MIXED SIGNAL VLSI WIRELESS DESIGN

Circuits and Systems

Emad N. Farag
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Kluwer Academic Publishers

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7219

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KLUWER ACADEMIC PUBLISHERS
Boston / Dordrecht / London

Distributors for North, Central and South America:
Kluwer Academic Publishers
101 Philip Drive
Assinippi Park
Norwell, Massachusetts 02061 USA
Telephone (781) 871-6600
Fax (781) 871-6528
E-Mail <kluwer@wkap.com>

Distributors for all other countries:
Kluwer Academic Publishers Group
Distribution Centre
Post Office Box 322
3300 AH Dordrecht, THE NETHERLANDS
Telephone 31 78 6392 392
Fax 31 78 6546 474
E-Mail <orderdept@wkap.nl>

Electronic Services <http://www.wkap.nl>

Library of Congress Cataloging-in-Publication Data
Farag, Emad N.
Mixed signal VLSI wireless design: circuits and systems/Emad N. Farag and Mohamed I. Elmasry.
p. cm.
Includes bibliographical references and index.
ISBN 0-7923-8687-6 (alk. paper)
1. Integrated circuits--Very large scale integration--Design and Construction. 2. Wireless communication systems--Design and construction. 3. Radio circuits--Design and construction. 4. Cellular telephones--Equipment and supplies--Design and Construction. I. Elmasry, Mohamed I., 1943- II. Title.

TK7874.75.F37 1999
621.39'5--dc21 99-046689

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Printed on acid-free paper.
Printed in the United States of America

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Preface

''Wireless is coming'' was the message received by VLSI designers in the early 1990's. They believed it. But they never imagined that the wireless wave would be coming with such intensity and speed. Today one of the most challenging areas for VLSI designers is VLSI circuit and system design for wireless applications.

New generation of wireless systems, which includes multimedia, put severe constraints on performance, cost, size, power and energy. The challenge is immense and the need for new generation of VLSI designers, who are fluent in wireless communication and are masters of mixed signal design, is great.

No single text or reference book contains the necessary material to educate such needed new generation of VLSI designers. There are gaps. Excellent books exist on communication theory and systems, including wireless applications and others treat well basic digital, analog and mixed signal VLSI design. We feel that this book is the first of its kind to fill that gap.

In the first half of this book we offer the reader (the VLSI designer) enough material to understand wireless communication systems. We start with a historical account. And then we present an overview of wireless communication systems. This is followed by detailed treatment of related topics; the mobile radio, digital modulation and schemes, spread spectrum and receiver architectures.

The second half of the book deals with VLSI design issues related to mixed-signal design. These include analog-to-digital conversion, transceiver design, digital low-power techniques, amplifier design, phase locked loops and frequency synthesizers.

The book can be used in a senior undergraduate or graduate course on VLSI Design For Wireless Applications and can be also used by practicing engineers and managers working in this area. Basic background in both communication systems and VLSI design are assumed.

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We are aware of the hazards of trying , in a 300-plus page book, to bridge the gap between two engineering disciplines. Trading depth and breadth is only one such hazard. But our conviction for the need of such a book motivated us to write it. Moreover, the experience of writing it was enjoyable and we hope the book proves useful to our readers.

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Acknowledgments

We first acknowledge the blessings of God Almighty in our lives. The contributions of many people to this book, through discussions, is very much appreciated. The partial support received from Canadian Research granting agencies, and from Canadian, U.S. and Japanese industry and the University of Waterloo is acknowledged.

Lucent Technology has provided to one of us (Farag) an excellent environment to complete this book. The VLSI Research Group at the University of Waterloo has been instrumental during the different phases of writing and we thank the faculty, staff and students.

Finally, our families offered the necessary support to complete this book and we thank them dearly.

List of Acronyms

3G:	Third Generation
ACI:	Adjacent Channel Interference
ACTS:	Advanced Communications Technologies and Services
ADC:	Analog-to-Digital Converter
AGC:	Automatic Gain Control
AM:	Amplitude Modulation
AMPS:	Advanced Mobile Phone Service
ARIB:	Association of Radio Industries and Businesses
ASIC:	Application Specific Integrated Circuit
ASK:	Amplitude Shift Keying
AWGN:	Additive White Gaussian Noise
BCCH:	Broadcast Control Channel
BER:	Bit Error Rate
BiCMOS:	Bipolar Complementary Metal Oxide Semiconductor
BJT:	Bipolar Junction Transistor
BPSK:	Binary Phase Shift Keying
CDF:	Cumulative Distribution Function
CDMA:	Code Division Multiple Access
CDPD:	Cellular Digital Packet Data
CDVCC:	Code Digital Verification Color Code
CELP:	Code Excited Linear Prediction
CEPT:	Conference of European Posts and Telecommunications
CMOS:	Complementary Metal Oxide Semiconductor
CRC:	Cyclic Redundancy Check
CSMA:	Carrier Sense Multiple Access
DAC:	Digital-to-Analog Converter
DBPSK:	Differential Binary Phase Shift Keying
DCCH:	Dedicated Control Channel
DDFS:	Direct Digital Frequency Synthesis

