



# Contents

Editor's Preface to the Series	v
Author's Preface	vii
List of Letter Symbols	xi
1. INTRODUCTION .. .. .	1
2. FREQUENCY STABILITY MEASURES .. .. .	13
2.1 Introductory remarks on Frequency Stability .. ..	13
2.2 Statistical Measures .. .. .	15
2.3 Oscillator Noise Model .. .. .	24
2.4 Spectrum Estimation from Time-Domain Data .. ..	29
2.5 Phase-Noise and Signal Spectrum Approximate Relation ..	33
References .. .. .	35
3. STANDARD FREQUENCY GENERATORS AND CLOCKS ..	37
3.1 Introduction .. .. .	37
3.2 Quartz Crystal Oscillators .. .. .	37
3.3 Atomic Frequency Standards .. .. .	43
3.4 Frequency Multiplication and Division .. .. .	65
3.5 Frequency Synthesis .. .. .	82
References .. .. .	93
4. TIME SCALES .. .. .	96
4.1 Introduction .. .. .	96
4.2 Clocks and Time Scales .. .. .	96
4.3 International Coordination .. .. .	103
4.4 Time Scale Generation .. .. .	105
4.5 Time Codes .. .. .	124
References .. .. .	133

5. FREQUENCY AND PERIOD MEASUREMENTS BY MEANS OF COUNTERS .. .. .	136
5.1 Introduction .. .. .	136
5.2 Direct Frequency Measurements by Counting Through a Timed Gate .. .. .	136
5.3 Period Measurement .. .. .	144
5.4 Frequency Ratio Measurements .. .. .	147
5.5 Time Interval Measurements .. .. .	148
5.6 Increasing the Resolution of Frequency Measurements .. .. .	152
5.7 Microwave Frequency Measurements .. .. .	155
References .. .. .	158
6. PHASE-TIME MEASUREMENTS .. .. .	159
References .. .. .	164
7. FREQUENCY DOMAIN MEASUREMENT TECHNIQUES .. .. .	165
7.1 Introduction .. .. .	165
7.2 Direct Spectrum Analysis .. .. .	165
7.3 Measurement of Low Level Phase Noise by means of a Phase-locked Loop .. .. .	169
7.4 Use of the Phase-locked Loop for Time-Domain Measurements .. .. .	176
References .. .. .	178
8. RADIO SIGNAL COMPARISON METHODS .. .. .	179
8.1 Introduction .. .. .	179
8.2 HF Standard Frequency and Time Signals .. .. .	181
8.3 Low Frequency CW Systems .. .. .	187
8.4 Loran-C .. .. .	192
8.5 VLF-Systems .. .. .	202
8.6 Television Timing Methods .. .. .	205
8.7 Satellite Systems .. .. .	211
8.8 Miscellaneous Radio (and other) Time Comparison Systems .. .. .	216
References .. .. .	218
Appendices .. .. .	220
9. ADDITIONAL REFERENCES AND NOTES .. .. .	253
Index .. .. .	256