

Mismatch-Insensitive N -Path Multirate SC Sigma-Delta Modulator for High-Frequency Applications

by Lou Fan, Frederick

Call_No: MST(E)019.LOU

| Table of Contents | | |
|--------------------------|---|-------------|
| Abstract | | iii |
| Table of Contents | | iv |
| List of Figures | | vii |
| Abbreviations | | xi |
| Acknowledgments | | xiii |
| Chapter 1 | Introduction | 1 |
| 1.1 | Motivation | 1 |
| 1.2 | Research Goals | 2 |
| 1.3 | Statement of Originality | 2 |
| 1.4 | Thesis Organization | 3 |
| Chapter 2 | Sigma-Delta Modulator | 4 |
| 2.1 | Overview | 4 |
| 2.2 | Nyquist-Rate Analog-to-Digital Converters | 4 |
| 2.2.1 | Sampling | 5 |
| 2.2.2 | Quantization | 6 |
| 2.2.3 | Limitations of the Additive White Noise Model | 9 |
| 2.2.4 | Limitations of Nyquist-Rate A/D Converters | 10 |
| 2.3 | Sigma-Delta Modulator | 11 |
| 2.3.1 | Oversampling | 12 |
| 2.3.2 | Noise-shaping | 13 |
| 2.3.3 | Sigma-Delta Modulation | 15 |

| | | |
|------------------|--|-----------|
| 2.3.4 | Limitation of Sigma-Delta Modulator | 20 |
| 2.4 | Summary | 21 |
| Chapter 3 | Multirate SDM Techniques | 22 |
| 3.1 | Overview | 22 |
| 3.2 | Multirate Signal Processing | 22 |
| 3.2.1 | Decimator | 22 |
| 3.2.2 | Interpolator | 25 |
| 3.2.3 | Noble Identities | 27 |
| 3.2.4 | Polyphase Decomposition | 28 |
| 3.2.5 | Filter Banks | 31 |
| 3.2.6 | Block Digital Filter | 33 |
| 3.2.7 | <i>N</i> -Path Filter | 36 |
| 3.3 | Multirate SDM | 40 |
| 3.3.1 | Time-Interleaved Sigma-Delta Modulator | 40 |
| 3.3.2 | Multirate Multibit SDM | 43 |
| 3.3.3 | Multirate Single-bit SDM | 47 |
| 3.3.4 | Multirate 2-2 Cascade SDM | 50 |
| 3.4 | Summary | 51 |
| Chapter 4 | <i>N</i>-Path Multirate SDM | 53 |
| 4.1 | Overview | 53 |
| 4.2 | Pure <i>N</i> -Path and <i>N</i> -Path Multirate Approaches | 54 |
| 4.3 | Mismatch Effects Between Paths | 59 |
| 4.4 | <i>N</i> -Path Comb Filter Plus Integrator | 60 |
| 4.5 | Mismatch-Insensitive Architecture | 62 |
| 4.6 | Summary | 68 |
| Chapter 5 | Design Examples of <i>N</i>-Path Multirate SC Comb Filter Plus Integrator | 69 |
| 5.1 | Practical considerations | 69 |
| 5.1.1 | Single-Ended Input SC Integrator | 71 |
| 5.1.2 | Fully-Differential SC Integrator | 72 |
| 5.1.3 | Double-Sampling | 73 |
| 5.2 | Video Application | 75 |
| 5.2.1 | Application Requirements | 75 |

| | | |
|-------------------|--|------------|
| 5.2.2 | Possible Architecture of an 4-Path SC Comb Filter Plus Integrator | 77 |
| 5.2.3 | Improved architecture of a 4-Path SC Comb Filter Plus Integrator | 81 |
| 5.3 | Monte Carlo Simulation | 89 |
| 5.4 | Summary | 92 |
| Chapter 6 | Conclusions | 94 |
| 6.1 | Conclusions | 94 |
| 6.2 | Suggestion for Further Research | 95 |
| Appendix A | SWITCAP Netlists for N-Path Multirate Second-Order SDMs | 96 |
| A.1 | SWITCAP Netlist for N-Path Multirate Second-Order SDM Using Direct Form Comb Filter | 96 |
| A.2 | SWITCAP Netlist for N-Path Multirate Second-Order SDM Using Cascade Comb Decimation Filter | 101 |
| References | | 106 |