DECT:	Digital European Cordless Telephone
DDI:	Daini-Denden, Inc.
DQPSK:	Differential Quadrature Phase Shift Keying
DSSS:	Direct Sequence Spread Spectrum
DSP:	Digital Signal Processing/Processor
DTC:	Dedicated Traffic Channel
EEPROM:	Electrical Erasable Programmable Read Only Memory
EIRP:	Effective Isotropic Radiated Power
EPROM:	Erasable Programmable Read Only Memory
ETACS:	Extended Total Access Communication System
ETSI:	European Telecommunications Standards Institute
FACCH:	Fast Associated Control Channel
FCC:	Federal Communications Commission
FCW:	Frequency Control Word
FDD:	Frequency Division Duplexing
FDMA:	Frequency Division Multiple Access
FEC:	Forward Error Correction
FET:	Field Effect Transistor
FHSS:	Frequency Hopping Spread Spectrum
FM:	Frequency Modulation
FPLMTS:	Future Public Land Mobile Telecommunications System
FS:	Frequency Synthesizer
FSK:	Frequency Shift Keying
FSVQ:	Full Search Vector Quantization
GaAs:	Gallium Arsinide
GHz:	Giga Hertz
GMSK:	Gaussian Minimum Shift Keying
GSM:	Global System for Mobile communications previously known as Group Speciale Mobile
HDL:	Hardware Description Language
IF:	Intermediate Frequency
IMPS:	Improved Mobile Phone System
IMT-2000:	International Mobile Telecommunications 2000
IS:	Interim Standard
ISI:	Intersymbol Interference
ITU:	International Telecommunications Union
JFET:	Junction Field Effect Transistor
JTACS:	Japanese Total Access Communication System
JTC:	Japanese Cordless Telephone
kbps:	Kilo bits per second
Kcps:	Kilo chips per second
LAN:	Local Area Network

LNA:	Low Noise Amplifier
LOS:	Line of Sight
Mbps:	Mega bits per second
Mcps:	Mega chips per second
MHz:	Mega Hertz
MIPS:	Million Instructions Per Second
MMIC:	Microwave Monolithic Integrated Circuit
MOSFET:	Metal Oxide Semiconductor Field Effect Transistor
MSC:	Mobile Switching Center
MSK:	Minimum Shift Keying
MTS:	Mobile Telephone System
NAMPS:	Narrow-band Advanced Mobile Phone Service
NF:	Noise Figure
NMOS:	N-type Metal Oxide Semiconductor
NMT:	Nordic Mobile Telephone
NTACS:	Narrow-band Total Access Communication System
NTT:	Nippon Telephone and Telegraph
OOK:	On Off Keying
OQPSK:	Offset Quadrature Phase Shift Keying
PCS:	Personal Communications System
PDC:	Personal Digital Cellular
pdf:	Probability Density Function
PHS:	Personal Handy (phone) System
PLL:	Phase Locked Loop
PN:	Pseudorandom Noise
ppm:	Part-Per-Million
PSD:	Power Spectral Density
PSK:	Phase Shift Keying
PSTN:	Public Switched Telephone Network
QAM:	Quadrature Amplitude Modulation
QPSK:	Quadrature Phase Shift Keying
RACE:	Research into Advanced Communications in Europe
RAM:	Random Access Memory
RF:	Radio Frequency
ROM:	Read Only Memory
QAM:	Quadrature Amplitude Modulation
QPSK:	Quadrature Phase Shift Keying
RACH:	Random Access Channel
RAM:	Random Access Memory
RSSI:	Received Signal Strength Indicator
SACCH:	Slow Associated Control Channel
SCF:	Shared Channel Feedback

SiGe:	Silicon Germanium
SMS:	Short Message Service
SNR:	Signal-to-Noise Ratio
SOI:	Silicon-On-Insulator
SPACH:	SMS Point-to-Point and Access Response Channel
TACS:	Total Access Communication System
TDD:	Time Division Duplexing
TDMA:	Time Division Multiple Access
THSS:	Time Hopping Spread Spectrum
TIA:	Telecommunications Industry Association
TSVQ:	Tree Structured Vector Quantization
UE:	User Equipment
UMTS:	Universal Mobile Telecommunications System
VCO:	Voltage Controlled Oscillator
VHDL:	VHSIC Hardware Description Language
VHSIC:	Very High Speed Integrated Circuit
VLSI:	Very Large Scale Integration
VSELP:	Vector Sum Excited Linear Prediction
W-CDMA:	Wideband Code Division Multiple Access
WARC:	World Administrative Radio Conference

