Digital Signal Processing SS 2019/20

Exercise Sheet 5

Due date: 14.06.2019
(time of the lecture)

Problem 1

Derive the inverse Discrete Time Fourier Transform (DTFT) of $X(e^{j\omega}) = \cos^3 \omega$. Hint: Use the Euler formula to replace the cosine term by exponentials and then apply the inverse DTFT.

Problem 2

Assume, $X(e^{j\omega})$ is the DTFT of $x[n]$. Derive the DTFT of

a) $x^*[-n]$ (the complex conjugate of $x[-n]$)

b) $x[2n]$

c) $x[n] * x[n-2]$

Problem 3

Determine analytically the DTFT of each of the following sequences. Plot the magnitude and angle of $X(e^{j\omega})$ over $0 \leq \omega \leq \pi$.

a) $x(n) = 2(0.5)^n u(n+2)$

b) $x(n) = (0.6)^{|n|}[u(n+10) - u(n-11)]$

Problem 4

Using the matrix-vector multiplication approach discussed in chapter 3 of "Digital Signal Processing Using MATLAB", write a MATLAB function to compute the DTFT of a finite-duration sequence. The format of the function should be

```
function [X] = dtft(x,n,w)
% Computes Discrete-time Fourier Transform
% [X] = dtft(x,n,w)
% X = DTFT values computed at w frequencies
% x = finite duration sequence over n
% n = sample position vector
% w = frequency location vector
```

Use this function to compute the DTFT $X(e^{j\omega})$ of the following finite-duration sequences over $-\pi \leq \omega \leq \pi$. Plot DTFT magnitude and angle graphs in one figure window.

a) $x(n) = (0.6)^{|n|}[u(n+10) - u(n-11)]$. Comment on the angle plot.

b) $x(n) = n(0.9)^n[u(n) - u(n-21)]$.

c) $x(n) = [\cos(0.5\pi n) + j\sin(0.5\pi n)][u(n) - u(n-51)]$. Comment on the magnitude plot.

d) $x(n) = (\underset{\uparrow}{4}, 3, 2, 1, 1, 2, 3, 4)$. Comment on the angle plot.

e) $x(n) = (\underset{\uparrow}{4}, 3, 2, 1, -1, -2, -3, -4)$. Comment on the angle plot.