CS : 215
Signal & Data Communication Laboratory

Experiment: VIII-B

Mritunjay Aman (1912170)

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Discrete Time Fourier Transform(DTFT)

Aim

To use DTFT to find the System Response for a given input and Frequency Response.

Theoretical Background

DTFT Discrete Fourier transforms (DFTs) are extremely useful because they reveal periodicities in input data as well as the relative strengths of any periodic components. And thus they are used to covert Signal to its Frequency Domain for efficient Analysis.
The DTFT for a given signal x(t) is given by

$$X\left(e^{jw}\right) = \sum_{n=-\infty}^{\infty} x[n].e^{-jwn}$$

And the inverse DTFT for corresponding $X\left(e^{jw}\right)$ is given by:

$$x\left[n\right] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X\left(e^{jw}\right).e^{jw}\,dw$$

The fast Fourier transform is a particularly efficient algorithm for performing discrete Fourier transforms of samples containing certain numbers of points.

Methodology

1. TriangularPulse function is used for Triangular Signal tri$[n]$.
2. Convert the Excitation Signal to its Frequency Domain by taking its DTFT.
3. Compute the Impulse Response by taking the Inverse DTFT of Frequency Response.
4. The System Response $y\left[n\right]$ can be obtained by first multiplying Frequency Response with the DTFT of $x\left[n\right]$ and then taking the Inverse DTFT.
5. The plots of Excitation, Impulse Response and System Response, thus obtained is plotted against time.

Code

```
clc;
clear;

% Symbolic expression for:
% a)Excitation
```

```
syms n x(n);
x(n) = triangularPulse((n-8)/8);
% b)Frequency Response
syms w H(w);
H(w) = exp(j*w)/(exp(j*w) - 0.7);

% Plot of Excitation x(t)
range = 0:1:128;
x_ Value = x(range);
stem(range, x_ Value, 'b', 'filled', 'Linewidth', 1.5, 'MarkerSize', 3);
ylabel("Plot Excitation x(t)");
xlabel("Time(s)");
set(gca, ...
     'Box', 'on', ...
     'XTick', [0:1:16], ...
     'Ytick', [0:0.2:1.2], ...
     'TickDir', 'out', ...
     'YGrid', 'on', ...
     'FontSize', 13, ...
     'FontName', 'Calibri')
axis([-0.5 16.5 0 1.2]);

X_ fdom = fft(double(x_ Value));
freq_ Range = (0:length(X_ fdom)-1)/length(X_ fdom);
H_ fdom = double(H(2*pi*freq_ Range));

% Calculating Impulse Response from frequency response
```

```
h_ Values = ifft(H_ fdom, 'symmetric'); stem(range, h_ Values, 'b', 'filled', 'Linewidth', 1.5, 'MarkerSize', 3);
ylabel("Impulse Response y(t)");
xlabel("Time(s)");
set(gca, ...
    'Box', 'on', ...
    'XTick', [0:1:16], ...
    'Ytick', [0:0.2:1.2], ...
    'TickDir', 'out', ...
    'YGrid', 'on', ...
    'FontSize', 13, ...
    'FontName', 'Calibri')
axis([-0.5 16.5 0 1.2]);

% System Response
% System Response can be obtained after multiplying
Frequency Response
% and X(w) in freq domain and taking their inverse DTFT;
Y_ fdom = X_ fdom .* H_ fdom;
y_ Values = ifft(Y_ fdom, 'symmetric');
stem(range, y_ Values, 'b', 'filled', 'Linewidth', 1.5, 'MarkerSize', 3);
ylabel("System Response y(t)");
xlabel("Time(s)");
set(gca, ...
    'Box', 'on', ...
    'TickDir', 'out', ...
    'YGrid', 'on', ...
    'FontSize', 13, ...
```

