Modelling and System Identification – Microexam 2

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January 26, 2016, 8:15, Freiburg

Surname: Name: Matriculation number:

Study: Studiengang: Bachelor ☐ Master ☐

Please fill in your name above and tick exactly one box for the right answer of each question below.

1. What quantity of a continuous time transfer function $G(s)$ shows the Bode phase diagram in single logarithmic (x-axis) scale?

(a) ☐ $\lvert G(e^{j\omega})\rvert$	(b) ☐ $\arg G(j\omega)$	(c) ☐ $G(j\omega)$	(d) ☐ $\lvert G(j\omega)\rvert$

2. Which phase shows the Bode diagram of $G(s) = \frac{1}{1+s+s^2}$ for very low frequencies?

(a) ☐ -180 deg	(b) ☐ -90 deg	(c) ☐ 0 deg	(d) ☐ 90 deg

3. At which frequency f [Hz] is the resonance peak of the Bode amplitude diagram of the oscillator $G(s) = \frac{1}{k^2+s^2}$?

(a) ☐ $f = k$	(b) ☐ $f = \frac{k}{2\pi}$	(c) ☐ $f = \frac{\sqrt{k}}{2\pi}$	(d) ☐ $f = \sqrt{k}$

4. Regard a periodic signal with period T that is sampled with sampling frequency f_s (with T a multiple of $1/f_s$). How many different frequencies are contained in the discretized signal ?

(a) ☐ $\frac{Tf_s}{2}$	(b) ☐ $\frac{T}{2f_s}$	(c) ☐ $\frac{f_s}{2T}$	(d) ☐ $\frac{2}{f_s T}$

5. Regard a periodic signal with period T that is sampled with sampling time Δt (with T a multiple of Δt). What is the **lowest** non-zero angular frequency (in rad/s) that can be present in the signal ?

(a) ☐ $\frac{\pi}{T}$	(b) ☐ $\frac{\pi}{\Delta t}$	(c) ☐ $\frac{2\pi}{\Delta t}$	(d) ☐ $\frac{2\pi}{T}$

6. In Question 5 what is the **highest** possible frequency (in Hz) that can be present in the same signal?

(a) ☐ $\frac{1}{T}$	(b) ☐ $\frac{1}{\Delta t}$	(c) ☐ $\frac{1}{2\Delta t}$	(d) ☐ $\frac{1}{2T}$

7. What should be in practice a good sampling rate for a acquiring a periodic signal with $f = 65$Hz?

(a) ☐ 460Hz	(b) ☐ 120Hz	(c) ☐ 65Hz	(d) ☐ 13000Hz

8. Which of the following statements about the FT and the DFT is **NOT** correct?:

(a) ☐ The FT works on continuous time signals whereas the DFT on discrete time signals	(b) ☐ The FT works with integrals whereas the DFT with finite sums
(c) ☐ Both of them are limited by the Nyquist theorem	(d) ☐ They transform signals from time domain to frequency domain

9. A continuous function in the time domain $u_c(t)$ is sampled with a frequency f_s, resulting in a set of discrete values $u = [u(0), \ldots, u(N-1)]^\top$. Applying the DFT to u yields $U = [16, 4, 0, 0, 16, 0, 0, 4]^\top$. Reconstruct the function $u_c(t)$ from U.

DFT: $U(m) = \sum_{k=0}^{N-1} u(k) e^{i\frac{-2\pi mk}{N}}$, for $m = 0, \ldots, N-1$

IDFT: $u(n) = \frac{1}{N}\sum_{k=0}^{N-1} U(k) e^{i\frac{2\pi kn}{N}}$, for $n = 0, \ldots, N-1$

(a) ☐ $u_c(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_s t}{4}) + \cos(\pi f_s t)$	(b) ☐ $u_c(t) = 2 + \cos(\frac{\pi f_s t}{4}) + 2\cos(\pi f_s t)$
(c) ☐ $u_c(t) = \cos(\frac{\pi f_s t}{4}) + 4\cos(\pi f_s t)$	(d) ☐ $u_c(t) = 2 + \cos(\frac{\pi f_s t}{8}) + 2\cos(\frac{\pi f_s t}{2})$

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10. Rewrite now the DFT as defined above as $U = M \cdot u$, where $u = [u(0), u(1), u(2), u(3)]^\top$ and $M \in \mathbb{C}^{N\times N}$ is a matrix. Which of the following represents the element in the fourth row and second column of M:

