

Contents

Abstract	vii
List of Acronyms	xiii
List of Symbols	xvii
1. Introduction	1
1.1. Motivation	1
1.2. Concept of Thesis	3
2. Theory of $\Sigma\Delta$ -Modulation	5
2.1. Oversampling and First Order Noise Shaping Using $\Sigma\Delta$ -Modulation	5
2.2. $\Sigma\Delta$ -ADC Performance Metrics	9
2.3. $\Sigma\Delta$ -ADCs with High Order Noise Shaping	11
2.4. Implementation of $\Sigma\Delta$ -ADCs	14
3. RC-Resonators in Continuous-Time- $\Sigma\Delta$ -ADCs	23
3.1. Zero-Optimized Loop Filter	23
3.2. Loop Filter Resonators	24
3.3. Twin-T Resonator	28
3.4. Cross-Coupled Single-Opamp Resonator	30
3.5. Second Order Numerator Using Capacitive Feed-in	38
3.6. Second Order Numerator Using Bypass	41
4. Resonant Low Power Single-Opamp Integrators	45
4.1. Resonant Single-Opamp Loop Filter	45
4.2. Differential Mode	47

4.3.	Common Mode	52
4.4.	Implementation Example	53
4.5.	Integrator Swing Scaling for High-Order Modulators	55
5.	Analysis of DAC Sensitivity to Extrinsic Noise	57
5.1.	Time Domain Synthesis	58
5.2.	Jitter-Modulated Clock Signals	60
5.3.	Jitter-Induced Baseband Noise	61
5.4.	Digital Suppression of Jitter-Induced Baseband Noise	64
5.5.	Multi-Rate Application to Arbitrary Return to Zero DACs	64
5.6.	Spectral Interpretation	65
6.	Extrinsic-Noise-Tolerant DACs	71
6.1.	Mitigation of Jitter- and Reference-Induced Noise	71
6.2.	Finite-Impulse-Response-DAC	76
6.3.	FIR-DAC Compensation	78
6.4.	Jitter-Noise-Reduction-DAC	79
6.5.	Infinite-Impulse-Response-Quantizer	84
6.6.	Single-Bit-Modulator Interpretation	85
6.7.	Multi-Bit-Modulator Interpretation	87
6.8.	Non-Moving-Average FIR-DAC Coefficients	89
7.	Testchip 1: A Mostly-Analog Continuous-Time $\Sigma\Delta$ -ADC	93
7.1.	Concept of Testchip	93
7.2.	Loop Filter	96
7.3.	Quantizer	104
7.4.	Feed-Forward Summation Gain Stage	105
7.5.	Feedback DAC	106
7.6.	Passive Pre-Filter	109
7.7.	Implementation	110
7.8.	Testbench	113
7.9.	Measurement Results	115
8.	Testchip 2: A Mostly-Digital Continuous-Time $\Sigma\Delta$ -ADC	121
8.1.	Concept of Testchip	121
8.2.	Resonant Single-Opamp Loop Filter	125
8.3.	Integrator Loss Compensation	127

8.4. Inverter-Based Opamp	132
8.5. Pseudo-Differential Modulator Topology	138
8.6. Feedback DACs and Quantizer	139
8.7. Optimizer-based Design	142
8.8. Implementation and Testbench	150
8.9. Measurement Results	152
9. Conclusion	159
9.1. Summary of Original Contributions	159
9.2. Benchmark	160
9.3. Future Work	162
A. Appendix	163
A.1. Derivation of Cross-coupled Resonator from Multistage Polyphase RC-Filters	163
A.2. Derivation of Cross-coupled Resonator from Twin-T Resonator	171
A.3. Second and Third Order Integrator with Generic Cross-coupled RC-Notch	172
A.4. Analytic Common Mode Transfer Function	174
Bibliography	175
List of Figures	191
List of Tables	197