

CONTENTS

Glossary

xiii

Chapter 1 PRELIMINARY CONCEPTS

1.1	Introduction	1
1.2	Review of Complex Arithmetic	1
1.3	The Fourier Transform	4
1.4	The Boxcar Function and Its Fourier Transform	13
1.5	Linear Systems	15
1.6	Convolution and Causality	19
1.7	The Effects of Finite Sample Length	21
1.8	Sampled Data and the Nyquist Frequency	24
1.9	Discrete Fourier Transform of Length N	29
1.10	The z Transform	37

Chapter 2 PROBABILITY AND STATISTICAL CONCEPTS

2.1	Introduction	40
2.2	Sample Values and Estimates	43
2.3	Normal Distribution	45
2.4	Correlation and Regression	49
2.5	Power Spectral Density Function	52
2.6	How to Compute Mean and Variance	55
2.7	Probability Histograms	57

2.8	Peak Probability Density Functions	63
2.9	Multidimensional Density Functions	66
2.10	Examples and Applications of Probability Density Functions	67

Chapter 3
COLLECTING AND PREPROCESSING DATA

3.1	Introduction	76
3.2	Data Acquisition	77
3.3	Digital Representation of Information	80
3.4	Analog to Digital Conversion	85
3.5	Other Errors	89
3.6	Conversion to Physical Units	93
3.7	Wild Point Editing	95
3.8	Trend Removal	98

Chapter 4
DESIGN OF DIGITAL FILTERS

4.1	Basic Concepts	106
4.2	First-Order Filters	108
4.3	Second-Order Filters	113
4.4	Higher-Order Filters	126
4.5	Basic Ideal Filters	133
4.6	Sine Butterworth Lowpass Filter	137
4.7	Sine Butterworth Highpass Filter	145
4.8	Bandpass Filters	146
4.9	Band Reject Filters	152
4.10	Tangent Filters	156
4.11	Other Recursive Filters	164
4.12	Nonrecursive (FIR) Filters	165
4.13	Filter Approximation Techniques	171

Chapter 5
PRACTICAL ASPECTS OF DIGITAL FILTERING

5.1	Introduction	179
5.2	Noise and Distortion	180
5.3	Deterioration	185

5.4	Filter Implementation	197
5.5	Decimation	202
5.6	Upwards Decimation	209
5.7	Reduction to a Common Sampling Rate	211
5.8	Complex Demodulation	212

Chapter 6 FOURIER TRANSFORMS

6.1	Background and Theory	219
6.2	Fast Fourier Transform Algorithm	239
6.3	Examples	260

Chapter 7 COVARIANCE AND CONVOLUTION FUNCTIONS

7.1	Background and Theory	277
7.2	Differences Between Covariance and Convolution	284
7.3	Long Record Lengths and Basic Covariance Computations	285
7.4	Covariance and Convolution via FFT's	288
7.5	Wraparound and Aliasing Effects	295
7.6	How to Compute Covariance and Convolution Functions	303
7.7	Impulse Response Length and Bandwidth for Convolution Filtering	304
7.8	Normalization and Mean Removal in Covariance Computations	306
7.9	Examples of the Use of Covariance and Convolution	308

Chapter 8 POWER AND CROSS SPECTRAL DENSITIES

8.1	General Considerations in Computing Spectra	316
8.2	Concept of Density	319
8.3	Effective Resolution Bandwidth	320
8.4	Resolution Limits	322
8.5	Statistical Stability	324
8.6	Leakage	330
8.7	How to Compute Spectral Functions	334
8.8	Tapering Functions—Data Windows	336
8.9	Examples of the Use of PSD Functions	360

Chapter 9

TRANSFER FUNCTIONS AND COHERENCE FUNCTION

9.1	Properties of Transfer Functions	363
9.2	Spectral Relationships for Single Input System	368
9.3	Spectral Relationships for Multiple Input Linear Systems	371
9.4	Ordinary, Multiple, and Partial Coherence Functions	374
9.5	Confidence Limits for Coherence	376
9.6	Confidence Limit Computations for Transfer Functions	379
9.7	How to Compute Transfer Functions	382
9.8	The Sweep Operator	386
9.9	Transfer Function from Sine Waves	388
9.10	Transfer Function from Random Inputs	393
9.11	Coherence Function for $B_e = 1/P$	394
9.12	Examples of Transfer Function Computations	396

Appendix A

COMPUTER SUBROUTINES FOR TIME SERIES ANALYSIS

A.1	Introduction	413
A.2	Random Number Generator	414
A.3	Plotting on the Printer	416
A.4	Fast Fourier Transform	417
A.5	Generation of Lowpass Filter Weights	421
A.6	Transfer Function of a Digital Filter	423
A.7	Test Case and Results	425

Appendix B

**BLACKMAN-TUKEY COMPUTATIONAL
PROCEDURE FOR PSD'S**

B.1	Introduction	432
B.2	Computational Formulas	434
B.3	Procedure for Cross Spectra	437
B.4	Comments	439
	References	441
	Index	445