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Institutt for fysikk

Eksamensoppgave i TFY4280 Signalanalyse

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Tlf.: 41466510

Eksamensdato: 20. mai

Eksamenstid (fra-til): 15.00-19.00

Hjelpemiddelkode/Tillatte hjelpemidler: C – formula tables are included as a resource

Annen informasjon:

Merk! Studenter finner sensur i Studentweb. Har du spørsmål om din sensur må du kontakte instituttet ditt. Eksamenskontoret vil ikke kunne svare på slike spørsmål.

1 Answer Problem 1

Read the course presentation below, especially about the Contents, Learning Outcome and Learning activities.

<https://www.ntnu.edu/studies/courses/TFY4280#tab=omEmnet>

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TFY4280 - Signal Processing

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Examination arrangement

Examination arrangement: Written examination

Grade:

Evaluation form	Weighting	Duration	Examination aids
Written examination	100/100	4 hours	C

Course content

The course focuses on basic tools in analysis of analogue and digital signals and systems. Time and frequency domain description of signals. Use of Laplace, Fourier, and Z-transforms. Basic analogue and digital filter design, frequency response, data sampling. Excitation-response analysis of linear systems. Description and analysis of stochastic signals and measured signals with noise, correlations and energy spectrum analysis. Analysis of signals and systems using mathematical methods involving differential and integral calculus, as well as numerical methods using Matlab or python.

Learning outcome

The student is expected to: 1. Obtain, through a combined theoretical and experimental approach to the subject, a fundamental understanding of signal processing and needed theoretical and mathematical background to describe signals and systems, experimental measurement signals and time series. 2. Learn how to analyze various problems in signal processing using mathematical methods involving differential and integral calculus, as well as ICT-based/numerical methods by using Matlab or python.

Learning methods and activities

Lectures, calculation assignments, compulsory computer laboratory exercises (MATLAB or python). When lectures and lecture material are in English, the exam may be given in English only. Students are free to choose Norwegian or English for written assessments.

Compulsory assignments

Laboratorieøvinger

Please comment with some 10 - 25 sentences: What do you think was the most positive parts of the course.

What moments of the course can be better? Is there any particular signal processing area you think should be added or emphasized more?

Fill in your answer here

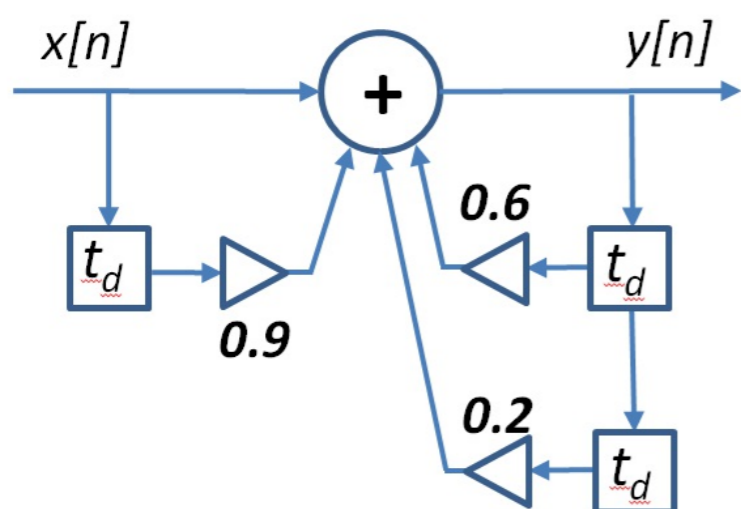
Format | B | I | U | x_2 | x^2 | I_x | | | | | | | Ω | | | Σ |

Words: 0

Maximum marks: 20

2 Answer Problem 2

Consider the following digital net.



where the boxes are delays and the triangles with their gain factors correspond to amplifiers. You only give answers:

- Write down the difference equation associated by the net. (in the form $y[n]= \dots$)
- Write down the first 4 terms of the digital impulse response: $\{..,0,0,\mathbf{1},0,0,.. \}$
- Write down the first 4 terms to the input signal: $x[n] = \{\mathbf{3},1,2\}$.

