TSDT14 Signal Theory
Course Information Autumn 2018

General

TSDT14 Signal Theory is an introductory course in signal processing, dealing with both time-continuous and time-discrete signals, that are both deterministic and stochastic, real and complex. The focus is on stochastic signals, real as well as complex. The signal processing systems are usually linear and time-invariant, but we also consider some momentary non-linear systems. One part of the course deals with multi-dimensional processes, where we concentrate on two-dimensional processes. We also consider traditional analog modulation methods and perform noise analysis of them. We are especially interested in transformations between time-continuous and time-discrete signals. A part of the course is estimation of power spectral densities using Fourier methods, where DFT is used. Signal Theory is a basis for further studies in signal processing, e.g. Tele(data)-communication, image processing, automatic control, et. cetera.

Time

Teaching is offered according to the following.

- Lectures: 12 × 2 = 24 hours
- Tutorials: 12 × 2 = 24 hours
- Laborations: 4 × 2 = 8 hours

Course Litterature

The following litterature will be available at the bookshop in Kårallen.

- Mikael Olofsson, Signal Theory, Studentlitteratur, 2011.
- Mikael Olofsson, Tables and Formulas for Signal Theory, Studentlitteratur, 2011.

The following will be available for download from the course room in Lisam.

- Lab Memo: Mikael Olofsson, Time-Discrete Stochastic Signals, August 2017.
- Additional lab material: Mikael Olofsson, Short Matlab Manual, August 2017.

Additional material will be distributed, either as files in the course room or in paper form.

Teachers

- Lectures, Tutorials and Examination:
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Examination

One demand on examiners is that the course syllabus in LiU Study Info must contain a few aims, and it must be clear how those aims are tested in the examination of the course. All those aims must be tested at every examination opportunity. A consequence of this is that those aims are given a fairly vague formulation, and that those aims rather are section titles in a more traditional aim description.

For that reason, here follows a specification of the aims in the syllabus and how they are examined, grouped according to in what part of the exam they are treated.

TEN1: Written Exam

The Introductory Task
This task tests basic knowledge and abilities, i.e. the following aim. It contains three subtasks, and as partial fulfillment for passing the exam, you have to treat at least two of those three subtasks correctly. The following aims are examined with this task, one subtasks for each aim. Those aims are tested by samples within them.

- **be able to clearly define central concepts regarding stochastic processes, using own words.**
  The following concepts can be treated here: Stochastic process, ensemble averages, strict and wide sense stationarity, exact predictable process, Gaussian process, white noise, all for both time-continuous and time-discrete processes.
- **be able to reliably perform standard calculations regarding stochastic processes, e.g. LTI filtering (both time continuous and time discrete), sampling and pulse amplitude modulation.**
  This deals with linear operations. The aim is examined with a rather simple task that treats one of the examples mentioned in the aim. You are expected to handle relations between power spectral densities of the input output processes. Both one-dimensional and multi-dimensional signals and systems can occur.
- **be able to reliably perform standard calculations regarding stochastic processes being exposed to certain momentary non-**

linearities that are common in telecommunication, especially uniform quantization and monomial non-linearities of low degrees.
This deals with non-linear operations. The aim is examined with a rather simple task that treats one of the examples mentioned in the aim. You are expected to handle relations between auto-correlation functions for squaring and "cubing", and also distortion calculations for quantization of a stochastic variable.

See also previous exams that you can find in the course room.

The Rest of the Tasks
Tasks number two to six on the exams examine the following aim.

- **with some reliability be able to solve problems that demand integration of knowledge from different parts of the course.**
  This is where you find traditional exam tasks. This is the largest of the aims, and it should be related to the course contents, excluding the estimation and the case study.
  - Continuous and discrete time stochastic processes, real as well as complex: Probability distribution, probability density, expectation, ensemble expectation, auto correlation function, power spectral density, cross correlation function, cross spectral density, stationarity, ergodicity. Especially Gaussian processes and white processes. Multidimensional processes.
  - LTI filtering of stochastic processes: Relations between statistical properties of the input process and the output process. Especially matched filters and white Gaussian noise as input.
  - Amplitude and angle modulation of stochastic processes: Relations between statistical properties of the input process and the output process. Especially Gaussian processes as input. Noise analysis of those modulation forms, primarily with white Gaussian noise as disturbance.
  - Non-linear momentary systems: Quantization and polynomial non-linearities. Relations between statistical properties of the input process and the output process. Especially Gaussian processes as input. Properties of quantization noise.
  - Transformation between continuous time and discrete time stochastic processes: Sampling and pulse amplitude modulation, the sampling theorem, reconstruction and reconstruction error.

You are expected to handle problems that incorporates several parts of the course. See previous exams for examples of what those tasks can look like.

These five tasks can each give you at most five points, i.e. totally at most 25 points. Grade limits:

- Grade 3: 10 points.
- Grade 4: 15 points.
- Grade 5: 20 points.

LAB1: Laborations

The laborations consist of four tasks. All of them deal with the estimation of auto-correlation functions and power spectral densities of processes. This is examined by a written report. This part examines the following aims:

- **be able to estimate the auto correlation function and power spectral density of a stochastic process based on a realization of the process. Also, clearly and logically account for those estimations and conclusions that can be drawn from them.**
  The report should thus account for the measurements you have done, and estimations based on those measurements. Based on those measurements, you should be able to draw conclusions, such as if the studied system is an LTI system or not.
- **be able to account for the connection between different concepts in the course in a structured way using adequate terminology.**
  This is really about comparing your estimations with theoretical analyses of corresponding situations, for instance by deriving power spectral densities of the output of a system.

The laborations are specified in a separate lab memo.