

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Book Organization	4
	References	4
2	Transformer Design and Characterization in CMOS Process	7
2.1	Background	7
2.2	Transformer Layout	9
2.3	Transformer Measurement and Characterization	12
	References	19
3	Design Considerations for CMOS Voltage-Controlled Oscillators (VCOs)	21
3.1	Basic Concepts	21
3.1.1	Start-Up Oscillation Conditions	21
3.1.2	Phase-Noise Definition	22
3.1.3	LC-Tank Properties	24
3.1.4	Frequency Tuning	27
3.2	Phase-Noise Analysis	28
3.2.1	Linear and Time-Invariant (LTI) Model	29
3.2.2	Linear and Time-Variant (LTV) Model	31
3.3	Design Insights Using the Time-Variant Model	34
3.3.1	Phase Noise in $1/f^2$ Region	35
3.3.2	Phase Noise in $1/f^3$ Region	38
3.3.3	Comparison of Different LC-VCO Topologies	43
3.3.4	VCO Figure of Merit	46
3.4	Quadrature VCOs	48
3.5	Low-Voltage CMOS VCOs	52
3.6	Wideband CMOS VCOs	52
	References	53

4	Design Considerations for CMOS Frequency Dividers	57
4.1	Background	57
4.2	Latch-Based Frequency Dividers	57
4.3	Injection-Locked Frequency Dividers	59
4.3.1	Indirect-Injection ILFDs	60
4.3.2	Direct-Injection ILFDs	65
4.3.3	Design Consideration for the LC-Tank	68
4.3.4	Phase-Noise Performance	69
4.3.5	ILFD Figure of Merit	70
4.4	Miller Frequency Dividers	71
4.5	Summary	74
	References	76
5	Ultralow-Voltage VCO and QVCO Using Transformer Technique	77
5.1	Introduction	77
5.2	Transformer-Feedback VCO (TF-VCO)	78
5.2.1	Topology and Circuit Model	78
5.2.2	Oscillation Frequency and Phase Noise	79
5.2.3	Circuit Implementation	85
5.2.4	Experimental Results	87
5.3	Transformer-Coupled QVCO (TC-QVCO)	89
5.3.1	Topology and Circuit Model	89
5.3.2	Oscillation Frequency	95
5.3.3	IQ Imbalance and Phase Noise	96
5.3.4	Circuit Implementation	97
5.3.5	Experimental Results	100
	References	105
6	Transformer-Based Dual-Mode VCO	107
6.1	Introduction	107
6.2	Analysis of the Transformer-Based Dual-Mode Oscillators	111
6.2.1	One-Port Oscillators	111
6.2.2	Two-Port Oscillators	118
6.2.3	Comparison of One-Port and Two-Port Oscillators	122
6.3	Case Study of a Dual-Mode QVCO for SDR Frequency Synthesizer	128
6.3.1	Circuit Implementation	128
6.3.2	Experimental Results	132
	References	139

7	Magnetically-Tuned Multimode CMOS VCO	141
7.1	Introduction	141
7.2	Transformer-Based Magnetic-Tuning Method	142
7.2.1	Working Principle	142
7.2.2	Analysis of the Switched-Triple-Shielded Transformer	145
7.3	Design and Analysis of the MT-VCO	150
7.4	Experimental Results	154
	References	160
8	Transformer-Based Injection-Locked Frequency Divider	161
8.1	Introduction	161
8.2	Ultralow-Voltage ILFDs Using Transformer Feedback	162
8.2.1	Regenerative-ILFD Architecture	162
8.2.2	Ultralow-Voltage Regenerative ILFD	163
8.2.3	Experimental Results	171
8.3	Self-Frequency-Tracking ILFD	178
8.3.1	Locking Range Limitation of the Conventional Direct-Injection ILFDs	178
8.3.2	Self-Frequency-Tracking ILFD	179
8.3.3	Experimental Results	184
	References	188
9	Conclusion	189
	References	193
	Appendix	197
	Index	203