Contents

PREFACE ix

PART I Introduction to Fourier Analysis 1

1 TIME AND FREQUENCY: TWO BASES OF DESCRIPTION 3

Time Histories Need Time Bases 4

Sinusoids Look Different from a Frequency Viewpoint 7

Nonsinusoidal Waveforms Are Composed of Sinusoids 12

Getting into the Frequency Domain 15

2 DESCRIBING THE FREQUENCY DOMAIN—THE FOURIER SERIES 17

Conditions for Existence 18

The Fourier Series Yields Discrete Spectra 19

Using The Fourier Series—Matters of Practicality 25

3 FOURIER INTEGRAL YIELDS SPECTRA FOR NONPERIODIC WAVEFORMS 27

The Fourier Integral Is Related to the Fourier Series 27

Understanding Frequency-Domain Diagrams 32

Functions Are Even or Odd or the Sum of Even and Odd Parts 41

Periodic or Nonperiodic?—It's Your Point of View 46

A Summary of Some Important Fourier Transform Properties 53

Using the Fourier Integral—Matters of Practicality 58

PART II Digital Fourier Analysis 61

4 INTRODUCTION TO THE DISCRETE AND FAST FOURIER TRANSFORMS 63

Windowing and Sampling Are Old Ideas with New Names 63

The DFT Works on Sampled Data 67

How the FFT Algorithm Came About 72

Putting the Algorithm to Work—Hardware, Firmware, or Software? 74

5 UNDERSTANDING FFT RESULTS—BASIC DATA FORMATS 76

A Brief Recap and a Look Ahead 76

Providing Time-Domain Data for the FFT 77

FFT Results Are Normally in Rectangular Form 79

FFT Results Can Be in Polar Form 82

6 UNDERSTANDING FFT RESULTS—RECOGNIZING THE REALITIES OF DIGITAL FOURIER ANALYSIS 92

What Is Being Transformed? 93

What Are the Effects of Analog-to-Digital Conversion? 98

Other Sources of Error 123

7 A GUIDE TO USING THE FFT 124

Some Important Properties of the FFT 124

Some Guidelines for Improving FFT Results 125

8 A BRIEF LOOK AT SOME FFT APPLICATIONS 146

Distortion Analysis 146

Vibration and Mechanical Signature Analysis 148

Frequency Response Estimation (Transfer Functions) 150

Convolution 152

Correlation 154

Power Spectra 160

PART III Mathematics of the FFT 161

9 AN ALGORITHM FOR COMPUTING THE DFT 163

The Sande-Tukey Algorithm for Computing the DFT 164

A BASIC Program for FFT–IFT Computation 168

BIBLIOGRAPHY 173

INDEX 175