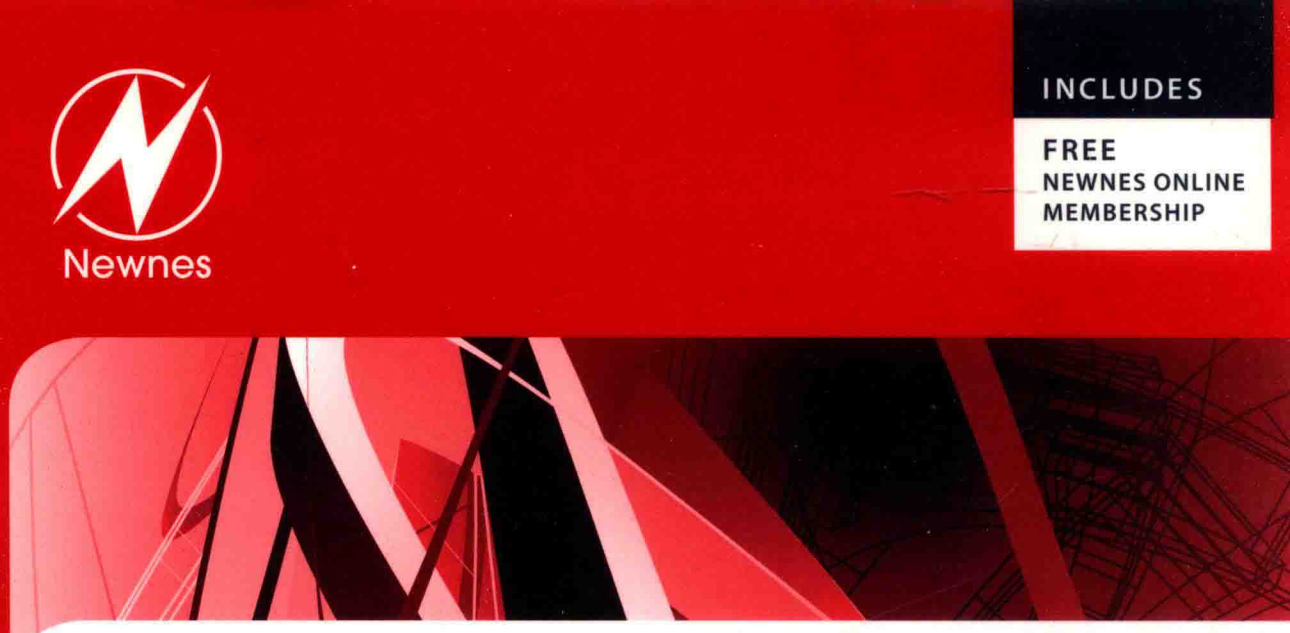

ROBERT LACOSTE'S THE DARKER SIDE

Practical Applications for Electronic Design Concepts

- Step into the light! Tips, tricks, and know-how that enhance design performance
- Learn from the very best of Lacoste's *Circuit Cellar* columns
- Helps you understand the tougher engineering topics, from digital modulation to electromagnetic interference

Robert Lacoste

CIRCUIT CELLAR®

Robert Lacoste's the Darker Side

Practical Applications for Electronic Design Concepts

Robert Lacoste

常州大学山书馆
藏书章

ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Newnes is an imprint of Elsevier

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data

Application submitted.

ISBN: 978-1-85617-762-7

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

For information on all Newnes publications
visit our Web site at *www.elsevierdirect.com*

Printed in the United States

09 10 11 12 13 10 9 8 7 6 5 4 3 2 1

Working together to grow
libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER BOOK AID International Sabre Foundation

Newnes is an imprint of Elsevier
30 Corporate Drive, Suite 400
Burlington, MA 01803, USA

The Boulevard, Langford Lane
Kidlington, Oxford, OX5 1GB, UK

Copyright © 2010 Elsevier Inc. All rights reserved.
No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: *www.elsevier.com/permissions.*

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

The Circuit Cellar logo is a registered trademark of Circuit Cellar Inc. Used with permission.

