Assignment 3

Course: DSAA, Monsoon 2017 @IIITS

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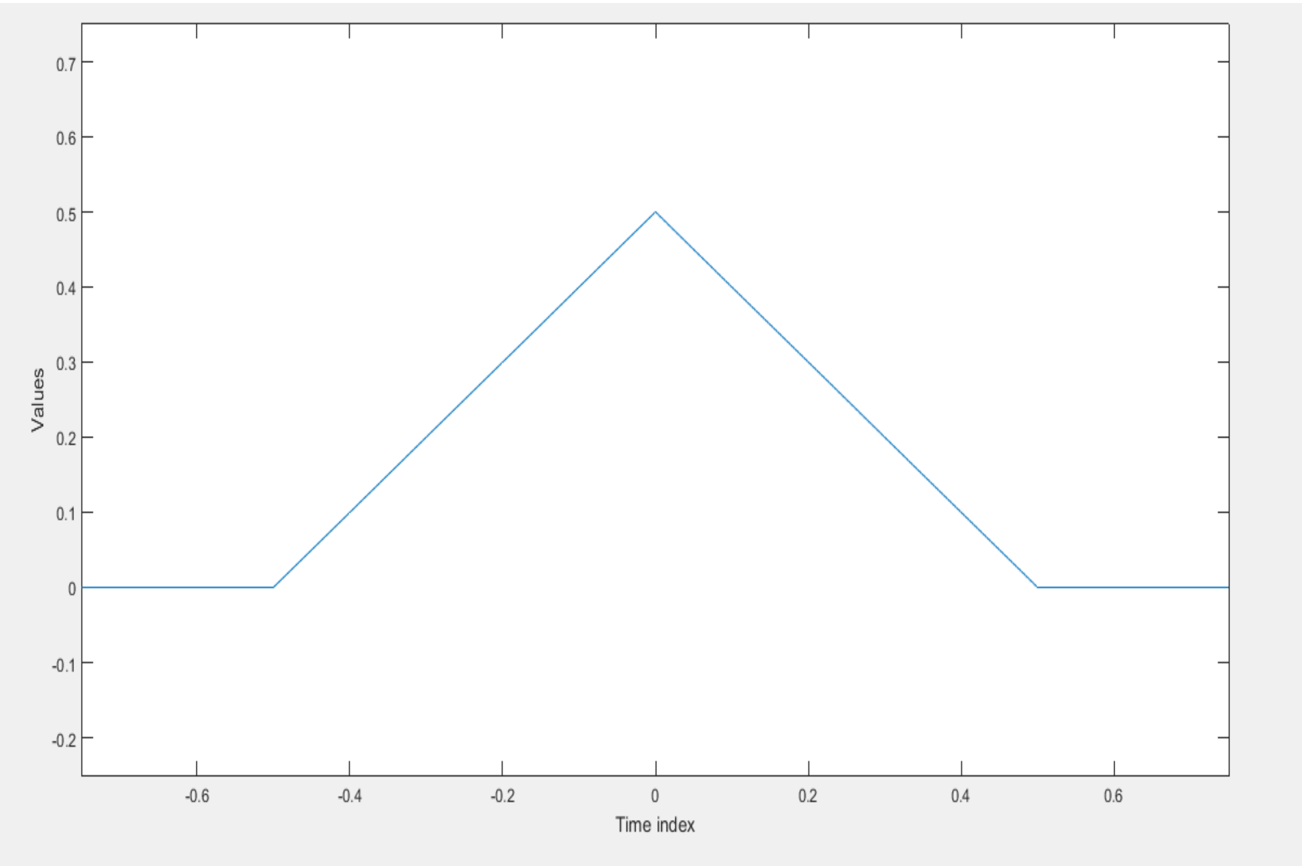
MATLAB CODE:

```
clc
clear all
close all
%%
T = 0.5;
Fs = 20;
t = -2 * T: 1 / Fs: 2 * T;
x = zeros(size(t));
for i = 1: length(t);
        p = t(i);
        if p <= 0 && p >= -T
                x(i) = p + T;
        elseif p > 0 && p <= T
                x(i) = T - p;
        end;
end;
figure;
plot(t, x);
xlabel('Time index');
ylabel('Values');
xlim([-T - T / 2, T + T / 2]);
ylim([-T / 2, T + T / 2]);
nfft = 2 ^ (nextpow2(length(x)));
