UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2010

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	DIGITAL SIGNAL PROCESSING
COURSE CODE:	E420
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. **There are six questions in this paper. Answer any FIVE questions. Each question carries 20 marks.**
2. **If you think not enough data has been given in any question you may assume any reasonable values.**
3. **Tables of selected functions are attached to the end of this question paper.**

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THIS PAPER CONTAINS FOUR (4) PAGES INCLUDING THIS PAGE

Q.1 *a)* Mention some advantages of DSP. *2 marks*

b) Draw a block diagram of a typical DSP system, explain each block and give any two applications of a DSP system. *8 marks*

c) What is the advantage of FFT over the DFT? Determine the number of complex multiplications for FFT and DFT when a sequence of data is 1024 points. *5 marks*

d) Determine the expressions for the magnitude and phase responses of the following digital system with a sampling rate of 8000 Hz :

$$y(n) = 0.5x(n) + 0.5x(n-1)$$

Use your expressions to determine the magnitude and phase of the response at a radian frequency of 0.25π. *5 marks*

Q.2 *a)* How can aliasing be eliminated in a sampled signal? *2 marks*

b) Given the transfer function

$$H(z) = \frac{0.4(1-z^{-2})}{1+1.2z^{-1}+0.28z^{-2}}$$

Obtain the filter realizations using the following:

-Direct form I and Direct form II IIR filter

-Cascade IIR form via the first order section *8 marks*

c) Given an analog filter whose transfer function is $H(s) = \frac{5}{s+5}$.

Convert it to the digital filter transfer function and obtain the corresponding difference equation when sampling period $T = 0.01$ sec. *5 marks*

d) Determine the transfer function, *H(z)*, and impulse response for the following IIR filter: $y(n) = 0.2x(n) + 0.3x(n-1) + 0.4y(n-1)$ *5 marks*

Q.3 *a)* Using the Bilinear Transformation (BLT) method, determine the transfer function *H(z)* and corresponding difference equation for a first order low pass Butterworth filter with the following specifications:

3 dB attenuation at the pass band frequency of 1.5 kHz
10 dB stop band attenuation at the frequency of 3 kHz, and
Sampling frequency of 8 kHz *10 marks*

b) What are the conditions required for a stable IIR filter? Illustrate your answer with a map between the s-plane and z- plane. *5 marks*

c) Write down a general expression for a 4th order FIR filter and obtain the number of filter coefficients, memory elements, multipliers and adders required.
Draw its realization structure in transversal form and in linear phase form. *5 marks*

Q.4 *a)* What are the differences between FIR and IIR filters? Write down their generalized difference equations *5 marks*

b) Calculate the filter co-efficients for a 3-tap FIR low pass FIR filter with a cut off frequency of 800 Hz and sampling rate of 8000 Hz using the Fourier Transform method. Determine the transfer function and difference equation of the designed FIR system, and compute the magnitude frequency response for $\Omega = 0, \pi/4, \pi/2$, and $3\pi/4$. *15 marks*

Q.5 *a)* With the aid of schematic diagrams show the differences between Von Neumann architecture processors and Harvard architecture processors. *6 marks*

b) Draw the basic architecture of floating point digital signal processor and explain it. *8 marks*

c) Write down the categories of the instruction set for a fixed point processor TMS 320C54x and give suitable examples for each category. *6 marks*

Q.6 *a)* A unit step sequence, *u(n)*, is applied to a system whose z-domain transfer function is $H(z) = \dfrac{3}{z - 0.5}$.

Obtain an expression for its output sequence. *(10 marks)*

b) Obtain the z-domain transfer function of the discrete system shown in Fig.Q.6.

(10 marks)