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Contents

List of Figures ix
List of Tables xvii
Preface xix
Acknowledgments xxi
List of Acronyms xxiii

1. INTRODUCTION 1
   1.1 The History of Wireless Communications 1
   1.2 Wireless Communications Basics 4
   1.3 Wireless Communications Standards 9
   1.4 Terminology 18
   1.5 Book Organization 20

2. WIRELESS COMMUNICATION SYSTEMS - OVERVIEW 23
   2.1 Introduction 23
   2.2 Digital Communication Systems 23
   2.3 Minimum Bandwidth Requirement (The Nyquist Limit) 27
   2.4 The Shannon Limit 36
   2.5 Optimum Receiver Design for Band-pass Digital Systems 45

3. THE MOBILE RADIO 55
   3.1 Introduction 55
   3.2 The Cellular Concept 55
   3.3 Channel Impairments 66
   3.4 Large Scale Fading 71
   3.5 Doppler Shift 72
   3.6 Small Scale Fading 75
   3.7 Diversity Techniques in Wireless Communications 85

4. DIGITAL MODULATION SCHEMES 87
   4.1 Introduction 87

4.2 Amplitude Shift Keying 88
4.3 Phase Shift Keying 91
4.4 Frequency Shift Keying 106
4.5 Digital Modulation Techniques Comparisons 111

5. SPREAD SPECTRUM 115
5.1 Introduction 115
5.2 Basic Principles of Spread Spectrum 117
5.3 Spread Spectrum Techniques 118
5.4 Pseudorandom Noise Sequence 121
5.5 Practical Considerations in Spread Spectrum Systems 126

6. RECEIVER ARCHITECTURES 133
6.1 Introduction 133
6.2 Noise Figure 133
6.3 Intermodulation distortion 138
6.4 The Superheterodyne Receiver 144
6.5 The Homodyne Receiver 150
6.6 Software Radio 151

7. ANALOG TO DIGITAL CONVERSION 155
7.1 Introduction 155
7.2 Performance Metrics of Analog-to-Digital Converters 158
7.3 Sampling 158
7.4 Band-pass Sampling 165
7.5 Quantization 167
7.6 Types of Analog-to-Digital Converters 171
7.7 Sigma-Delta Analog-to-Digital Converters 188

8. VLSI DESIGN ISSUES IN WIRELESS TRANSCEIVER DESIGN 195
8.1 Introduction 195
8.2 Transceiver Design Constraints 197
8.3 Baseband Subsystem Design 199
8.4 RF Subsystem Design 204

9. LOW-POWER DESIGN TECHNIQUES 211
9.1 Introduction 211
9.2 Sources of Power Dissipation 213
9.3 Estimating the Power Dissipation 215
9.4 Low-Power Examples of Portable Systems 217
9.5 Reducing the Power Dissipation at the Device and Circuit Levels 218
9.6 Low-Voltage Low-Power Operation 219
9.7 Reducing the Power Dissipation at the Architecture and Algorithm Levels 223

10.AMPLIFIER DESIGN FOR WIRELESS COMMUNICATION SYSTEMS 227
10.1 Introduction 227
10.2 Amplifier Design 228
10.3 Low Noise Amplifier 233
10.4 Automatic Gain Control Amplifiers 238
10.5 Power Amplifiers 243

11.PHASE LOCKED LOOPS 255
11.1 Introduction 255
11.2 Operation of the Phase Locked Loop 255
11.3 Phase Detectors 261
11.4 Frequency Dividers 269
11.5 Oscillator Design 273

12.FREQUENCY SYNTHESIZERS 285
12.1 Introduction 285
12.2 Frequency synthesizer (FS) parameters 286
12.3 Frequency Synthesizer Techniques 288
12.4 Analyzing phase noise in frequency synthesizers 299
12.5 Summary 303
Bibliography 306
Index 316

List of Figures

1.1	Frequency assignments made to terrestrial and satellite FPLMTS (IMT-2000) systems by WARC-92.	3
1.2	Classification of wireless communication systems.	4
1.3	Electromagnetic spectrum of radio waves.	5
1.4	A generic transceiver.	6
1.5	A single-stage up conversion transmitter.	7
1.6	Direct conversion (homodyne) receiver.	8
1.7	A Two-stage superheterodyne receiver.	8
1.8	Allocated frequency spectrum for the AMPS system.	9
1.9	Frame structure for IS-136.	14
1.10	Slot format for a forward link digital traffic channel.	14
1.11	Slot format for a reverse link digital traffic channel.	15
1.12	Coding of a voice channel in IS-136.	15
1.13	Signal processing in the forward link transmitter of a CDMA system.	18
1.14	Signal processing in the reverse link transmitter of a CDMA system.	19
2.1	A wireless telecommunications system.	24
2.2	Generic block diagram of a digital transmitter.	25
2.3	Generic block diagram of a digital receiver.	26
2.4	Inter-symbol interference-free filters.	29
2.5	The transfer function of a raised cosine filter.	31
2.6	The impulse response of a raised cosine filter.	32
2.7	The impulse response of a realizable approximation of the impulse response of a raised cosine filter.	33
2.8	The input impulse sequence to a raised cosine filter having a truncated and delayed impulse response.	34
2.9	The output response of a raised cosine filter having a truncated and delayed impulse response.	35

