

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 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

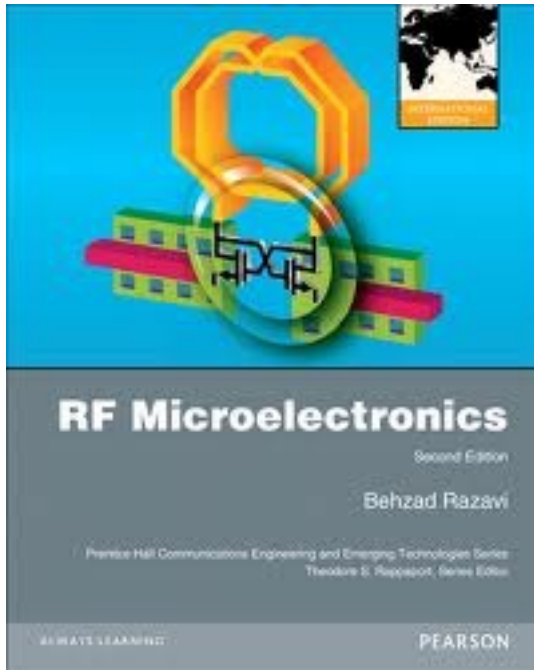
Schedule

- 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.

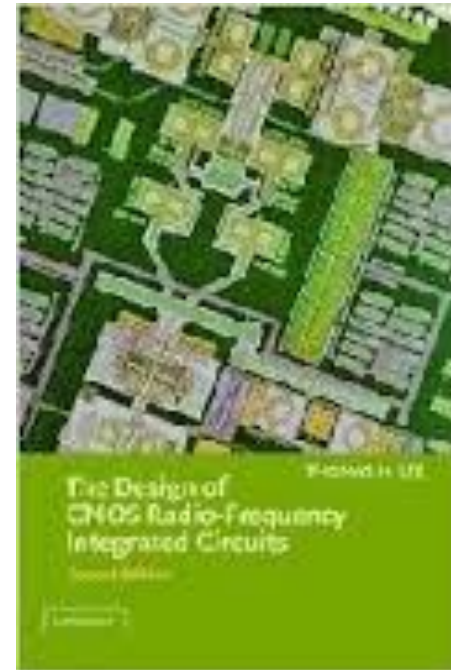
Labs

- 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



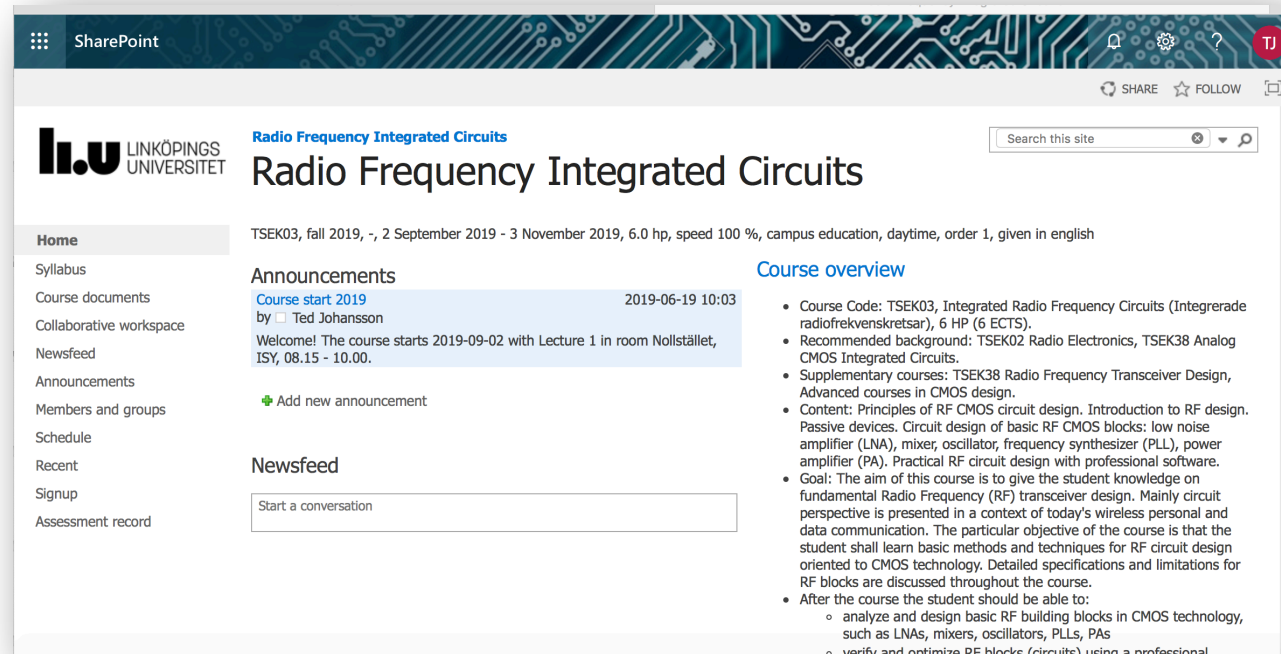
B. Razavi,
RF Microelectronics,
2nd ed., Prentice Hall, 2012
(paper back int. version).