(a) ☐ i	(b) ☐ $-i$	(c) ☐ -1	(d) ☐ 1

11. Which of the following properties holds for M (A^H being the conjugate transpose of A):

(a) ☐ $M = M^H$	(b) ☐ $M = M^\top$	(c) ☐ $M = -M^H$	(d) ☐ $M = -M^\top$

12. Using the variables defined in Question 9, but with $u_c(t)$ containing a single frequency f, when do leakage errors occur? Leakage errors occur if:

(a) ☐ f is higher than the Nyquist frequency	(b) ☐ f is not an harmonic of the base frequency
(c) ☐ N is too small	(d) ☐ N is not a power of 2

13. Continuing with the above: in the DFT the base frequency ω_s is defined by:

(a) ☐ $\pi f_s/N$	(b) ☐ $\pi f/N$	(c) ☐ $2\pi f/N$	(d) ☐ $2\pi f_s/N$

14. You measure a signal where the signal-to-noise-ratio (SNR) at a certain frequency f_0 is given by 40 dB. How accurately can you estimate the amplitude of this frequency component (approximately)?

(a) ☐ 2 %	(b) ☐ 40 %	(c) ☐ 20 %	(d) ☐ 1 %

15. A system is excited with a periodic excitation signal $u(t)$ of period T that is for $t \in [0, T/2]$ given by $u(t) = -7$ and for $t \in [T/2, T]$ by $u(t) = 1$. What is the **crest factor** of this signal?

(a) ☐ $1/7$	(b) ☐ $7/\sqrt{7}$	(c) ☐ $7/5$	(d) ☐ $7/4$

16. You want to identify the transfer function $G(j\omega)$ of an LTI system in the frequency band $\omega \in [\omega_{\min}, \omega_{\max}]$ with periodic multisine excitations. You choose a period length T that is an integer multiple of the sampling time Δt. Which other conditions should Δt and T satisfy?

(a) ☐ $\Delta t < \frac{\pi}{\omega_{\max}}, \quad T > \frac{2\pi}{\omega_{\min}}$	(b) ☐ $\Delta t < \frac{2\pi}{\omega_{\max}}, \quad T > \frac{2\pi}{\omega_{\min}}$
(c) ☐ $\Delta t < \frac{2\pi}{\omega_{\max}}, \quad T > \frac{\pi}{\omega_{\min}}$	(d) ☐ $\Delta t < \frac{\pi}{\omega_{\max}}, \quad T > \frac{\pi}{\omega_{\min}}$

17. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is MT with a large integer M. Which procedure should you follow to identify the transfer function $\hat{G}(j\omega_k)$ at a given frequency $\omega_k = \frac{2\pi k}{T}$?

(a) ☐ compute the DFTs of each window, then average the DFTs and then build the quotient of the average	(b) ☐ compute the DFTs of each window, build the DFT quotients and then average the quotients
(c) ☐ average the M windows, build the quotient of the average and apply DFT	(d) ☐ build the quotients of the M windows, average the quotients and apply the DFT on the quotients

18. Which of the following steps is NOT part of the Kalman filter algorithm?

(a) ☐ initialization	(b) ☐ prediction
(c) ☐ normalization	(d) ☐ innovation update

19. Which of the following formulas is associated with the covariance prediction step of the Kalman filter?

(a) ☐ $P_{[k,k]} = A_{k-1}^\top \cdot P_{[k-1,k-1]} \cdot A_{k-1} + W_{k-1}$	(b) ☐ $P_{[k,k-1]} = A_{k-1} \cdot P_{[k-1,k-1]} \cdot A_{k-1}^\top + W_{k-1}$
(c) ☐ $P_{[k,k]} = A_{k-1} \cdot P_{[k,k]} \cdot A_{k-1}^\top + W_{k-1}$	(d) ☐ $P_{[k,k-1]} = A_{k-1}^\top \cdot P_{[k,k-1]} \cdot A_{k-1} + W_{k-1}$

20. Given the process model $\boxed{x_{k+1} = x_k + b_k}$ and measurement model $\boxed{y_k = x_k + d_k}$ with noises $b_k \simeq \mathcal{N}(0, 2)$ and $d_k \simeq \mathcal{N}(0, 4)$, which value W_{k-1} would you select for the covariance prediction step of Question 19?

(a) ☐ 4	(b) ☐ 2	(c) ☐ $1/2$	(d) ☐ $1/4$

points on page: 11	