

TSEK03: Radio Frequency Integrated Circuits (RFIC)

Lecture 1a: Introduction

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RFIC – Main Objectives

- Advanced continuation of TSEK02 Radio Electronics
- Main focus is on CMOS digital transceivers
- Main building blocks of digital transmitters and receivers
- Often the RX is more demanding => focus on downconversion, noise calculations/considerations
- Different architectures for each block are presented
- Design trade-offs for these building blocks are discussed
- Tutorials: dedicated to calculation of different metrics associated to these blocks (a lot of circuit analysis!)
- Lab sessions: main focus is on practical design issues, both measurements and simulations.

RFIC – Course Organization

- Lectures: 11 x 2h
- Tutorials: 6 x 2h
- Labs: 3 x 4 h – Sign-up is required for Lab 1 (ES lab) (if more than six students)

- Examination: Written exam at the end of the course
To pass: Attend the labs (1.5 HP)
Pass the written exam (4.5 HP)

- Examinations: 2018-10-22, 08-12
2019-01-07, 14-18
Aug 2019

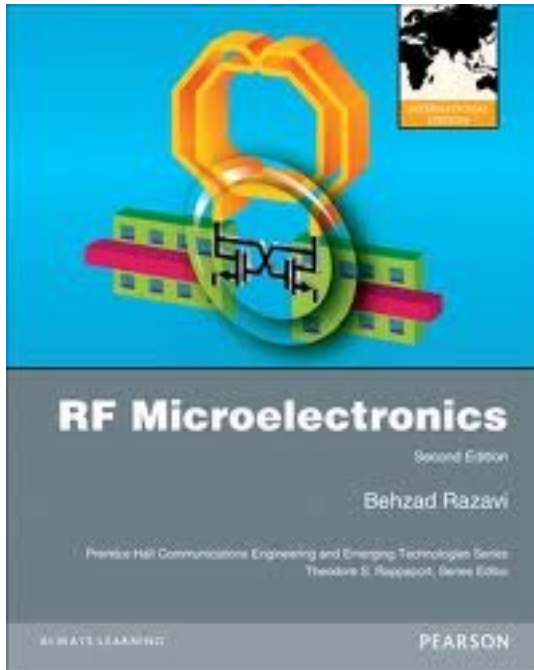
Schedule

- Link to TimeEdit: <https://cloud.timeedit.net/liu/web/schema/ri1X50gQ3560YvQQ06Z9175Y0Zy4507550Y58Q771.html>
- Location "Nollstället" for all lectures and tutorials.
- Lab 1: LNA circuit design in Cadence, computer lab (Sep 26)
- Lab2: LNA measurements, EKS-lab, 3D:542, 6 students/group, sign up (Doodle?) (Oct 3 + 10)
- Lab 3: Mixer circuit design in Cadence, computer lab (Oct 17)

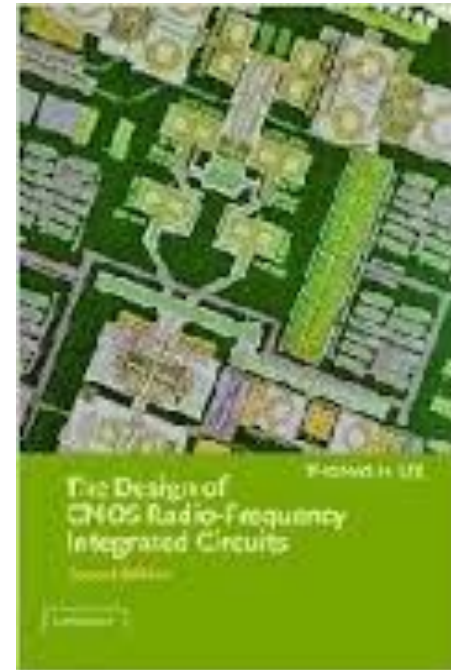
Labs

- All labs include have preparatory material that you should read carefully and assignments in the lab manual that you should complete prior to performing the lab work.
- Lab 1 & 3 are Cadence spectre simulation labs of LNA and mixer performance.
- Lab 2 is about measurements of performance parameters of a low-noise amplifier (LNA) operating in the FM broadcast band: linearity, compression point, SFDR, noise figure. Sign-up is required, 6 students each time.
- Lab manuals will be downloadable from the course home page.

