Analog and Digital Signal Processing
Course Code: CSE363
Fall Semester Exam.

BME Program
Level 300
Exam Date: 29-12- 2018
Allowed Time: 2 Hours

Open-Sheet Exam

يمنع الإجابة بالقلم الرصاص – يراعى حسن تنسيق ورقة الإجابة

Attempt all questions. Assume any missed data. Full Mark is 50

Q.1.a) Determine whether or not each of the following signals is periodic. If a signal is periodic, determine its fundamental period.

i. $x(n) = \cos(\pi/3)n + \sin(\pi/4)n$

ii. $x(t) = \cos(t) + \sin(\sqrt{2}t)$ **[5 Marks]**

Q.1.b) Determine whether the following signals are energy signals, power signals, or neither.

i. $x(t) = tu(t)$

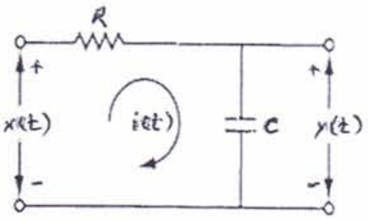
ii. $x(n) = 2e^{j3n}$ **[5 Marks]**

Q.1.c) a system given by $y(t) = \int_{-\infty}^{t} e^{-(t-\tau)} x(\tau) d\tau$.

i. Find the impulse response of the system.

ii. Show that the function e^{st} is an eigen-function of the system. **[5 Marks]**

Q.2.a) Derive an expression for the frequency response of the shown circuit. Sketch the magnitude the frequency response. Indicate the cut-off frequency on your sketch. Choose suitable values for *R* and *C* to realize a cut-off frequency of *1KHz*. **[5 Marks]**



Q.2.b) Consider an LTI system described by the differential equation

$$y'(t) + 2y(t) = x(t)$$

Find the frequency response, hence find the output of the system if $x(t) = e^{-t}u(t)$ **[5 Marks]**

Q.2.c) Consider an ideal low-pass filter given by:

$$H(\omega) = \begin{cases} 1 & \omega \le \omega_c \\ 0 & \omega > \omega_c \end{cases}$$

The input to this filter is $x(t) = e^{-2t}u(t)$. Find the value of ω_c such that this filter passes exactly one-half of the normalized energy of the input signal x(t). **[5 Marks]**

Q.3.a) Consider an LTI system described by the differential equation

$$y''(t) + y'(t) - 2y(t) = x(t)$$

i. Find the system function H(s).
ii. Find the impulse response if the system is causal – stable **[5 Marks]**

Q.3.b) Find the inverse Z-transform the following function using partial fraction method. Verify your result using power series expansion. **[5 Marks]**

$$X(z) = \frac{z}{2z^2 - 3z + 1} \qquad |z| < 1/2$$

Q.3.c) Consider a system described by

$$y(n) - 3y(n-1) = x(n), \quad y(-1) = 2, \quad , \quad x(n) = (2)^n u(n)$$

i. Determine the output of the system.
ii. Express the output *y(n)* as a sum of two components; the zero-state response and the zero-input response. **[5 Marks]**

Q.4.a) Design a digital low-pass filter to be used in A/H(z)-D/A structure with -3 dB cut-off frequency of 0.5π rad and at least -15 dB for frequencies greater than 0.75π rad. **[5 Marks]**

Q.4.b) Design a linear-phase LPF to be used in A/D-H(z)-D/A structure that satisfies the following specifications:

(1) minimum stop—band attenuation of 40 dB for frequencies greater than 15 KHz.

(2) Transition band of 5KHz

(3) Sampling frequency of 50 KHz

Window Type	Transition Width	Minimum Stop-band attenuation
Rectangular	4π/N	-21 dB
Bartlet	8π/N	-25 dB
Hanning	8π/N	-44 dB
Hamming	8π/N	-53 dB
Blackman	12π/N	-74 dB

Hint: $$W_{Han}(n) = \begin{cases} 0.50 - 0.50\cos\frac{2\pi n}{N-1} & 0 \le n \le N-1 \\ 0 & elsewhere \end{cases}$$ **[5 Marks]**

Q.4.c) A system is represented by its transfer function H(z) given by:

$$\frac{(z^2 + z)(z^2 - 3z + 2)}{(z^2 - z + 1/2)(z^2 + 1/16)}$$

i. Implement the system using cascade realization.
ii. Implement the system using direct form I. **[5 Marks]**

My best wishes to all of you!

