

TSEK02: Radio Electronics

Lecture 1a:

Course Introduction

Ted Johansson, EKS, ISY

Objectives (from Studieinfo)

- The course gives the student basic knowledge in radio electronics. The system perspective is addressed both in the context of traditional radio and today's wireless communication systems.
The objectives of the course is that the student will learn operation principles of radio systems and their fundamental limitations.

After the course the students should be able to:

- explain the principles of radio transmission and reception
- explain the existing physical and technical limitations of a radio system
- analyze the functionality of radio transmitters and receivers
- calculate basic radio specifications in terms of power, gain, noise and frequency for basic modulation schemes
- explain differences between traditional radio and today's digital radio systems

Objectives (short version)

- You will acquire basic knowledge in radio electronics on a system level (no transistors!).
- You will be able to read and understand specifications of a modern wireless system and design the corresponding radio on a block diagram level.

Course Outline

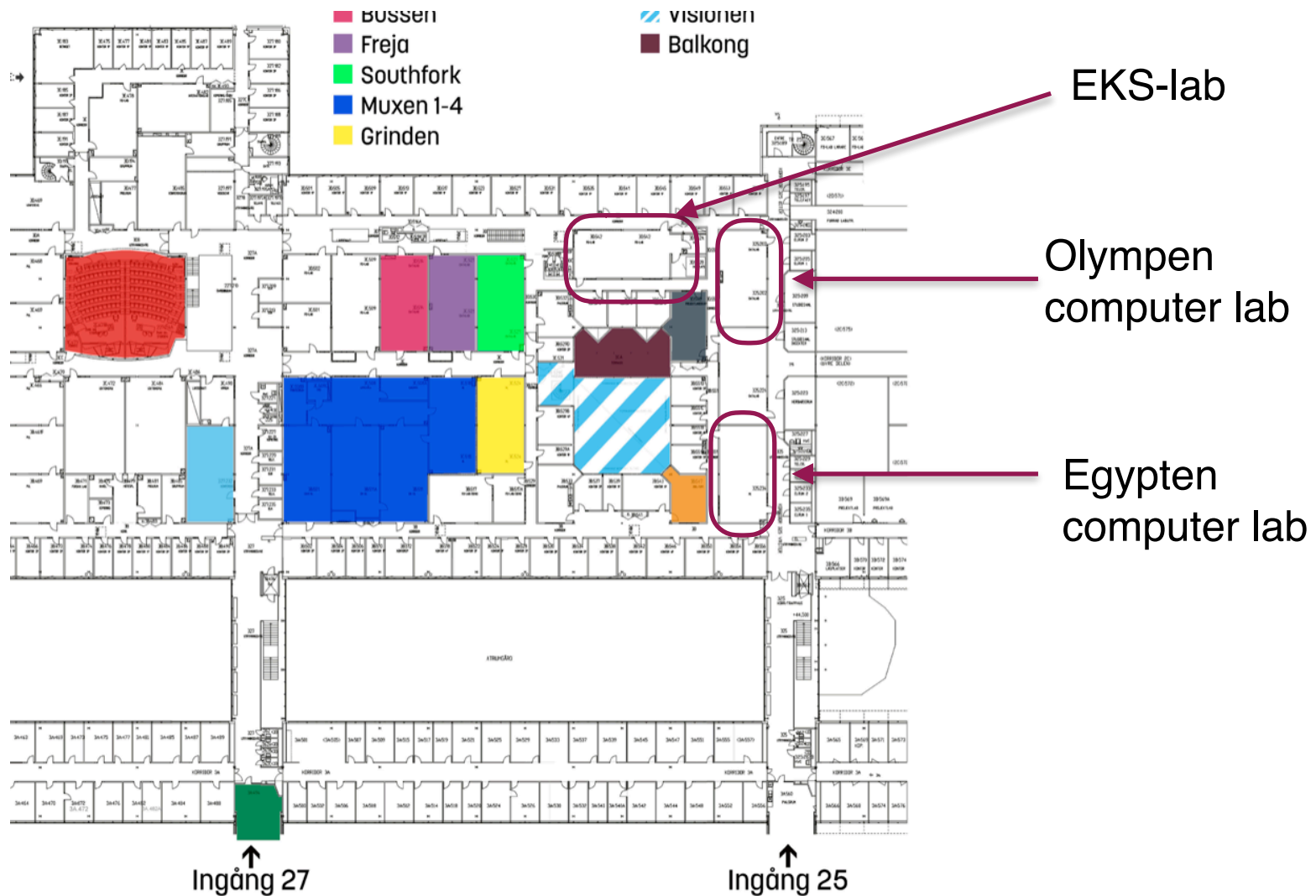
- Lectures: 8 x 2h
- Tutorials: 5 x 2h
- Labs: 2 x 4h 1. Simulation lab (OLYM/EGYP)
 2. Measurement lab (EKS-lab)
 Sign-up is required for both labs
- Exam preparation: 1 x 2h
- Examination: Written exam at the end of the course.

