TSEK03: Radio Frequency Integrated Circuits (RFIC)

Lecture 1a: Introduction

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LINKÖPING UNIVERSITY

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 2 (in the EKS lab): six students per lab
- 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: 2019-10-21, 08-12
  2020-01-07, 14-18
  Aug 2020

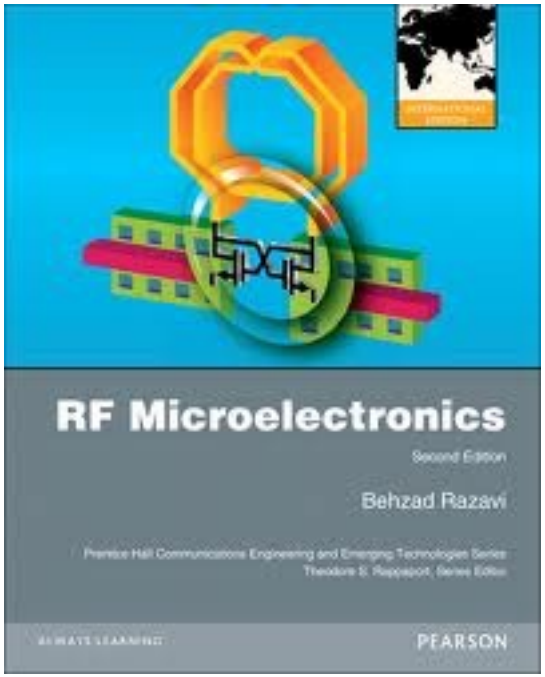
Schedule

- Link to TimeEdit: https://cloud.timeedit.net/liu/web/schema/s/s.html?tab=3&object=CO_94326&type=Alla&p=0.n,6.n
- Location ”Nollstället” for all lectures and tutorials. Lab 1: LNA circuit design in Cadence, lab ”Southfork”, Sep 18.
- Lab2: LNA measurements, EKS-lab, 3D:542, six students/group, sign up required (Lisam), Sep 25 & Oct 2.
- Lab 3: PA circuit design with GoldenGate and ADS, lab Olympen, Oct 17.

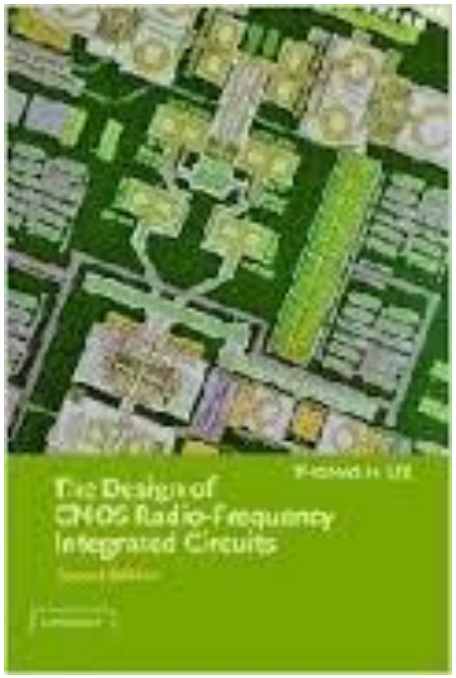
Labs

- 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 is Cadence spectre simulation labs of LNA design and PA design/new design tools.
- 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, six students each time.
- Lab 3 is using Keysight's GoldenGate in Cadence (replacement for spectre) and ADS with Cadence schematics.
- Lab manuals will be downloadable from the course home page.

