IEEE

IEEE-SCV-CAS Half Day Tutorial

Broadband and Radio Frequency Circuit Analysis and Design In CMOS Technology partII

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Dr. John Choma

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Professor of Electrical Engineering & Professor of Systems Architecture Engineering, USC**

June 16th (Saturday), 2007,

8:30am-1:00 pm

Cadence Design Systems, Bldg. 5 Cafeteria
2655 Seely Ave., San Jose, CA 95134
(Subject to change)

ABSTRACT

This tutorial, a continuation of the Sept 2006 event, will familiarize engineering professionals with both classic and innovative new broadbanding techniques for CMOS technology amplifiers appropriate for state of the art communication system applications, ***with a focus on Distributed Amplifiers.*** *A unified circuit broadbanding strategy is propounded, as is a practical methodology for the monolithic realization of narrowband radio frequency (RF) amplifiers. Because broadband and RF design necessarily entails the incorporation of suitable matching filters in signal flow paths, a reasonably extensive discussion of lossless filter architectures is incorporated in the tutorial. All theoretic and conceptual disclosures are verified through the results of realistic SPICE simulations*

REGISTRATION

Fees: $50/person; $40 for IEEE members; $25 for IEEE students (with IEEE student ID)
Register on/before 6/04/06. Check must be postmarked before 6/4/06.
After June 4 – if Space Available, $5.00 Surcharge
Registration fee includes donuts and coffee for breakfast and lunch box

Contact: Dr. Weikai Sun at swka@hotmail.com or 408 857-7098 (cell)
Dr. Howard Sun at hjsun_1@yahoo.com or 510-928-7270 (cell)

Make check payable to "IEEE SCV CAS". Receipt handed on site during registration. Send check to
IEEE SCV CAS
c/o:Weikai Sun
PO Box 3162
Fremont, CA 94539

Agenda

8:30am-9:00am Registration (Donuts and coffee
9:00am-9:15am "Introduction and Overview" *by Dr. William Kao*
9:15am-10:30am "Tutorial Part III" *by Dr. John Choma*
10:30am-10:45am Break
10:45am-12:15pm "Tutorial Part IV" *by Dr. John Choma*
12:15pm-1:00pm Discussion, networking, Sponsor Presentations and Lunch

TUTORIAL SUMMARY

Although circuit broadbanding endeavors are often seen as embodying more engineering art than science, a unified theory underpinning a systematic broadbanding design strategy can be formulated. As a complement to this formulation, computationally efficient manual analyses can also be forged to bracket the effectiveness of an adopted broadbanding strategy in advance its definitive computer-aided assessment. Equally important is the need to couch all relevant analytical results in forms that render transparent an insightful understanding of circuit operation, circuit performance attributes, and circuit performance shortfalls. Most of the broadbanding techniques advanced in this tutorial are applicable to voltage and power amplifiers, as well as to high performance transconductors suitable for high performance active biquadratic filter applications.

Both open loop and closed loop broadband design strategies are developed in this course. The open loop techniques include conventional shunt peaking, second order and third order series peaking, and shunt-series peaking featuring an innovative constant resistance, lossless filter that enables a *3-dB* bandwidth enhancement of the high frequency response characteristics of an otherwise conventional common source amplifier by a factor of almost three. The closed loop broadbanding strategies feature pole-zero compensation via RC time constant source circuit degeneration, as well as a match terminated dual loop feedback methodology. The dual loop architecture differs from architectures found in archival literature in that it incorporates constant resistance input and output port filters that achieve broadband impedance matches for arbitrary resistive load and source terminations.

The design and implementation of broadband active networks in CMOS or in any other type of device technology require that appropriate filters be designed and prudently incorporated into the signal flow paths of the considered active structures. Accordingly, considerable attention is given to passive filter design issues and strategies. In addition to demonstrating how these filters facilitate broadbanding exercises, an example of a high performance, nominally allpass, three-terminal delay filter is offered. This filter features maximally flat delay but unlike conventional Bessel realizations, its observable delay is not fundamentally limited by the 3-dB bandwidth of its magnitude response.

CONTENT OF THE TUTORIAL

A partial list of the topics earmarked for discussion in this tutorial is itemized herewith. A pdf of all lecture material and related notes will be provided to all attendees. Topics covered in the prior session will be briefly reviewed.

- Overview of MOS Transistor Modeling
- Noise Sources In NMOS and PMOS Devices
- Gain and Bandwidth Optimization In Common Source Amplifiers
- Broadband Architectures
  - *Pole-Zero Offset Via Source Terminal Impedance Degeneration*
  - *Optimized Shunt Peaking For Maximally Flat Magnitude Response*
  - *Optimized Series Peaking*
  - *Constant Resistance Series-Shunt Peaking*
  - ***Distributed Amplifier***
- Lossless Filters
  - *LC Pads*
  - *Tapped Coil Pads*
  - *Tapped Capacitor Pads*
  - *Constant Resistance Architectures*
- Linearity Considerations

Harmonic Distortion
Intermodulation Products
Spurious Free Dynamic Range

TUTORIAL PREREQUISITES

The professional credentials of tutorial attendees should include the equivalent of a baccalaureate degree in electrical engineering. In addition, either a masters degree in electrical engineering or three -to- five years of analog integrated circuit design experience is recommended.

THE LECTURER

John Choma earned his B.S., M.S., and Ph.D. degrees in electrical engineering from the University of Pittsburgh in 1963, 1965, and 1969, respectively. He is a Fellow at Scintera Networks in San Jose, California, and is Professor of Electrical Engineering at the University of Southern California, where he teaches undergraduate and graduate courses in electrical circuit theory, filters, and analog integrated electronics. Prof. Choma also holds a joint USC appointment as Professor of System Architecture Engineering. Prof. Choma has consulted extensively in the areas of broadband analog and high-speed digital integrated circuit analysis, design, and modeling.

Prior to joining the USC faculty in 1980, Prof. Choma was a senior staff design engineer in the TRW Microelectronics Center in Redondo Beach, California. His earlier positions include technical staff at Hewlett-Packard Company in Santa Clara, California, Senior Lecturer in the Graduate Division of the Department of Electrical Engineering of the California Institute of Technology, lectureships at the University of Santa Clara and the University of California at Los Angeles, and a faculty appointment at the University of Pennsylvania.

Prof. Choma, the author or co-author of some 150 journal and conference papers and the presenter of more than sixty invited short courses, seminars, and tutorials, is the 1994 recipient of the Prize Paper Award from the IEEE Microwave Theory and Techniques Society. He is the author of a Wiley Interscience text on electrical network theory and a forthcoming World Scientific Press text on feedback circuit design for communication system applications. Prof. Choma has contributed several chapters to five edited electronic circuit texts, and he is an area editor of the IEEE/CRC Press *Handbook of Circuits and Filters*.

Prof. Choma has served the IEEE Circuits and Systems Society as a member of its Board of Governors, its Vice President for Administration, and its President. He has been an Associate Editor and Editor–In–Chief of the *IEEE Transactions on Circuits and Systems, Part II*. He is an Associate Editor of the *Journal of Analog Integrated Circuits and Signal Processing* and a former Regional Editor of the *Journal of Circuits, Systems, and Computers*.

A Fellow of the IEEE, Prof. Choma has been awarded the IEEE Millennium medal, and he has received three awards from the IEEE Circuits and Systems Society; namely, the Golden Jubilee Award, the 1999 Education Award, and the 2000 Meritorious Service Award. He is also the recipient of several local and national teaching awards. Prof. Choma has served as a "Distinguished Lecturer" in the IEEE Circuits and Systems Society.

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