Labs

- Lab 1 (Egypten/Olympen), MATLAB simulations:
 - half of the group (max ?) Nov 26, 17-21. Preliminary
 - half of the group (max ?) Nov 27, 17-21. Preliminary
- Lab 2 (EKS-lab 3D:542), measurements:
 - 6 students/group, Dec 3, 4, 10, 11, 17, 18.
(we probably only need 4 times). Preliminary

B-house, upper floor

6



Lectures (8)

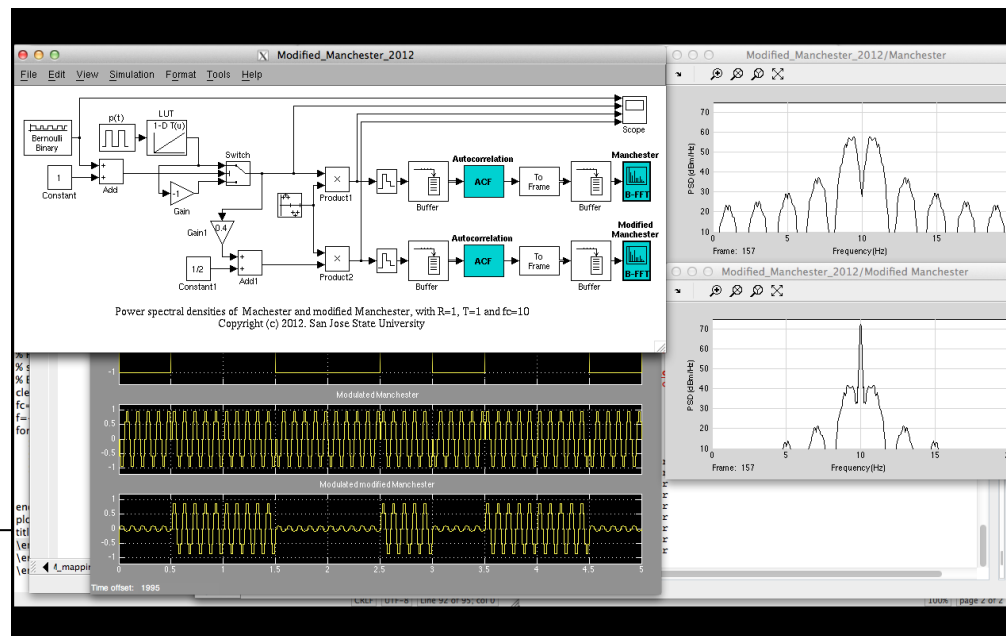
- Theoretical concepts, fundamental and practical limitations, design techniques.
- A logical and homogenous approach to radio design is applied: from baseband, the modulator to transmitter, channel, the receiver, demodulator, and baseband again.

Tutorials (5)

- After each topic you will practice the new knowledge by solving selected problem to complement to the lectures.
- The answer to these questions will be given so that you can verify your solution.
- Some of the problems will be selected and solved on the board in tutorial sessions.
- You are always welcome to ask if you need more explanation on these problems.
- Last tutorial will be a preparation for the exam.