Course material



B. Razavi,
RF Microelectronics,
2nd ed., Prentice Hall, 2012
(paper back int. version).



T. H. Lee,
*The design of CMOS radio-
frequency integrated circuits*,
2nd ed., Cambridge, 2004,
(optional).



Course homepage

- www.isy.liu.se/en/edu/kurs/TSEK03/

Or just google "TSEK03"!

Lecture notes,
tutorials + solutions,
home work,
lab manuals + reading,
old exams.

The screenshot shows the course homepage for TSEK03 - Radio Frequency Integrated Circuits. The page is part of the Department of Electrical Engineering at Linköping University. The header includes the university logo and a search bar. The main content area is titled "TSEK03 - Radio Frequency Integrated Circuits" and includes a "NEWS 2017" section with a welcome message for the first lecture. The "GENERAL" section provides details about the course code, required background, goal, content, and course books. A sidebar on the right lists navigation options: Lectures, Lessons, Laboratories, Exams, and Course syllabus. The left sidebar contains a navigation menu with categories like Information, Education, and Division.

RFIC - Staff

- Ted Johansson
- Docent, Adjunct Professor
- Integrated Circuits and Systems (EKS), Dept. of Electrical Engineering (ISY)
- ted.johansson@liu.se, people.isy.liu.se/eks/ted/
- Lectures, examiner.

Ted Johansson: CV in short

- 1985: M.Sc. (Y, LiU + RWTH, Germany)
- 1985-1989: Institute of Microelectronics, Kista
- 1989-2002: Ericsson Microelectronics, Kista
- 1992-1998: Industrial PhD (LiU)
- 2002-2007: Infineon Technologies, Kista
- 2008-2011: Huawei R&D Center, Kista
- Own company/consulting 2008-
- Adjunct professor (external, part-time): 2009-
Docent 2015
Research on PA design in CMOS
PhD supervision
2015-/HT2: undergraduate course TSEK02
2015-/VT1: undergraduate course TSEK03
2017-/HT1: undergraduate course TSEK38



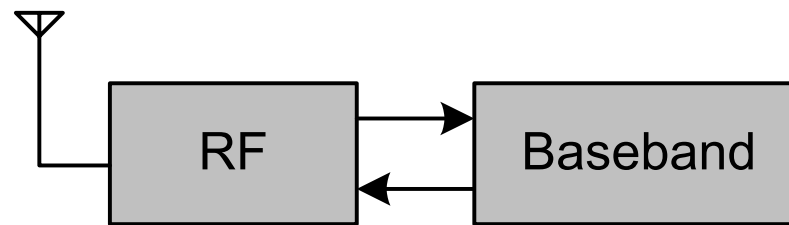
RFIC - Staff

- Oscar Morales
- Research Assistant
- Integrated Circuits and Systems (EKS), Dept. of Electrical Engineering (ISY)
- oscar.morales@liu.se
- Tutorials, labs.



