1-5	1.8.1	Periodic CT Signal .....	1-28
1.3.6	Rectangular Signals .....	1-5	1.8.2	Non-periodic CT Signal .....	1-28
1.3.7	Delta or Unit Impulse Function $[\delta(t)]$ ...	1-6	1.8.3	Periodic discrete time signal .....	1-28
1.3.7(A)	Important Properties of a Delta Function	1-6	1.8.4	Non-periodic DT Signal .....	1-29
1.3.8	Unit Sample Signal $\delta(n)$ .....	1-7	1.9	Deterministic and Random Signals .....	1-35
1.3.9	Unit Ramp Signal .....	1-7	1.9.1	Deterministic Signal .....	1-35
1.3.10	C.T. Complex Exponential Signals .....	1-8	1.9.2	Random Signals .....	1-35
1.3.11	Discrete Time Exponential Signals .....	1-8	1.10	Symmetrical (Even) or Antisymmetrical (Odd) Signals .....	1-36
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1.3.13	Unit Triangle Function .....	1-11	1.10.2	C.T. Antisymmetrical (Odd) Signal .....	1-36
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1.5.2	Addition of Signals .....	1-12	1.10.6	Stochastic Signals .....	1-37
1.5.3	Subtraction of Signals .....	1-13	1.11	Energy and Power Signals .....	1-37
1.5.4	Multiplication of Two Signals .....	1-14	1.11.1	Power Signal .....	1-37
1.5.5	Differentiation .....	1-15	1.11.2	Energy Signals .....	1-37
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			1.11.5	Energy of a CT Signal .....	1-38
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			1.11.8	Power of the Energy Signals .....	1-39
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1.14 Computation of Linear Convolution .....1-49	2.6.2 Stable and Unstable D.T. Systems .....2-15
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1.14.1(A)Solved Examples on Graphical Method .....1-49	2.7.1 Static DT Systems .....2-16
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1.15 Solved University Examples .....1-54	2.8 Invertibility of Systems .....2-18
• <b>Review Questions.....1-61</b>	2.9 Solved Examples .....2-19

<b>Module 1</b>
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<b>Chapter 2 : Introduction to Systems</b>	<b>2-1 to 2-28</b>
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<p><b>Syllabus : Classification of systems</b> : Linear / Non-linear, Time-variant / Invariant, Causal / Anti causal, Stable / unstable, Memory / Memory less system (static and dynamic), Sampling theorem (Derivation is not required).</p>
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2.1 System .....2-2	2.10.1 Sampling Process .....2-24
2.1.1 Examples of Practical Systems .....2-2	2.11 Sampling Theorem for Low Pass Signals in Time Domain .....2-24
2.2 Classification of Systems .....2-2	2.11.1 Aliasing or Foldover Error .....2-26
2.2.1 Classification of C.T. Systems .....2-2	2.11.2 Nyquist Rate and Nyquist Interval .....2-27
2.2.2 Classification of D.T. Systems .....2-3	2.11.3 Effect of Nonideal Filter .....2-27
2.3 Linear and Non linear Systems .....2-3	• <b>Review Questions .....2-28</b>
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2.3.2 Linear and Nonlinear C.T. Systems .....2-3	
2.3.3 Linearity of D.T. System .....2-4	
2.4 Time Variant or Time Invariant Systems .....2-9	
2.4.1 Time Invariant and Time Variant C.T. Systems .....2-9	
2.4.2 Shift Invariant and Shift Variant D.T. Systems .....2-9	
2.5 Causal or Noncausal Systems .....2-13	
2.5.1 Causal or Realizable C.T. Systems .....2-13	

