Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination
August, 2018

Level : B.E.		Course	: ETEG 305
Year : III		Semester	: II
Exam Roll No. :	Time: 30 mins.	F. M.	: 10
Registration No.:		Date	AUG 23 2018

SECTION "A"
[20 Q. × 0.5 =10 marks]

Choose the most appropriate answer:

1) Which of the following sequence has the z-transform $X(z) = (1 + 2z)(1 + 3z^{-2})$

a) $x[n] = \{2, 1, 6, 3\}$
b) $x[n] = \{3, 6, 1, 2\}$
c) $x[n] = 2\delta[n + 1] + \delta[n] + 6\delta[n - 1] + 3\delta[n - 2]$
d) $x[n] = 3\delta[n + 1] + 6\delta[n] + \delta[n - 1] + 2\delta[n - 2]$

2) What is the ROC of the z-transform of the signal $x[n] = \left(\frac{1}{2}\right)^n (u[n] - u[n - 10])$?

a) $|z| < \frac{1}{2}$
b) $|z| > \frac{1}{2}$ and $z \neq \infty$
c) $|z| > \frac{1}{2}$ and $z \neq 10$
d) $|z| > \frac{1}{2}$ and $z \neq 0$

3) What is the ROC of the signal $x[n] = \alpha^n u[n] + \beta^n u[-n - 1]$?

a) $|\alpha| < |z| < |\beta|$
b) $|\alpha| > |z| > |\beta|$
c) $|\alpha| > |z| < |\beta|$
d) $|\alpha| < |z| > |\beta|$

4) What is the z-transform of the signal $x[n] = u[n] - u[n - N]$?

a) $\frac{1 - N}{1 - z^{-1}}$
b) $\frac{1 - z^N}{1 - z^{-1}}$
c) $\frac{1 + z^{-N}}{1 - z^{-1}}$
d) $\frac{1 - z^{-N}}{1 - z^{-1}}$

5) If $x[n]$ is a complex sequence, then the z-transform of the real part of the sequence $(\mathcal{R}\{x[n]\})$ is:

a) $\frac{1}{2}[X(z) - X^*(z^*)]$
b) $\frac{1}{2}[X(z) + X^*(z^*)]$
c) $\frac{1}{2}[X(z) + X^*(z)]$
d) $\frac{1}{2}[X(-z) + X^*(z)]$

6) The 2 point DFT of the sequence $x[n] = \{1, 1\}$ is:

a) $X[k] = \{0, 2\}$
b) $X[k] = \{2, -2\}$
c) $X[k] = \{2, 0\}$
d) $X[k] = \{2, 2\}$

7) If $\delta[n]$ represents a DT unit impulse signal, the N point DFT of $\delta[n - P]$ is:

a) W_N^{kp}
b) W_N^{kp}
c) W_N^{np}
d) W_N^{-np}

8) Which of the following is true regarding the direct computation of N point DFT?

a) It requires N^2 complex additions and N^2-N complex multiplications.

b) It requires N^2 complex multiplications and N^2-N complex additions.

c) It requires N^2 complex multiplications and N^2+N complex additions.

d) It requires N^2 complex additions and N^2+N complex multiplications.

9) Which of the following is not an algorithm to compute DFT?

a) DIT FFT b) DIF FFT

c) DCT d) Goertzel Algorithm

10) The computational complexity of a structure includes.....................required to compute the output from the input.

a) number of additions b) number of arithmetic operations

c) number of complex multiplications d) number of delay elements

11) The frequency sampling realization of a FIR filter can be viewed as cascade of ....filters.

a) 4 b) 3 c) 2 d) 1

12) If W_N represents the twiddle factor used in DFT equation, $W_N^{\frac{N}{2}}$ is equal to..........

a) 1 b) -1 c) j d) -j

13) In FIR filter design using windows, if a particular window reduces the ripple, it has trade off that....

a) it has higher computation complexity b) it uses more memory elements

c) it has larger transition bandwidth d) it will be less stable

14) Coefficient symmetry is important consideration in FIR filters, because it provides.............

a) smaller pass band ripple b) smaller stop band ripple

c) larger transition band d) linear phase response

15) For the rectangular window, the peak side lobe will be ....dB below the main lobe.

a) 43 b) 20 c) 13 d) 7

16) If M and N are the order of numerator and denominator polynomials of system function of an IIR system, the number of multiplications required in direct form I realization is ......

a) M+N+1 b) M+N c) M+N+2 d) larger of M and N

17) The system function for the individual second order section used in cascade realization of IIR systems has the form of.....................