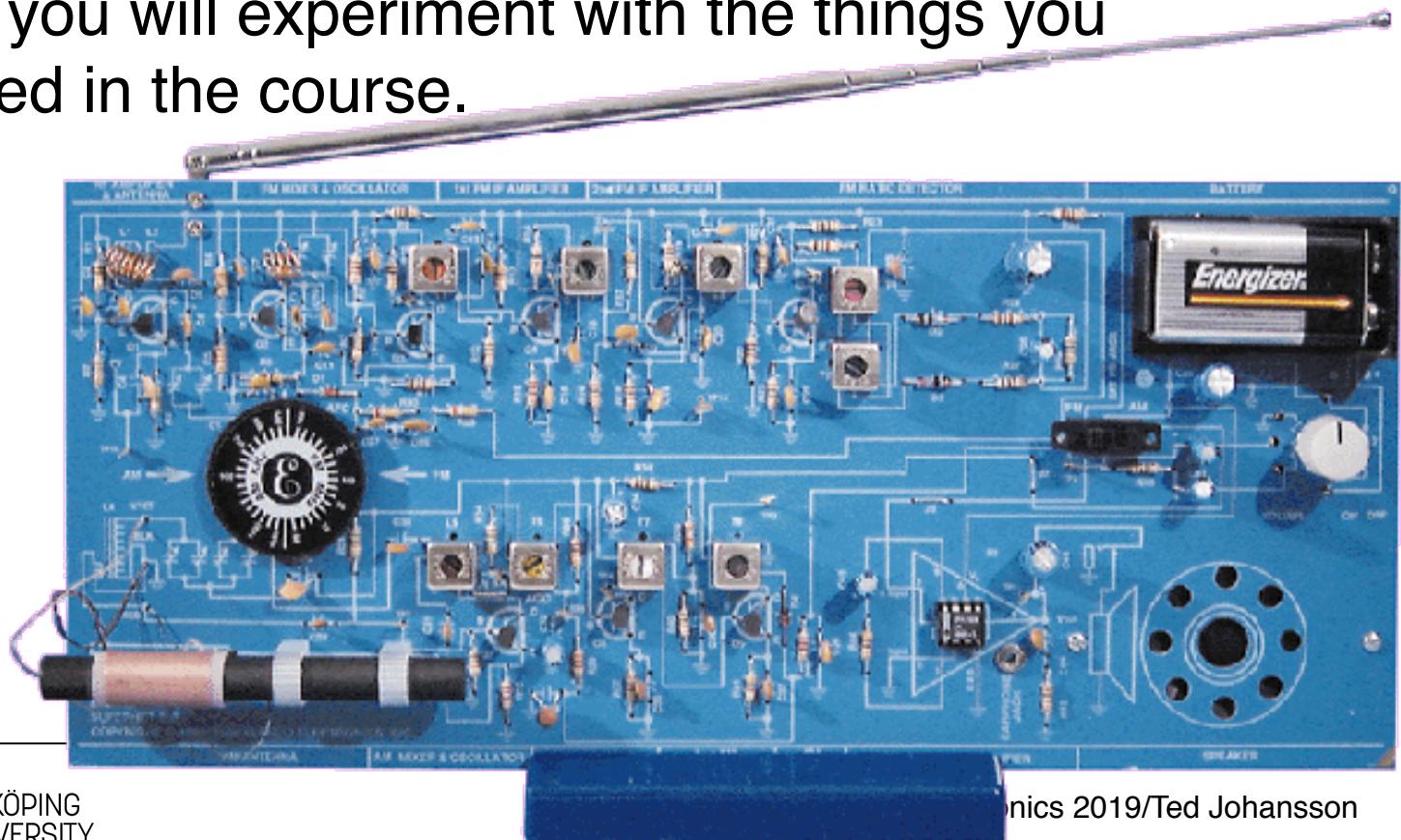
Lab 1: System simulations lab

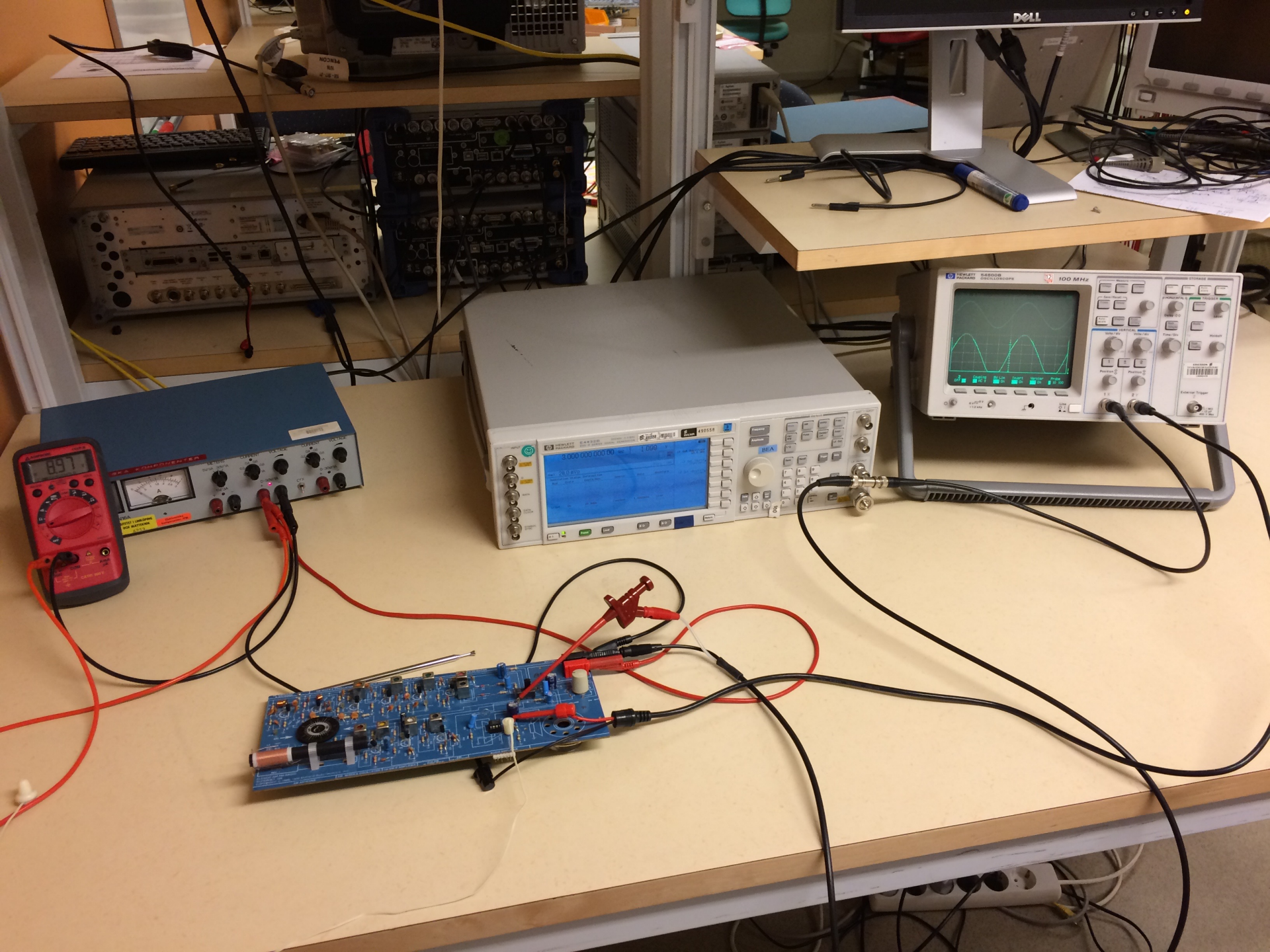
- You will design and simulate a digital transceiver in Simulink.
- Here you will see many of the concepts which have been covered in the lectures and tutorials.



Lab 2: System measurements lab

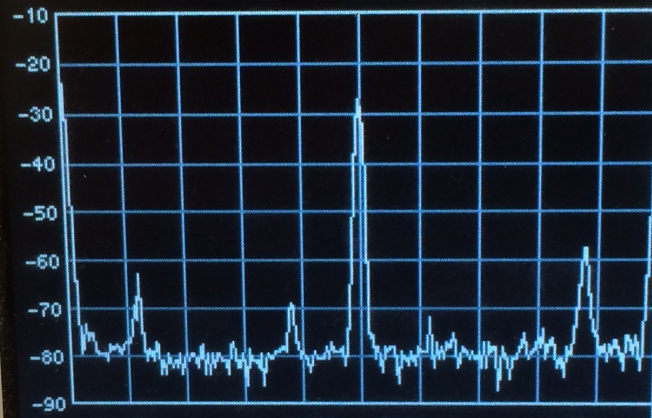
- You will go to the lab and measure a radio receiver in practice.
- Here you will experiment with the things you learned in the course.





