

Regular and MATLAB HOMEWORKS

Set 1

2.28 (b) (d)
2.32
2.35
2.39

Set 2

4.24
4.25
4.35
MATLAB-1

Set 3

8.4
8.29
8.36
MATLAB-2
(8.40, 8.57 – not assigned)

Set 4

8.39
8.43
9.32
MATLAB-3
(8.69 – not assigned)

Set 5

10.21
10.23
10.24
MATLAB-4
(10.27,10.30,10.34,10.40 (a)-(c) – not assigned)

Set 6

3.21(b)
3.22(b)
3.32
3.44
3.46
(3.23, 3.24 – not assigned)

Set 7

3.23
5.22
5.24
5.27
5.28 (a) (b)
(5.35, 5.45(a), 5.64 – not assigned)

Set 8

5.23

5.38

5.40

5.43

5.48

Set 9

7.34

7.35

7.36

MATLAB-5

Set 10

7.21

7.26

7.31

7.40

MATLAB-6

Set 11

4.26

4.29

4.40

4.41

4.46 (a) (b)

4.53

MATLAB Problem Set 1

- 1) The frequency of a sine or cosine signal is defined as the derivative of its argument (also called generalized phase) with respect to time. Write MATLAB code to generate a cosine signal with 301 samples, whose frequency increases linearly with the index n such that the minimum frequency is 0 and the maximum frequency is π . Such signals are called swept-frequency signals. Plot the signal using the *stem* command. Label all axes.
- 2) We are given two filters
FIR Filter: $y[n] = 0.5x[n] + 0.27x[n-1] + 0.77x[n-2]$
IIR Filter: $y[n] = 0.45x[n] + 0.5x[n-1] + 0.45x[n-2] + 0.53y[n-1] - 0.46y[n-2]$
 - a) Write MATLAB code to compute the output of both filters, using *filter* command, given the input
$$x[n] = \cos\left(\frac{20\pi n}{256}\right) + \cos\left(\frac{200\pi n}{256}\right)$$
 - b) Plot the input signal and the output of each filter; and state the type of each filter (e.g., low-pass, high-pass, band-pass etc.) Comment on which filter suppresses stop-band frequencies better.
 - c) Now input the swept-frequency cosine you generated in Exercise 1 to these same filters. Plot the output of each filter. Comment on which filter suppresses stop-band frequencies better.

MATLAB Problem Set 2

- 1) Write a MATLAB program to compute and plot the L-point DFT $X[k]$ of a triangular pulse sequence $x[n]$ of length N . Then, compute and plot the L-point IDFT of $X[k]$.
 - i) Take $N=15$, $L=16$
 - ii) Take $N=15$, $L=32$
 - iii) Take $N=15$, $L=128$Comment on your results.
- 2) Let $x[n] = \left(\frac{1}{3}\right)^n u[n]$.
 - a) Compute the DTFT $X(e^{j\omega})$ analytically.
 - b) Compute 16-point DFT $X_{16}[k]$ of $x[n]$.
 - c) Compute 512-point DFT $X_{512}[k]$ of $x[n]$.
 - d) Find $X\left(e^{j\frac{\pi}{4}}\right)$ from $X_{16}[k]$ and $X_{512}[k]$, respectively. Which one is closer to the value found from the analytical expression? Explain why.
- 3) a) Let's define an 8 point sequence, $x[n]=1$, $n=0,1,2,3$, and it is zero for $n=4,5,6,7$. Compute and plot the magnitude of its 8-point DFT.
b) Let's now define a new sequence of length 16 by

$$y[n] = \begin{cases} x\left[\frac{n}{2}\right] & \text{for } n \text{ even} \\ 0 & \text{for } n \text{ odd} \end{cases}$$

i) Compute the 16-point DFT of the new sequence. ii) Find an analytical relationship between the 16-point DFT of $y[n]$ and 8-point DFT of $x[n]$.

MATLAB Problem Set 3

1)

a) Compute analytically 16-pt DFT of $x[n]=\cos(5\pi n/8)$, $n=0, \dots, 15$.

Write MATLAB code to verify the result. Plot the real and imaginary parts of the result. Plot the magnitude and phase of the result. Comment on the symmetry of the coefficients.

b) Compute analytically 16-pt DFT for $x[n]=\cos(5\pi n/16)$, $n=0, \dots, 15$.

Write MATLAB code to verify the result. Plot the real and imaginary parts of the result. Plot the magnitude and phase of the result. Comment on the symmetry of the coefficients.

c) Explain the difference between part a) and part b).

d) Pad the sequence in part b) with 16 zeros and compute 32-pt DFT. Explain the result. How is the result different than part b).

2) a) Write MATLAB code to compute the result of Problem 8.29 (in the textbook) using the DFT method. Submit MATLAB code and plots of the results.

b) Show that the result of circular convolution can be expressed as shifted summation of linear convolution for $N=6$.

