

Lecture 1: Introduction on simulation of communication systems

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Why do we need to do the simulations

What we learned from text books ?

Example: The signal after the matched filter becomes

$$r(t) = \sum_{k=1}^N s_{mk} f_k(t) + \sum_{k=1}^N n_k f_k(t) + n'(t)$$

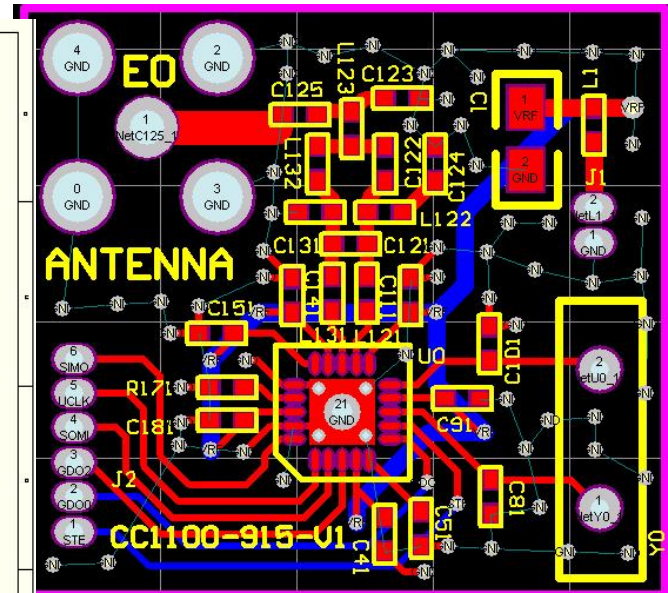
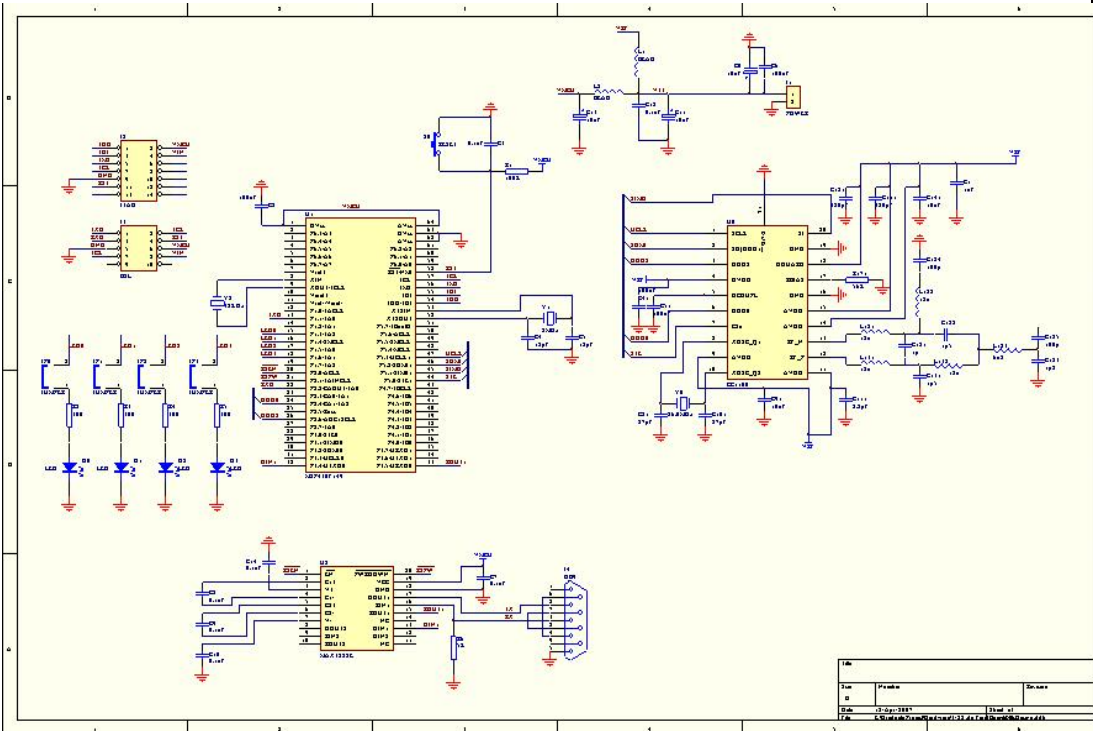
$$= \sum_{k=1}^N r_k f_k(t) + n'(t)$$

