EENG/INFE 226 SIGNALS AND SYSTEMS
LAB 6
FOURIER SERIES and FOURIER TRANSFORM REPRESENTATION

Objective

The objective of this experiment is to introduce using MATLAB to perform Discrete-Time Fourier Series (DTFS), Continuous-Time Fourier Series (CTFS), and to compute the frequency response of a causal LTI-system.

6.1 Compute the DTFS with fft:

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

$$x[n] = \sum_{k=0}^{N-1} X[k] e^{jk(2\pi/N)n} \text{.........synthesis}$$

$$X[k] = \frac{1}{N}\sum_{n=0}^{N-1} x[n] e^{-jk(2\pi/N)n} \text{.........analysis}$$

x: represent one period of an N periodic signal.
X: gives DTFS coefficient as a vector.

MATLAB contains two very efficient routines for computing Analysis and synthesis:

- If x is an N-point vector containing $x[n]$ for the period $0 \le n \le N-1$, then the DTFS of $x[n]$ can be computed by:

  $$>> X = (1/N) * fft(\text{x}).$$

- If X is an N-point vector containing $X[k]$ for the period $0 \le k \le N-1$, then the synthesis of DTFS of $X[k]$ can be computed by:

  $$>> \text{x} = (N) * \text{i}fft(\text{x}).$$

Exercise 1:

Consider using MATLAB to solve Problem 3.3(a) in (Simon Haykin 2nd Edition) book. For the DTFS coefficient, the signal:

$$x[n] = 1 + \sin\left(\frac{n\pi}{12} + \frac{3\pi}{8}\right)$$

This signal has period N=24.

Procedure:

- Define the signal period N.
- Define the index vector n to range from 0 to 23.
- Define the signal x as a vector of ones using the (**ones**) command plus sin valus. Also plot the signal in figure 1 using ***stem.***
- Use the function (***fft***) function to evaluate the DTFS coefficients. and store it in X.
- Plot the *real* and *imaginary* parts of fourier series coefficient x using ***subplot*** and ***stem*** on figure 2.
- Plot the *absolute value* and *angles* of fourier series coefficient x using ***subplot*** and ***stem*** on figure 3.
- Use the function (***ifft***) function to reconstruct the orginal time domain signal x . and store it in x_recon. Plot it on figure 4 as *real* and *imaginary* part using subplot.

***Q**: Comment on the relationship between figures of x[n] and x_recon?*

……

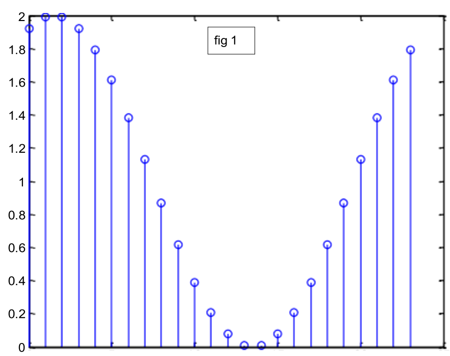

Figure 1

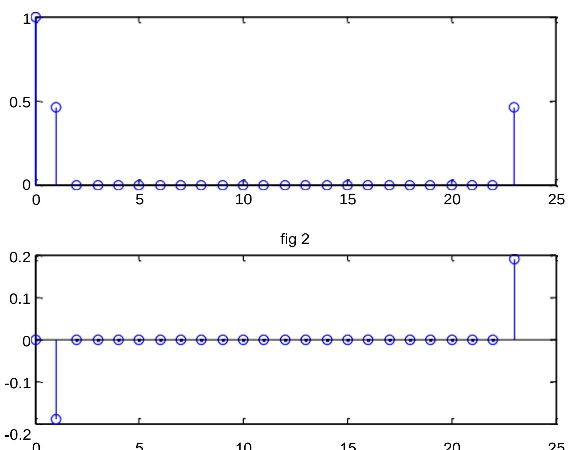

Figure 3

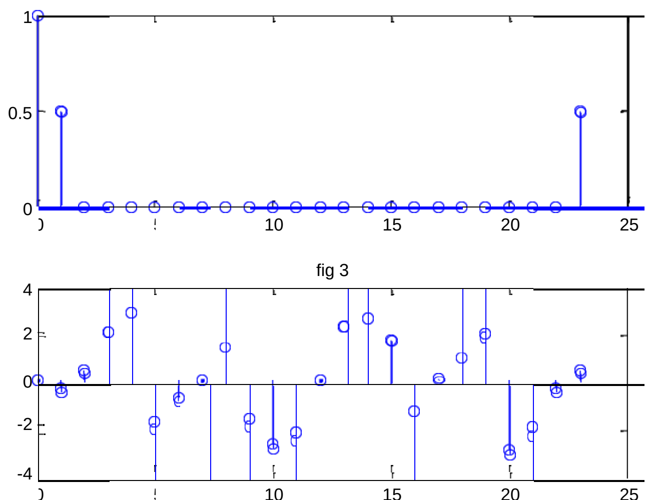

Figure 2

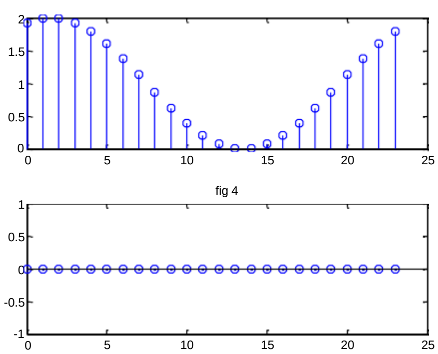

Figure 4

6.1 Frequency Response Of LTI System From Impulse Response:

For a causal LTI system described by a difference equation,

- the command [H omega]=***freqz (b,a,N)*** computes the frequency response $H(e^{jw})$ at N evenly spaced frequencies between 0 and π , i.e., $w_k = (\pi/N)k$ for $0 \le k \le N-1$.
- the command [H omega]=***freqz (b,a,N,'whole')*** computes the frequency response $H(e^{jw})$ at N evenly spaced frequencies between 0 and 2π , i.e., $w_k = (2\pi/N)k$ for $0 \le k \le N-1$.

  - the coefficient vectors *a* and *b* specify the difference equation using the same format in *lab 5.*
  - ***Freqz*** returns $H(e^{jw})$ in ***H*** and the frequencies w_k in ***omega.***

Assignment:

Consider the following difference equation:

$$y[n] - 0.75y[n-1] + 0.6y[n-2] = 2x[n] - x[n-2]$$

1) Evaluate the Frequency Response at 4 evenly spaced between 0 and π ?

Procedure:

- Define **a** and **b** to describe the previous causal LTI system as a vectors.
- Use ***freqz*** with the coefficients **a** and **b** define ***H1*** to be the value of the frequency response at 4 evenly spaced frequencies between 0 and π and ***omega1*** to be thosefrequencies.

2) Evaluate the Frequency Response at 4 evenly spaced between 0 and 2 π ?