MATLAB Problem Set 4

1) Plot the magnitude of $V[k]$ of the 128-point DFT of $v[n]=x[n] w[n]$, where $w[n]$ is

i) a rectangular window and

ii) a Hamming window

of 128 points for each of the following:

$$x1[n] = \cos(\pi n/4) + \cos(0.26 \pi n)$$

$$x2[n] = \cos(\pi n/4) + 1/3 \cos(\pi n/8)$$

$$x3[n] = \cos(\pi n/8) + 1/3 \cos(\pi n/16)$$

2) Plot the spectrogram $|X[n, k]|$ using 256 point rectangular window and 256 point DFTs for

$$x[n] = \cos\left(\frac{\pi n}{4} + 1000 \sin\left(\frac{\pi n}{8000}\right)\right) \quad \text{for } 0 \leq n \leq 16,000$$

MATLAB Problem Set 5

Design a causal, linear-phase, low-pass FIR filter with the following specifications:

Pass-band edge $f_p = 2$ kHz,

Stop-band edge $f_s = 2.5$ kHz,

Pass-band tolerance $\delta_p =$ Stop-band tolerance $\delta_s = 0.05$

and the sampling rate 8 kHz.

- 1) Using the Kaiser window method.
- 2) Using the Parks-McClellan method
- 3) Plot the magnitude response of both filters to show that they satisfy the given specifications. Compare the orders of the two filters and write your conclusions.

MATLAB Problem Set 6

- 1) Given passband corner frequency 4 kHz, stopband corner frequency 8 kHz, sampling rate 44 kHz, passband ripple of 0.5 dB, and minimum stopband attenuation of 40 dB. Determine the minimum order of a digital IIR lowpass filter with analog Butterworth, Chebyshev-I, Chebyshev-II and elliptic prototypes using the MATLAB. Compare the orders of the two filters and write your conclusions.
- 2) Find the transfer function $H(z)$ of all four types of filters using the MATLAB. Write the resulting $H(z)$ expressions explicitly in analytical form. Compute and plot the magnitude and phase response of the resulting filters and show that they satisfy the given specifications.

10.30

$$(a) \quad x[n] = \left[\sin \frac{\pi n}{2} \right]^2 u[n]$$

$$x[0, k] = x[0, \lambda] \Big|_{\lambda = \frac{2\pi k}{7}}$$

$$w[n] = \begin{cases} 1 & 0 \leq n \leq 13 \\ 0 & \text{otherwise} \end{cases}$$

$$\left(\sin \frac{\pi m}{2}\right)^2, 0, 1, 0, 1, \dots$$

$$x[n, \lambda] = \sum_{m=0}^{L-1} x[n+m] w[m] e^{j\lambda m}$$

$$N=7, \quad L=14$$

$$x[n, \lambda] = \sum_{m=0}^{13} x[n+m] e^{j\lambda m}$$

$$x[0, \lambda] = \sum_{m=0}^{13} x[m] e^{-j\lambda m}$$

$$x[0, k] = e^{-j\lambda} + e^{-j3\lambda} + e^{-j5\lambda} + e^{-j7\lambda} + e^{-j9\lambda} + e^{-j11\lambda} + e^{-j13\lambda}$$

$$x[0, k] = e^{-j\frac{2\pi}{7}k} + e^{-j\frac{6\pi}{7}k} + e^{-j\frac{10\pi}{7}k} + e^{-j\frac{14\pi}{7}k} + e^{-j\frac{18\pi}{7}k} + e^{-j\frac{22\pi}{7}k} + e^{-j\frac{26\pi}{7}k}$$

$$x[0, k] = 1 + e^{-j\frac{\pi}{7}k} + e^{-j\frac{2\pi}{7}k} + \dots + e^{-j\frac{6\pi}{7}k} = \sum_{n=0}^6 e^{-j\frac{\pi 6n}{7}} = \frac{1 - e^{j\pi k}}{1 - e^{\frac{j\pi k}{7}}}$$

$$(b) \sum_{k=0}^6 x[n, k] = ?$$

$$x[n+m] w[m] = \frac{1}{N} \sum_{k=0}^{N-1} x[n, k] e^{j\frac{2\pi}{N}km} \quad \text{set } m=0, N=7 \quad x[n] w[0] = \frac{1}{7} \sum_{k=0}^6 x[n, k]$$

10.35

$$x(j\Omega) = 0 \quad |\Omega| \geq 2\pi(10000) \quad \text{Bandwidth} = 10\text{kHz}$$

$$x(t) \rightarrow 100\text{ms long}$$

Method 1:

$$T_s = 25\mu\text{s} \quad 4000 \text{ samples} \rightarrow 100\text{ms}$$

$$\Delta f = \frac{1}{NT} = \frac{1}{4000 \cdot 25 \cdot 10^{-6}} = 10 \text{ Hz} \rightarrow \text{do not satisfy}$$

Method 2:

$$T_s = 50 \mu\text{s} \quad 2000 \text{ samples} \rightarrow 100 \text{ ms}$$

$$\Delta f = \frac{1}{NT} = \frac{1}{4000 \cdot 50 \cdot 10^{-6}} = 5 \text{ Hz} \rightarrow \text{satisfies}$$