here

$$n'(t) = n(t) - \sum_{k=1}^N n_k f_k(t)$$

$$E[n_k] = 0$$

Why do we need to do the simulations



How those equations can be used in different devices

From theoretical study to hardware implementation

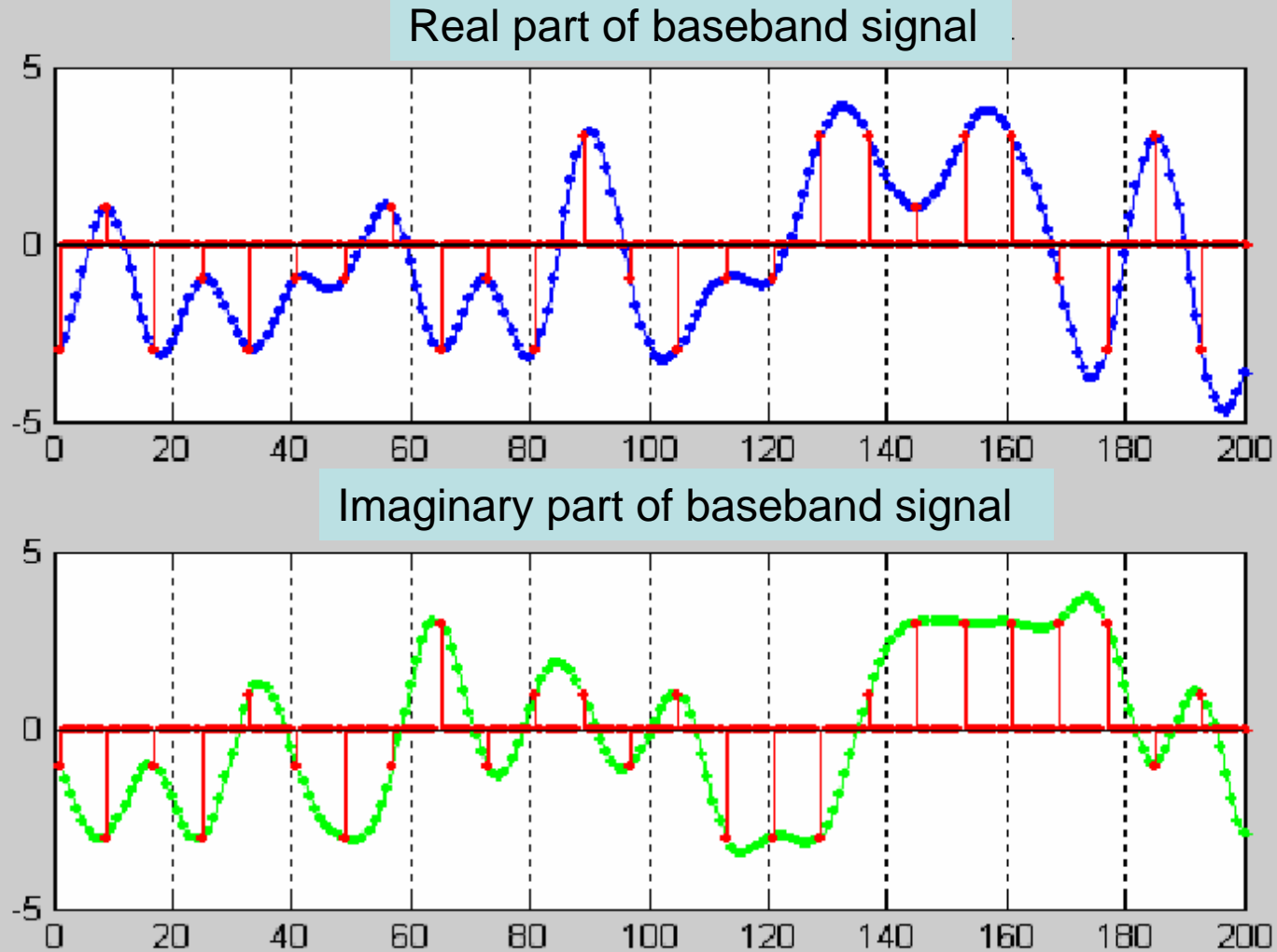
- **Theoretical study**
- **Build the simulation model**
 - **Baseband model: focusing on baseband**
 - **Passband model: build the equivalent baseband model**
- Fixed point simulations
- Hardware languages description (VHDL, Verilog)
- FPGA test bench implementation
- Chip set oriented design
- Chip set implementation