Course material



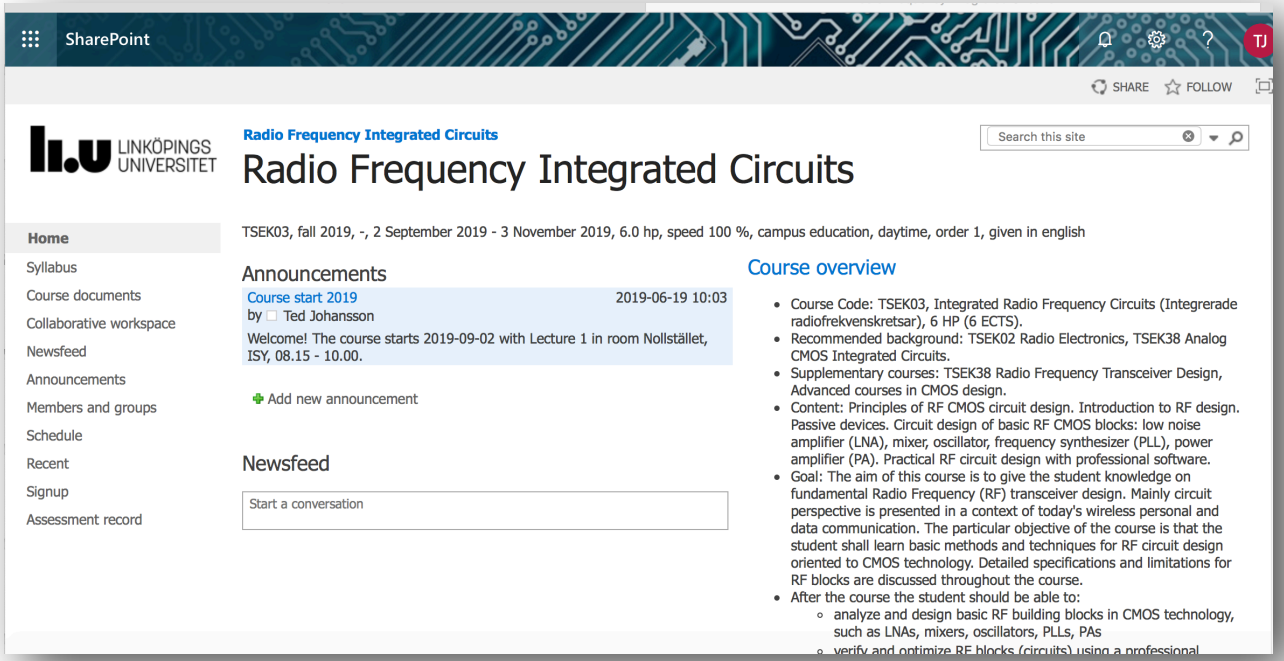
B. Razavi,
RF Microelectronics,
2nd ed., Prentice Hall, 2012
(paper back int. version).



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


ni.com/eumw

Lisam: register to access!



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

RFIC - Staff

- Ted Johansson
- Docent, Adjunct Professor
- Integrated Circuits and Systems (EKS), Dept. of Electrical Engineering (ISY)
- ted.johansson@liu.se, https://liu.se/medarbetare/tedjo76

- Lectures, lab 3, 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

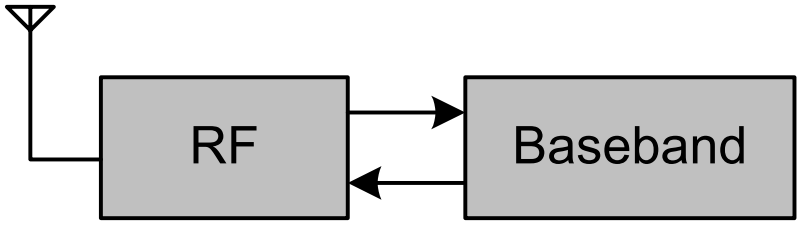
RFIC - Staff

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

- Tutorials, labs 1 and 2.