ROHDE & SCHWARZ FS300 Spectrum Analyzer 9kHz...3GHz

Ref: -10.0 dBm M1: 153.84 MHz /
CLR RBW: **LN** 10 kHz M2: 99.20504 MHz /



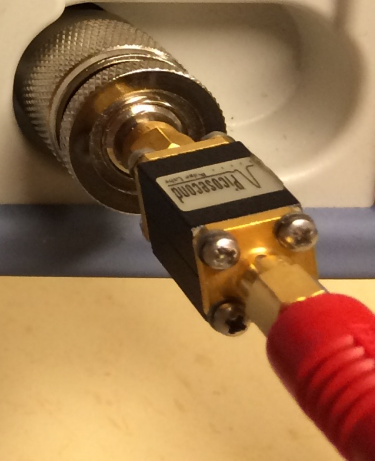
- CENTER
- SPAN
- START
- STOP
- CF-STEP SIZE ⇒
- SPAN SETTINGS ⇒
- SIGNAL TRACK ⇒

- FREQ/SPAN
- AMPT
- MKR
- BLW/SWEEP
- TRACE
- TRIG
- MEAS

- 7 8 9 GHz s
- 4 5 6 MHz ms
- 1 2 3 kHz μs
- 0 . - Hz

RF IN Δ MAX +33 dBm

- Power button
- ON (green LED)
- STBY
- SYS
- ESC CANCEL
- ENTER
- Left arrow
- Right arrow

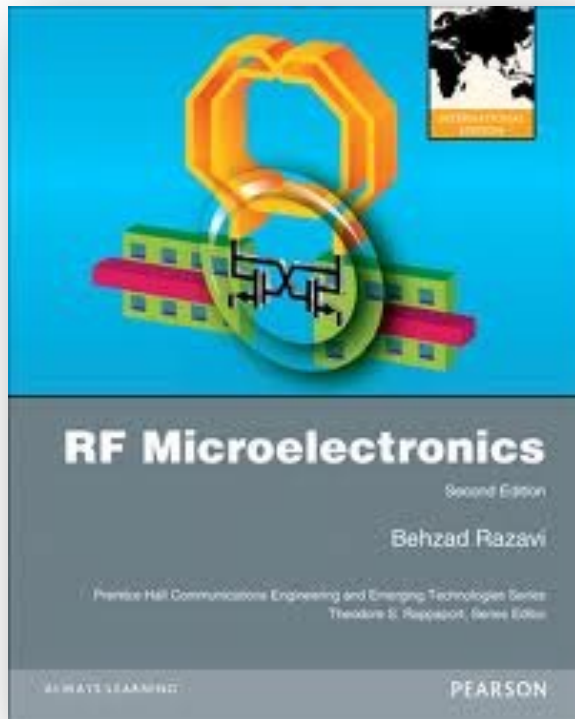


Examination

- After having learnt, practiced, simulated, and designed, you will know the radio system pretty well!
- However, in order to pass the course:
 - Attend the two labs (2 HP),
 - Pass the written exam (4 HP).
 - Exam date: Jan 18, 2020, 14-18.

Course material

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

Lectures notes, tutorial material,
and lab notes will be available at
the course page in **Lisam**

There are also several other
books on Radio Electronics,
as well as material on internet.

The book is also used in
the TSEK03 RFIC course

Lisam Course pages

lisam.liu.se

li.u LINKÖPINGS UNIVERSITET SharePoint

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li.u LINKÖPINGS UNIVERSITET **Radio Electronics**

TSEK02, fall 2018, Valla, 5 November 2018 - 20 January 2019, 6.0 hp, speed 100 %, campus education, daytime, order 1, given in english

Home
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Course documents
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Announcements

TSEK02 Radio Electronics now in Lisam NEW 2018-10-28 11:23
by Ted Johansson
Trying to use Lisam for this year's Radio Electronics. I have put material from 2017 (lecture, tutorials) as a reference, compiled the old home page material into a "Syllabus", and set up Signup for the two labs.

Welcome to the first lecture 2018-11-05 in U10. 2018-10-17 21:41
by Ted Johansson

Add new announcement

Newsfeed

Start a conversation

Ted Johansson
I have also checked the official course mailing list (37 students) and added those who were on the list but not in here. There are a few students which are indicated as Chosen or Rereg that I think should also get access to this page when the course starts, otherwise I will manually add those students too.
torsdag at 00:00 Like Reply ...

SHOW MORE POSTS

- Recommended background: basic knowledge of semiconductor devices and analog circuits.
- Supplementary courses: TSEK03 Radio Frequency Integrated Circuits, TSEK38 Radio Frequency Transceiver Design, Advanced courses in RF CMOS design
- Goal: The course gives students a basic knowledge in radio electronics on a system level. After completion of the course, students will be able to read and understand specifications of a modern wireless system and design the corresponding radio on a block diagram level.
- Content: The course starts with fundamentals of data transmission and discusses certain fundamental and practical limitations. Transmitter and receiver architectures as well as properties of the wireless channel will be introduced and signal impairments will be studied from the time it is transmitted to the time it is detected. The course is organized in a very homogeneous and logical order for the student to learn how a radio system is step by step designed.
- Course book: B. Razavi, RF Microelectronics (2nd Ed) (International paperback version), Pearson, ISBN 0132839415/9780132839419, 2012. Same book is used in TSEK03.
- Studieinfo for TSEK02 HT 2018
- Schema: [LIU TimeEdit for TSEK02](#)

Latest changes

- [TSEK02_2017_T1_solutions_ver2](#) in Course documents
Modified by Ted Johansson 2018-10-24 20:32
- [TSEK02_2017_T4T5](#) in Course documents
Modified by Ted Johansson 2018-10-24 20:32
- [TSEK02_2017_T6](#) in Course documents
Modified by Ted Johansson 2018-10-24 20:32
- [TSEK02_2018_CourseSyllabus](#) in Syllabus
Modified by Ted Johansson 2018-10-24 17:41
- [TSEK02_2017_Lab2_Manual](#) in Course documents
Modified by Ted Johansson 2018-10-24 17:19