Assoc. Prof. Hossam El-Din Moustafa

TABLE 3.2 ANALOG-TO-ANALOG TRANSFORMATION

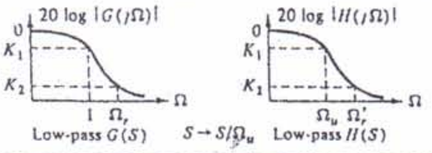
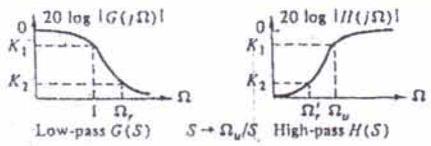
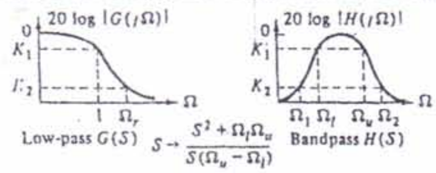
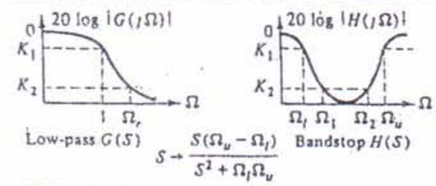
Prototype response	Transformed filter response	Design equations
		Forward: $\Omega_r' = \Omega_r\Omega_u$ Backward: $\Omega_r = \Omega_r'/\Omega_u$
		Forward: $\Omega_r' = \Omega_u/\Omega_r$ Backward: $\Omega_r = \Omega_u/\Omega_r'$
		Forward: $\Omega_{av} = (\Omega_u - \Omega_l)/2$ $\Omega_1 = (\Omega_r^2\Omega_{av}^2 + \Omega_l\Omega_u)^{1/2} - \Omega_{av}\Omega_r$ $\Omega_2 = (\Omega_r^2\Omega_{av}^2 + \Omega_l\Omega_u)^{1/2} + \Omega_{av}\Omega_r$ Backward: $\Omega_r = \min\{\lvert A\rvert, \lvert B\rvert\}$ $A = (-\Omega_1^2 + \Omega_l\Omega_u)/[\Omega_1(\Omega_u - \Omega_l)]$ $B = (+\Omega_2^2 - \Omega_l\Omega_u)/[\Omega_2(\Omega_u - \Omega_l)]$
		Forward: $\Omega_{av} = (\Omega_u - \Omega_l)/2$ $\Omega_1 = [(\Omega_{av}/\Omega_r)^2 + \Omega_l\Omega_u]^{1/2} - \Omega_{av}/\Omega_r$ $\Omega_2 = [(\Omega_{av}/\Omega_r)^2 + \Omega_l\Omega_u]^{1/2} + \Omega_{av}/\Omega_r$ Backward: $\Omega_r = \min\{\lvert A\rvert, \lvert B\rvert\}$ $A = \Omega_1(\Omega_u - \Omega_l)/[-\Omega_1^2 + \Omega_l\Omega_u]$ $B = \Omega_2(\Omega_u - \Omega_l)/[-\Omega_2^2 + \Omega_l\Omega_u]$

TABLE 3.1b BUTTERWORTH POLYNOMIALS IN STANDARD AND FACTORED FORMS

Standard form

$$B_n(s) = a_n s^n + a_{n-1}s^{n-1} + \cdots + a_1 s + a_0$$

a_8	a_7	a_6	a_5	a_4	a_3	a_2	a_1	a_0	n
							1	1	1
						1	$\sqrt{2}$	1	2
					1	2	2	1	3
				1	2.613	3.414	2.613	1	4
			1	3.236	5.236	5.236	3.236	1	5
		1	3.864	7.464	9.141	7.464	3.864	1	6
	1	4.494	10.103	14.606	14.606	10.103	4.494	1	7
1	5.126	13.138	21.848	25.691		13.138	5.126	1	8