Signal Analysis WS2013: Questionnaire

Note that the possible questions presented in each section can only be a subset of the final question. This means, that the questions in the exam will be a combination of questions.

1 General/ Stochastic Processes

- Explain the concept of stochastic processes?
- What is a stationary stochastic process?
- What is a non stationary stochastic process?
- What is an ergodic stochastic process?
- What is the general definition of the ACF? What is the main simplification for stationary stochastic processes?
- What is a power signal, what is an energy signal?
- What is the PSD?
- What is the relation between the signal power, the PSD and the ACF?
- What is the relation between the PSD S_{yy} of the output signal and the PSD S_{xx} of the input signal of an LTI system with impulse response $h[n]$?
- What is the relation between the ACF S_{yy} of the output signal and the ACF r_{xx} of the input signal of an LTI system with impulse response $h[n]$?
- What is the relation between the CCF S_{xy} and the ACF r_{xx} of the input signal for an LTI system with impulse response $h[n]$?

2 Time Cont. LTI Systems

- Several prototype transfer functions are known for analog filters. What are the main differences between those prototypes with respect to their frequency response?
- Explain some of the prototype transfer functions in more detail!
- What is the group delay? What is the meaning and the effect of the group delay of filters?

3 Signal Acquisition

- Explain the working principle of an oversampling ADC.
- Explain the relation between the SNR and the oversampling ratio of an oversampling ADC. Is the gain worth the effort?
- Explain the working principal and the components of a $\Sigma\Delta$ ADC.
- What is a 1^{st} order $\Sigma\Delta$ modulator?
- Explain the properties of a $\Sigma\Delta$ modulator stage.
- Explain the relation between the SNR and the oversampling ratio of a $\Sigma\Delta$. Is the gain worth the effort?

4 Time Domain SA

- What is the ROC of the z-Transform of causal systems (rational transfer function)?
- What is the ROC of the z-Transform of acausal systems (rational transfer function)?
- What can you say about the position of the poles of an FIR-system?
- What is an analytic signal?
- What is Hilbert a Hilbert transformer?
- How can an analytic signal be computed from a real valued signal using an FIR-Hilbert approximation?
- There are two types of ACF-estimators. Explain the difference with respect to the statistical properties

5 DFT based measurement System

- What is a DFT based measurement system?
- What is the result of a DFT based measurement system?
- How is an N-point DFT related to the DTFT?
- Explain the relations (if they exist) between DTFT, DFT, DFS, and the z-Transform for energy signals.
- Explain the relations (if they exist) between DTFT, DFT, DFS, and the z-Transform for power signals.

- Explain the relations (if they exist) between DTFT, DFT, DFS, and the z-Transform for periodic signals.
- Given the DTFT $X(e^{j\omega})$ of a signal. Provide all relations between ω, ω_k (N-point DFT) and the continuous frequency f and f_k for a sampling frequency f_S.
- Explain all relations between the frequency variables $f, \Omega, \omega, \omega_k$ f_k (N-point DFT).
- How can a DFT based measurement system be used to estimate the cont. Fourier transform?
- What is the window function? Explain the effect of the window in a DFT-based measurement system.
- Which window has to be used to analyze FIR signals?
- What are the main properties to describe the effect of window functions?
- What are the special properties of the rectangular window with respect to any other window function?
- What effects can be observed in a DFT based measurement system when analyzing sinusoidal signals
- What is the leackage effect?
- How is the frequency resolution effected by the window function
- What type of windows have to be used to analyze "different"(no FIR signals) signals?
- What is the effect of zero padding in time domain?
- What can frequency domain zero padding be used for?

6 STFT

- When is STFT analysis required?
- What is the spectrogram?
- What are the parameters of STFT analysis?
- Explain the effect on the result of an STFT analysis when using a short/long window.
- What does overlapping mean with respect to STFT analysis.
- What is the meaning of the uncertainty principle?

- What is the time/frequency resolution of the STFT?
- Explain the properties of the STFT with respect to the uncertainty principle.
- What is the Garbor transform?

7 Wavelets

- What is the idea of the Wavelet Transform and what is the difference with respect to the STFT?
- What is the time/frequency resolution of the Wavelet Transform?
- Explain the properties of the Wavelet transform with respect to the uncertainty principle.
- What is dyadic sampling? What is the effect of dyadic sampling on the result of the DWT?
- Explain the realization of a dyadic sampling scheme by means of a filter bank.
- How can a filter bank be used to realize a DWT transform. Why are filter banks so important in the field of the WT?
- Explain the scaling of the Heisenberg box of the DWT with respect to a filter bank implementation.
- What is Wavelet denoising?
- Explain the structure of a Wavelet denoising algorithm.

8 PSD Estimation

- What are the two main directions with respect to the algorithms we learned for PSD estimation?
- What are non-parametric PSD estimators?
- What is the periodogram?
- What are the properties of the periodogram and why can we use it for the estimation of the PSD?
- Explain the influence of the window in a periodogram estimator?
- What are modified periodogram estimators? Why are they used?
- Explain the Welch's methods.

- What are parametric PSD estimators?
- What is an ARMA(p,q)-process?
- Explain the derivation (principal steps) of the Yule-Walker equations for ARMA processes.
- What are the difficulties with respect to the Yule-Walker equations for ARMA processes?
- Why are the Yule-Walker equations favorable with AR processes?
- Explain the computational steps within a PSD-estimator based on the Yule-Walker equations for AR processes.

9 Multivariate Signals

- What is the measurement model that leads to the methods like the PCA and the ICA?
- Explain the intention of the PCA and the ICA.
- Explain the choice of using the eigenvectors of the covariance matrix of the data for the PCA.
- Describe the structure of ICA algorithms using optimization algorithms

10 Possible Numerical Questions

- Examples of old tests.
- Show that any FIR filter with a (even) symmetric impulse response has a constant group delay.
- Show that any FIR filter with a (odd) symmetric impulse response has a constant group delay.
- The autocorrelation function of a stochastic process is given by $r_{xx} = [a, b]$ Solve the Yule-Walker equation for an AR(1) process.