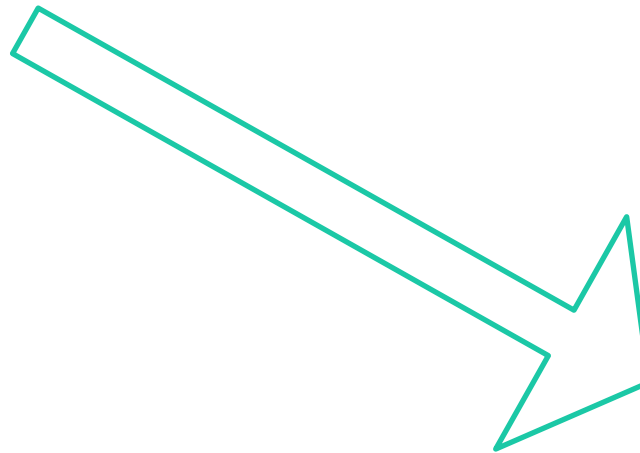
Schedule

- Link to TimeEdit on the Lisam course start page

Tid	Kurs	Lokal	Undervisningstyp	Lärare	Studentgrupp	Information till student
Fr 2019-11-22						
15:15 - 17:00	TSEK02	S25	Lektion	Oscar Andres Morales Chacon	ELE1 SY2	Tu 4
v 48 Ti 2019-11-26						
17:15 - 21:00	TSEK02	OLYM	Datalaboration	Oscar Andres Morales Chacon Ted Johansson	ELE1 SY2	Lab Simulink, group 1, 20 students, signup required.
On 2019-11-27						
17:15 - 21:00	TSEK02	EGYP	Datalaboration	Oscar Andres Morales Chacon Ted Johansson	ELE1 SY2	Lab Simulink, group 2, 20 students, signup required.
v 49 Ti 2019-12-03						
13:15 - 17:00	TSEK02		Laboration	Oscar Andres Morales Chacon	ELE1 SY2	Lab Radio receiver measurements, group 1 (6 students), signup required. Room: EKS-lab 3D:542.
On 2019-12-04						
17:15 - 21:00	TSEK02		Laboration	Oscar Andres Morales Chacon	ELE1 SY2	Lab Radio receiver measurements, group 2 (6 students), signup required. Room: EKS-lab 3D:542.
To 2019-12-05						
08:15 - 10:00	TSEK02	S25	Lektion	Oscar Andres Morales Chacon	ELE1 SY2	Tu 5
v 50 Ti 2019-12-10						
13:15 - 17:00	TSEK02		Laboration	Oscar Andres Morales Chacon	ELE1 SY2	Lab Radio receiver measurements, group 3 (6 students), signup required. Room: EKS-lab 3D:542.
On 2019-12-11						
17:15 - 21:00	TSEK02		Laboration	Oscar Andres Morales Chacon	ELE1 SY2	Lab Radio receiver measurements, group 4 (6 students), signup required. Room: EKS-lab 3D:542.
To 2019-12-12						
08:15 - 10:00	TSEK02	S25	Lektion	Oscar Andres Morales Chacon	ELE1 SY2	Tu 6

Lab Signup (required for both labs)


- In Lisam, go to Signup on first course page



The screenshot shows the Lisam interface for the course TSEK02, fall 2019. At the top, there is a header with the Linköping University logo (li.u) and the course title 'Radio Electronics'. Below the header is a navigation menu with links: Home, Syllabus, Course documents, Collaborative workspace, Newsfeed, Announcements, Members and groups, Schedule, Recent, and Signup. The 'Signup' link is highlighted with a green box. To the right of the menu, there is a section titled 'Announce' with a 'Welcome!' message by Ted Johansson. Below that is a 'Newsfeed' section with a 'Start a conversation' button.

Lab Signup (required for both labs)

Signup



Lisam / Radio Electronics / Activities

Activities

+ Add activity

Lab 2, Radio Receiver Measurements

Sign up period

2018-11-05 01:00 - 2018-12-19 21:00

Occasion	Signups	
Group 1. Tue, Dec 4 17:15-21:00	0	...
Group 2. Wed, Dec 5 17:15-21:00	0	...
Group 3. Tue, Dec 11 17:15-21:00	0	...
Group 4. Wed, Dec 12 17:15-21:00	0	...
Group 5. Tue, Dec 18 13:15-17:00	0	...
Group 6. Wed, Dec 19 17:15-21:00	0	...

Lab1, Radio Transceiver Simulations

Sign up period

2018-11-05 00:00 - 2018-11-28 21:00

Occasion	Signups	
Group 1 Tue, Nov 27 17:15-21:00	0	...
Group 2 Wed, Nov 28 17:15-21:00	0	...

Problems accessing the course pages in Lisam?

- Mail me! (ted.johansson@liu.se)



Staff

- Ted Johansson
- Docent, Adjunct Professor
- Integrated Circuits and Systems (EKS), ISY
- ted.johansson@liu.se,
- <https://liu.se/medarbetare/tedjo76>
- Lectures, lab 1, examiner.

