The Johns Hopkins University
Department of Electrical and Computer Engineering

505.460 — Introduction to Linear Systems — Spring 1996

Quiz No. 3.

Answer any <u>FOUR</u> of the following five questions.
All four questions are worth 25% of the final grade

1. Give a block diagram description of a Quadrature amplitude modulation scheme. Describe what this scheme does and how it does it.

2. The signal with the amplitude frequency spectrum shown below

   is to be sampled using an ideal sampler.

   (a) Sketch the spectrum of the resulting signal for $|\omega| \leq 120\pi$ rad/s when sampling at rates of 15 Hz, 20 Hz, and 40 Hz.

   (b) Which of the sampling frequencies is acceptable for use if the signal is to be reconstructed using an ideal low-pass filter?

3. (a) Sketch the magnitude $|H_h(\Omega)|$ of a discrete-time ideal high-pass filter (make sure that you cover at least $\Omega \in [-4\pi, 4\pi]$).

   (b) Briefly describe how this filter can be be implemented using a low-pass filter.

   (c) In part (b), if the impulse response of the low-pass filter is $h_l[n]$, what is the corresponding impulse response for the high-pass filter?

4. Consider the *discrete-time* signal

$$x[n] = \left(\frac{1}{2}\right)^{|n|}$$

   (note the absolute value sign!) Find the Discrete-Time Fourier Transform of the signal.

5. Consider the discrete-time signal:

$$x[n] = \delta[n-2] + 2\delta[n-1] + 3\delta[n] + 2\delta[n+1] + \delta[n+2]$$

   Answer True or False: [+5 pts for a correct answer, -2 pts for an incorrect answer]. **Hint:** You can answer all the questions *without* computing the Discrete-Time Fourier Transform.

   (a) $\text{Re}\{X(\Omega)\} = 0$.

   (b) $\text{Im}\{X(\Omega)\} = 0$.

   (c) $\int_{-\pi}^{\pi} X(\Omega) d\Omega = 0$.

   (d) $X(\Omega)$ is periodic.

   (e) $X(0) = 0$.

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Quiz No. 4 (Final Exam).

Answer ALL of the following ten questions.

1. If $X(\omega)$ is the Fourier Transform of $x(t)$ and $z(t) = -2x(10t)$.
   (a) The amplitude spectrum of $z(t)$ is frequency compressed compared to that of $x(t)$.
   (b) The phase spectrum of $z(t)$ is the negative of the phase specturm of $x(t)$.
   (c) The Nyquist sampling rate for $z(t)$ is the same as the Nyquist sampling rate for $x(t)$.
   (d) $Z(\omega)$ will contain impulses at $\omega = \pm 10$.
   (e) None of the above.

2. For an LTI system with impulse response $h(t) = -\delta(t) + e^{-t}u(t)$ and input signal $x(t) = u(t)$, the value of the output signal at $t = 1$ is
   (a) $y(1) = -\infty$.
   (b) $y(1) = 0$.
   (c) $y(1) = 2 + 1/e$.
   (d) $y(1) = -1/e$.
   (e) None of the above.

3. For a discrete-time LTI system with impulse response

   $$h[n] = nu[n]$$

   and input sketched below,

   the output signal $y[n]$ is zero on the range
   (a) $n \leq 0$, $n \geq 5$.
   (b) $n \geq 5$.
   (c) $n \leq -1$.
   (d) $n \leq -1$, $n \geq 5$.
   (e) None of the above.

4. If $x(t) = 4\cos^2 t$
   (a) $X(\omega)$ does not exist.
   (b) $X(\omega) = 4\pi\delta(\omega) + 2\pi\delta(\omega - 2) + 2\pi\delta(\omega + 2)$.
   (c) $X(\omega) = 4\pi\delta(\omega) + \frac{1}{2+j\omega} - \frac{1}{2-j\omega}$.
   (d) $X(\omega) = 4\pi\delta(\omega - 2) + 4\pi\delta(\omega + 2)$.
   (e) None of the above.

5. The system described by

$$y[n] = 3|x[n-1]| - nx[n-2] \qquad \text{is}$$

(a) Linear.
(b) Time-invariant.
(c) Causal.
(d) Both linear and causal.
(e) None of the above.

6. If the Discrete-time Fourier Transform of the signal $x[n]$ is $X(\Omega)$, then the Discrete-Time Fourier Transform of the signal

$$z[n] = (n-1)x[n-2]$$

is

(a) $e^{-j2\Omega}\left(\frac{dX(\Omega)}{d\Omega} + X(\Omega)\right)$.
(b) $e^{-j2\Omega}\left(X(\Omega) + 1\right)$.
(c) $X(\Omega - 2) + 1$,
(d) $e^{-j2\Omega}X(\Omega)$.
(e) None of the above.

7. A DSBSC modulation scheme

(a) Sends a copy of the carrier.
(b) Requires more bandwidth than a SSB scheme.
(c) Is ideal for a situation where there is one sender and many receivers such as commercial radio.
(d) All of the above.
(e) None of the above.

8. Ideal high pass filters are not used in practice because:

(a) They are too expensive.
(b) They are not causal.
(c) They require too much bandwidth.
(d) They can be made directly from low pass filters.
(e) None of the above.

9. For the signal

$$x(t) = \sin(50\pi t) + 4\cos(100t)$$

the minimum sampling frequency that can be used to obtain samples of $x^2(t)$ without loss of information is

(a) 50 Hz.
(b) 100 Hz.
(c) 50π Hz.
(d) 200 Hz.
(e) None of the above.

10. The Fourier series coefficients for the periodic signal defined over the period $-\pi$ to π according to

$$x(t) = \begin{cases} 0 & t \in [-\pi, -\pi/2) \\ \cos t & t \in [-\pi/2, \pi/2) \\ 0 & t \in [\pi/2, \pi) \end{cases}$$

satisfy

(a) $C_0 = 1/\pi$.

(b) C_k go to zero as $k \to \infty$.

(c) $C_k = -C_{-k}$.

(d) All of the above.

(e) None of the above.