

Chapter 1 : Introduction to Digital Signal Processing		1-1 to 1-7	2.6.3 Circular Time Shift.....2-30
			2.6.4 Circular Frequency Shift2-36
			2.6.5 Time Reversal2-37
			2.6.6 Symmetry Property.....2-38
			2.6.7 Complex Conjugate Property.....2-43
			2.6.8 Parseval's Theorem.....2-43
			2.6.9 Multiplication of Two Sequences.....2-46
			2.6.10 Circular Convolution.....2-46
1.1 Introduction.....1-1			2.7 Circular Convolution 2-47
1.2 Digital Signal Processing System.....1-2			2.7.1 Concentric Circle Method2-47
1.2.1 Difference between Digital and Analog Signal Processing.....1-3			2.7.2 Matrix Method2-49
1.2.2 Converting a Analog Signal to a Discrete Time Signal.....1-3			2.7.3 Getting Linear Convolution from Circular Convolution.....2-50
1.3 Aliasing 1-4			2.8 Filtering of Long Duration Signals..... 2-59
1.3.1 Solved Examples on Aliasing.....1-4			2.8.1 Overlap -Save Method.....2-60
1.3.2 Nyquist Rate.....1-6			2.8.2 Overlap -Add Method2-62
1.4 Basic Elements of a DSP System.....1-7			2.9 Summary of DFT Properties 2-66
Chapter 2 : Discrete Fourier Transform (DFT)		2-1 to 2-66	
2.1 The Fourier Transform.....2-1			Chapter 3 : Fast Fourier Transform 3-1 to 3-48
2.2 Discrete Fourier Transform (DFT) 2-2			
2.2.1 DFT of Simple Signals		2-2	3.1 Introduction 3-1
2.3 The Fourier Spectrum 2-12			3.2 Computational Complexity of DFT 3-1
2.4 Inverse Discrete Fourier Transform (IDFT) 2-13			3.3 Radix-2 Decimation In Time FFT (DIT-FFT) 3-3
2.5 Computing DFT by Matrix Method.....2-14			3.3.1 Bit Reversal Format3-7
2.5.1 Solved Examples on DFT Matrix Method.....2-18			3.3.2 Solved Examples on DIT-FFT.....3-7
2.5.2 Relationship between DFT and ZT2-27			3.4 Radix Decimation in Frequency FFT (DIF-FFT) 3-19
2.6 Discrete Fourier Transform (DFT) Properties 2-27			
2.6.1 Linearity		2-28	
2.6.2 Periodicity.....		2-29	

3.4.1	Solved Examples on DIF-FFT	3-22	5.2.1	Designing FIR Filters using Windows.....	5-3
3.5	Computational Complexity Comparison between DFT and FFT.....	3-34	5.3	Windowing Techniques.....	5-3
3.5.1	Computation of Inverse DFT using FFT Algorithms	3-35	5.3.1	Rectangular Window.....	5-3
3.5.2	Filtering using FFT Algorithms	3-42	5.3.1(A)	Gibbs Phenomena	5-12
Chapter 4 : Basics of Digital Filter		4-1 to 4-19	5.3.2	Hamming, Hanning, Blackman and Bartlett Window.....	5-15
4.1	Introduction.....	4-1	5.3.3	Bartlett Window (Triangular Window).....	5-16
4.2	Basics of Filters.....	4-1	5.4	Designing FIR Filters using Frequency Sampling Method.....	5-18
4.2.1	Analog Filters	4-1	5.5	Solved Examples on FIR Filter Design.....	5-20
4.2.2	Digital Filters	4-2	5.6	Solved Examples	5-37
4.2.3	Drawing the Frequency Response of Digital Filter	4-2	Chapter 6 : IIR Filter Design		
4.3	Ideal Filter Responses	4-4	6.1	Introduction	6-1
4.4	Basics of Filtering.....	4-6	6.2	Stability of IIR filter	6-1
4.4.1	Ideal Filters	4-7	6.2.1	Approach of IIR Filter Design	6-2
4.5	Types of Digital filters	4-9	6.3	Impulse Invariance Method.....	6-2
4.5.1	Difference between IIR and FIR.....	4-9	6.3.1	Solved Examples on Impulse Invariance Method	6-4
4.5.2	Additional Points in Filters	4-10	6.4	Impulse Invariance Mapping of s-plane to z-plane	6-9
4.6	Minimum, Maximum and Mixed Phase Systems.....	4-14	6.4.1	Disadvantage of Impulse Invariant Method	6-10
Chapter 5 : FIR Filter Design		5-1 to 5-40	6.5	Bilinear Transformation Method	6-11
5.1	Introduction.....	5-1	6.5.1	Frequency Warping.....	6-12
5.1.1	Characteristics of FIR Filters.....	5-1	6.5.2	Comparison between Impulse Invariance and Bilinear Transformation Method.....	6-13
5.1.2	Linear Phase	5-2	6.5.3	Solved Examples on Bilinear Transformation Method.....	6-13
5.2	Designing of FIR Filters.....	5-2	6.6	Design of Analog Butterworth Filter	6-17