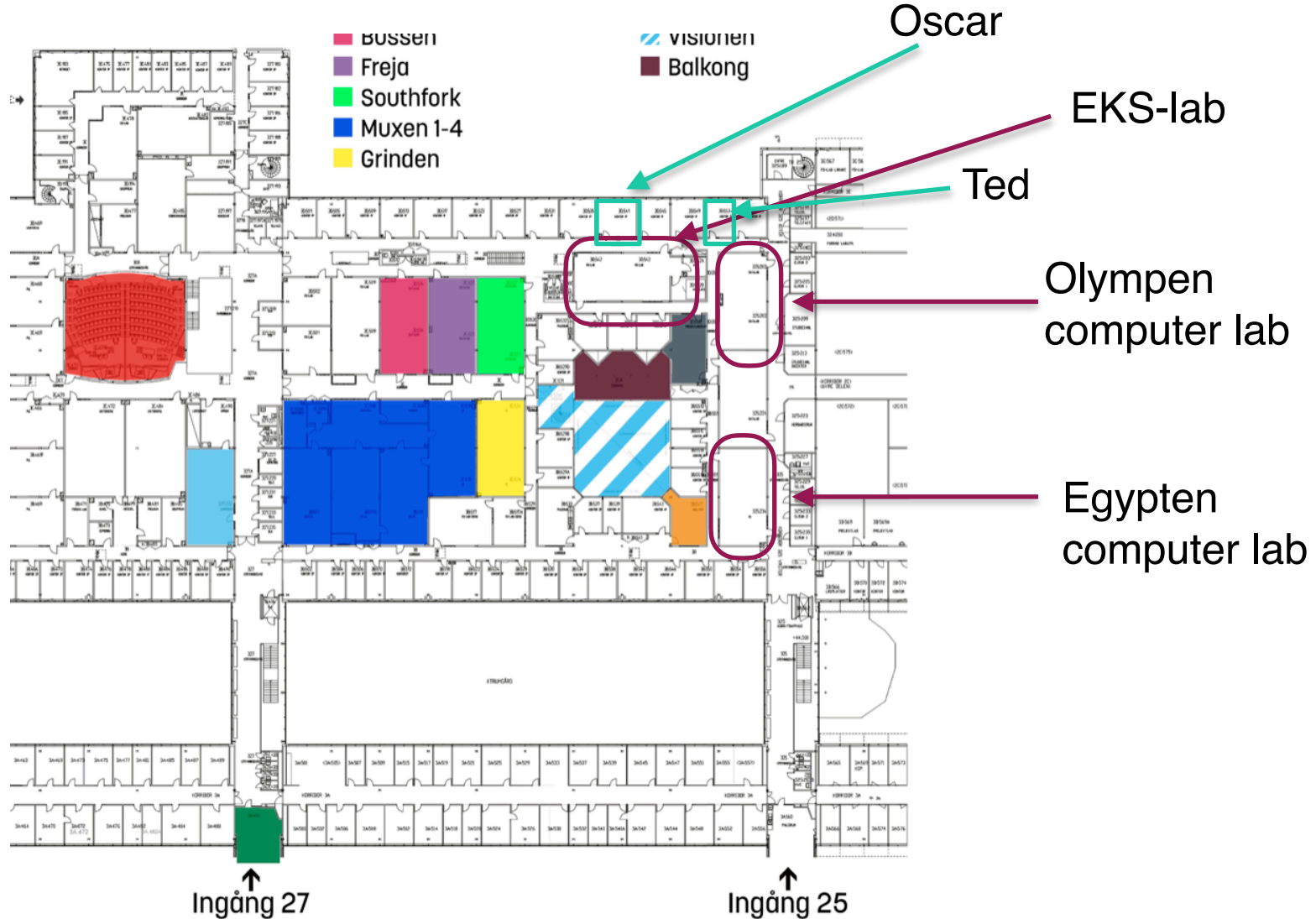
Staff

- Oscar Morales
- Ph.D. student
- Integrated Circuits and Systems (EKS), ISY
- oscar.morales@liu.se
- Tutorials, labs.



B-house, upper floor

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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-/VT1: undergraduate course TSEK03
2015-/HT2: undergraduate course TSEK02
2017-/HT1: undergraduate course TSEK38
2019-/VT1: Bachelor thesis course TSIU09



Lectures overview

Lecture	Content	Book chapters
1	Course introduction Basic definitions	not in the book 1, 2.1.1
2	Modulation Techniques	3.1 - 3.3.1
3	Modulation Techniques	3.3.2 - 3.3.6
4	Multiple Access Techniques TX Architectures	3.6 4.3
5	Nonlinearity Issues	2.1.2-3, 2.2.1-2, 2.2.4-5
6	Channel and antenna Noise	not in the book 2.3
7	Noise Receiver Architectures	2.3.5 4.1, 4.2.1, 4.2.3
8	RX Nonlinearity Issues Demodulation	2.2, 2.4 not in the book

Courses in Radio Electronic Design

TSEK02: Radio Electronics

HT2 4th year

Intro to radio transmissions

TX, link (antennas), RX

No circuit level details

No system calculations

MATLAB/Simulink

System level

Introduction/Advanced level

TSEK38: Radio Frequency Transceiver Design

VT1 4th year

No circuit level details

Many system calculations

Transceiver design using ADS

TSEK03: Radio Frequency Circuit Design

HT1 5th year

Intro to radio block design, circuit level

Noise, LNA, Mixer, Oscillator, PLL, PA

Cadence



Radio

- **Radio** is the technology of signaling and communicating using radio waves.
- Radio waves are **electromagnetic waves** of frequency between **30 hertz (Hz) and 300 gigahertz (GHz)**.
- They are generated by an electronic device called a **transmitter** connected to an **antenna** which radiates the waves, and received by a radio **receiver** connected to another antenna.
- Radio is very widely used in modern technology, in **radio communication, radar, radio navigation, remote control, remote sensing and other applications**.
- In radio communication, ... radio waves are used to carry information across space from a transmitter to a receiver, by **modulating** the radio signal (impressing an information signal on the radio wave by varying some aspect of the wave) in the transmitter.