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



Lisam: register to access!



SharePoint

LINKÖPING UNIVERSITET

Radio Frequency Integrated Circuits

TSEK03, fall 2019, -, 2 September 2019 - 3 November 2019, 6.0 hp, speed 100 %, campus education, daytime, order 1, given in english

Home

- Syllabus
- Course documents
- Collaborative workspace
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- Recent
- Signup
- Assessment record

Announcements

[Course start 2019](#) 2019-06-19 10:03
by Ted Johansson
Welcome! The course starts 2019-09-02 with Lecture 1 in room Nollstället, ISY, 08.15 - 10.00.

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Course overview

- Course Code: TSEK03, Integrated Radio Frequency Circuits (Integrerade radiofrekvenskretsar), 6 HP (6 ECTS).
- Recommended background: TSEK02 Radio Electronics, TSEK38 Analog CMOS Integrated Circuits.
- Supplementary courses: TSEK38 Radio Frequency Transceiver Design, Advanced courses in CMOS design.
- Content: Principles of RF CMOS circuit design. Introduction to RF design. Passive devices. Circuit design of basic RF CMOS blocks: low noise amplifier (LNA), mixer, oscillator, frequency synthesizer (PLL), power amplifier (PA). Practical RF circuit design with professional software.
- Goal: The aim of this course is to give the student knowledge on fundamental Radio Frequency (RF) transceiver design. Mainly circuit perspective is presented in a context of today's wireless personal and data communication. The particular objective of the course is that the student shall learn basic methods and techniques for RF circuit design oriented to CMOS technology. Detailed specifications and limitations for RF blocks are discussed throughout the course.
- After the course the student should be able to:
 - analyze and design basic RF building blocks in CMOS technology, such as LNAs, mixers, oscillators, PLLs, PAs
 - verify and optimize RF blocks (circuits) using a professional

