THEORY, ANALYSIS AND DESIGN OF A DISCRETE TIME PARAMETRIC AMPLIFIER AND ITS VARIANTS

by

SHRIMALI HITESHBHAI KANTILAL

DEPARTMENT OF ELECTRICAL ENGINEERING

Submitted in fulfillment of the requirements of the degree of

Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

May 2012

Certificate

This is to certify that the thesis entitled ***"Theory, analysis and design of a discrete time parametric amplifier and its variants"***, being submitted by **Shrimali Hiteshbhai Kantilal** to the Indian Institute of Technology Delhi, is worthy of consideration for the award of the degree of **Doctor of Philosophy** and is a record of the original bonafide research work carried out by him under my guidance and supervision. The results contained in the thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

I certify that he has pursued the prescribed course of research.

Dr. Shouri Chatterjee

Assistant Professor,

(Supervisor of Student)

Department of Electrical Engineering

Indian Institute of Technology Delhi

Hauz Khas, New Delhi – 110016

Acknowledgments

I would like to thank the Department of Information Technology, Govt. of India, for supporting the fabrication of integrated circuits, through SMDP-phase-II. I would also like to thank the Department of Science and Technology, Govt. of India, for the instrumentation setup for the VLSI Design Tools and Technology laboratory, through the grant SR/FST/ETI-008/2008.

I express my deep heartfelt gratitude to my respected parents, Smt. Nirmala Shrimali and Shri Kantilal Shrimali for their blessings and patience which allowed me to pursue this research. I would especially like to acknowledge my parents for their encouragement to allow me to pursue higher studies in the last few years.

I thank my advisor, Dr. Shouri Chatterjee, who kept his faith in me and always enhanced my research-abilities throughout the course of learning from him. I would like to thank Prof. G.S.Visweswaran who has given opportunities to explore my teaching abilities through the assisted courses under him.

I thank my research committee members Prof. Basabi Bhaumik and Prof. Suneet Tuli for their useful inputs. A special thanks to Prof. Gouranga Bose, Prof. Rakesh Patni and Prof. S.D.Joshi for free ranging discussions on various topics. I would also like to thank ADC team experts Mr. Rakesh Malik and Mr. Chandrajit Debnath of STMicroelectronics India for their valuable and expert comments.

I thank the past and the present graduate students of VDTT, VLSI, Cyber, DRDO and Impact laboratories of the department of electrical engineering; Varun Raj, Girish K, Avikal Bansal, Nitin Goyal, M. Sultan M. Siddiqui, Anoop C. Nair, Girish V, Vimal Prakash Singh, Nagarjuna Nallam, Sushrant Monga, Radhakrishnan Sithanandam, N. Kannan, Sudarshan Varadarajan and Soumit Biswas. I would like to acknowledge Nagarjuna Nallam for his technical inputs during the testing of chips. Special acknowledgements to Soumit Biswas for his technical help in the layout making. Apart part from my colleagues, I am thankful to my seniors Dr. Lalit Jewani, Dr. Vinod Pathak and Dr. Raghvendra Sahai Saxena who motivated me for the focused research by sharing their research-experiences.

I also would thank my friends Kirtiman Rathore, Anubhuti Chopra, Seema Bharti, Vivek Bhatia, Ashish Sharma, Shubham Gupta and Ajay Singh of STMicroelectronics for supporting me during the thesis-writing phase.

– Shrimali Hiteshbhai Kantilal

Abstract

A discrete-time Parametric amplifier is a low power, low noise and a low gain amplifier. However, the discrete-time parametric amplifier suffers from a poor driving capability, high harmonic distortion at the output and a large output common-mode voltage shift. The thesis presents the modified clocking scheme and a feed-forward compensation circuit as a technique to reduce harmonic distortion in a discrete-time parametric amplifier. The same techniques may be applied to other variants of the discrete-time parametric amplifier (DTPA), such as, the complementary discrete-time parametric amplifier (CDTPA), the reverse discrete-time parametric amplifier (RDTPA), and the double-complementary discrete-time parametric amplifier (DCDTPA), to achieve similar reductions in harmonic distortion. In literature, distortion analyses for weakly non-linear systems has been reported. This research work presents systematic distortion analyses using Volterra series for the discrete-time parametric amplifier. As an application of the discrete-time parametric amplifier, the DCDTPA based comparator has been used to design a 10 bit, 1 Gsamples/sec, 128 over sampling ratio continuous-time $\Sigma\Delta$ analog to digital converter in a standard 0.13 μm CMOS technology. In order to achieve such a high speed, the high-bandwidth operational transconductance amplifier and a DCDTPA based quantizer have been designed as an integral part of a continuous-time $\Sigma\Delta$ analog-to-digital converter.

Contents