Radio

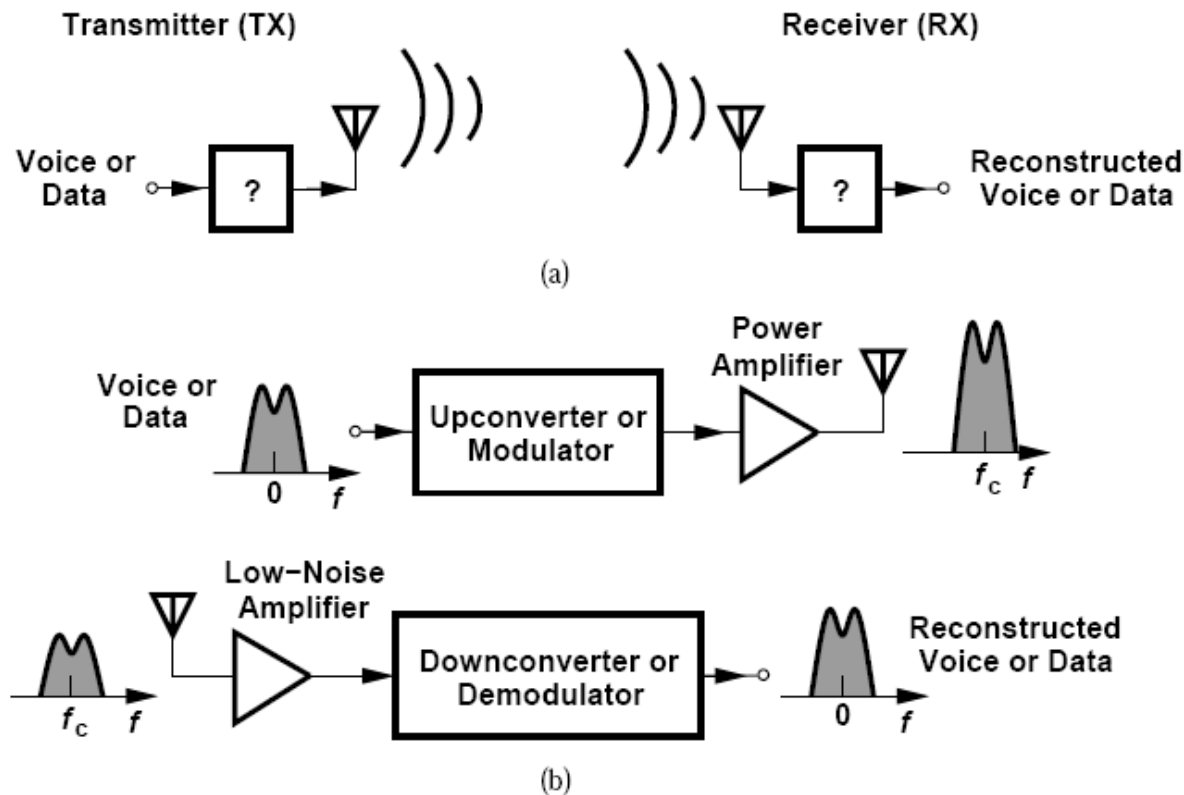


- Radio waves were first identified and studied by German physicist **Heinrich Hertz** in 1886.
- The first practical radio transmitters and receivers were developed around 1895-96 by Italian Guglielmo **Marconi**, and radio began to be used commercially around 1900.
- To prevent interference between users, the emission of radio waves is strictly regulated by law.
- <https://en.wikipedia.org/wiki/Radio>

