Assignment-6b

Companion Book MATLAB Problems (chapter3)

3.1 Tutorial: Computing the Discrete-Time Fourier Series with *fft*

The discrete-time Fourier seriers (DTFS) is a frequency-domain representation for periodic discrete-time sequences. For a signal x[n] with fundmental period N, the DTFS synthesis and analysis equations are given by:

$$x[n] = \Sigma_{k=0}^{N-1} a_k e^{jk(2\pi/N)n} \qquad (3.1)$$

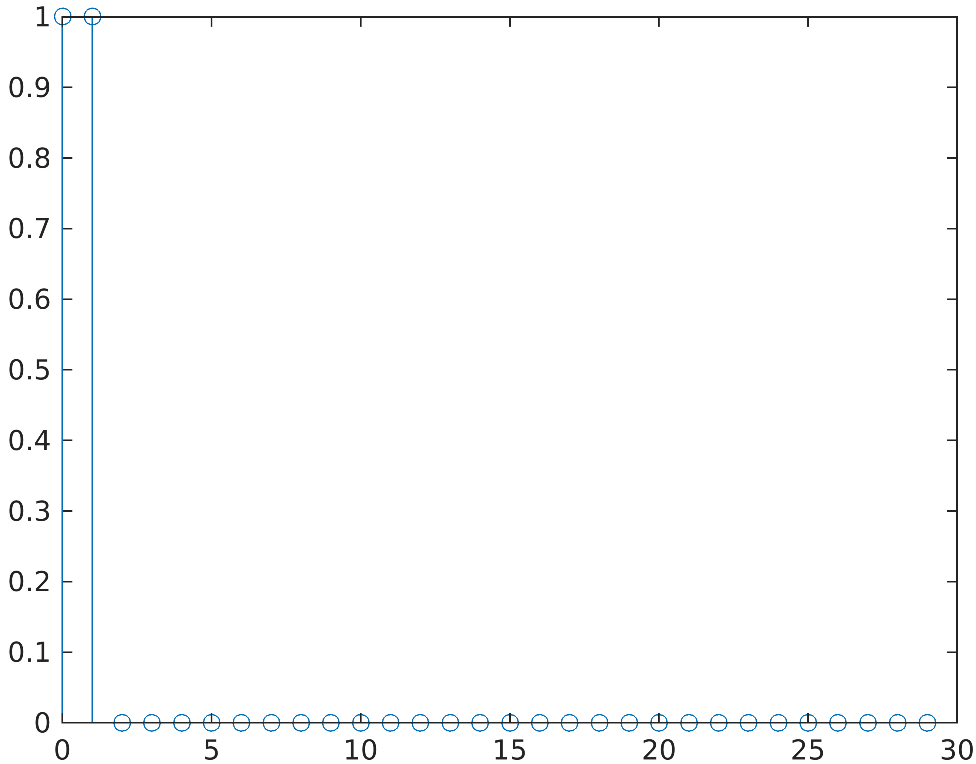
$$a_k = \frac{1}{N} \Sigma_{n=0}^{N-1} x[n] e^{-jk(2\pi/N)n} \qquad (3.2)$$

For example, assume x[n] is the signal with fundamental period N=30. The signal is given by

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

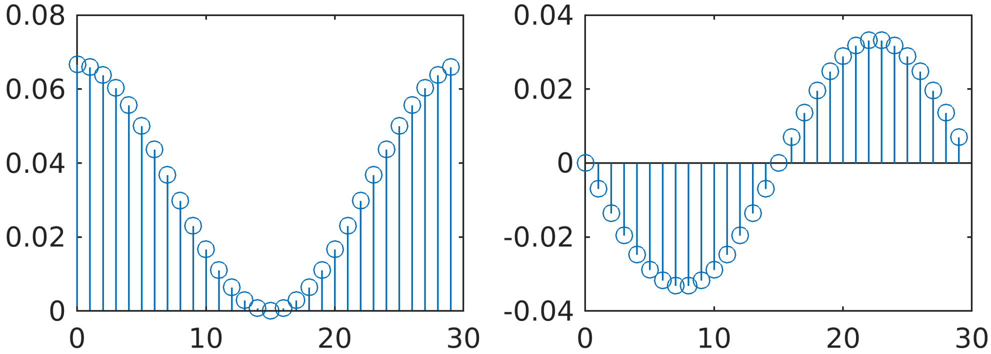
on the interval $0 \le n \le 29$. Plot x[n] over interval [0, N-1]

```
% 3.1 of companion book
clf;

N = 30;
n = 0: N-1;
x = (n==0) + (n==1);

stem(n, x);
```



