**Module Description, available in: EN**

# *Statistical Digital Signal Processing and Modeling*

## General Information

**Number of ECTS Credits**

3

**Module code**

TSM_StatDig

**Valid for academic year**

2026-27

**Last modification**

2024-09-24

**Coordinator of the module**

Heinz Mathis (OST, heinz.mathis@ost.ch)

**Explanations regarding the language definitions for each location:**

- Instruction is given in the language specified for each location and module execution.
- Documentation is available in the language(s) listed for each location and module execution. If the documentation is in multiple languages, the percentage distributed is indicated (100% = all documentation provided).
- The examination, including both questions and answers, is provided entirely (100%) in the language(s) specified for each location and module execution. The exams are on-site.

| | Lausanne | | | Lugano | Zurich | | |
|---|---|---|---|---|---|---|---|
| **Instruction** | | | | | **X** E 100% | | |
| **Documentation** | | | | | **X** E 100% | | |
| **Examination** | | | | | **X** E 100% | | |

**Module Category**

TSM Technical scientific module

**Profile Recommendations**

This module is recommended for the following profiles:

| | Zurich |
|---|---|
| **Profile** | EIE |

**Lessons**

2 lecture periods and 1 tutorial period per week

## Entry level competences

**Prerequisites, previous knowledge**

Understanding of the following concepts at the Bachelor of Science level

- Calculus
- Linear algebra
- Probability/Statistics
- Digital signal processing

## Brief course description of module objectives and content

The goal of this module is to introduce the students to the powerful world of statistical digital signal processing. While at the bachelor level digital signal processing is most often taught with deterministic signals, in the real world most interesting signals are stochastic in nature. Hence in more advanced applications, such as prediction or noise removal, the theories presented in this module are essential.

The basic digital signal processing, linear algebra and probability theory necessary to understand the module are brushed-up at the beginning. Then stochastic processes are introduced which allows the proper formulation of the optimal filtering and spectral estimation problem later on. After an in-depth treatment of the optimal filtering and estimation problem, adaptive filters are introduced which are a popular choice for many advanced statistical digital signal processing problems.

## Aims, content, methods

### Learning objectives and competencies to be acquired

- The student becomes familiar with stochastic signals and systems
- The student understands and can apply the different methods for signal modeling
- The student has an in-depth understanding of Wiener filtering and knows how a discrete Kalman filter can be used to solve a stochastic filtering problem
- The student understands and can apply the different methods for spectrum estimation
- The student knows the most common adaptive filters and is able to select the proper one for the application at hand

### Module content with weighting of different components

The module starts with a review of basic digital signal processing, linear algebra and probability theory. It then introduces some concepts about stochastic processes, which are necessary to understand the following applications of statistical signal processing. Then the module discusses several different ways of signal modeling which can be used for parametric methods later on. Then one of the core topics is presented, which is the optimal linear mean square error estimation of a signal which is corrupted by additive noise. The module then presents a chapter about the very important topic of spectral estimation and finally concludes with the application of the learned theory for designing adaptive filters.
The available 14 weeks are organized as follows:

- 2 weeks: Background (review of digital signal processing and linear algebra)
- 3 weeks. Discrete-time random processes (including a review of probability)
- 2 weeks: Signal modeling
- 3 weeks: Wiener filtering (including the discrete Kalman Filter)
- 2 weeks: Spectrum estimation
- 2 weeks: Adaptive filtering

### Teaching and learning methods

- A three hour session each week for 14 weeks
- The first hour is a homework review session where the homework is discussed. The homework is “paper and pencil” homework and small Matlab programming assignments
- The next two hours are lecture hours, where new theory is introduced

### Literature

“Statistical Digital Signal Processing and Modeling” by Monson H. Hayes

## Assessment

### Additional performance assessment during the semester

The module does not contain an additional performance assessment during the semester

### Basic principle for exams

**As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.**

### Standard final exam for a module and written resit exam

#### Kind of exam

Written exam

#### Duration of exam

120 minutes

#### Permissible aids

*Aids permitted as specified below:*

**Permissible electronic aids**

No aids permitted

**Other permissible aids**

Open book

**Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.**

**Special case: Resit exam as oral exam**

**Kind of exam**

Oral exam

**Duration of exam**

30 minutes

**Permissible aids**

No aids permitted