RFIC – Course Content

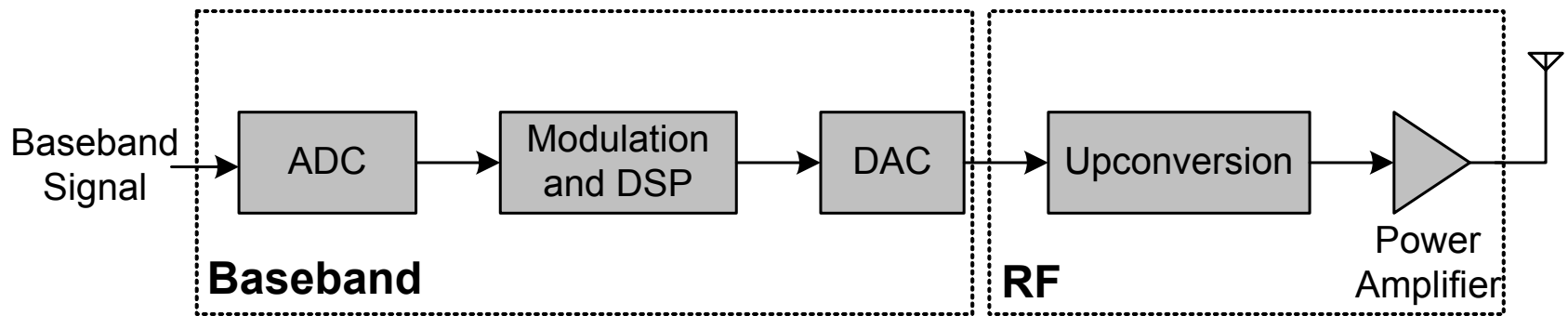
- RF Transceivers



- RF section consists of mostly analog circuits.
- Baseband is mostly digital and it processes data, which should be sent to or received from the RF part.
- In this course, we will focus on building blocks in the RF part.

RFIC – Course Content

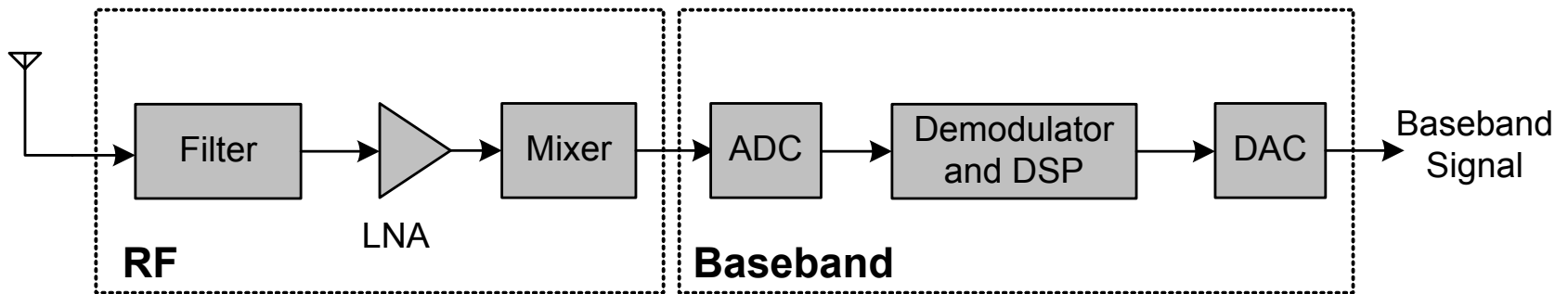
- Digital RF Transmitter



- Baseband signal is compressed and coded and modulated in the first step.
- In the RF part, upconversion is performed and the signal is amplified in order to be transmitted.

