Introduction to RF IC Design
From concept to implementation

Eng. Pedro Toledo

NSCAD Microeletronica

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Introduction

The main goal of this course is to broadcast the RF IC Design knowledge for the the Laboratorio de Microelectrónica -Sección Electricidad y Electrónica - Pontificia Universidad Católica del Perú. This report summarizes all topics that will be taught during the entire course.

1 Basic Concepts in RF Design: From communication theory perspective

1.1 Analog Modulations

Amplitude and *Phase* and *Frequency Modulation* will be the topics addressed in this [Razavi (2011)].

1.2 Digital Modulations

Introduction to Hilbert Space, *Quadrature Modulation*, *GMSK* and *GFSK Modulation*, *Quadrature Amplitude Modulation* and *Orthogonal Frequency Division Multiplexing* will be the topics addressed in this sections [Razavi (2011)].

1.3 Multiple Access Techniques and Some Wireless Standard

Concepts such as *Time and Frequency Division Duplexing*, *Frequency-Division Multiple Access*, *Time-Division Multiple Access* and *Code-Division Multiple Access* are studied in this sections as well as several wireless standards like *GSM*, *Bluetooth* and *ZigBee* [Razavi (2011) and Nguyen *et al.* (2006)].

2 Basic Concepts in RF Design: From system design perspective

2.1 Transceiver Architecture

Receiver Architectures *Basic and Modern Heterodyne*, *Direct-Conversion*, *Image-Reject* and *Low-IF Receivers* will the the topics addressed in this part of course [Razavi (2011)].

Transmitter Architectures *Modern Direct-Conversion*, *Heterodyne* and *Polar Architectures* will the topics addressed in this part of course [Razavi (2011)].

Synthesizers Architectures Basics concepts of *integer-N* and *fractional-N synthesizers* will be shown, including analysis of their dynamics and their non-idealities [Razavi (2011)].

2.2 RF Figures of Merit

Noise Concepts, such as *Noise as a Random Process*, *Noise Spectrum*, *Device Noise*, *Representation of Noise in Circuits*, *Sensitivity*, *Dynamic Range* and *cascaded noise figure*, will be studied in this part of course [Razavi (2011)].

Phase Noise *Phase Noise Basic Concepts*, *Effect of Phase Noise* and *Analysis of Phase Noise* are the basic subjects of this part of course [Razavi (2011)].

Non-linearity *Harmonic Distortion*, *Gain Compression*, *Cross Modulation*, *Intermodulation*, *Cascaded Nonlinear Stages*, *AM/PM Conversion* and *I-Q Mismatch* will the topics addressed in this part of course [Razavi (2011)].

Quantization Noise of Data converter The question, "*How to define the ADC and DAC resolution and sample rate for a specified radio ?*", is here answered [Marcelo Negreiros et Fabris (2015)].

EVM and Output Transmitter Power The importance of *EVM* and *minimum output power* for the communication link is here discussed [Razavi (2011)].

2.3 Specifying a Zigbee Transceiver

To make sure that all previous concepts have been learned by the attendees, a ZigBee radio is here defined from scratch delivering specifications such as *receiver noise figure*, *receiver IIP3 or P1dB*, *receiver I/Q Mismatch*, *Synthesizer Frequency Planning*, *Synthesizer Phase Noise and Spurs*, *transmitter output power* and *transmitter P1dB* Nguyen *et al.* (2006)].

3 CMOS Implementation of RF Blocks

The RF Blocks designed in this part of course are inserted in CMOS ZigBee solution developed in the IC Brazil Program context. Figure 1 shows the entire radio solution in which the *LNA*, the *receiver mixer* and the *synthesizer VCO* used in this course as example are highlighted.

3.1 LNA Design

Introduction to LNA LNA Topologies are introduced: *Common-Source Stage with Inductive Load*, *Common-Source Stage with Resistive Feedback*, *Common-Gate Stage*, *Cascode CS Stage with Inductive Degeneration* and *Noise-Cancelling LNAs*;

ZigBee LNA Implementation A design recipe for *Common-Source Stage with Inductive Load* is presented

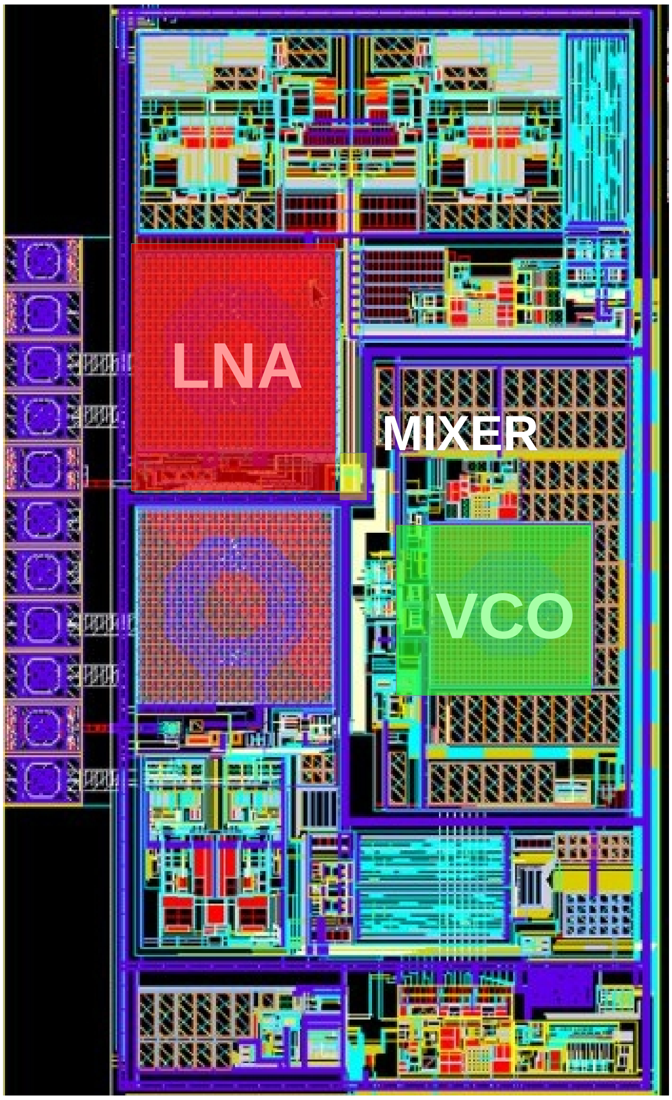

Fig. 1. IEEE 802.15.4 RF Frontend Transceiver

3.2 Mixers Design

Introduction to Mixers theory Topics which will be addressed are *Single-Balanced* and *Double-Balanced Mixers*, *Passive Downconversion Mixers*, *Active Downconversion Mixers with Current-Source Helpers*, *with Enhanced Transconductance*, *with High IP2 and with Low Flicker Noise.*

Downconverter ZigBee Mixer Implementation A design recipe for *Passive Downconversion Mixers* is presented

3.3 VCO Design (optional)

VCO Design (optional) *Basic Principles: Feedback View of Oscillators* and its *Mathematical Model of VCOs* will be described in this part of course [Razavi (2014a,b, 2015)].

ZigBee VCO Implementation (optional) A design recipe for *Cross-Coupled Oscillator* is presented.

4 RF Design Trends

4.1 Low Power Strategies

Mainly strategies, shown in [Burdett (2015)], are shown and analyzed in this part of program.

4.2 Discrete time Implementations

There have been a trend to use discrete time processing for RF Blocks. Some interpretations about this topic will be addressed herein as well [Staszewski (2011)].

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