Theoretical study

- The basic knowledge for communications
 - Time domain signal analysis
 - Frequency signals analysis
 - Statistics analysis
 - Random process
 - Basic theories for digital communications

Build the simulation model

Example: Baseband signals

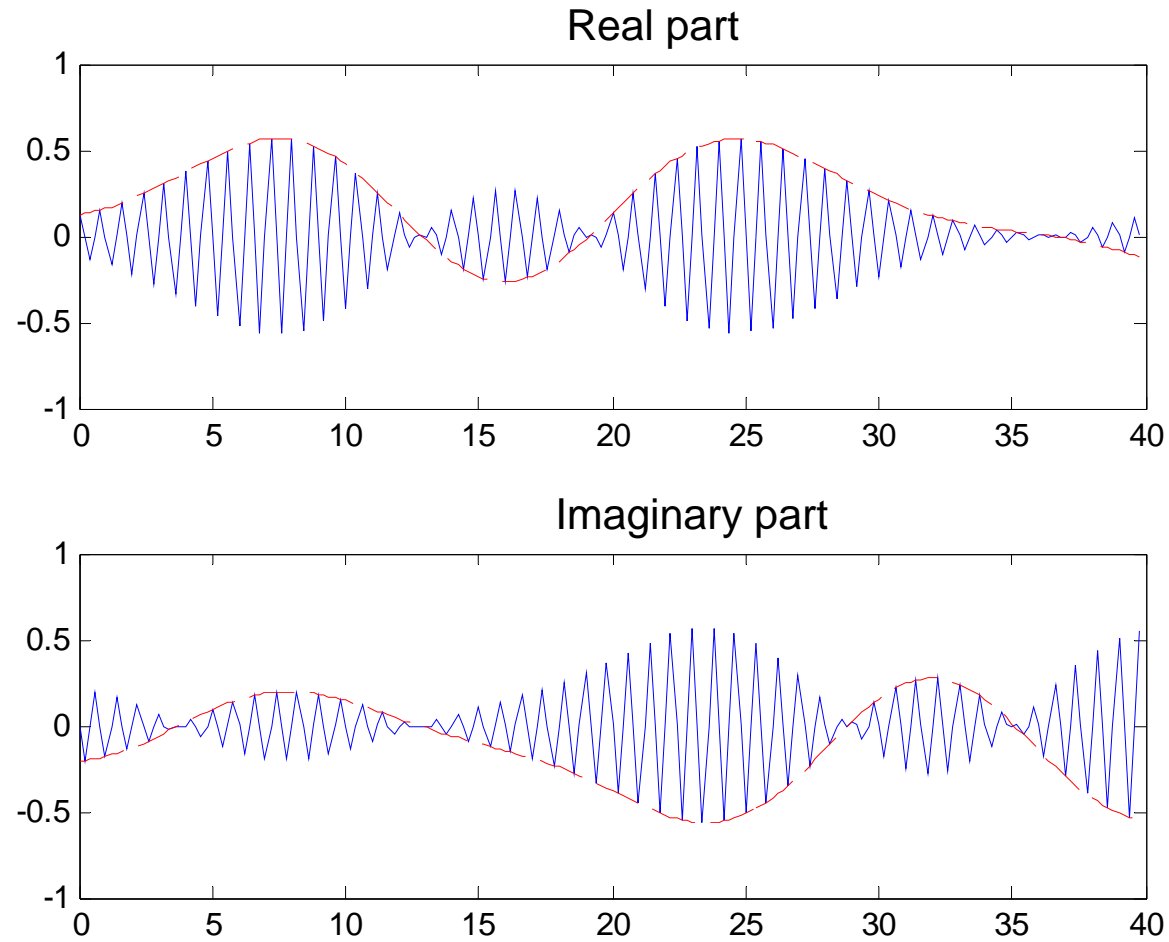


Problems in baseband simulations

- How to simulate continuous signals?
- How build the simulation to reflect reality?