2.10	The peak-to-peak jitter, J_{pp}, versus the roll-off factor, α, of a raised cosine filter.	37
2.11	A rate-1/2 convolution encoder, with a constraint length of 3.	41
2.12	The finite state machine representation of a convolution encoder.	41
2.13	The trellis diagram of a convolution encoder.	42
2.14	Interleaving and De-interleaving.	42
2.15	Block Interleaving and de-interleaving.	43
2.16	Convolution Interleaver and De-interleaver.	44
2.17	Additive white Gaussian noise channel model.	46
2.18	Conditional probability density function at the output of the receiver's sampler.	48
2.19	Correlation receiver.	51
2.20	Wireless system satisfying the Nyquist criteria for no inter-symbol interference and the matched filter criteria for optimum bit error rate performance.	53
3.1	Cell shape.	57
3.2	Base station location relative to the cell boundary.	58
3.3	Co-channel interference in the cellular system.	58
3.4	Relative positioning of two cells allocated the same portion of the frequency spectrum in a cellular system.	59
3.5	Cellular system cell plan having a cluster size of seven cells.	60
3.6	Cell splitting in cellular systems.	63
3.7	Intersystem handoff.	66
3.8	Two ray propagation model: Direct line of sight (LOS) ray and ground reflected ray.	70
3.9	Illustration of the Doppler shift.	73
3.10	Small scale fading in a multi-path time-variant channel.	76
3.11	Rayleigh fading: Multi-wave reception.	79
3.12	Probability distribution function (pdf) and cumulative distribution function (CDF) for a Rayleigh distributed random variable.	81
3.13	Envelope variation of a band-limited Rayleigh distributed random process versus time.	82
3.14	Envelope probability density function in a Ricean fading environment.	84
3.15	A three rake finger receiver.	86
4.1	Amplitude shift keying (ASK) waveforms.	88
4.2	The power spectral density of an amplitude shift keying (ASK) modulated signal.	89

4.3	Bit error rate for coherent and non-coherent amplitude shift keying (ASK) demodulation.	90
4.4	Binary phase shift keying (BPSK) waveforms.	92
4.5	Differential binary phase shift keying (DBPSK) modulation and demodulation.	94
4.6	Differential binary phase shift keying (DBPSK) waveforms.	95
4.7	Signal-space diagram for quadrature phase shift keying (QPSK) modulation.	96
4.8	Quadrature phase shift keying (QPSK) modulator.	97
4.9	Quadrature phase shift keying (QPSK) waveforms.	98
4.10	Quadrature phase shift keying (QPSK) demodulator.	98
4.11	Offset quadrature phase shift keying (OQPSK) waveforms.	100
4.12	Differential quadrature phase shift keying (DQPSK) demodulator.	102
4.13	The space diagram of a $\pi/4$-DQPSK system showing all allowable phase state transitions.	104
4.14	The carrier recovery circuit for a $\pi/4$-DQPSK modulated signal.	105
4.15	Limiter discriminator detector for a $\pi/4$-DQPSK modulated signal.	106
4.16	Differential detector for a $\pi/4$-DQPSK modulated signal.	106
4.17	The bit error rate of a $\pi/4$-DQPSK modulation scheme.	107
4.18	Minimum Shift Keying (MSK) waveforms.	108
4.19	Minimum Shift Keying (MSK) Modulator.	109
4.20	Minimum Shift Keying (MSK) Demodulator.	110
4.21	Pulse response of a Gaussian low-pass filter.	112
4.22	Gaussian Minimum Shift Keying (GMSK) Modulator.	112
4.23	Power spectrum density for digital modulation schemes.	113
4.24	Bit error rate for digital modulation schemes.	114
5.1	The operation of spread spectrum systems.	116
5.2	The direct sequence spread spectrum (DSSS) approach.	119
5.3	Waveforms of a direct sequence spread spectrum (DSSS) system.	119
5.4	The frequency hopping spread spectrum (FHSS) approach.	120
5.5	The time hopping spread spectrum (THSS) approach.	121
5.6	The Fibonacci Linear Feedback Shift Register.	122

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