LAB 3: Discrete-Time Fourier Series

Objective

In Lab 3, you will learn about discrete-time Fourier series (DTFS). You will implement DFTS and discrete-time Fourier series (IDFTS) by MATLAB. You also will examine some properties od DFTS.

Discrete-Time Fourier Series

The Discrete-time Fourier series D_r for a periodic signal $x[n]$ with the fundamental period N_0 is defined as follows

$$x[n] = \sum_{r=0}^{N_0-1} D_r e^{jr\Omega_0 n}$$

$$D_r = \frac{1}{N_0} \sum_{n=0}^{N_0-1} x[n] e^{-jr\Omega_0 n}$$

where, $\Omega_0 = \frac{2\pi}{N_0}$ is the fundamental frequency.

Preparation

- Read chapter 9, specially section 9.1, from *Linear Signals and Systems by B.P. Lathi*.
- Work through Computer Example 9.2 of the text.
- Work through Computer Example 9.7-1, and 9.7-2 of the text.

Lab Assignment

A. Discrete-Time Fourier Series

In this assignment, you will find the discrete-time Fourier series of the signal $x[n]$.

$$x[n] = 4\cos(2.4\pi n) + 2\sin(3.2\pi n)$$

1) Find the fundamental period N_0 and fundamental frequency Ω_0 of x[n].
2) Use MATLAB to compute the DTFS of the signal $x[n]$ by implementing Eq. (9.4) from the textbook. Plot $x[n]$, the magnitude $|D_r|$ and phase $\angle D_r$ spectra with respect to r.
3) Repeat steps 1 and 2 for the signal $y[n]$ depicted in Figure 1.

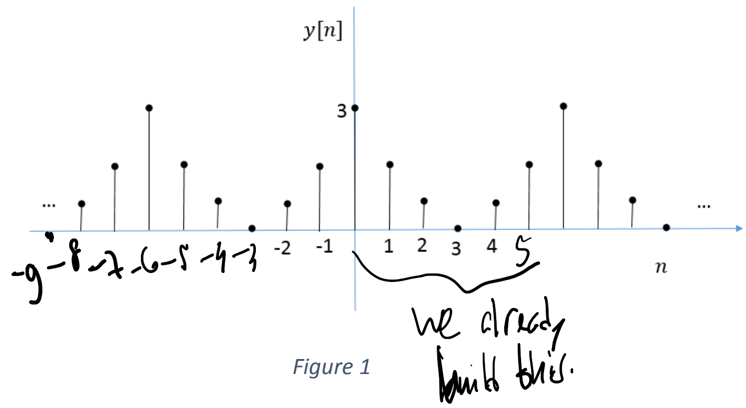

Figure 1

B. Inverse DTFS and time shifting property

In this assignment, you will compute the inverse discrete Fourier transform and examine the time shifting property.

1) The Fourier series spectrum of a periodic discrete signal is shown in Figure 2. Use MATLAB to implement the inverse DTFS and find the $x[n]$. Plot $x[n]$ with respect to n.

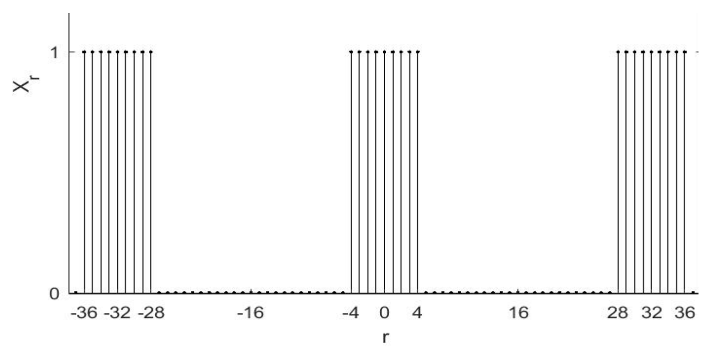

Figure 2

2) Multiply $X[r]$ to $e^{-j5\Omega_0 r}$ and find the inverse DTFS of the product. Plot the result and explain how it differs from $x[n]$ in part 1.

C. System Response

In this assignment, you will compute the response of an LTID system to an input signal using DTFS.

1) Consider an LTID system with frequency response $H[r]$ as depicted in Figure 3. For $N_0 = 32$ and $\Omega_0 = 2\pi/N_0$, plot $H[r]$ with respect to Ω_0.

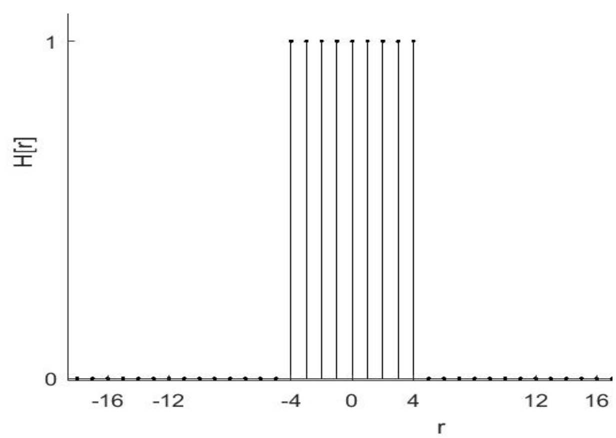

Figure 3

2) Find and plot the output $y_1[n]$ if the input $x_1[n]$ is applied to the system. For this purpose, find the DTFS of signal $x[n]$ and then compute $Y_1[r] = X_1[r]H[r]$.

$$x_1[n] = 4\cos(\pi n/8)$$

3) Repeat part 2 for the signal $x_2[n]$ defined below,

$$x_2[n] = 4\cos(\pi n/2)$$

4) Compare the results in part 1 and 2 and discuss why they are different.