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



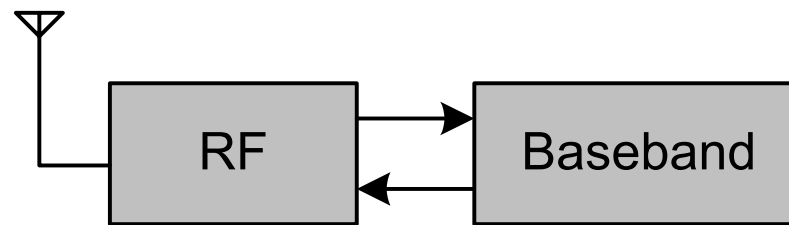
RFIC - Staff

- 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

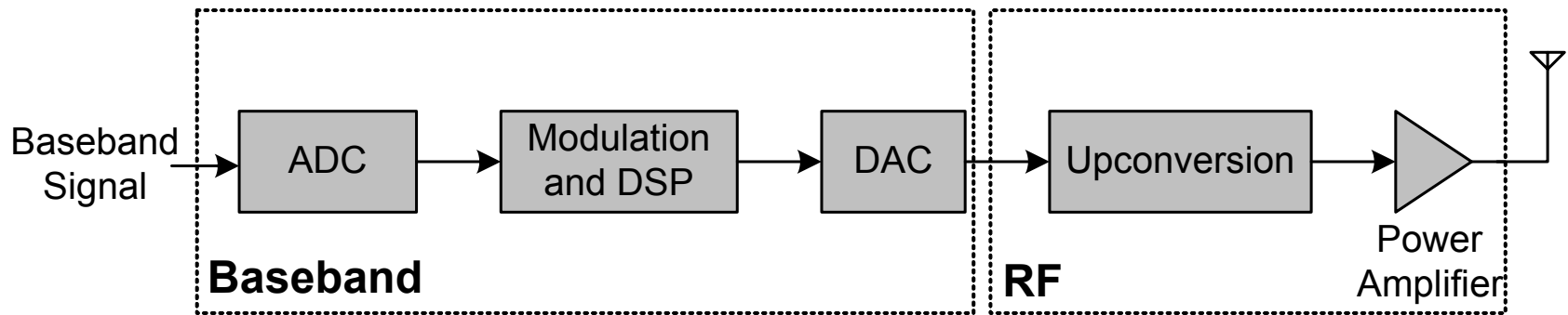
- RF Transceivers



- 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

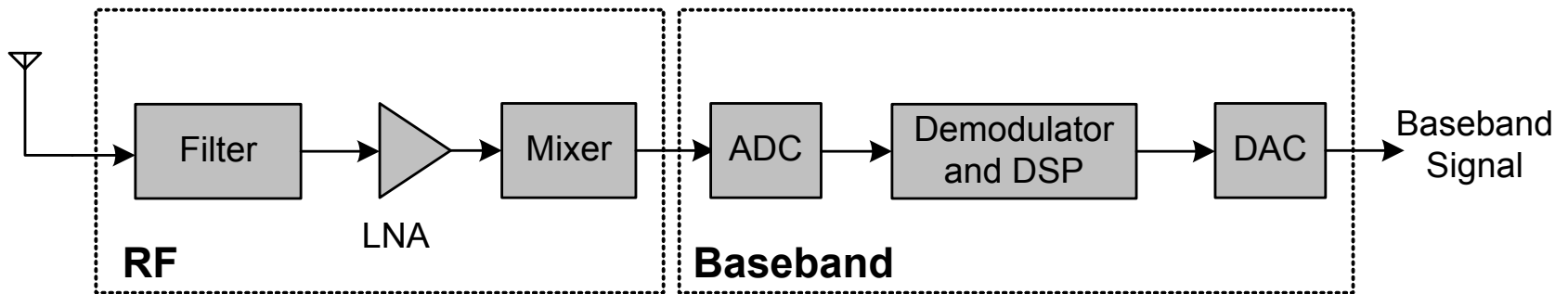
- Digital RF Transmitter



- 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