RFIC – Course Content

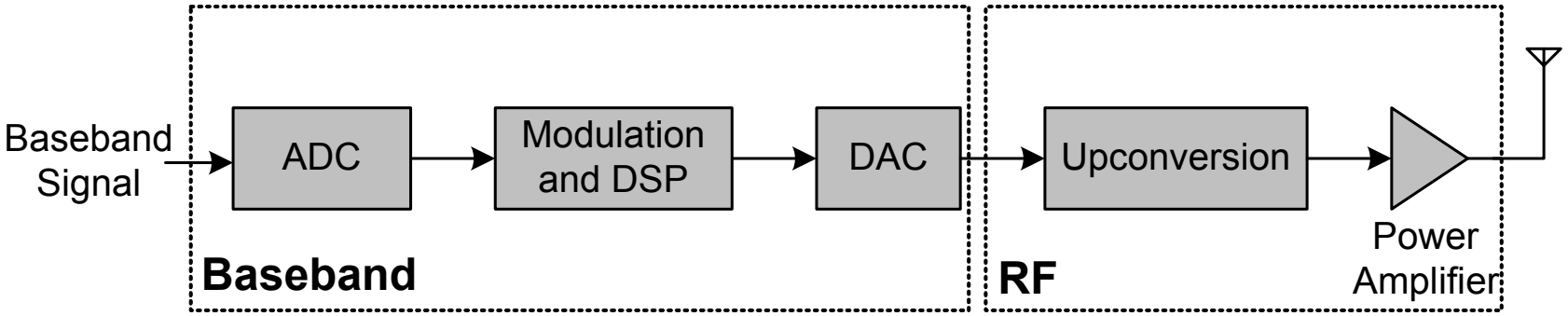
- RF Transceivers



- 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

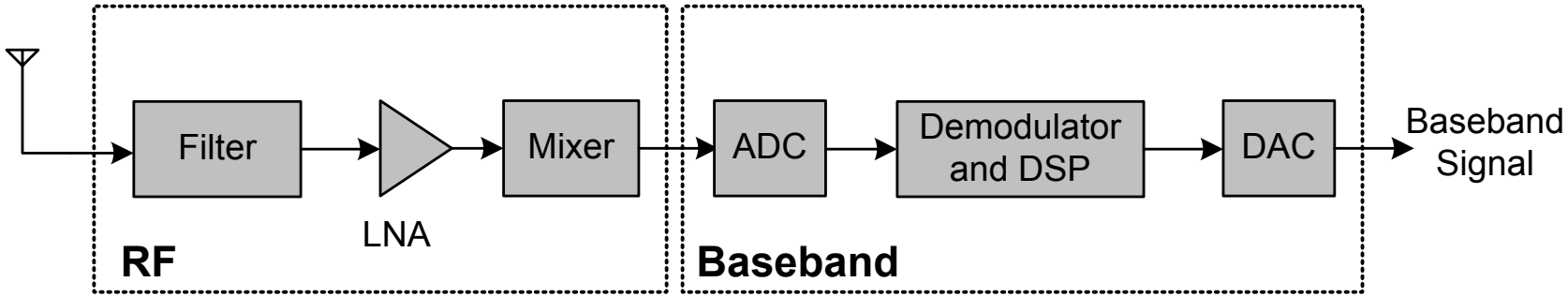
- Digital RF Transmitter



- 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

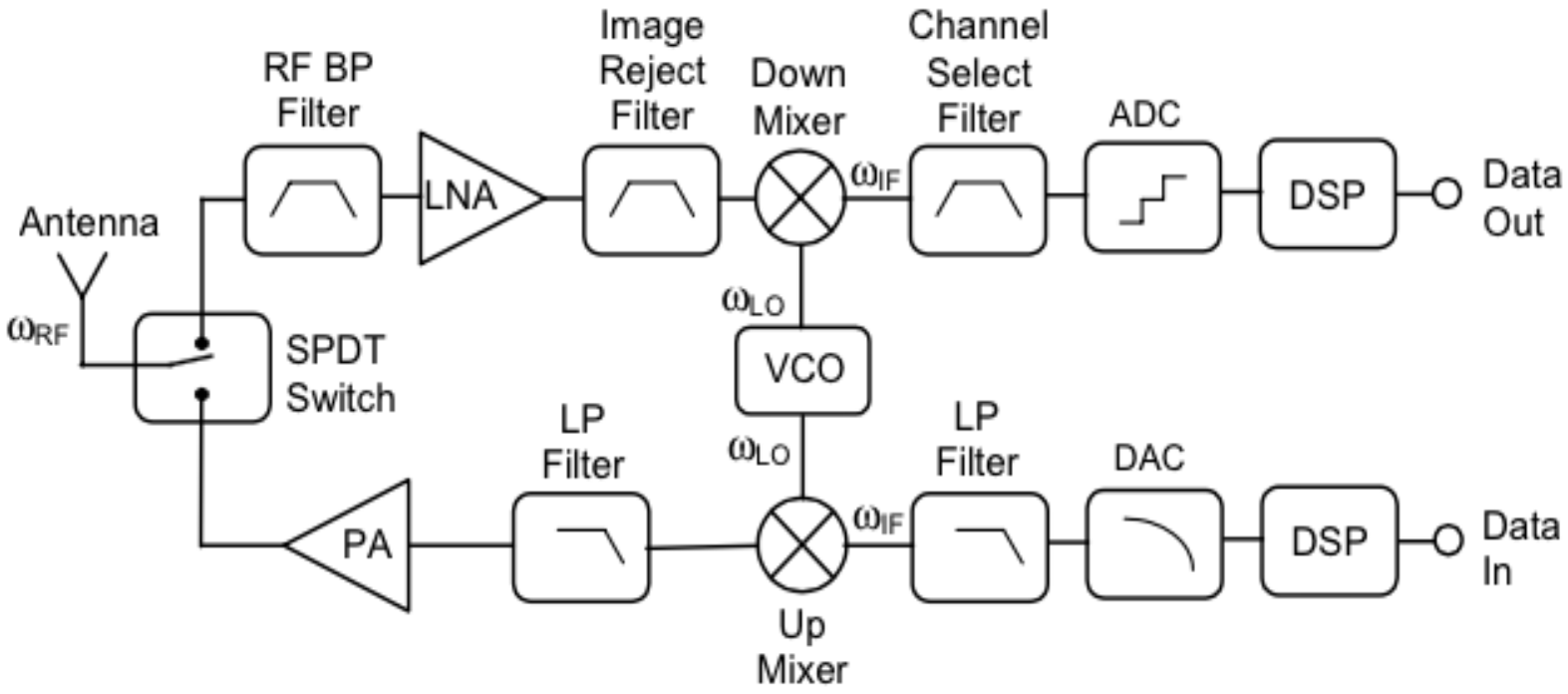
- Digital RF Receiver



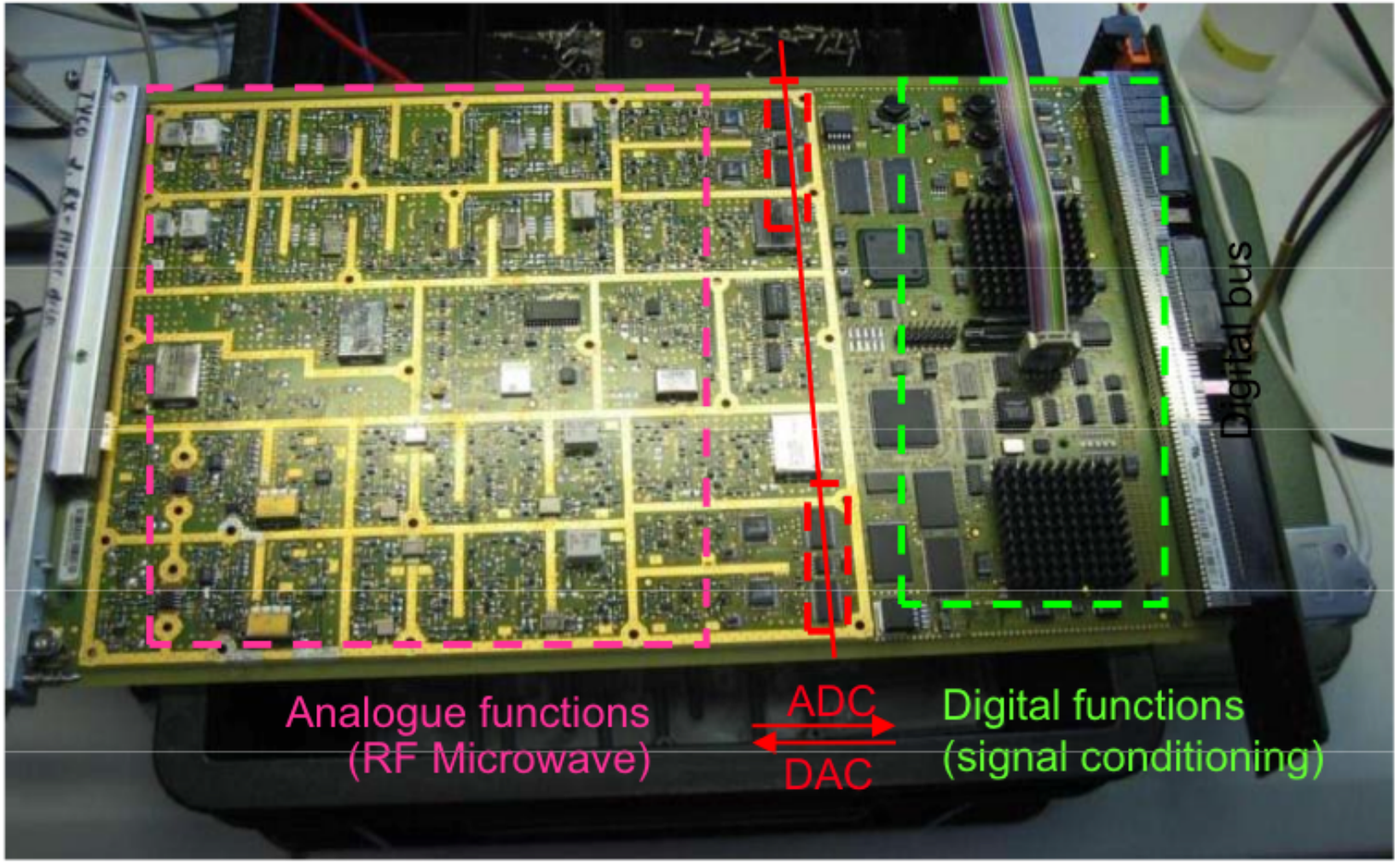
- In the RF part, received signal is filtered and amplified by a low-noise amplifier (LNA). Then image rejection and down conversion is performed.
- Decoding and demodulation is performed in baseband section.

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.
- L2: continued
- L3: Linearity, impedance transformation, s-parameters, Ch. 2.2, 2.5, 2.6. LNA, Ch. 5.1-5.3.
- L4: continued
- L5: Mixers, Ch 6.1-6.3.
- L6: continued
- L7: Passive devices, Ch 7.
- L8: Oscillators, Ch. 8.1-8.7
- L9: continued
- L10: PLL, Ch.9.1-9.3 + highlights from Ch. 10 and 11.
- L11: PA, Ch. 12.1-12.4.

Tu1: noise

Tu2: LNA

Tu3: mixers

Tu4: oscillators

Tu5: PLL + PA

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.

Chapter	***Concept***	***Architecture***	***Circuit analysis***	***Theory***
Noise	+	-	+++	+
LNA	+	++	+++	+
Mixer	++	++	++	++
Oscillator	++	+	++	+
PLL	+++	+++	+	+++
PA	+	+	-	

Background material/knowledge

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