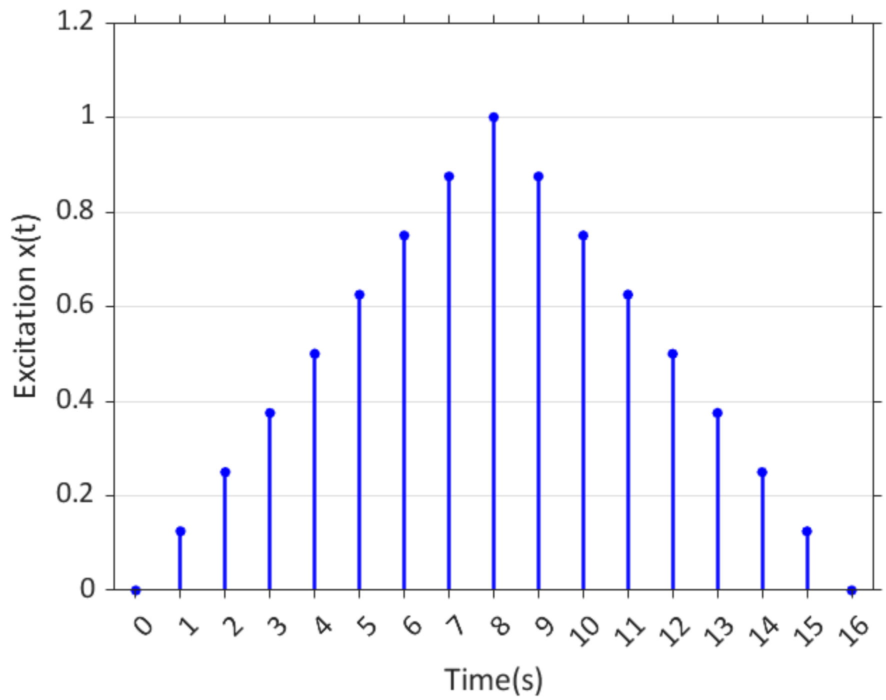
```
    'FontName', 'Calibri');
Y_ fdom = X_ fdom .* H_ fdom;
y_ Values = ifft(Y_ fdom, 'symmetric'); stem(range, y_ Values, 'b', 'filled', 'Linewidth',
1.5, 'MarkerSize', 3);
ylabel("System Response y(t)");
xlabel("Time(s)");
set(gca, ...
    'Box', 'on', ...
    'TickDir', 'out', ...
    'YGrid', 'on', ...
    'FontSize', 13, ...
    'FontName', 'Calibri');
axis([-0.5 32 0 2.8]);
```

Input Data Description

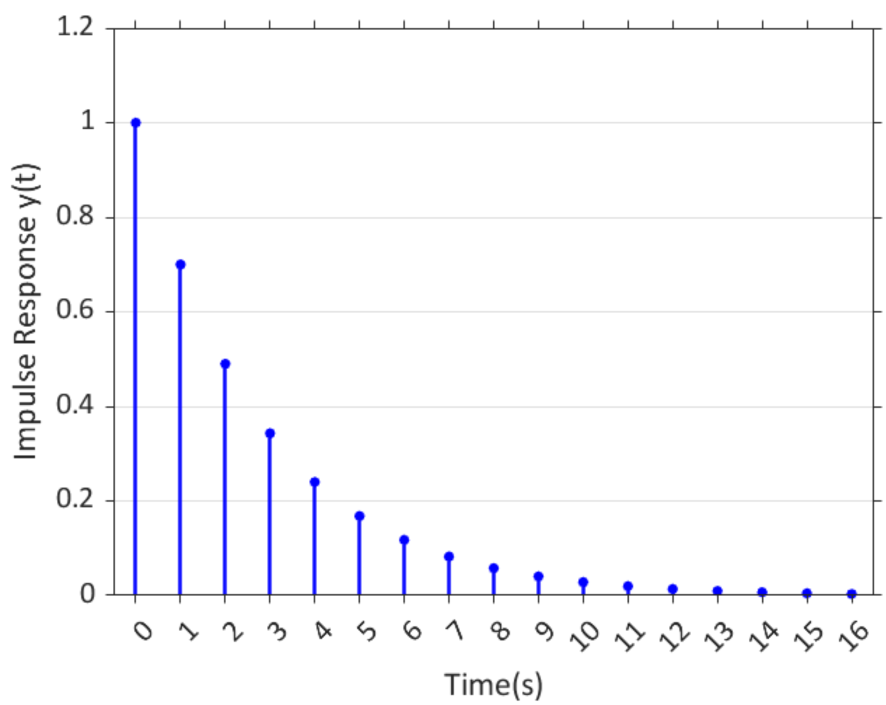
Excitation : tri ($\frac{n-8}{8}$

Frequency Response: $H\left(e^{jw}\right) = \frac{e^{jw}}{e^{jw} - 0.7}$

Plots



1.2
1
0.8
0.6
0.4
0.2
0
Excitation x(t)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Time(s)



