

TUTORIAL PROPOSAL for VLSI 2011

Radio receivers circuit design

Presenter:

Danilo Manstretta

Department of Electronics

University of Pavia, Pavia - Italy

Abstract:

The RF front-end is a key part of integrated wireless radio receivers. This tutorial will present the main circuit design techniques of low-noise amplifiers, down-conversion mixers and voltage-controlled oscillators. The main metrics used in the design of these blocks will be introduced: receiver noise figure, second and third-order intercept points, gain compression/ expansion, impedance matching and oscillators phase noise.

Contact Address:

Dipartimento di Elettronica

Via Ferrata,1

27049 Pavia

Italy

Target Audience:

The intended audience is analog and RF design engineers with limited experience with the design of RF IC front-end circuits and graduate students pursuing their studies in analog and RF IC design.

Keywords:

RF front-end, low noise amplifier, down-conversion mixer, voltage-controlled oscillator, noise figure, IIP2, IIP3, compression point, phase noise, impedance matching, inductive-degeneration amplifier, shunt-feedback, Gilbert cell, current-mode, voltage-mode, passive mixers, negative gm, LC oscillator, impulse, sensitivity function

Detailed program

The proposal is for a half-day tutorial. The tutorial will cover circuit design aspects of the main building blocks of integrated wireless receiver front-ends: low-noise amplifiers, down-conversion mixers and voltage-controlled oscillators.

1. Receiver design metrics (1/2 hr)

The main design metrics used in wireless receivers design will be reviewed with special emphasis on the aspects related to the circuit blocks covered in the tutorial. The concept of receiver noise figure, second and third-order intercept points, gain compression/ expansion, impedance matching and oscillators phase noise will be reviewed.

2. Low-noise amplifiers (3/4 hr)

The main design stages used to achieve low-noise impedance matching will be analyzed: common-gate amplifier, inductive-degeneration amplifier, common-source amplifier with shunt feedback, common-gate amplifier with shunt and series feedback. The performances in terms of noise, linearity, power dissipation and achievable bandwidth will be derived for each stage. A final comparison will be given with the main applications of each stage.

3. Down-conversion mixers (1 hr)

The basic analysis framework for periodic time-varying circuits will be briefly reviewed, with specific emphasis on noise and non-linearity in direct down-conversion mixers. The basic down-conversion stages will be analyzed: active current-commutating (Gilbert cell), passive voltage-mode and passive current mode. Circuit techniques to circumvent common design issues in direct down-conversion mixers such as flicker noise and IIP2 will be described.

4. Voltage-controlled oscillators (3/4 hr)

Starting from the basic LC resonator the oscillation conditions and the operating regimes (current-limited and voltage-limited) of a classic negative-gm LC oscillator will be derived. The fundamental processes leading to phase noise in the oscillator spectrum will be described, based on the impulse-sensitivity function model. The main LC oscillators topologies will be compared and the oscillator figure of merit will be defined.

Bibliography:

1. T. H. Lee, *The Design of CMOS Integrated Circuits*, Cambridge University Press
2. B. Razavi, *RF Microelectronics*, Prentice Hall
3. D. Manstretta, M. Brandolini, F. Svelto, *Second-order intermodulation mechanisms in CMOS down-converters*, IEEE JSSC, March 2003

Presenter Biography:

Danilo Manstretta (M'03) received the Laurea degree (summa cum laude) and the Ph.D. degree in electrical engineering and computer science from Università degli Studi di Pavia, Pavia, Italy, in 1998 and 2002, respectively. During his studies, he worked on CMOS RF front-end circuits for wireless applications. From 2001 to 2003 he was with Agere Systems as a Member of Technical Staff, working on WLAN transceivers and linear power amplifiers for base stations. From 2003 to 2005 he was with Broadcom Corporation, Irvine, CA, working on RF tuners for TV applications. In 2005 he joined the Università degli Studi di Pavia, Pavia, Italy, as an Assistant Professor and was granted tenure in 2008. His research interests are in the field of analog, RF and millimeter-wave integrated circuit design. He was a co-recipient of the 2003 IEEE Journal of Solid State Circuits Best Paper Award. Since 2006 he has been member of the Technical Program Committee of the IEEE Radio Frequency Integrated Circuits conference.