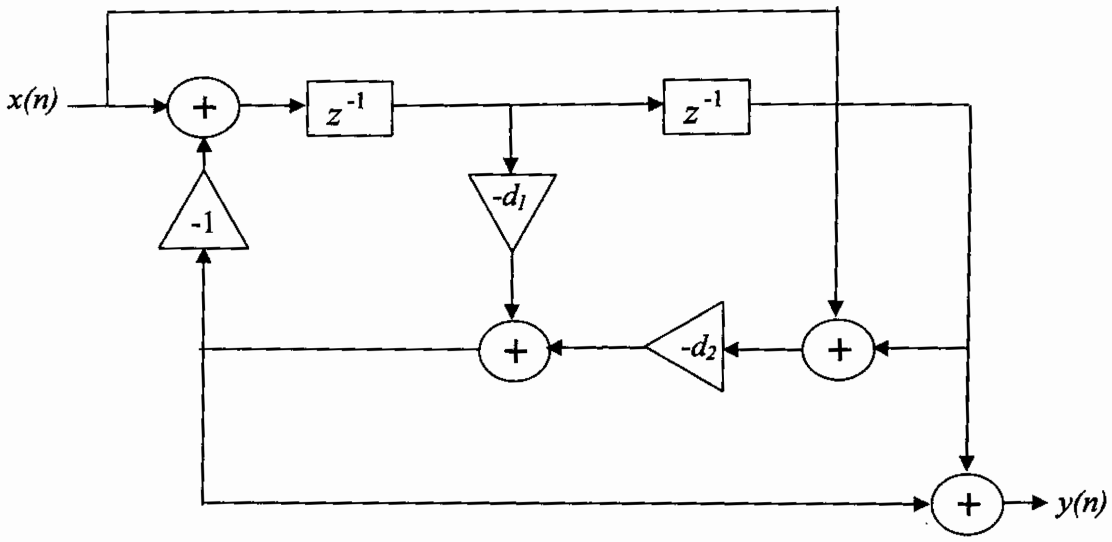

Fig. Q6b

TABLE OF Z-TRANSFORMS OF SOME COMMON SEQUENCES

Discrete-time sequence $x(n),\ n \geq 0$	**Z-transform** $H(z)$
$k\delta(n)$	k
k	$\frac{kz}{z-1}$
$ke^{-\alpha n}$	$\frac{kz}{z-e^{-\alpha}}$
$k\alpha^n$	$\frac{kz}{z-\alpha}$
kn	$\frac{kz}{(z-1)^2}$
kn^2	$\frac{kz(z+1)}{(z-1)^3}$
$kn\alpha^n$	$\frac{k\alpha z}{(z-\alpha)^2}$

TABLE OF 3-dB BUTTERWORTH LOWPASS PROTOTYPE TRANSFER FUNCTIONS

(ε=1)

n	$H_P(s)$
1	$\frac{1}{s+1}$
2	$\frac{1}{s^2+\sqrt{2}\,s+1}$
3	$\frac{1}{s^3+2s^2+2s+1}$

Analog Filter Specifications	Lowpass Prototype Specifications
Lowpass: $\omega_{ap},\ \omega_{as}$	$\nu_p = 1,\ \nu_s = \omega_{as}/\omega_{ap}$
Highpass: $\omega_{ap},\ \omega_{as}$	$\nu_p = 1,\ \nu_s = \omega_{ap}/\omega_{as}$
Bandpass: $\omega_{apl},\ \omega_{aph},\ \omega_{asl},\ \omega_{ash}$	$\nu_p = 1, \nu_s = \frac{\omega_{ash}-\omega_{asl}}{\omega_{aph}-\omega_{apl}}$
$\omega_0 = \sqrt{\omega_{apl}\omega_{aph}},\ \omega_0 = \sqrt{\omega_{asl}\omega_{ash}}$	
Bandstop: $\omega_{apl},\ \omega_{aph},\ \omega_{asl},\ \omega_{ash}$	$\nu_p = 1, \nu_s = \frac{\omega_{aph}-\omega_{apl}}{\omega_{ash}-\omega_{asl}}$
$\omega_0 = \sqrt{\omega_{apl}\omega_{aph}},\ \omega_0 = \sqrt{\omega_{asl}\omega_{ash}}$	

SUMMARY OF IMPORTANT FEATURES OF SELECTED WINDOW FUNCTIONS

Name of Widow	**Normalized Transition Width**	**Passband Ripple (dB)**	**Main lobe relative to Sidelobe (dB)**	**Max. Stopband attenuation (dB)**	**6 dB normalized bandwidth (bins)**	**Window Function** $\omega(n)$, $\lvert n\rvert \le (N-1)/2$
Rectangular	0.9/N	0.7416	13	21	1.21	1
Hanning	3.1/N	0.0546	31	44	2.00	$0.5 + 0.5\cos\left(\frac{2\pi n}{N}\right)$
Hamming	3.3/N	0.0194	41	53	1.81	$0.54 + 0.46\cos\left(\frac{2\pi n}{N}\right)$
Blackman	5.5/N	0.0017	57	74	2.35	$0.42 + 0.5\cos\left(\frac{2\pi n}{N-1}\right) + 0.08\cos\left(\frac{4\pi n}{N-1}\right)$
Kaiser	2.93/N (β=4.54)	0.0274		50		$\dfrac{I_o\left(\beta\left\{1-\left[\frac{2n}{N-1}\right]^2\right\}^{\frac{1}{2}}\right)}{I_o(\beta)}$
	4.32/N (β=6.76	0.00275		70		
	5.71/N (β=8.96)	0.000275		90		

$$\text{Bin width} = \frac{f_s}{N}\ \text{Hz}$$