a) $\frac{b_{k0} + b_{k1}z^{-1}}{1 + a_{k1}z^{-1} + a_{k2}z^{-2}}$ b) $\frac{b_{k0} + b_{k1}z^{-1} + b_{k2}z^{-2}}{1 + a_{k1}z^{-1} + a_{k2}z^{-2}}$

c) $\frac{1 + b_{k1}z^{-1} + b_{k2}z^{-2}}{1 + a_{k1}z^{-1} + a_{k2}z^{-2}}$ d) $\frac{a_{k0} + a_{k1}z^{-1}}{1 + a_{k1}z^{-1} + a_{k2}z^{-2}}$

18) Bilinear transformation involves................

a) conformal mapping

b) many to one mapping

c) one to many mapping

d) approximating the differentiation

19) At the frequency $\omega = 1$, the normalized Butterworth low pass filter has its ....

a) folding frequency

b) half power frequency

c) pass band edge frequency

d) stop band edge frequency

20) When bilinear transformation is used with sampling time of 1ms, analog frequency of $\frac{\pi}{2}$ rad/s is mapped to.......in digital frequency

a) 1.57×10^{-3}

b) 45×10^{-3}

c) $\frac{\pi}{2}$

d) 3.92×10^{-7}

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F. M. : 40

SECTION "B"
[5Q × 8 = 40 marks]

Attempt *ANY FIVE* questions. Symbols and abbreviations have usual meanings. Assume suitable values for missing data.

1. a. Digital signal processing has found applications in wide variety of areas. Explain any two application areas of DSP making it clear how and why it is applied. [2]

   b. Consider a CT signal $x(t) = \sin 2000\pi t + 5\ \cos 12000\pi t + 10\ \sin 6000\pi t$. What is the corresponding DT signal obtained when the sampling rate is 5000 samples per second? What is the highest frequency present is the DT signal? [2]

   c. For the following z-transform, determine the inverse z-transform using the partial fraction expansion method. [4]

$$X(z) = \frac{1 - \frac{1}{2}z^{-1}}{1 + \frac{3}{4}z^{-1} + \frac{1}{8}z^{-2}} \qquad ROC: |z| > \frac{1}{2}$$

   Also determine the first three sample values of the inverse z-transform using power series expansion method to verify your result.

2. a. Using the known z-transform pair of $x[n] = a^n u[n]$ and $X(z) = \frac{1}{1-az^{-1}}$ and the properties of z-transform, find the z-transform of the following DT signal: [3]

$$y[n] = -na^n u[-n-1] + \delta[n]$$

   b. Two signal $x[n]$ and $y[n]$ are related as: [2]

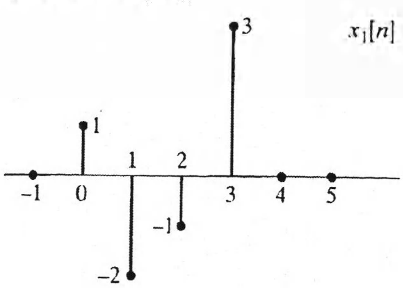
$$y[n] = \sum_{k=-\infty}^{n} x[k]$$

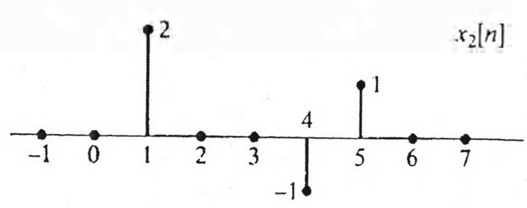
   Show that, $Y(z) = \frac{X(z)}{1-z^{-1}}$. Where, $X(z)$ and $Y(z)$ are respective z-transforms of $x[n]$ and $y[n]$.

   c. DFT of a DT signal are equivalently the samples of its DTFT. Using this known principle, derive the expressions for forward and inverse DFT operations from the corresponding DTFT expressions. What is the significance of '*point of DFT (N)*'? [3]