1.2
1
0.8
0.6
0.4
0.2
0
Impulse Response y(t)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Time(s)

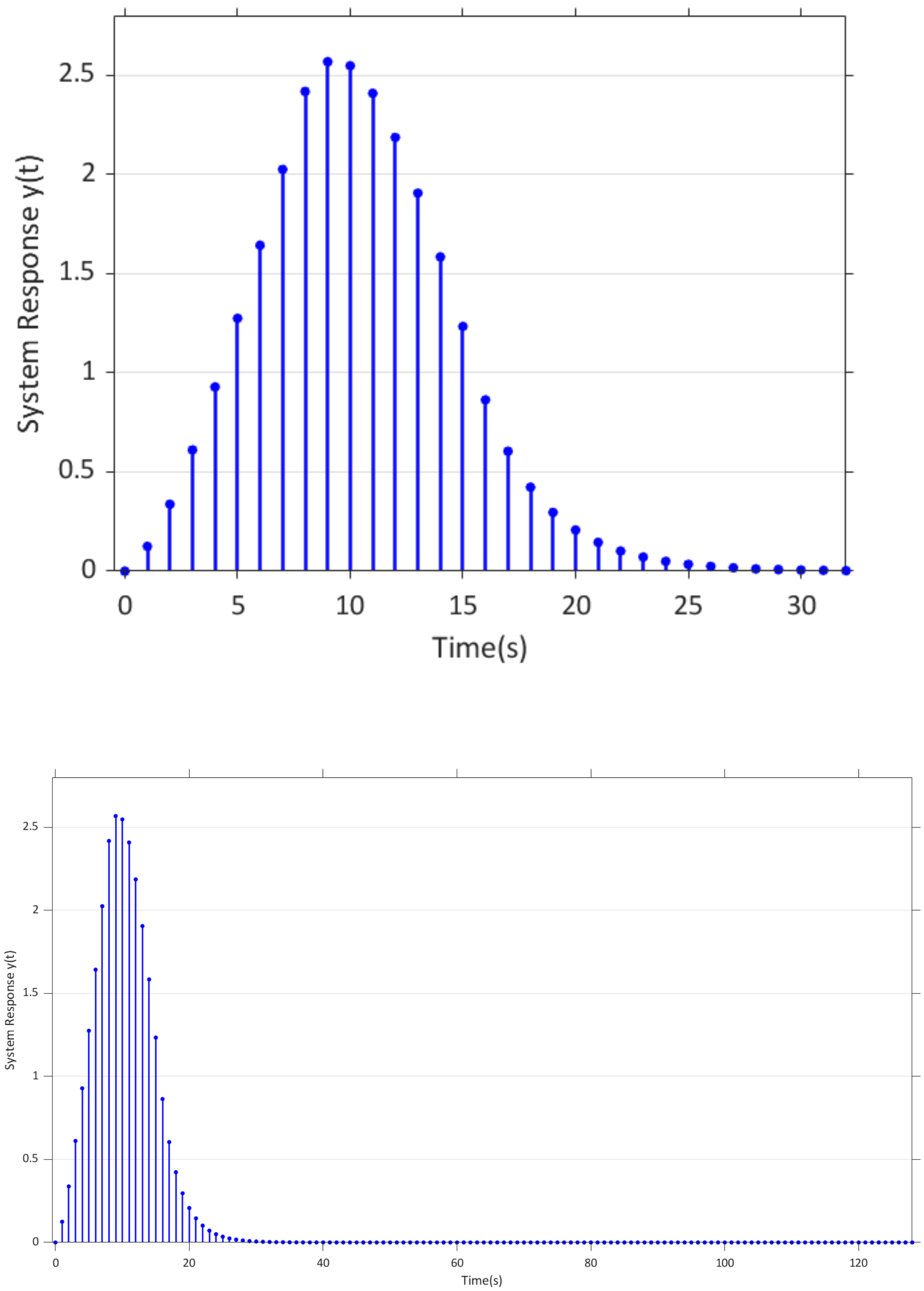


Figure 1: System Response for 1st 128 Sample points

Result

The System Response Fourier Transforms and by taking the inverse DTFT of result is in great agreement with original Signal obtained by Convolution.

Conclusion

With increasing time, the System response dies down to zero and closely depicts the impulse reponse in this manner.