- How to make the exact same signals as hardware devices?

Build the simulation model

Example: Baseband signals after the carrier modulation



Problems in carrier band simulation

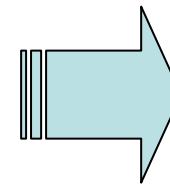
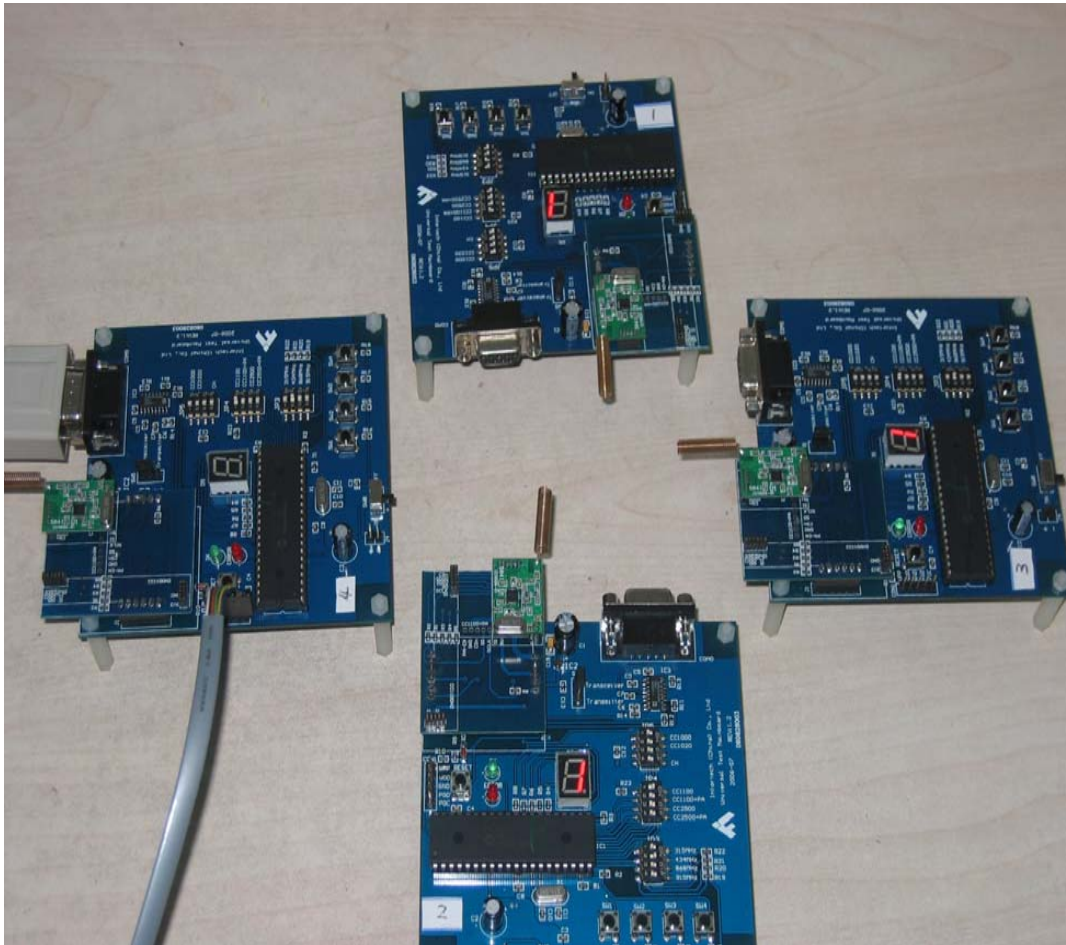
- Is it necessary to make simulation of carrier modulated signals?
 - In most cases, No!
- How to simulate the carrier errors in the baseband simulations?