y = fft(x, nfft);
fvec = Fs / 2 * linspace(-T, T, nfft);
Xw = fftshift(y);
Xw = Xw / max(Xw);
figure;
plot(fvec, abs(Xw));
xlabel('fvec');
ylabel('Xw');
ylim([-0.5, 1]);
x_an = (sin((T) * 2 * pi * fvec). / ((T) * 2 * pi * fvec)). ^ 2;
x_an(fvec == 0) = 1;
figure;
plot(fvec, abs(x_an));
xlabel('fvec');
ylabel('x_a_n');
ylim([-0.5, 1]);
Energy = trapz(abs(Xw). ^ 2);
init_energy = 0;
start = nfft / 2;
stop = nfft / 2 + 1;
fmax = 0;
while init_energy / Energy <= 0.99
        init_energy = sum(abs(Xw(start: stop)). ^ 2);
        fmax = fmax + 1;
        start = start - 1;
        stop = stop + 1;
        Egvec(fmax) = init_energy / Energy;
end;
freRange = 1: fmax;
disp(start);
disp(stop);
bandwidth = fvec(stop) - fvec(start);
```

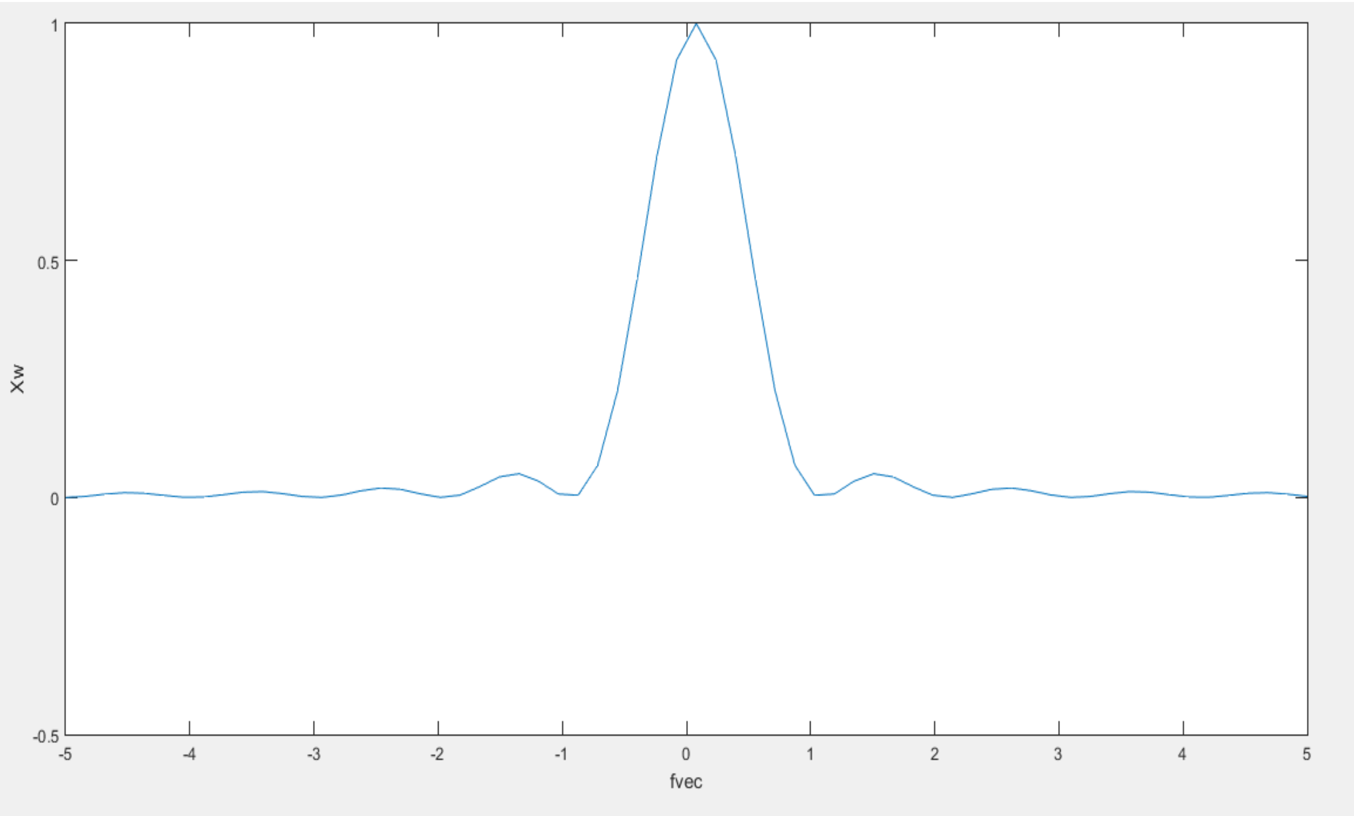
```
disp(bandwidth);
disp(init_energy);
figure;
plot(freRange, Egvec), grid;
xlabel('Energy %');
ylabel('fmax Index');
Energy2 = trapz(abs(x_an). ^ 2);
init_energy2 = 0;
start2 = nfft / 2;
stop2 = nfft / 2 + 1;
fmax2 = 0;
while init_energy2 / Energy2 <= 0.99
       init_energy2 = trapz(abs(x_an(start2: stop2)). ^ 2);
       fmax2 = fmax2 + 1;