<b>Module 2</b>
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<b>Chapter 3 : Z-Transform</b>	<b>3-1 to 3-55</b>
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<p><b>Syllabus</b> : z-Transform of bilateral signal, Definition of ROC, Properties of ROC, Properties of z-transform, Inverse z-Transform (only partial fraction). Formation of Difference Equation, Solution of difference Equation (with &amp; without initial Conditions)</p>
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3.1 Introduction .....3-2	3.3.1 z-Transform of Unit Impulse $\delta(n)$ .....3-10
3.2 Definition of z-Transform .....3-2	3.3.2 z-Transform of a Delayed Unit Impulse $\delta(n - k)$ .....3-11
3.3 z-Transform of Standard Sequences .....3-10	3.3.3 z-Transform of a Unit Step $u(n)$ .....3-11
3.3.1 z-Transform of Unit Impulse $\delta(n)$ .....3-10	3.3.4 z-Transform of Unit Ramp .....3-12
3.3.2 z-Transform of a Delayed Unit Impulse $\delta(n - k)$ .....3-11	
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3.4.2	Time Shifting .....	3-14
3.4.3	Scaling .....	3-15
3.4.4	Time Reversal .....	3-15
3.4.5	Differentiation Property .....	3-16
3.4.6	Convolution .....	3-17
3.4.7	Initial Value Theorem .....	3-18
3.4.8	Final Value Theorem .....	3-18
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3.6	Inverse z-Transform .....	3-31
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3.7	Relationship between The z-transform and Other Transforms .....	3-41
3.7.1	Relationship between Laplace Transform and z-Transform .....	3-41
3.7.2	Relationship between Fourier Transform and z-Transform .....	3-41
3.7.3	Relationship between DFT and ZT .....	3-42
3.8	Solved Examples .....	3-42
3.9	Solved University Examples .....	3-51
	• <b>Review Questions</b> .....	<b>3-55</b>

### Module 2

#### Chapter 4 : Analysis & Characterization of LTI Systems using Z-Transform 4-1 to 4-24

**Syllabus** : Pole-zero plot in DT domain, Formation of Difference Equation, Zero input, Zero state and Total Response of the system

4.1	Introduction .....	4-2
4.1.1	Relation between Pole and Time Domain .....	4-2
4.2	Transfer Function .....	4-7
4.3	Checking Causality and Stability using z-Transform .....	4-13
4.4	Solved Examples .....	4-14
	• <b>Review Questions</b> .....	<b>4-24</b>

### Module 3

#### Chapter 5 : Introduction to Fourier Series 5-1 to 5-30

**Syllabus** : Introduction to Fourier series : Representation of continuous time periodic signals, Convergence of Fourier series, Properties of continuous time Fourier series, Fourier series representation of discrete time periodic signals, Properties of discrete time Fourier series.

5.1	Frequency Domain Representation .....	5-2
5.1.1	How to Plot Line Spectrum ? .....	5-2
5.1.2	Double Sided Line Spectrum .....	5-3
5.2	CT Fourier Series .....	5-4
5.2.1	Types of Fourier Series .....	5-4
5.2.2	Trigonometric or Quadrature Fourier Series .....	5-4
5.2.3	Polar Fourier Series .....	5-5
5.2.4	Exponential Fourier Series (or Complex Exponential Fourier Series) .....	5-6
5.2.5	Dirichlet Conditions for the Existence of Fourier Series .....	5-6
5.2.5(A)	Knowledge of Waveform Symmetry used to Calculate Fourier Coefficient .....	5-7
5.2.6	Examples on Fourier Series .....	5-7
5.3	Properties of C.T. Fourier Series .....	5-22
5.3.1	Linearity .....	5-22
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	• <b>Review Questions</b> .....	<b>5-30</b>

