NTNU
Norwegian University of Science and Technology
Department of Physics

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TFY4280 Signalanalyse (Signal Processing)

Examination May 26th, 2010, Time: 09.00 – 13.00

Allowed aid
NTNU allowed standard mathematics/physics tables (Rottman/Barnett and Cronin)
Electronics: NTNU allowed calculator.

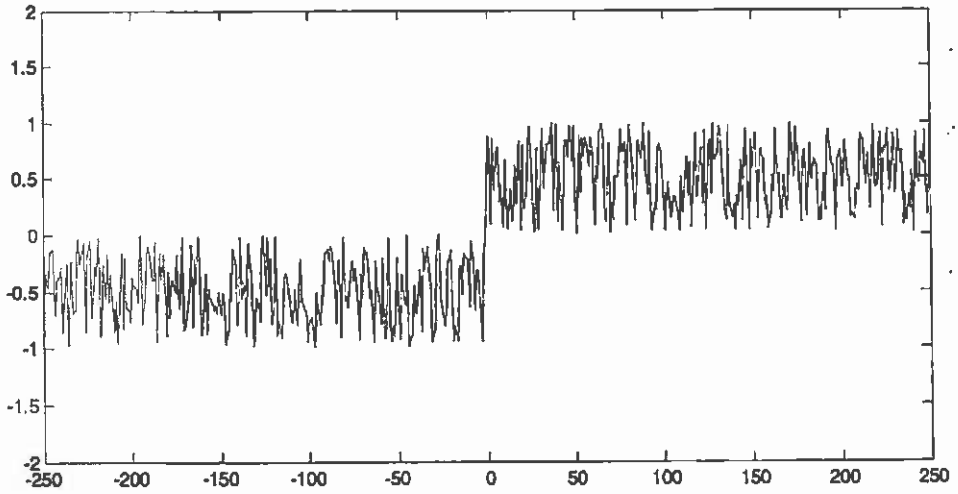
Contents:
Examination problems (4 pages with this page)
- Part A: only answers should be handed in (1 page).
- Part B: solutions and answers should be handed in (2 pages).

Attachment (6 pages with transform tables and properties).

Grades to be announced around June 11th, 2010.

Evaluation/grades
Total number of points of the written examination is 100. The following table recommended by NTNU will be used for converting to A, B, C, ...-scale.
A: 100-90 points
B: 89-80 points
C: 79-60 points
D: 59-50 points
E: 49-40 points
F: 39-0 points

Section A: 4 problems to which only answers shall be given. (A correct answer can each give maximum 10 points.)



A1: Sketch the self-convolution of the noisy step-function as above.

A2: Sketch the self-correlation of the noisy step-function as above.

A3: A system has a system response $H(s)$ given by

$$H(s)=\frac{2}{(s+2)^2}$$

Determine the output signal *y(t)* following the unit step response starting at $t = 0$.

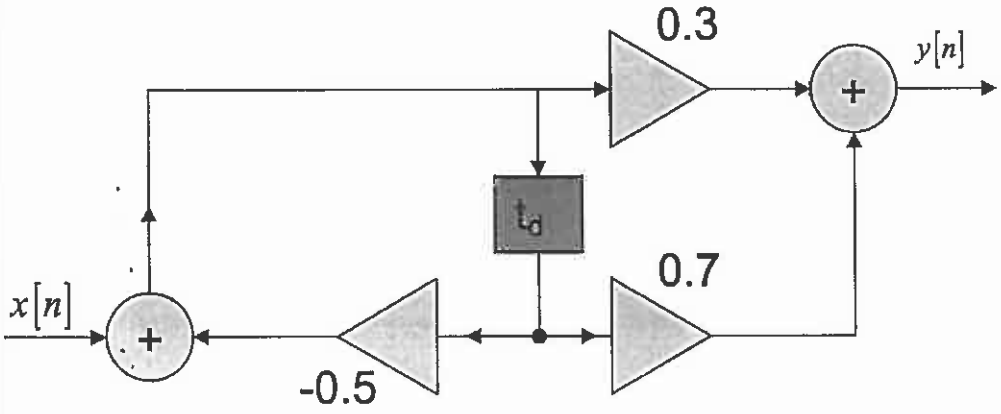
A4: A dice is loaded with an active magnetic system and operated in such a way that the number six always appear at every 6th throw i.e., at throws $k = 6N$, $N = 1, 2, 3, \ldots$ All other throws results in the expected 'random number' of a regular dice.