Articles reprinted as follows that are from Circuit Cellar (U.S.A.) are copyright by Circuit Cellar Inc. All rights reserved. Published from *Circuit Cellar* with the permission of Circuit Cellar, Inc., # 4 Park Street, Vernon, Connecticut 06066, USA. Reproduction in any manner, in any language, in whole or in part without prior written permission from Circuit Cellar, Inc., is expressly prohibited:

Microstrip techniques, reprint of CC#223 article, with supplements and correction; "Time domain reflectometry," reprint of CC#225 article, with corrections; "Let's play with EMI," reprint of CC#205 article, with supplements and corrections; "Cable shielding experiments," reprint of CC#219 article, with supplements and corrections; "No fear with FIR: Put a Finite Impulse Response filter to work," reprint of CC#207 article, with supplements, deletions, and corrections; "Let's be crystal clear," reprint of CC#215 article, with supplements and corrections; "Are you locked? A PLL primer," reprint of CC#209 article, with supplements and corrections; "Direct digital synthesis 101," reprint of CC#217 article, with supplements and correction; "Open your eyes! A primer on high-speed signal transmission techniques," reprint of CC#227 article, with supplements and corrections; "Antenna basics," reprint of CC#211 article, with supplements, deletions, and corrections; "Low power techniques: Build better energy-saving systems," reprint of CC#213 article, with supplements and corrections; and "PID control without math," reprint of CC#221 article, with minor supplements and corrections.

Other materials in this book not referenced above are reprinted by permission from Circuit Cellar, Circuit Cellar, Inc.:

"Impedance Matching Basics," written exclusively for this publication, is based on the first section of CC#211 article "Antennas"; and "The Fast Fourier Transform from A to Z," written exclusively for this publication, is based on the first section of the CC#207 article "No fear with FIR."

Please visit circuitcellar.com for further information.

Foreword

While I would like to tell a story about how *Circuit Cellar* magazine made Robert Lacoste into the respected authority on electronic engineering that he is today, I do not pride myself a thief. His success has been his own doing. I have never seen a man so skilled at his craft, yet so willing to work diligently to demystify what is often referred to as black magic electronics engineering. Circuit Cellar owes Robert its sincere gratitude for allowing its pages to be his venue of choice over the last several years.

Having acknowledged this, I must to note that this book represents one of the finest examples of Circuit Cellar's evolutionary success. I first became aware of Robert's work through his project submissions to Circuit Cellar's embedded design contests. His résumé of contest success was so impressive, covering a wide range of expertise and knowledge of microcontrollers, that after nine contest entries and seven top-four placements (including one Grand Prize and multiple First Prizes), Robert became a third-party judge for future contests. The work of a design contest judge is grueling. Each project must be studied in tremendous detail and evaluated against a host of abstract and concrete design criteria. It's a job someone who cherishes the spirit of innovation in the design community. I know that Robert wears the title "*Circuit Cellar* Contest Judge" as badge of honor.

Robert quickly became a recurring feature contributor to *Circuit Cellar*'s magazine. Even his earliest contributions from over a decade ago reveal a drive for going above and beyond the requirements of the job. Robert was the teacher who cared about the student. His articles were the tools that would inspire everyone, from seasoned pros to design students.

此为试读,需要完整PDF请访问: www.ertongbook.com

Robert's willingness to tackle the most difficult-to-understand topics in electronics engineering and his ability to demystify them through his writing and project examples, made it very easy for him to go even further in his Circuit Cellar evolution. He was welcomed aboard as a bi-monthly columnist in August 2007 and has since presented much-acclaimed pieces under the heading "The Darker Side." The feedback from readers has been extremely positive. It's a joy to hear from those with decades of experience in embedded development and discover how much they're learning. In "The Darker Side" column, *Circuit Cellar* readers have a resource for thought-provoking design concepts. In *Robert Lacoste's the Darker Side,* the book you now hold in your hands, the embedded design community has a collection that is truly worthy of any developer's library.

Thanks, Robert, for being a part of the *Circuit Cellar* evolution success story.

Steve Ciarcia
Founder/Editorial Director
Circuit Cellar *Magazine*

Preface

An engineer always has the same difficult choice when placed in front of a new project. Is it better to rely on his knowledge and experience and to use solutions that he has already used somewhere else, or should he extend his knowledge and take a more risky route, meaning to learn and to try new and innovative techniques?

I call the first approach the "comfort zone" solution. It is of course a very reasonable one, and I hope it is the preferred method for most safety-critical systems designers. It is also the preferred method of project managers who know that the schedule will be less at risk. Staying in your comfort zone means that you probably will have no bad surprises. However, the downside is … that you will never have good surprises. Your product will not become significantly better than your competitor's, its price will not go down drastically, and your sales will not double.

On the contrary, the innovative approach has downsides too, and nobody should deny or ignore them. You may find more difficulties than anticipated, or even the solution you have tried may appear purely inadequate for the specific project. More frequently, your schedule may be in jeopardy and you may have some difficulties with your management. However, if you are clever (or lucky), then impressive achievements are possible. You could end up with a really disruptive solution, providing either better performances, more flexibility, more features, or lower cost than existing solutions. This means that you will please your customers or boss. And even if you are not designing something that will change our lives completely, this also means that you will leave your small contribution to humanity.