RFIC – Course Content

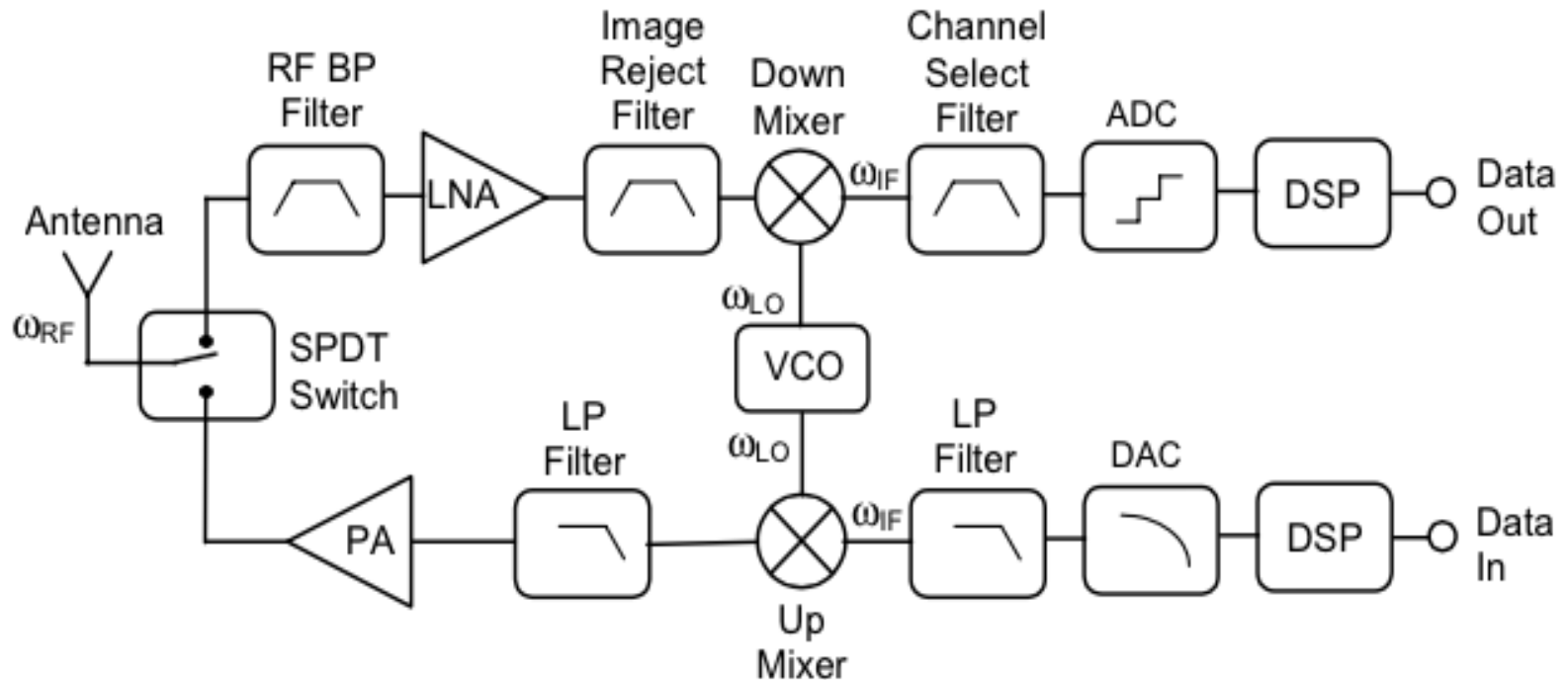
- Digital RF Receiver



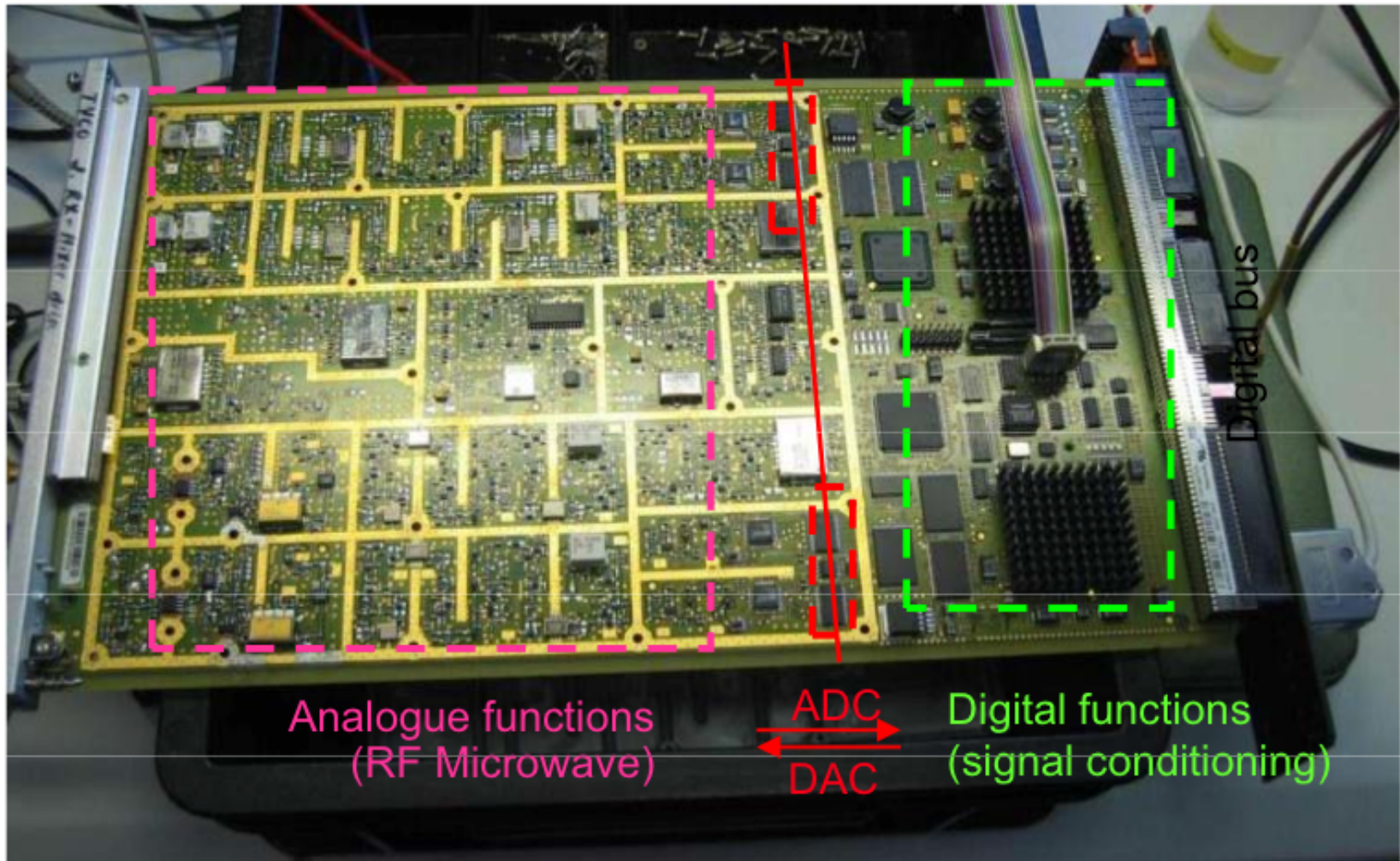
- In the RF part, received signal is filtered and amplified by a low-noise amplifier (LNA). Then image rejection and down conversion is performed.
- Decoding and demodulation is performed in baseband section.

