

Contents

<i>Foreword by Lute Maleki</i>	<i>page</i> ix
<i>Foreword by David Leeson</i>	xii
<i>Preface</i>	xv
How to use this book	xvi
Supplementary material	xviii
<i>Notation</i>	xix
1 Phase noise and frequency stability	1
1.1 Narrow-band signals	1
1.2 Physical quantities of interest	5
1.3 Elements of statistics	9
1.4 The measurement of power spectra	13
1.5 Linear and time-invariant (LTI) systems	19
1.6 Close-in noise spectrum	22
1.7 Time-domain variances	25
1.8 Relationship between spectra and variances	29
1.9 Experimental techniques	30
Exercises	33
2 Phase noise in semiconductors and amplifiers	35
2.1 Fundamental noise phenomena	35
2.2 Noise temperature and noise figure	37
2.3 Phase noise and amplitude noise	42
2.4 Phase noise in cascaded amplifiers	49
2.5 ★ Low-flicker amplifiers	52
2.6 ★ Detection of microwave-modulated light	62
Exercises	65
3 Heuristic approach to the Leeson effect	67
3.1 Oscillator fundamentals	67
3.2 The Leeson formula	72

3.3	The phase-noise spectrum of real oscillators	75
3.4	Other types of oscillator	82
4	Phase noise and feedback theory	88
4.1	Resonator differential equation	88
4.2	Resonator Laplace transform	92
4.3	The oscillator	96
4.4	Resonator in phase space	101
4.5	Proof of the Leeson formula	111
4.6	Frequency-fluctuation spectrum and Allan variance	116
4.7	★★ A different, more general, derivation of the resonator phase response	117
4.8	★★ Frequency transformations	121
5	Noise in delay-line oscillators and lasers	125
5.1	Basic delay-line oscillator	125
5.2	Optical resonators	128
5.3	Mode selection	130
5.4	The use of a resonator as a selection filter	133
5.5	Phase-noise response	138
5.6	Phase noise in lasers	143
5.7	Close-in noise spectra and Allan variance	145
5.8	Examples	146
6	Oscillator hacking	150
6.1	General guidelines	150
6.2	About the examples of phase-noise spectra	154
6.3	Understanding the quartz oscillator	154
6.4	Quartz oscillators	156
	Oscilloquartz OCXO 8600 (5 MHz AT-cut BVA)	156
	Oscilloquartz OCXO 8607 (5 MHz SC-cut BVA)	159
	RAKON PHARAO 5 MHz quartz oscillator	162
	FEMTO-ST LD-cut quartz oscillator (10 MHz)	164
	Agilent 10811 quartz (10 MHz)	166
	Agilent noise-degeneration oscillator (10 MHz)	167
	Wenzel 501-04623 (100 MHz SC-cut quartz)	171
6.5	The origin of instability in quartz oscillators	172
6.6	Microwave oscillators	175
	Miteq DRO mod. D-210B	175
	Poseidon DRO-10.4-FR (10.4 GHz)	177
	Poseidon Shoebox (10 GHz sapphire resonator)	179
	UWA liquid-N whispering-gallery 9 GHz oscillator	182

6.7 Optoelectronic oscillators	185
NIST 10 GHz opto-electronic oscillator (OEO)	185
OEwaves Tidalwave (10 GHz OEO)	188
Exercises	190
Appendix A Laplace transforms	192
<i>References</i>	196
<i>Index</i>	202