Signals and Systems

Assignment 5

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Question 1

Let x[n] be a signal with Fourier transform $X(\omega)$, express the Fourier transforms of the signals listed below in terms of $X(\omega)$.

(a) $x_1[n] = x[2 - n] - x[1 - n]$

(b) $x_2[n] = n^2 x[n]$

(c) $x_3[n] = e^{j\omega_0 n} \sum_{k=-\infty}^{n} x[k]$

Question 2

Find the Fourier transforms of the following signals.

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

(b) $x[n] = \frac{(n+1)(n+2)}{2}\left(\frac{1}{4}\right)^n u[n]$

(c) $x[n] = sinc(\frac{\pi}{3}n)cos(\frac{\pi}{6}n)$

(d) $x[n] = u[n+3] - u[n-4]$

(e) $x[n] = sin^2[\frac{\pi}{8}n] + cos[\frac{\pi}{8}n] + cos^2[\frac{\pi}{8}n]$

Question 3

Find the inverse Fourier transforms for the following signals.

(a) $X(\omega) = \frac{1}{1-e^{-j\omega}} \frac{2}{2-e^{-j\omega}} + 2\pi\delta(\omega)$

(b) $X(\omega) = \sum_{k=0}^{\infty} e^{-j\omega k}$

(c) $X(\omega) = \frac{2-12e^{-j\omega}}{1-12e^{-j\omega}+35e^{-2j\omega}}$

(d) $X(\omega) = cos^2(\omega) + sin^2(3\omega)$

Question 4

A causal LTI system is described by the difference equation:

$$y[n] + \frac{1}{2}y[n-1] = x[n]$$

(a) Find the frequency response of this system.

(b) Find the impulse response of this system.

(c) Determine system's output given input $x[n] = (\frac{1}{2})^n u[n]$.

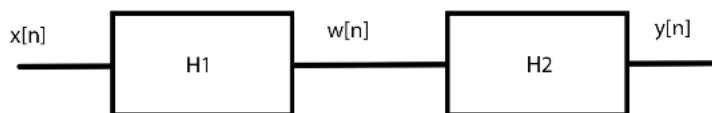(d) Determine system's output given input $x[n] = \delta[n] + \frac{1}{2}\delta[n-1]$.

Question 5

Consider an LTI system with impulse response $h[n] = \frac{sin(\frac{\pi}{3}n)}{\pi n}$.

(a) Find the frequency response of the system and plot it.

(b) Find and plot the system's output to input $x[n] = sin(\frac{2\pi}{5}n)$.

(c) Find and plot the system's output to input $x[n] = (-1)^n cos(\frac{3\pi}{4}n)$.

Question 6

Consider the following system.

Where:

$$x[n] = cos[\frac{\pi}{3}n] + jsin[\frac{2\pi}{3}n]$$

$$h_1[n] = e^{j\frac{\pi}{2}n}\frac{sin[\frac{\pi}{6}n]}{\pi n}$$

$$H_2(\omega) = e^{-j\omega} - 2e^{-2j\omega}$$

(a) Determine $X(\omega)$.

(b) Determine $H_1(\omega)$.

(c) Determine $W(\omega)$.

(d) Determine $w[n]$.

(e) Determine $h_2[n]$.

(f) Determine $y[n]$.

(g) Determine $Y(\omega)$.

(h) Determine $H_{eq}(\omega)$.

(i) Determine $h_{eq}[n]$.

Matlab Question 1

Consider the signal $x(t) = cos(20\pi t) + sin(10\pi t)$.

(a) Sample $x(t)$ with sampling frequency 40Hz to generate discrete-time signal $x_1[n]$.

(b) Use fft to compute Fourier transform of $x_1[n]$. Plot the result.

Matlab Question2

Compute the Fourier transform of signal $x(t) = \frac{sin(3\pi t)}{sin(\frac{\pi}{2}t)}$ using fft and plot the result. Use an appropriate sampling rate.