3. a. State and prove the convolution property of the z-transform. How can this property be used to simplify the analysis of DT LTI filters? [3]

   b. The figures below show two finite length DT sequences $x_1[n]$ and $x_2[n]$. Obtain and plot the sequence $x_3[n]$ such that $x_3[n] = x_1[n] \circledast x_2[n]$. Where, $\circledast$ represents 6 point circular convolution. Use circular graph method and illustrate all intermediate figures clearly. [3]





c. Using the definition of DFT, compute the N-point DFT of the sequence: [2]

$$x[n] = a^n, \qquad 0 \le n \le N-1$$

4. a. What is FFT algorithm? What are the differences and similarities between the DIT and DIF algorithms? [2]

b. If $x[n] = \{1, 2, 2, 3, 1, 1, 4, 2\}$, find 8 point DFT $X[k]$ using decimation in time radix-2 FFT algorithm. (Use butterfly diagram and show all intermediate computations) Can you estimate the speed improvement factor as compared to the direct computation? [4]

c. Compare the relative advantages and disadvantages of FIR filter design methods using windows, frequency sampling and optimum equiripple design. [2]

5. a. A low pass linear phase FIR digital filter is to be designed for a cut off frequency of 1000 Hz and working at a sampling frequency of 5 kHz. Consider the length of the impulse response of the filter to be 7. If the stop band ripple 0.03162, select the suitable window and apply the windows method to design the FIR filter. [4]

b. Explain why alternative realizations of DT filters are important to study? Realize the causal DT IIR filter with system function given below using lattice ladder structure. [4]

$$H(z) = \frac{1 + 2z^{-1} + 3z^{-2} + 2z^{-3}}{1 + 0.9z^{-1} - 0.8z^{-2} + 0.5z^{-3}}$$

6. a. A signal filtering operation requires filter that has following parameters: $\omega_s = 500\,\pi$, $\omega_p = 200\,\pi$, $\alpha_{min} = 20\,dB$, $\alpha_{max} = 0.5\,dB$. The operation is to be implemented using an IIR digital filter. Design a Butterworth digital IIR filter using the bilinear transformation method. The sampling frequency to be equal to 1 kHz. Use the formula and tables provided at the end for the analog Butterworth filters. [4]

b. Bilinear transformation is considered the best transformation to convert an analog transfer function to the digital system function. Explain why is it so. Derive the mapping equations for bilinear transfer and explain its properties with related analysis and figures. [4]

Some useful relationships:

For Direct form to Lattice conversions:

$A_{m-1}(z) = \dfrac{A_m(z) - K_m B_m(z)}{1 - {K_m}^2}$	$B_m(z) = z^{-m} A_m(z^{-1})$

For ladder part, $C_{m-1}(z) = C_m(z) - v_m B_m(z)$

Design equations for analog Butterworth filters:

Minimum order required: $N = \dfrac{\log_{10}\left(\dfrac{10^{\frac{\alpha_{min}}{10}} - 1}{10^{\frac{\alpha_{max}}{10}} - 1}\right)}{2\ \log_{10}\left(\dfrac{\omega_s}{\omega_p}\right)}$	Cutoff frequency: $\omega_c = \dfrac{\omega_s}{\left[10^{\frac{\alpha_{min}}{10}} - 1\right]^{1/2N}}$

Analog Butterworth Low pass Transfer functions:

Order	Transfer function
2	$H_a(s) = \left(\dfrac{{\omega_c}^2}{s^2 + 0.707\omega_c s + {\omega_c}^2}\right)$
3	$H_a(s) = \left(\dfrac{\omega_c}{s + \omega_c}\right)\left(\dfrac{{\omega_c}^2}{s^2 + \omega_c s + {\omega_c}^2}\right)$
4	$H_a(s) = \left(\dfrac{{\omega_c}^2}{s^2 + 0.765\ \omega_c s + {\omega_c}^2}\right)\left(\dfrac{{\omega_c}^2}{s^2 + 1.848\ \omega_c s + {\omega_c}^2}\right)$

Properties of some windows:

Name	Width of main lobe (radian frequency)	Stopband Attenuation (dB) $20log_{10}\left(\frac{1}{\delta_s}\right)$	Passband Ripple(dB) $20log_{10}\left(1 + \delta_p\right)$	Peak Approximation Error $20log_{10}\ (\delta_s)$
Rectangular	4π/M	21	0.7416	-21
Bartlett	8π/M	25	0.4752	-25
Hanning	8π/M	44	0.0546	-44
Hamming	12π/M	53	0.0194	-53
Blackmann	4π/M	74	0.0017	-74

Definition of some windows of length M:

Blackman: $0.42 - 0.5\ \cos\frac{2\pi n}{M-1} + 0.08\cos\frac{4\pi n}{M-1}$

Hamming: $0.54 - 0.46\ \cos\frac{2\pi n}{M-1}$

Hanning: $0.5\left(1 - \cos\frac{2\pi n}{M-1}\right)$