Digital Signal Processing

Winter Term 2011/12

Lab Sheet 6 Submission: Tue, Dec, 6th, 2011, 2pm

Exercise 1: Discrete Time Fourier Transform 12

Find the DTFT of the following sequences:

a. $x[n] = \alpha^n \sin(n\omega_0)\, u[n] \quad \text{for } |\alpha| < 1$ (4)

b. $x[n] = \begin{cases} \left(\frac{1}{2}\right)^n & \text{if } n = 0, 2, 4, \ldots \\ 0 & \text{else} \end{cases}$ (4)

c. $x[n] = 3\delta[n] + 2(\delta[n-1] + \delta[n-5]) + 2(\delta[n-2] + \delta[n-4])$ (4)

Exercise 2 Frequency and impulse response 8

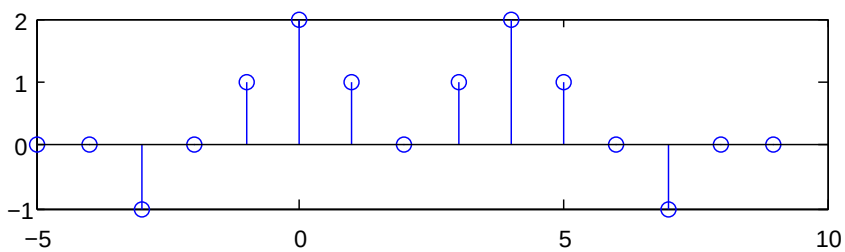
Find the impulse response of

a. the 90° phase shifter $H(e^{i\omega}) = \begin{cases} -j & 0 < \omega < \pi \\ j & -\pi < \omega < 0 \end{cases}$ (4)

b. $H(e^{i\omega}) = i\cos\frac{\omega}{2} + \sin\omega$ (4)

Exercise 3: Properties of Fourier transform 10

Let $X(e^{i\omega})$ be the Fourier transform of the signal $x[n]$, which is plotted below. Answer the following questions without computing $X(e^{i\omega})$ directly:



a. Compute $X(e^{i\omega})|_{\omega=0}$. (1)

b. Compute $X(e^{i\omega})|_{\omega=\pi}$. (1)

c. Compute $\arg X\left(e^{i\omega}\right)$. (2)

d. Compute $\int_{-\pi}^{\pi} X\left(e^{i\omega}\right) d\omega$. (2)

e. Determine and sketch the signal, whose Fourier transform is $X\left(e^{-i\omega}\right)$ (2)

f. Determine and sketch the signal, whose Fourier transform is $\Re\left\{X\left(e^{i\omega}\right)\right\}$ (2)

Exercise 4: Properties of Fourier transform 11

a. Download the image handwriting.png from the course webpage and read the file into matlab using imread. (2)

b. Distort the image by adding a signal $x_{dist} = 100\cos\left(\frac{2\pi n}{11}\right)$, where n is the index of the pixel column. (3)

c. Filter the distorted image with a 11-point moving averager. (3)

d. Plot the original, the distorted and the filtered image. Explain your observation. (3)

Total Score: 41