Fixed point simulations

- Why we need to make fixed point simulations?
 - Each signal in the hardware devices are represented by binary data
- How to make the fixed point simulations using Matlab?
- How to chose the number of bits for each signals?
- How to make compromise of the complexity and the accuracy of the system?

From theoretical study to hardware implementation

- Theoretical study
- Build the floating point simulation model
 - Baseband model: focusing on baseband
 - Passband model: build the equivalent baseband model
- **Fixed point simulations**
- Hardware languages description (VHDL, Verilog) – **Based on the Fixed point simulations**
- Test bench implementation – load the VHDL codes into FPGA board
- Chip set oriented design – considering power, occupied space, delay time...
- Chip set implementation - semiconductor



**Chip
set**

The goals for simulations

- Make further understanding of the theories
 - Example: what is frequency selective coding
- Explore the mechanisms hidden in the systems
 - If you find out some performance cannot be explained, the new findings might be waiting for you
- Evaluate whether your new algorithm is practical
 - Hardware cost, complexity...

Problems for simulations

- Does my module reflect the real world?
 - The hardware board
 - Real communication environment
- How to evaluate my simulation results
- How to speed up my simulations
- How to clearly represent my simulation results

These question will be answered during this lecture.
It will be learned through the following three exercises

Some Simulation techniques for hardware design

- How to perform fixed point simulation and floating point simulations
- How to make the accurate and correct fixed point simulations
- How to speed up simulations
- How to combine C language in MATLAB simulation platform

1. Build a 16QAM system that reflecting the hardware implementation

- How to simulate the continuous signals using sampled signals
- How to design the Matched filters that fulfill Nyquist conditions
- How to add the noise signals when the SNR, sampling rate, modulation level are defined
- How to simulate Eye diagram
- How to evaluate the BER, Symbol error rate (theory and simulations)

The exercise will be done during the lecture time ,
The exercise results need to be returned – home work 1

2. Characteristics of Multipath channel and Equalizer design

- Simulation of multipath delay channels with different delay taps
- Impact of multipath delay to time domain signals of wireless communications systems
- Impact of multipath delay to frequency domain response of wireless communications systems
- Impact of fixed point simulation to the system performance

The exercise will be done during the lecture time

3. Key problems in OFDM communication systems

- Principle simulations of OFDM
- Peak Power to average power ratio analysis
- Symbol synchronization of OFDM symbols
- Model of carrier frequency error and its impact to the OFDM signals
- Model of sampling frequency error and its impact to the OFDM signals
- Impact of Multipath delay to the OFDM systems
- Impact of fixed point simulation to the system performance

The exercise will be done during the lecture time
The exercise results need to be returned - home work 2

4. Fixed point simulations

-- Option 1

- Key techniques for OFDM systems
 - Carrier frequency error estimation scheme
 - Sampling clock frequency error estimation scheme
- Fixed point simulations: how to decide the number of bit for each variables
 - Make the fixed point simulation platform
 - Accuracy of the Carrier frequency error and Sampling clock frequency error estimation with respect to different number of bit for each variable

The exercise will be done during the lecture time
The exercise results need to be returned – home work 3

Requirement for home works

Write the simulation report

- The goal of simulation
- Simulation environment and block diagram
- Simulation codes (copy the codes at the end of the report, clear explanation of the codes is needed)
- Simulation results given by figures
- Discussions of the simulation results

Three reports should be given.

Note:

- 1. Send your three reports to my email at the same time**
- 2. The subject of the email is “TKK course”**
- 3. The deadline of submission: May 2 2008**

Contact information

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Thanks!