Digital Predistortion of Power Amplifiers for Wireless Applications

A Thesis Presented to The Academic Faculty

by

Lei Ding

In Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy

School of Electrical and Computer Engineering Georgia Institute of Technology March 2004



Digital Predistortion of Power Amplifiers for Wireless Applications

Approved by:

Dr. G. Tong Zhou, Advisor

Dr. Ye (Geoffrey) Li

Dr. J. Stevenson Kenney

Dr. Jianmin Qu

Dr. W. Marshall Leach

Date Approved: April 1, 2004



For my family.



ACKNOWLEDGEMENTS

It is time to draw a period to my PhD endeavor. I feel extremely lucky to meet so many talented people during these years. I am grateful for their friendship, help, encouragement, and support.

First, I would like to thank my advisor, Dr. G. Tong Zhou, for providing this opportunity for me to study at Georgia Tech. Her constant encouragement and valuable advices are essential for the completion of this thesis. I will be always inspired by the high standards she sets for herself and her sharp focus and deep devotion to whatever she works on.

I would like to thank my thesis committee members: Drs. J. Stevenson Kenney, W. Marshall Leach, Ye (Geoffrey) Li, and Jianmin Qu for taking time to serve on my committee and for their questions and suggestions. My special thanks also go to Drs. Monson Hayes and Douglas B. Williams for the excellent classes they offered, which benefit me a lot for my research work and job search.

I also benefit a lot from my two summer internships at Bell Labs, Lucent Technologies. I would like to thank Drs. Zhengxiang Ma and Dennis R. Morgan for making this possible. I enjoyed every aspect of my internship experience: talented colleagues, excellent research opportunities, cool weather, nice work environment, and the list goes on. My special thanks also go to Dr. Yiteng Huang for his friendship and help during my stay in New Jersey.

I would like to thank my group members: Yongsub, Krishna, Muhammad, Raviv, Gail, Ning, Hua, Chunpeng, Yuan, Thao, Vincent, and Bob for all the technical discussions and help along the way. I also enjoyed interactions with the nice Chinese student community here at CSIP.

A lot of credit goes to my parents. Their unconditional support has always helped me in all my endeavors. I would also like to thank my sister for her support and feeding me with great dishes from time to time. Last but not least, I would like to thank my wife, wenjin, for her love, encouragement, and support.



TABLE OF CONTENTS

Dedicat	ion .	
Acknowledgements iv		
List of Tables viii		
List of Figures		
Summary xii		
Chapter	. 1	Introduction
	1.1	Motivation
	1.2	Objectives
	1.3	Outline
Chapter	• 2	Background
	2.1	Modeling Memoryless Power Amplifiers
	2.2	Predistortion of Memoryless Power Amplifier
		2.2.1 Data Predistortion for Memoryless Power Amplifiers
		2.2.2 Signal Predistortion for Memoryless Power Amplifiers 8
	2.3	Modeling Power Amplifiers with Memory Effects
	2.4	Predistortion of Power Amplifiers with Memory Effects
Chapter	3	Digital Predistorter Design
	3.1	Hammerstein Predistorter Design
		3.1.1 Hammerstein Predistorter Training
		3.1.2 Hammerstein Predistorter Simulation
	3.2	Memory Polynomial Predistorter Design
		3.2.1 Memory Polynomial Predistorter Training
		3.2.2 Memory Polynomial Predistorter Simulation
		3.2.3 Memory Polynomial Predistorter Discussion
	3.3	A New Combined Predistorter Design
		3.3.1 Combined Predistorter Model
		3.3.2 Combined Predistorter Training
		3.3.3 Effects of Noise and Initial Estimates



DOCKET

Explore Litigation Insights



Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time** alerts and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