RFIC – Course Content

- "Real" Superheterodyne "sampling-IF" (TDD)



Analog vs. digital – the radio



RFIC – Course Content

- RF building blocks which are used in RF digital transceivers are discussed in this course:
 - Low-noise amplifiers (LNAs)
 - Mixers
 - Oscillators
 - Frequency synthesizers (PLLs)
 - Power amplifiers (PAs)
- Different design perspectives and with different architectures are discussed
- Performance metrics are introduced
- Practical design challenges are presented

RFIC – Course Content

LECTURES OVERVIEW

- ▶ L1: Course introduction. Noise, Ch 2.3. Tu1: noise
- ▶ L2: continued
- ▶ L3: Linearity, impedance transformation, s-parameters, Ch. 2.2, 2.5, 2.6. LNA, Ch. 5.1-5.3. Tu2: LNA
- ▶ L4: continued Tu3: mixers
- ▶ L5: Mixers, Ch 6.1-6.3.
- ▶ L6: continued Tu4: oscillators
- ▶ L7: Passive devices, Ch 7.
- ▶ L8: Oscillators, Ch. 8.1-8.7
- ▶ L9: continued Tu5: PLL + PA
- ▶ L10: PLL, Ch.9.1-9.3 + highlights from Ch. 10 and 11.
- ▶ L11: PA, Ch. 12.1-12.4. Tu6: repetition

Background material/knowledge

- Analog CMOS design (circuit analysis, oscillators, PLL; Razavi's Analog book).
- System understanding: TSEK02 Radio Electronics (Razavi RF book ch 2 (parts), 3, 4).
- Transfer functions, Laplace transforms.

<i>Chapter</i>	<i>Concept</i>	<i>Architecture</i>	<i>Circuit analysis</i>	<i>Theory</i>
Noise	+	-	+++	+
LNA	+	++	+++	+
Mixer	++	++	++	++
Oscillator	++	+	++	+
PLL	+++	+++	+	+++
PA	+	+	-	

Background material/knowledge

- Razavi's Analog book, used in TSEK37 Analog CMOS.
- circuit analysis, oscillators, PLL.