Define *x = [1 1 zeros(1,28)*}. The DTFS can be computed by tyhpeing *a* = *(1/N)* * *fft(x). The real and imaginary parts of a can be ploted as shown in Figures 3.2 and 3.3.*

```
k = 0:1:N-1;
ak = (1/N)*fft(x);

subplot(2, 2, 1);
stem(k, real(ak));

subplot(2, 2, 2);
stem(k, imag(ak));
```


0.08
0.06
0.04
0.02
0
0
10
20
30
0.04
0.02
0
-0.02
-0.04
0
10
20
30

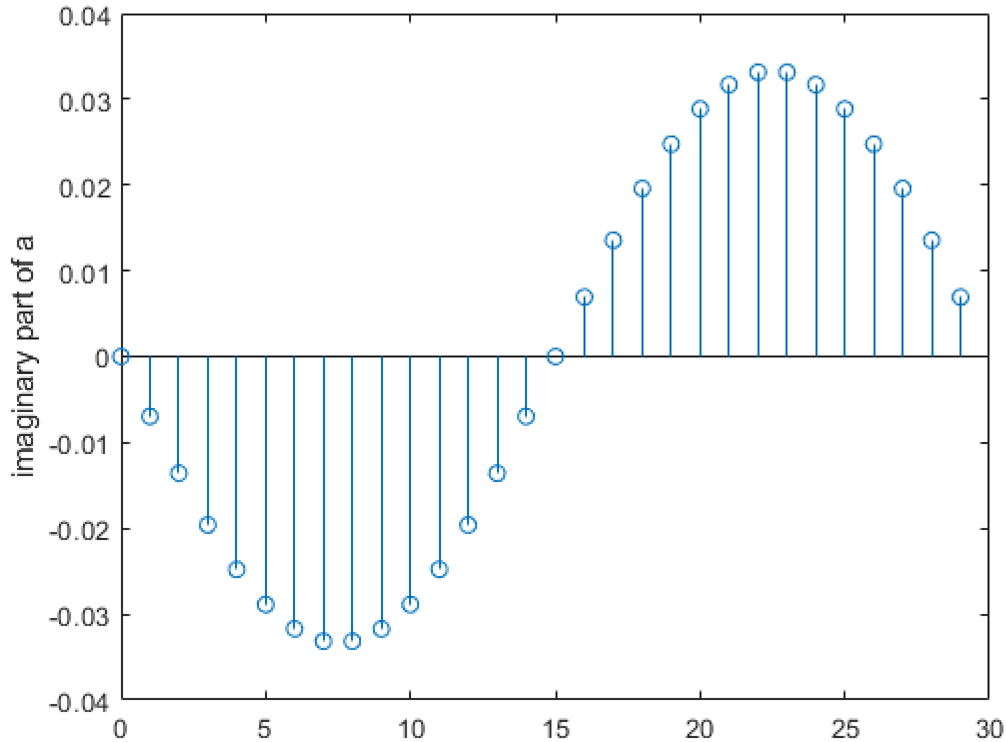
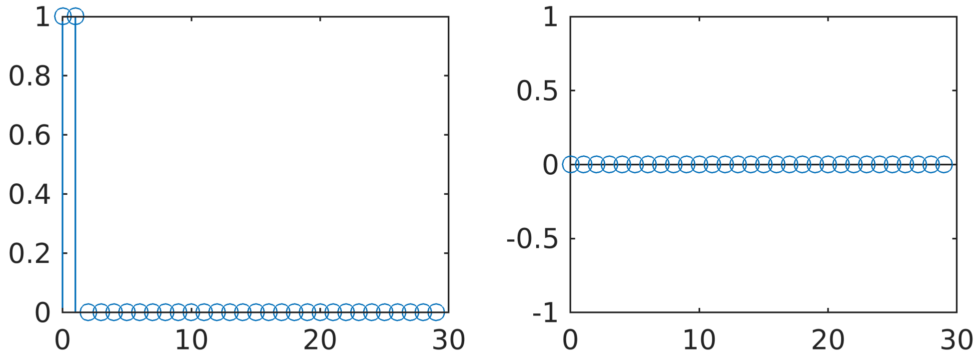