Let $y_i[k]$ be the expected number for each throw. Find the average $\overline{\mu_i[k]}$ and standard deviation $\sigma_y[k]$ of the expected outcome for a long test series of throws.

(Hint: recall that $\sigma_y^2[k]=E\{y_i^2[k]\}-\overline{\mu_i[k]}^2$)

Section B: 4 problems to which complete solutions must be handed in. (A correct answer can each give maximum 20 points.)

B1: A simple digital signal processing system is defined by the following net with adders (circles), multipliers (triangles) and time-delays (squares):



a) Find the difference equation that follows from the digital net involving only the input (x[n]) and output (y[n]) signals.

b) Find the system transfer function H(z).

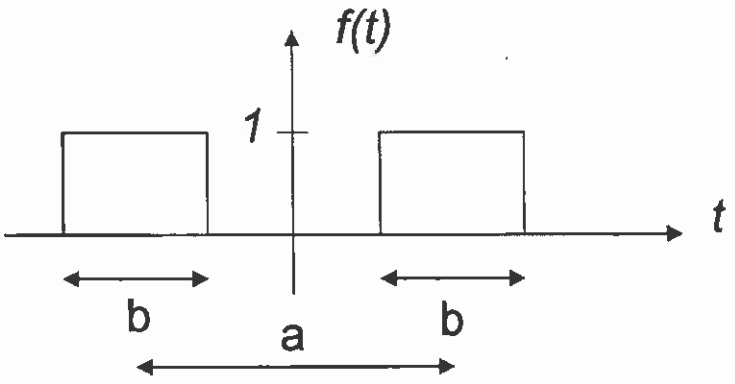
c) What is the 4 first terms of the output $y[n]$ as a response to the unit step function:

$$u[n]=\{\underset{\uparrow}{1},1,1,1,1,.....\}$$

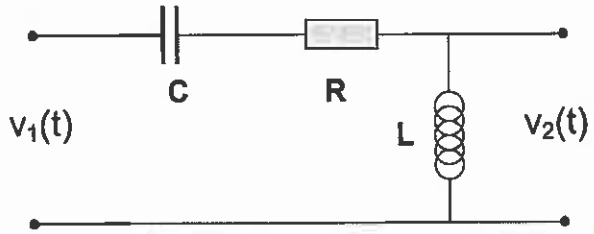
d) Suggest an alternative equivalent block diagram that uses two time-delays.

B2: a) Show the time-shift property of the Fourier transform i.e., $F\{f(t-t_0)\}=F(\omega)e^{-i\omega t_0}$ where $F\{f(t)\}=F(\omega)$.

b) Determine the Fourier transform of two time-slot functions of width b separated by time a, symmetrically around $t = 0$, as shown below.



B3: a) Study the electric circuit below. Use the impedance method to determine the system transfer function *H(s)*.



b) What condition must hold for R, L and C for matching the circuit so that the system transfer function *H(s)* can be written: $H(s) = \frac{s^2}{(s+a)^2}$, where a is some parameter determined by R, C and/or L. What kind of filter does the circuit represent?

c) Determine a, and associated R, C and/or L so that the cut-off frequency will be at $\omega = 100$.

d) Plot the amplitude frequency response $|H(\omega)|$ (in terms of dB) for the angular frequencies in the range $0.1 - 10^3$ (use logarithmic scale also for the frequency).