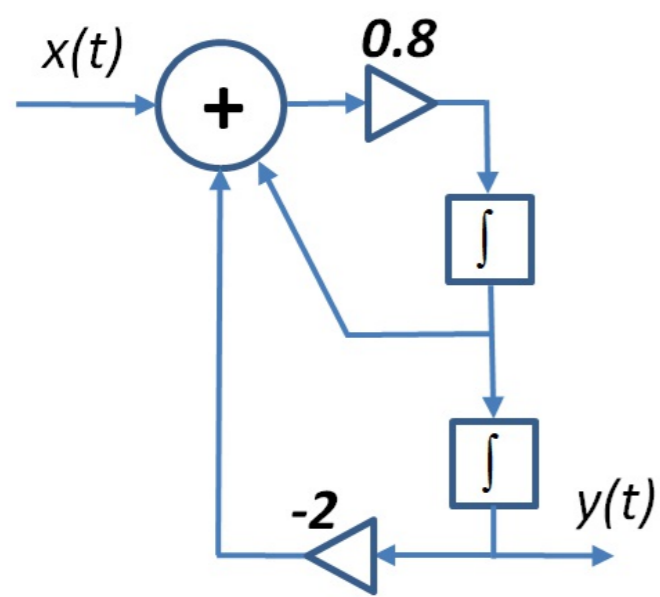
Notation for b) and c): In the sequence $\{a,\mathbf{b},c,d\}$ 'bold' **b** denotes index '0'.

Fill in your answer here

Maximum marks: 10

3 Answer Problem 3

Consider the following block diagram in direct form II:



Give a linear differential equation (in terms of $x(t)$, $y(t)$, dx/dt , etc...) that corresponds to the same system.

Fill in your answer here

Maximum marks: 10

4 Answer Problem 4

What is the time signal $f(t)$ giving rise to the following unilateral Laplace transform?

$$F(s) = (10s+10) / [(s^2+2s+1)(s+3)^2]$$

Fill in your answer here

Maximum marks: 10

5 MC2

How much amplification does a system have in dB if:

$$u_{\text{out}} = 10^4 u_{\text{in}}$$

u is an amplitude signal (voltage, current, etc)

Select one alternative:

- 20 dB
- 4 dB
- 80 dB
- 10 dB

Maximum marks: 5

6 MC3

An electronic filter consisting of a resistance, a condenser and a coil is described by the following impedance function: $Z(s) = sL + R / (1 + sRC)$

Specifically, $L = 1.2 \text{ H}$; $C = 1/6 \text{ F}$; $R = 1000 \text{ ohm}$. What kind of filter is this and what is the characteristic frequency.

Select one alternative:

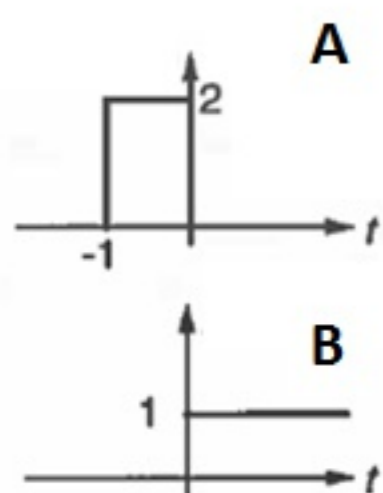
- Low-pass filter; Cut-off frequency 1.414 rad/s
- High-pass filter; cut-off frequency 0.2 rad/s
- Band-pass filter; pass frequency 2.236 rad/s
- Band-block filter; block frequency 5 rad/s

Maximum marks: 5

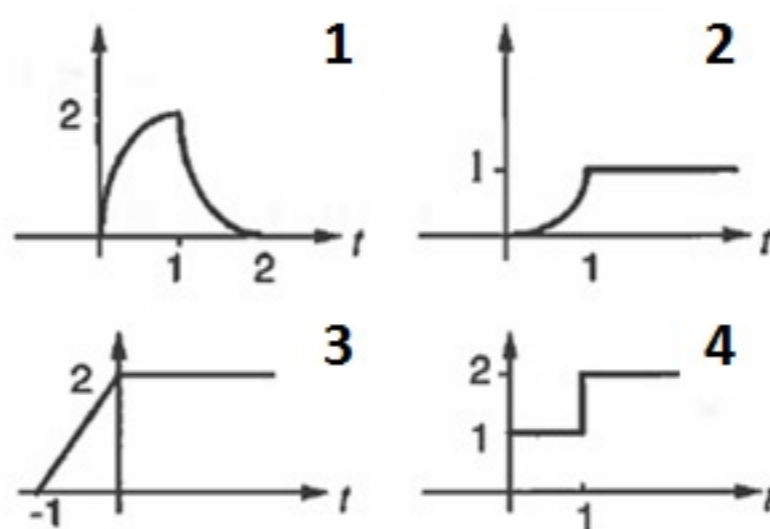
7 **MC4**

MC4:

Consider the following two signals:



Which would best describe their convolution product:



Select one alternative:

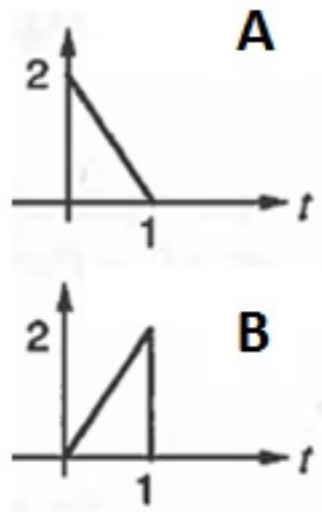
- Signal 1
- Signal 4
- Signal 2
- Signal 3

Maximum marks: 5

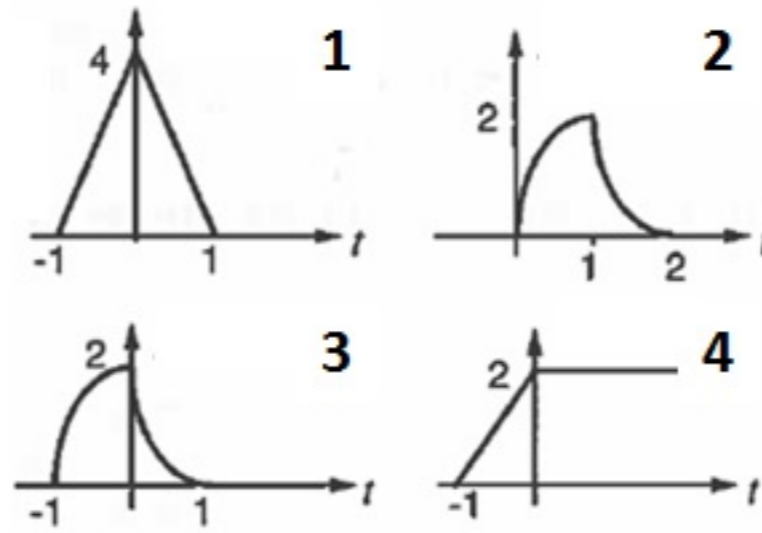
8 **MC5**

MC5:

Consider the following two signals:



Which would best describe their convolution product:



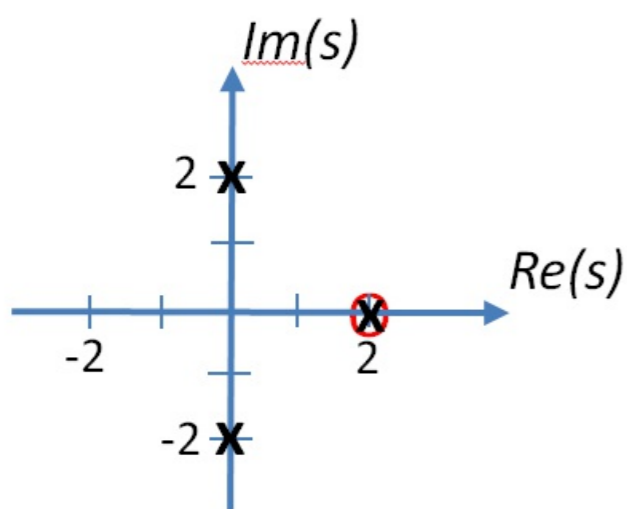
Select one alternative:

- Signal 1
- Signal 2
- Signal 4
- Signal 3

Maximum marks: 5

9 **MC6**

What transfer function has the following pole zero diagram?



K is an arbitrary real constant.