Figure 3.3 ak for 0 <= k <= N-1

You can verify analytically that these are the correct valuse for a_k, as shown in Figure 3.2 and 3.3.

Given a vector *a* containing the DTFS coefficients $a_k \;\; for \;\; 0 \le k \le N-1$, the function ***ifft*** can be used to construct a vector ***x*** containing $x[n] \;\; for \;\; 0 \le n \le N-1$ as follows:

```
clf;

N = 30;
n = 0: N-1;
x = (n==0) + (n==1);

k = 0:1:N-1;
ak = (1/N)*fft(x);

% use ifft()
x2 = N*ifft(ak);

subplot(2, 2, 1);
stem(n, real(x));

subplot(2, 2, 2);
stem(n, imag(x));
```



Note that the imaginary component is insignificant compared to the real component, so it was shown close to zero as shown in Figure 3.5.

3.2 Tutorial: freqz

The signals e^{jwn} are elements of LTI systems. For each value of ω the frequency response $H(e^{jw})$ is the eigenvalue of the LTI system for eigenfunction e^{jwn}; when the input sequence is $x[n] = e^{j\omega_0 n}$, the output sequence is $y[n] = H(e^{j\omega_0})e^{j\omega_0 n}$.

(a). Define a1 and b1 to describe the causal LTI system specified by the difference equaiton

$$y[n] - 0.8y[n - a = 2x[n] - x[n - 2].$$

(b). Use ***freqz*** with the coefficients from Part (a) to define ***H1*** to bbe the value of the frequency response at 4 evenly spaced frequencies between 0 and π and ***omeg1*** to be those frequencies. The following sample output shows the values each vector should have if you have defined things correctly:

(c). Use ***freqz*** to define ***H2*** to be the value of the frequency response at 4 evenly spaced frequencies between 0 and 2π and ***omega2*** to be those frequencies. The following sample output shows the values each vector should have if you have defined things correctly:

3.3 Tutorial: lsim with System Functions

As an example, consider the system function

$$H(s) = \frac{s + \frac{1}{2}}{s - 2}$$

where coefficients are defined by the voctors $b = [1 \ \ 1/2] \ \ and \ \ a = [1 \ \ -2]$. The command $y = lsim(b, a, x, t)$ stores in **y** the time response of the system to the input specified in the vector **x** at the times specified in **t**. The vector **y** has as many elements as the input vector **x**.

(a). Define coefficient vectors **a1** and **b1** to describe the causal LTI system specified by the system function

$$H_1(s) = \frac{s - 2}{s + 2}$$

(b). Define coefficient vectors a2 and b2 to describe the causal LTI system specified by the system function

$$H_2(s) = \frac{3}{s + 0.3}$$

(c). Define coefficient vectors a3 and b3 to describe the causal LTI system specified by the system function

$$H_3(s) = \frac{2s}{s + 0.8}$$

(d). Use ***lsim*** and vectors you defined in the previous parts to find the output of those causal LTI systems for the input given by ***t = [0:0.1:0.5], x=cos(t).*** The results shown below give the output for each system.