DIGITAL FILTERS 52337S
Exam 20.12.2002

YOU ARE ALLOWED TO BRING ONE A4-SIZE PAPER FILLED (BOTH SIDES CAN BE USED) WITH FORMULAS AND OTHER INFORMATION.

1. a) An analog signal is constructed from three sine waves with frequencies 10, 20 and 30 kHz and amplitudes 1, 2 and 3 respectively. The signal is sampled at 90 kHz frequency. Sketch the spectra of the original and sampled signals. Use the normalized frequency axis [0,1] for the sampled signal's spectrum. (1p)
   b) Choose a sampling frequency, which causes the signal to aliase clearly and present the sampled signal's spectrum using normalized frequency axis. (1p)
   c) Filter the digital signal with sampling frequency of 90 kHz in 1a) using digital FIR-filter $H(z)=0.19+0.2049z^{-1}+0.2101z^{-2}+0.2049z^{-3}+0.1900z^{-4}$. Sketch the spectrum of the resulting signal. (3p)
   d) Sketch a frequency response (both amplitude and phase response) of the FIR-filter in 1.c). (2p)

2. An application has an analog lowpass filter (3 dB frequency is f_p=5 kHz) with a normalized transfer function
$$H(s)=\frac{1}{s-1}$$
   The application will be transformed to use equivalent digital filtering, and the signal will be sampled at 20 kHz. Using the impulse invariant method, determine the transfer function of the digital filter. If the system uses FIR-filtering, which would be the 4 first coefficients? (4p)

3. Calculate the convolution for signals h(n) = {0 1 0} and x(n) = {1 0 1 0 1 0 1 0 1 1 1 1} using overlap-add –method. (3p)

4. a) A fourth order filter has a factored form
$$H(z)=\frac{(z-j)(z+j)(z-1)(z-1)}{(z-0.5)(z-0.5)(z-0.7j)(z+0.7j)}$$
   Present cascade realization based on second degree canonic sections. Justify your selections based on finite wordlength effects. (3p)
   b) The cascade you designed, will be realized using DSP-processor that has 32-bit accumulator register. The signal consists of 8-bit samples. Present the quantization noise model for the realization. Determine the