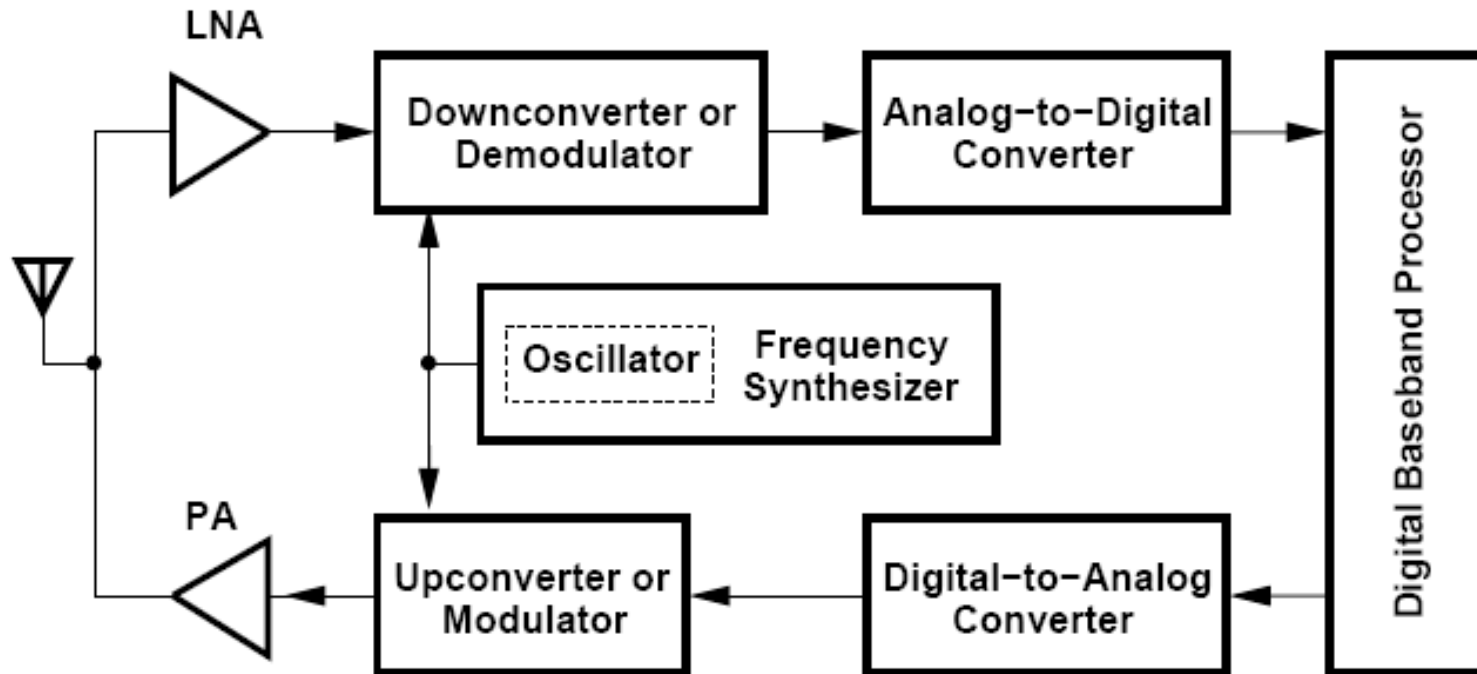
The Big Picture: RF Communication

TX: Drive antenna with high power level

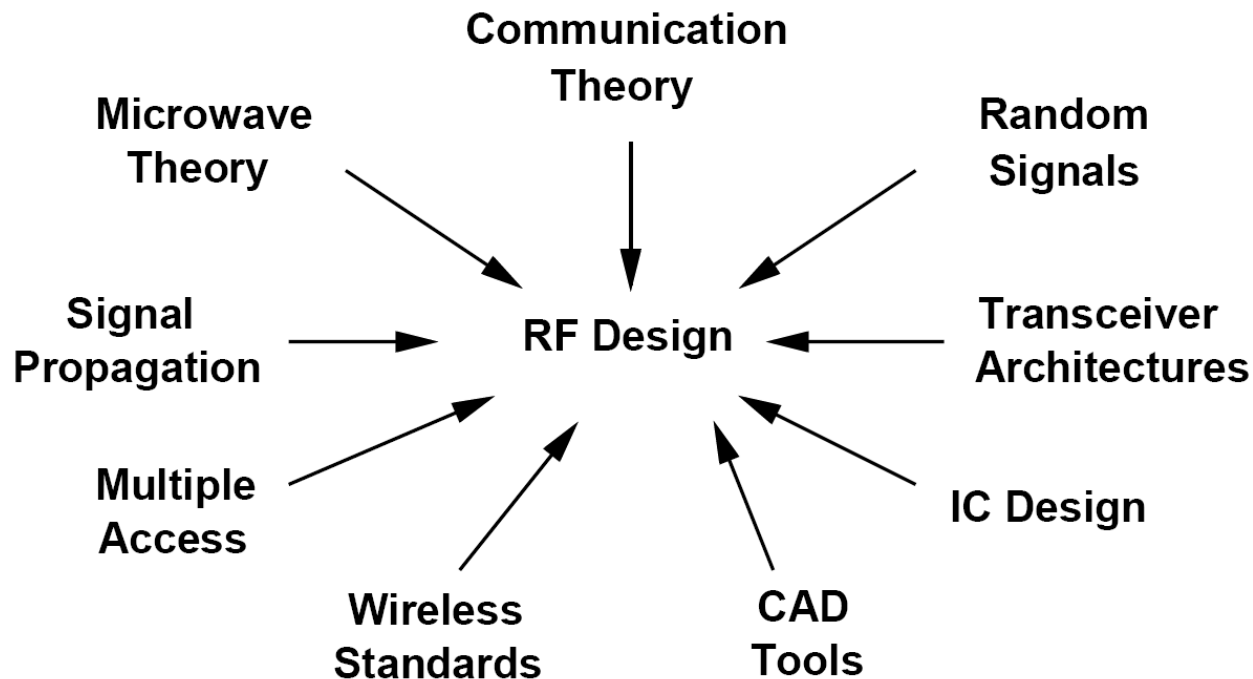
RX: Sense small signal (amplify with low noise)



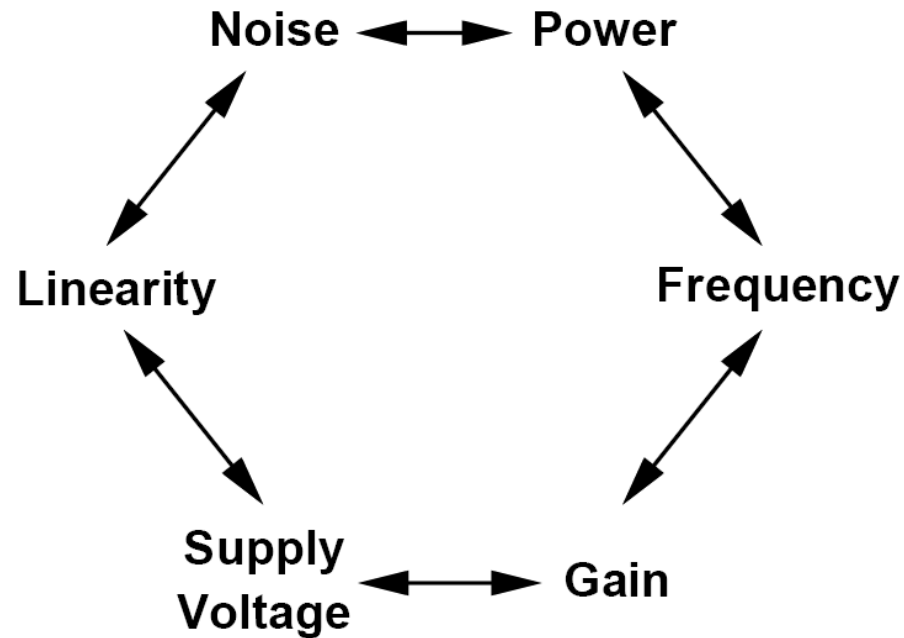
The Big Picture: Generic RF Transceiver



RF design challenges: multi-discipline



RF design challenges: Trade-offs



www.liu.se