Personally I think life is too short to stop learning. Of course risks must be mitigated, but I always ended up with a frustrating feeling when I was only staying in my comfort

zone. Honestly I spent the first fifteen years of my professional life in a quite schizophrenic mode. During working hours I managed huge technological projects in information technologies and telecommunications, meaning of course that I became farer and farer to technology and more and more reluctant to risks. To compensate I spent my nights developing innovative electronic devices as a hobbyist, using new techniques each time and especially focusing on things that I had never learned or tried. The design contests organized by *Circuit Cellar* were very helpful motivators to develop as impressive as possible solutions periodically!

Back in 2003 I decided that this life was not as optimal as possible, so I quit my last employer to launch my own consulting and design small company, ALCIOM. My goal was simply to bring the happiest part of my activities, meaning innovative design work, back into my daily time. It was a very fortunate decision. We are now working 70 percent for start-up companies who clearly ask us to use as innovative solutions as possible and 30 percent for large companies who are asking us to help them to go back to a start-up like approach. With my colleagues we are doing our best to keep the same spirit over the years, meaning we try to use new and innovative solutions in every project, even if it is only a small subpart of a project. This definitely increases our own comfort zone over time, makes us more proud of our lives, and we hope makes customers happier.

When Steve Ciarcia asked me to write a new bi-monthly column for *Circuit Cellar*, I immediately thought that the best idea would be to help readers go out of their own comfort zones. This means to present some of the lesser-known, more obscure aspects of electronic design, to highlight concepts too often perceived as expert-only subjects (if you read "analog" between these words, you will probably be right 90 percent of the time). I also wanted to explain what was really going on and to focus on application-oriented explanations and pragmatic tips rather than painful theory and math (although some equations may show up from time to time). The Darker Side column was born. As I got very positive feedback from readers, I continued with articles covering subjects from electromagnetic interferences to antennas, from digital filters to phase-locked loops, or from digital modulations to control systems.

This book is a collection of Darker Side columns. Because space constraints are easier in a book than in a magazine, I added plenty of additional examples and explanations, as well as a couple of exclusive chapters. Each chapter is nearly fully independent from

the others, so don't hesitate to jump directly to a specific section if you are in a hurry and have a short-term problem with the project on your desk. Two chapters deal with notions used in other sections, namely Chapter 1 on impedance matching and Chapter 6 on Fourier transform, so you'd better start with these two if you are not already fluent with these notions. You also will find some additional informations in the appendixes, in particular, appendix A gives you a tutorial on a tool that I used extensively through out this book, namely SciLab.

Anyway even if the chapters are independent of each other, I still suggest that you take your time and read the book from start to finish, maybe jumping over chapters where you are already in your comfort zone. This would help you discover that some techniques could be useful for your next project, either if you don't already know what it is. Plus, this will help you reduce your own darker side. That's my target!

Finally, don't hesitate to contact me by email. The topic I'm presenting in this book was indeed out of my comfort zone no long ago, so I may be wrong or imprecise from time to time. Moreover you may also be able to reduce my remaining darker side!

Acknowledgments

I would like to dedicate this book to all the people who helped me do what I love to do. They are really numerous, but here is a short list. To my father, who taught me how to solder my first transistor. To my mother, who supported my father and myself when we brought trashed TVs back home to dismount them in the living room. To Steve Ciarcia who didn't know at the time that I was reading every word of his articles from *Byte* magazine to *Circuit Cellar*, and especially as my first microcontroller-based project was built following one of his papers. To all the great *Circuit Cellar* team, who continuously encouraged me and helped me step by step to correct my Frenchy English. To the *Circuit Cellar* contest sponsors, who pushed me, as well as thousands of other engineers, to find new ideas and to make them work. To Elsevier, who pushed me to transform these materials into a book. To my colleagues at Alciom, who took the risk to join me in my consulting adventure. To our customers, who trusted us and gave us fantastic innovative projects to work on. And, of course, to my dear wife Isabelle and to our daughters Pauline and Adele, who patiently forgive my long nights spent with a soldering iron in hand or in front of my PC writing this book, rather than repairing the garage door.

