# Table of Contents

**Preface** .................................................. iii

**Chapter 1: Introduction to DSP-Based Testing** .............................................. 3
  Overview of Testing ..................................... 3
  Emulation versus Automation .......................... 5
  Invisible Instruments .................................... 5
  Numerical Vectors ....................................... 6
  Vector Transfer ......................................... 7
  Vector and Array Processing Speed ..................... 7
  Processor Speed ......................................... 8
  Floating-Point Mathematics ......................... 9
  Phase-Lock Synchronization ........................... 10
  Representative Digitizer ............................... 10
  DSP-Based Test Advantages Summarized ............... 13
  Price of Using DSP ..................................... 13

**Chapter 2: Accuracy and Speed of Emulated Instruments** .......................... 17
  Hardware Emulation ...................................... 17
  Integration versus Filtering for AC Measurements 17
  Coherent Measurement ................................... 19
  Unit Test Period ........................................ 19
  Coherent Filtering ...................................... 22
  Correlation ............................................... 23
  Fourier Voltmeter ....................................... 25
  Software Version of the FVM .......................... 27
  Orthogonal Signals and Fourier Voltmeters .......... 27
  DFT and FFT ............................................. 28
  Synthesis ............................................... 29
  Frequency Leakage ...................................... 30
  Graphical Example of FFT Application ............... 31

**Chapter 3: Noncoherent Sampling** ..................................................... 35
  Reconstruction ......................................... 35
  Time and Spectral Vectors ............................. 35
  Imaging and Noncoherent Undersampling ............. 36
  Heterodyning and Reconstruction ........................ 36
  Rules of Imaging ....................................... 37
  Sampling Rates and Spacing ........................... 37
  Nyquist's Limit ......................................... 37
  Universal Rule for Noncoherent Sampling ............. 38
  Sine-X-over-X Distortion and Correction ............. 39
  Receiver/Reconstruction Filtering ...................... 41
Chapter 4: Coherence  .................................................. 45
Vector Periodicity .................................................. 46
Amount of Information in a Vector .................... 46
Effective Sampling Rate  .................................. 47

Chapter 5: Multitone Testing ..................................... 61
Multitone Distortion Measurement .............. 62
Multitone Frequency Measurement .............. 62
Multitone versus Single Tone Applications .... 64
Error Sources and Accuracy .................. 65
Effect of Device Uncertainty on Multitone Tests .... 65
Factors Affecting Accuracy .................. 67
Out-of-Band Measurement Uncertainty ....... 71
Estimating Multitone Accuracy ................ 71
Estimating Multitone Uncertainty Due to Quantization .... 71

Chapter 6: Vector Operations for DSP Testing ................. 77
Vector Operations in DSP-Programming ........ 79
Program Examples  .................................. 80

Chapter 7: Event Digitizing ................................... 87
Explicit versus Implicit Sampling .......... 88
Event Digitizer .................................. 89
Testing Tape Decks  .................................. 91

Chapter 8: Measuring Random Noise .................. 99
Equivalent Input Noise .......................... 99
Normalized Spectral Noise Density .......... 99
Typical DSP Procedure ...................... 101
Input Resistors .................................. 101
Coupling Capacitor .......................... 101
Noise Bandwidth ................................ 102
Accuracy and Repeatability of Noise Measurements .... 102
Statistical Sampling versus DSP Sampling .... 103
Estimating the Repeatability of Local Measurements .... 103
Cautions about Averaging .................. 104
Computing Spectral Power from a Sparsely Sampled Signal .... 105
Exercises .................................. 106

Chapter 9: Introduction to A/D Testing ................. 115
A/D versus D/A Conversion .................. 115
Transfer Maps .................................. 115
Transmission Parameters versus Intrinsic Parameters .... 117
Conversion Formats and Types .............. 118
Uncertainty and Distortion of the Ideal ADC ........ 118
DAC Transfer Error .......................... 119
Superposition Error .......................... 120
Adapting D/A Parameters to ADC Measurement ........................................ 122
Probabilistic Estimation of ADC Input Noise ........................................ 123
Dynamic Testing .................................................................................... 123
Noise Improvement Figure ..................................................................... 124
Random Voltage Noise .......................................................................... 125
Induced Jitter Noise .............................................................................. 125
Equivalent Number of Bits ..................................................................... 126
Idle Noise and Noise Power Ratio .......................................................... 126
Separating Quantization Distortion from Noise ........................................ 127

**Chapter 10: Techniques for Flash Converter Testing** ................................ 133

Linear Histogram Testing ......................................................................... 135
Histograms with Sparkle Codes and Missing Codes ............................... 137
Obtaining the Transfer Function from the Histogram ............................. 139
Integral Linearity Error from the Transfer Curve ..................................... 139
ILE Directly from DLE: A Fast Method ................................................. 139
Centerlines for Histogram-Derived ILE .................................................. 141
Integral Linearity from Weighted Code Centers ...................................... 141
MIL-STD Regression Line Approach .................................................... 144
Extreme Values of Linearity Error .......................................................... 145
Differential Linearity from Weighted Code Center Information ............... 146
Dynamic Testing .................................................................................... 146
Sinusoidal Histogram Testing ................................................................. 147
Using the Tally to Find MAT T2 .............................................................. 148
Errors with Sinusoidal Histograms ......................................................... 149
Spectral Analysis .................................................................................... 154
Noise Measurement .............................................................................. 154
Noise Separation ................................................................................... 154
Progressive Spectra .............................................................................. 156
Unscrambling ......................................................................................... 156
Differential Phase (DP) ........................................................................... 156
Differential Gain (DG) ........................................................................... 161

**Chapter 11: Incremental Models for DSP-Based Testing** ........................ 165

with Applications to Transient and Flutter Measurement .......................... 165

Introduction .......................................................................................... 165
Limitations of Vector Processors ............................................................. 165
Incremental Modeling ........................................................................... 166
Comparison with Continuous Equations ............................................... 167
RC High Pass Model ............................................................................. 169
Time Scaling and Normalization ............................................................ 170
Ballistic Peaks ....................................................................................... 170
Ballistic Peak Detection Models ............................................................ 171
Generalized Approach .......................................................................... 172
Wow and Flutter Measurement ............................................................... 172
DIN/IEEE/ANSI/Quasi-Peak Detection ................................................. 172
DIN Frequency Weighting ..................................................................... 174
Importance of Phase Response in Peak-Reading Instruments .................. 175
Finite Impulse Response (FIR) Filtering .................................................. 177