6.6.1	Steps Involved in Designing Butterworth Lowpass Filter.....	6-19	7.5.1	Solved Examples of FIR Filter Structure Realization.....	7-26
6.6.2	Solved Examples on Butterworth Filter.....	6-19	7.6	Finite Word Length Effect in Digital Filter	7-28
6.7	Design of Analog Chebyshev Filter	6-32	<hr/>		
6.7.1	Solved Examples on Chebyshev Filter	6-35	Chapter 8 : Finite Word Length Effects in Digital Filters		
6.7.2	Elliptic Filter	6-39	8-1 to 8-26		
6.7.3	Comparison between Butterworth Filter, Chebyshev Filter and Elliptic Filter	6-40	8.1	Introduction	8-1
6.8	Frequency Transformation	6-40	8.2	Conversion from Decimal to Binary and Binary to Decimal	8-1
6.8.1	Frequency Transformation in the Analog Domain	6-40	8.3	Number Representation in a Digital System	8-3
6.9	Solved Examples.....	6-44	8.3.1	Fixed Point Representation	8-3
<hr/> Chapter 7 : Filter Structures			7-1 to 7-29		
7.1	Introduction of Filter Structure.....	7-1	8.3.1(A)	Sign Magnitude Form	8-3
7.1.1	Advantages of Filter Structure	7-1	8.3.1(B)	One's Complement Form	8-4
7.1.2	Block Diagram Representation	7-1	8.3.1(C)	Two's Complement Form	8-5
7.2	Structure for IIR Filter	7-2	8.3.2	Floating Point Numbers	8-5
7.2.1	Direct Form I Structure	7-2	8.3.3	Block Floating Point Numbers.....	8-6
7.2.2	Direct Form II Structure.....	7-6	8.4	Truncation and Rounding in Quantization.....	8-6
7.2.3	Cascade Form Structures.....	7-10	8.4.1	Truncation.....	8-6
7.2.4	Parallel Form Structure	7-12	8.4.2	Rounding.....	8-7
7.3	Solved Examples on IIR Filter Structures	7-13	8.5	Truncation and Rounding Errors	8-8
7.4	FIR Filter Structure Realization.....	7-23	8.6	Quantization Noise.....	8-9
7.4.1	Direct Form Structure	7-24	8.6.1	Input Quantization Error.....	8-10
7.4.2	Cascade Form Structure	7-24	8.6.1(A)	Steady State Input Noise Power	8-10
7.5	Structure for Linear Phase FIR Filters.....	7-25	8.6.1(B)	Steady State Output Noise Power	8-11
7.5.1	Design of Linear Phase FIR Filter	7-26	8.6.2	Product Quantization Error	8-11

8.6.3	Coefficient Quantization Error	8-12	9.12	Multistage Implementation of Sampling Rate Conversion	9-15
8.7	Zero Input Limit Cycle Oscillations	8-14	9.13	Solved Examples	9-15
8.8	Dead Band.....	8-16	<hr/>		
8.8.1	Overflow Limit Cycle Oscillation	8-17	Chapter 10 : DSP Processors and Applications		
8.8.2	Clipping	8-18	10.1	Introduction to General Purpose and Special Purpose DSP Processors	10-1
8.8.3	Disadvantage of Clipping	8-18	10.2	Comparison of General Purpose Microprocessor with DSP Processors	10-1
8.9	Scaling.....	8-18	10.3	Computer Architecture for Signal Processing & Harvard Architecture	10-2
8.10	Finite Word Length Effects in FIR Digital Filter	8-20	10.3.1	Von Neumann Architecture.....	10-2
8.11	Quantization in Floating Point Realization of IIR Filters.....	8-21	10.3.1(A)	Input Unit	10-3
8.12	Solved Examples.....	8-22	10.3.1(B)	Output Unit	10-3
<hr/> Chapter 9 : Multirate Signal Processing			10.3.1(C)	Arithmetic and Logic Unit (ALU).....	10-3
9.1	Introduction.....	9-1	10.3.1(D)	Control Unit.....	10-3
9.2	Down-sampling.....	9-1	10.3.1(E)	Memory Unit	10-3
9.3	Up-sampling.....	9-3	10.3.1(F)	Key Features of a Von Neumann Machine	10-3
9.4	Spectrum of Down Sampled Signal.....	9-4	10.3.1(G)	Detailed Structure of the CPU	10-3
9.5	Aliasing	9-8	10.3.2	Harvard Architecture	10-4
9.6	Spectrum of Up-sampled Signal.....	9-8	10.4	Pipelining	10-6
9.7	Anti-Imaging Filter	9-9	10.5	Replication and Extended Parallelism.....	10-6
9.8	Cascading Sample Rate Convertors	9-10	10.6	General Purpose Digital Signal Processors	10-7
9.9	Identities	9-12	10.6.1	Multiply and Accumulate (MAC)	10-8
9.10	Polyphase Decimation using z-transforms	9-13	10.6.2	Arithmetic and Logic Unit (ALU).....	10-8
9.11	Poly-phase Interpolation using z-transform	9-14	10.6.3	Program Address Generator	10-8
			10.6.4	Data Address Generator (DAG).....	10-8

10.6.5 Program Sequencers.....	10-8	10.10 Fixed Point and Floating Point DSP Processor and Special Instructions.....	10-15
10.6.6 Memory.....	10-8	10.10.1 Fixed Point Instructions.....	10-15
10.6.7 Input/Output Controller	10-8	10.11 Applications of DSP : Radar Signal Processing and Speech Processing.....	10-15
10.6.8 Fixed Point Representation	10-9	10.12 Speech Coding and Compression	10-16
10.7 A General Purpose of DSP Processor TMS 320 C54 XX.....	10-9	10.13 Applications of DSP for ECG Signal.....	10-16
10.7.1 Floating Point Representation	10-12	10.13.1 Types of Noises which Affects ECG Signal	10-17
10.8 Selecting Digital Signal Processors.....	10-13	10.13.2 De-noising of ECG Signals.....	10-17
10.9 On-Chip Memory	10-14		