### Module 4

#### Chapter 6 : Discrete Fourier Transform (DFT) 6-1 to 6-68

**Syllabus** : DTFT, DFT & IDFT (Only Matrix Method), Properties of DFT



6.1	The Fourier Transform .....	6-2
6.2	Discrete Time Fourier Transform .....	6-2
6.2.1	DTFT of Standard Signals .....	6-3
6.3	Properties of DTFT .....	6-5
6.3.1	Linearity .....	6-5
6.3.2	Time Shifting .....	6-5
6.3.3	Time Reversal .....	6-5
6.3.4	Differentiation .....	6-6
6.3.5	Convolution Theorem .....	6-6
6.3.6	Windowing (Modulation) Theorem .....	6-7
6.4	Relationship between DTFT and DFT .....	6-7
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6.5.1	DFT of Simple Signals .....	6-8
6.6	The Fourier Spectrum .....	6-17
6.7	Inverse Discrete Fourier Transform (IDFT) .....	6-18
6.8	Computing DFT by Matrix Method .....	6-19
6.8.1	Solved Examples on DFT Matrix Method .....	6-23
6.9	Discrete Fourier Transform (DFT) Properties .....	6-31
6.9.1	Linearity .....	6-31
6.9.2	Periodicity .....	6-32
6.9.3	Circular Time Shift .....	6-34
6.9.4	Circular Frequency Shift .....	6-39
6.9.5	Time Reversal .....	6-40
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6.9.7	Complex Conjugate Property .....	6-46
6.9.8	Parseval's Theorem .....	6-46
6.9.9	Multiplication of Two Sequences .....	6-49
6.9.10	Circular Convolution Theorem .....	6-49
6.10	Circular Convolution .....	6-49
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6.10.2	Matrix Method .....	6-52
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**Module 4****Chapter 7 : Fast Fourier Transform 7-1 to 7-30****Syllabus : DIT FFT Algorithm (Radix-2)**

7.1	Introduction .....	7-2
7.2	Computational Complexity of DFT .....	7-2
7.3	Radix-2 Decimation in Time FFT (DIT-FFT) .....	7-3
7.3.1	Bit Reversal Format .....	7-7
7.3.2	Solved Examples on DIT-FFT .....	7-8
7.4	Computational Complexity Comparison between DFT and FFT .....	7-25
7.4.1	Computation of Inverse DFT using FFT Algorithms .....	7-26
	• <b>Review Questions</b> .....	<b>7-30</b>

**Module 3****Chapter 8 : Basics of Digital Filter 8-1 to 8-19**

**Syllabus :** Minimum phase, Maximum phase, Mixed phase and Linear, Phase System based on location of zeros, Low pass, high pass, Band pass and band reject system based on pass band frequency, Magnitude and phase response (only Analytical Method).

8.1	Introduction .....	8-2
8.2	Basics of Filters .....	8-2
8.2.1	Analog Filters .....	8-2
8.2.2	Digital Filters .....	8-3
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8.2.4	Drawing the Frequency Response of Digital Filter .....	8-3
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8.4	Basics of Filtering .....	8-7
8.4.1	Ideal Filters .....	8-7
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8.5.1	Difference between IIR and FIR Filters .....	8-10
8.5.2	Additional Points in Filters .....	8-10
8.6	Minimum, Maximum and Mixed Phase Systems .....	8-14
	• <b>Review Questions</b> .....	<b>8-19</b>

**Module 5****Chapter 9 : FIR Filter Design 9-1 to 9-32**

**Syllabus :** Introduction to FIR System, Group Delay, phase Delay, Condition for Linear phase FIR system, Window Technique (only Rectangular window function, Hamming Window function)

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9.1.1	Characteristics of FIR Filters .....	9-2
9.1.2	Linear Phase .....	9-3
9.2	Designing of FIR Filters .....	9-3
9.2.1	Designing FIR Filters using Windows .....	9-3
9.3	Windowing Techniques .....	9-4
9.3.1	Rectangular Window .....	9-4
9.3.2	Hamming, Hanning, Blackman Window .....	9-12
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**Module 6****Chapter 10 : IIR Filter Design 10-1 to 10-29**

**Syllabus :** Introduction to IIR System & Bilinear Transformation, Digital Butterworth Filter design using Bilinear Transformation

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10.4	Design of Analog Butterworth Filter .....	10-9
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