Contents

Foreword xi

Preface xiii

Part 1: Impedance Concerns 1

Chapter 1: Impedance Matching Basics 3

Optimal Heating for the Winter 3

What About AC? 6

Matching Issues 8

LC Matching Networks 8

Matching and Reflections 13

Any Other Solution? 13

Wrapping Up 15

Chapter 2: Microstrip Techniques 17

Transmission Lines 17

Microstrip Tracks 20

Distributed Components 22

Need a Zero-Cost Filter? 24

To the Bench 26

Wrapping Up 30

Chapter 3: Time Domain Reflectometry 33

TDR Basics 33

1-ns Pulse Generator 35

www.newnespress.com

Where Are Your Magnifying Glasses? 36
First Experiments 39
Let's Simulate It 42
Real Life Versus Simulation 43
Wrapping Up 47

Part 2: Electromagnetic Compatibility 49

Chapter 4: Let's Play with EMI 51
EMC Basics 51
The Spectrum Analyzer 53
Radiated EMI 56
Conducted EMI 59
Is That All? 62

Chapter 5: Cable-Shielding Experiments 63
Theory Refresher 63
Experimental Setup 67
Comparative Results 69
Rules to Keep in Mind 73
Wrapping Up 75

Part 3: Signal Processing 77

Chapter 6: The Fast Fourier Transform from A to Z 79
Back to Basics 79
Play with FFT 81
DFT and FFT 84
FFT Variants 87
Windowing 88
FFT Applications 89
Wrapping Up 92

Chapter 7: No Fear with FIR: Put a Finite Impulse Response Filter to Work 93
Frequency Domain 93
From Frequency to Time 97

此为试读,需要完整PDF请访问: www.ertongbook.com

FIR for You 99
Anti-aliasing 100
Filter Frequency Response 101
Synthesis! 103
. . . and Simulation 103
Time to Solder 106
Wrapping Up 110

Chapter 8: Multirate Techniques and CIC Filters *111*
Multirate? 112
Digital Mixing 114
Decimation 115
Moving Averages and CIC Filters 116
CIC Filter Characteristics 118
Firmware Implementation 125
Wrapping Up 136

Part 4: Oscillators **137**

Chapter 9: Let's Be Crystal Clear *139*
Piezoelectricity 139
The Electrical Model 141
Parallel or Series? 143
HCMOS Pierce Oscillator 145
Oscillator Start-Up 148
Is It Stable? 150
Let's Overtone 152
Wrapping Up 154

Chapter 10: Are You Locked? A PLL Primer *155*
VCO Basics 156
PLL Basics 162
Integer or Fractional? 164
PLL Design 165
Silicon Trends 166
It's Your Turn! 168
Wrapping Up 170

Chapter 11: Direct Digital Synthesis 101 ..... *171*
DDS Basics 171
DDS Flexibility 173
Who Said Sin(x)/x? 176
Any Other Problem? 179
Software Implementation 183
Silicon Solutions 187
Wrapping Up 190

Part 5: Communications **193**

Chapter 12: Open Your Eyes! A Primer on High-Speed Signal Transmission *195*
High-speed Issues 195
Do You See This Eye? 197
Pre-emphasis 200
Equalization 207
Some Silicon 208
Wrapping Up 211

Chapter 13: Digital Modulations Demystified *213*
Modulation? 214
OOK? 215
Baseband Filtering 217
FSK and Its Variants 219
Phase Modulation 224
ASK + PSK = QAM 230
From FSK to OFDM 233
Wrapping Up 233

Chapter 14: Antenna Basics *235*
Impedance Matching—Again 235
Basic Antennas 236
Microstrip Antennas 240
Antennas in Real Life 246
Wrapping Up 248

Part 6: Power 249

Chapter 15: Low-Power Techniques: Build Better Energy-Saving Systems 251
SmartyCook 252
Power Budget Calculation 254
Reducing Operating Current 257
Reducing Operating Duration 258
Introducing New Operating Modes 261
Reducing Standby Current 263
Wrapping Up 263

Chapter 16: From Power Line Measurements to PFC 267
Some Basics 267
Regulations 272
Measurements 273
To the Bench 276
Shutting Power Down 282
Wrapping Up 282

Part 7: System Control 283

Chapter 17: PID Control Without Math 285
A Basic Case 286
Proportional? 292
A Derivative Helps! 297
Integral, for Full PID 300
Hardware Improvements 302
Wrapping Up 302

Chapter 18: Linear Control Basics 305
Physical System Modeling 308
Linear Control Standard Format 311
Observable and Reachable? 314
Pole Placement! 316
Wrapping Up 320

Appendix A: Scilab Tutorial *321*
Scilab? 321
Starting Scilab 322
Basic Functions 324
Vectors and Matrices 325
Plotting 328
Programming Language 330
Toolboxes 331

Appendix B: Complex Numbers 101 ..... *333*
Geometrical Interpretation 333
Polar Form 334
Operations 335

Resources **337**

Index **343**

www.newnespress.com

Part 1

Impedance Concerns

此为试读,需要完整PDF请访问: www.ertongbook.com