Select one alternative:

- $K(s+2)/(s+2i)^2$
- $K(s+2)/[(s-2)(s+4)^2]$
- $K(s+2)/(s+2)^2$
- $K/(s^2+4)$

Maximum marks: 5

10 MC7

What is correct for the Fourier transform of a real, causal signal with no particular symmetry:

Select one alternative:

- Real part is even; odd part is even.
- Real part is odd; imaginary part is odd.
- Real part is odd; imaginary part is zero.
- Real part is even; imaginary part is odd.

Maximum marks: 5

11 MC8

A second-order system is described by the following differential equation:

$$2 \frac{dy}{dt} + y = 3 \frac{d^2x}{dt^2} + 2 \frac{dx}{dt} + x$$

where x and y are functions of t . $x(t)$ is the input, and $y(t)$ the output. What is the internal system transfer function if the initial values of $y(t) = y(0) = k$. ($x(0) = 0$; and the initial values of dy/dt and dx/dt are also $= 0$)

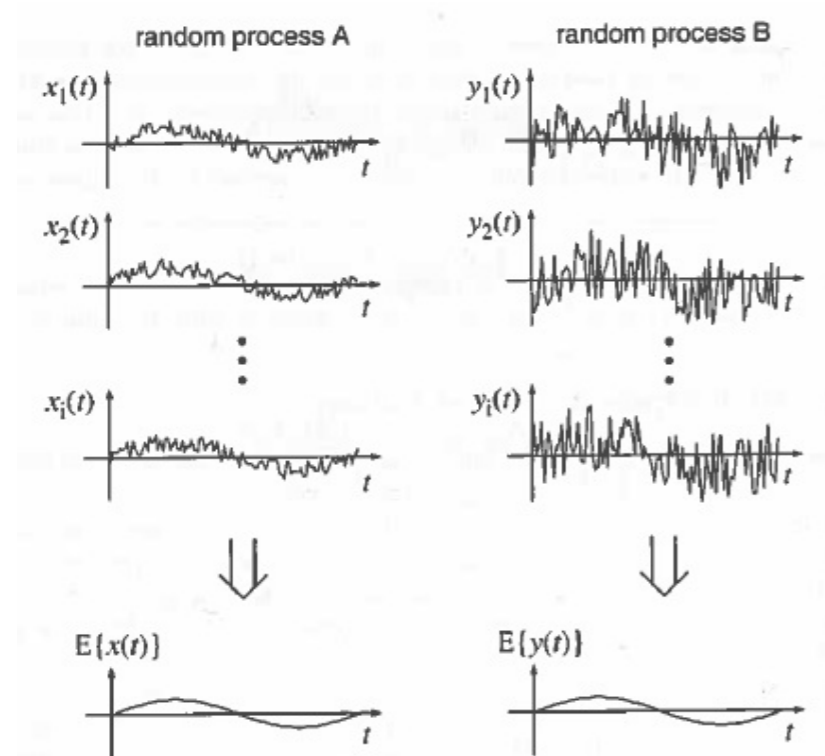
Select one alternative:

- $k^2/(2s^2+s+1)$
- $2k/(2s+1)$
- $k/(s+2)$
- $k/(s+1)$

Maximum marks: 5

12 MC9

Consider the two random processes A and B:



Which of the following statements is true?

Select one alternative:

- It is enough to know the square average in order to calculate the standard deviation.
- The first-order expected values of processes A and B are all the same.
- The random process A has lower variance than process B.
- None of the processes A or B can be stationary.

Maximum marks: 5

13 MC10

Find the Laplace transform of the following time function:

$$f(t) = -5 \cdot u(t-2) \cdot u(3-t)$$

$u(t)$ is the unit step function.

Select one alternative:

- $5s \cdot \sin(2s-3s)$
- $-5(e^{-2t} + e^{3t})$
- $5(e^{-3s} - e^{-2s})/s$
- $s \cdot (e^{3s} - e^{-2s})/5$

Maximum marks: 5

14 **MC11**

A signal $y(t)$ is composed of a random process $x(t)$ and a deterministic process $d(t)$ such that $y(t) = x(t) + d(t)$

The variance of the random process is $\sigma_x^2 = 7$.

Select one alternative:

- $\sigma_y^2 = 0$
- $\sigma_y^2 = 14$
- $\sigma_y^2 = 7$
- $\sigma_y^2 = \frac{\sigma_x}{\sigma_d^2}$

Maximum marks: 5