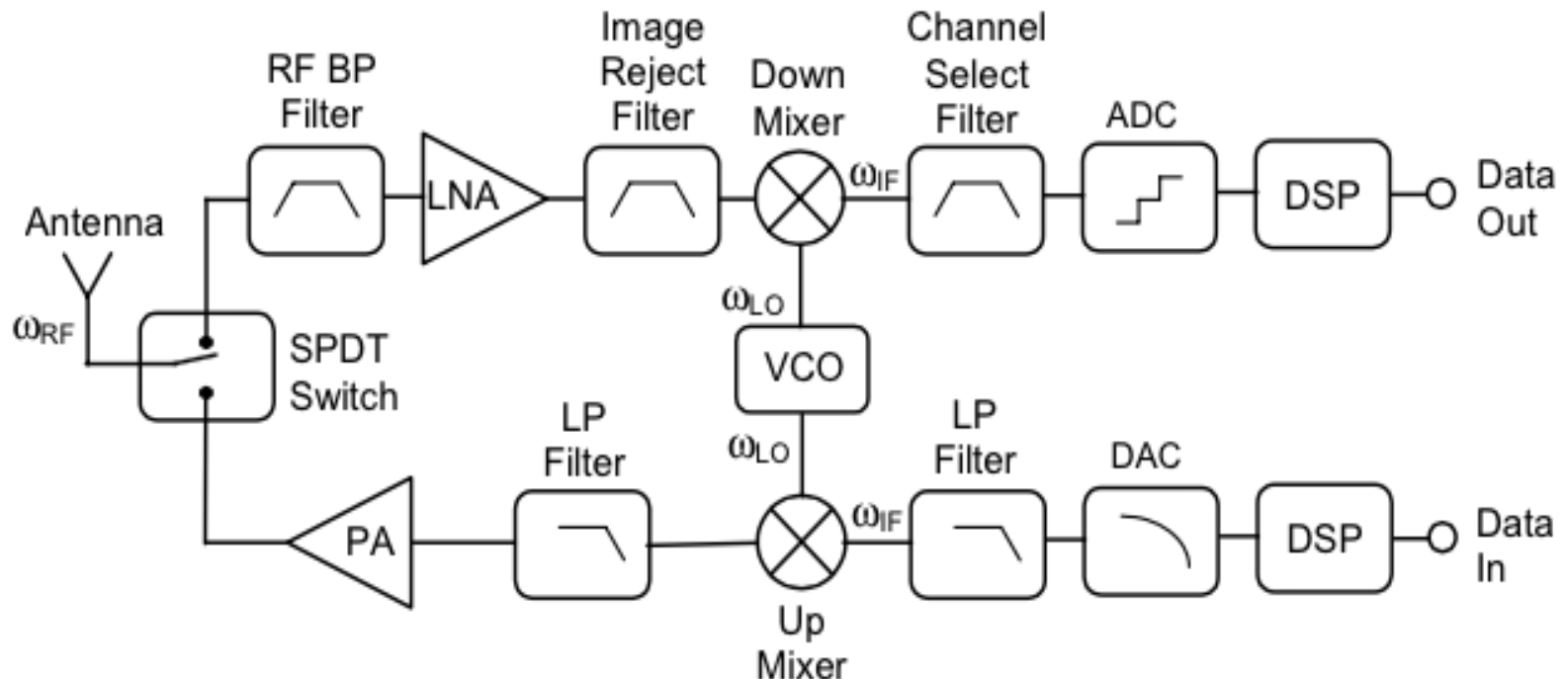
- Digital RF Receiver



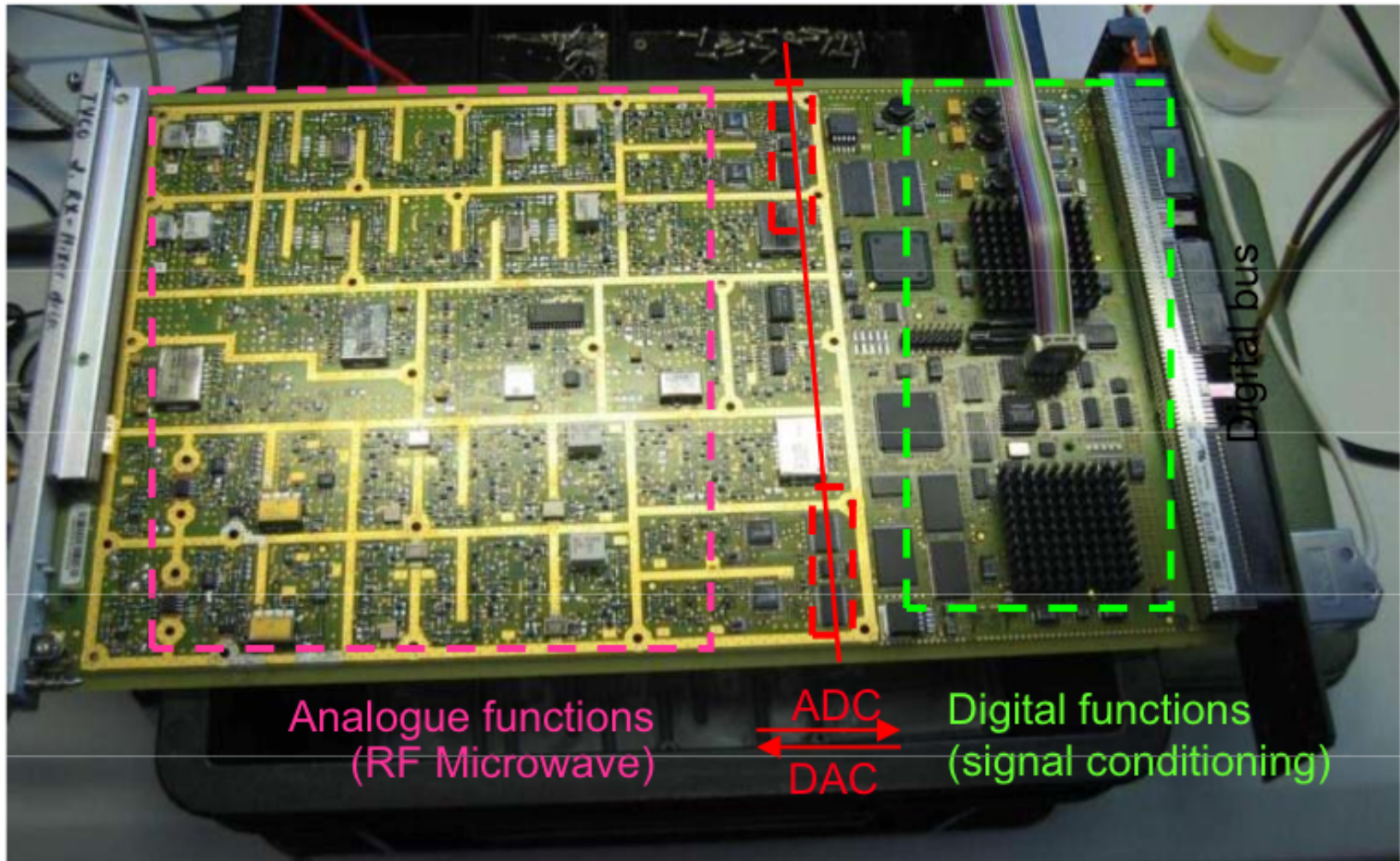
- In the RF part, received signal is filtered and amplified by a low-noise amplifier (LNA). Then image rejection and down conversion is performed.
- Decoding and demodulation is performed in baseband section.

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.

<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.