       start2 = start2 - 1;
       stop2 = stop2 + 1;
       Egvec2(fmax2) = init_energy2 / Energy2;
end;
freRange2 = 1: fmax2;
disp(start2);
disp(stop2);
bandwidth2 = fvec(stop2) - fvec(start2);
disp(bandwidth2);
disp(init_energy2);
figure;
plot(freRange, Egvec2), grid;
xlabel('Energy %');
ylabel('fmax Index');
disp(fvec(start2));
disp(fvec(stop2));
```

RESULTS:

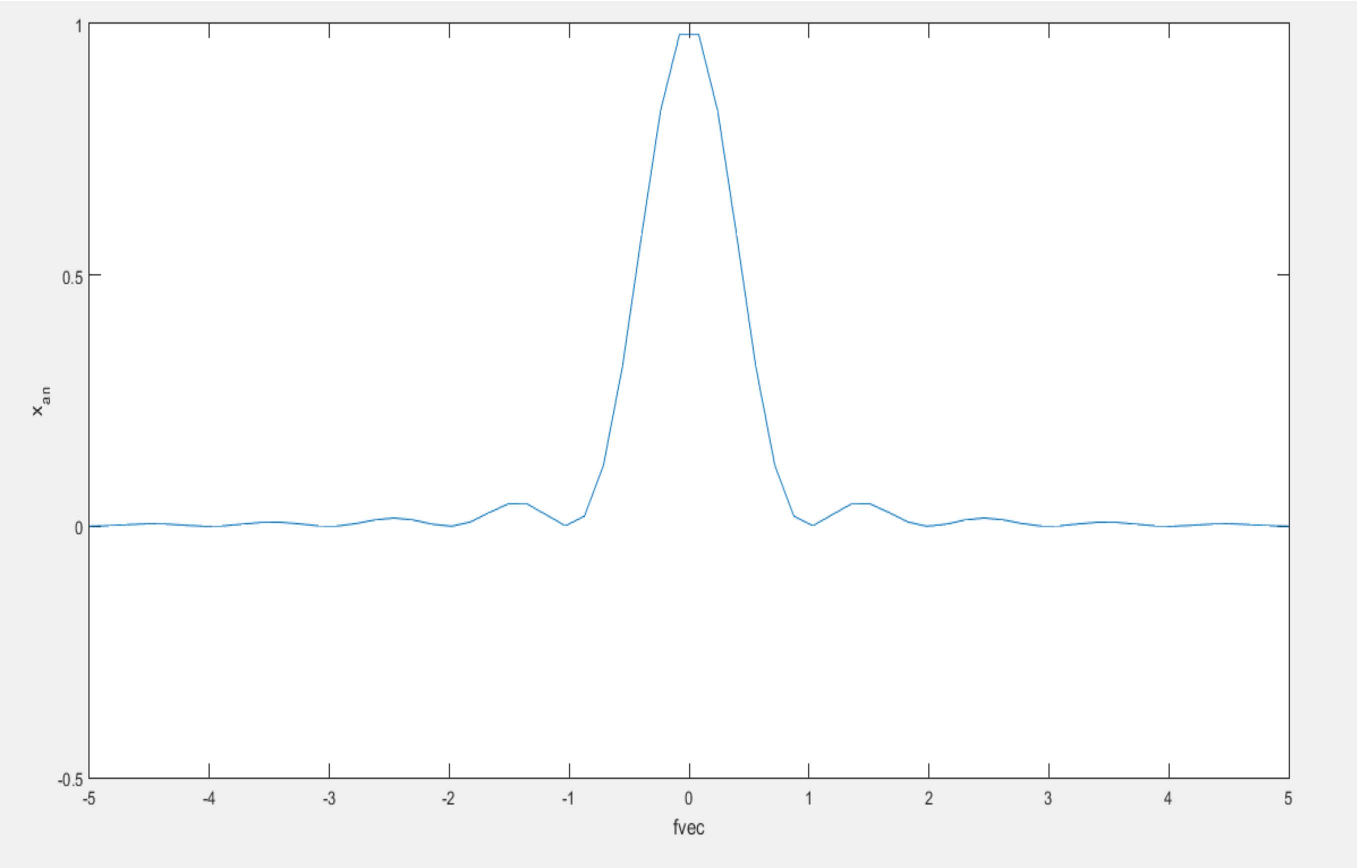
1. Figure 1: Original Signal



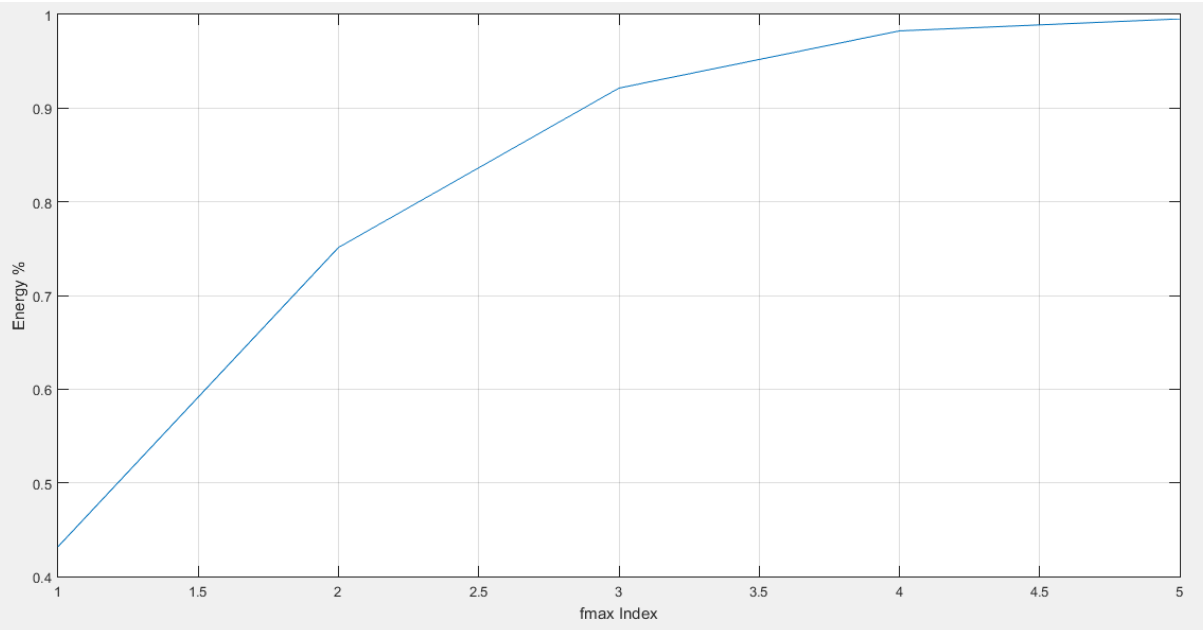
2. Figure 2: Fourier transform of the signal using fft function of matlab.



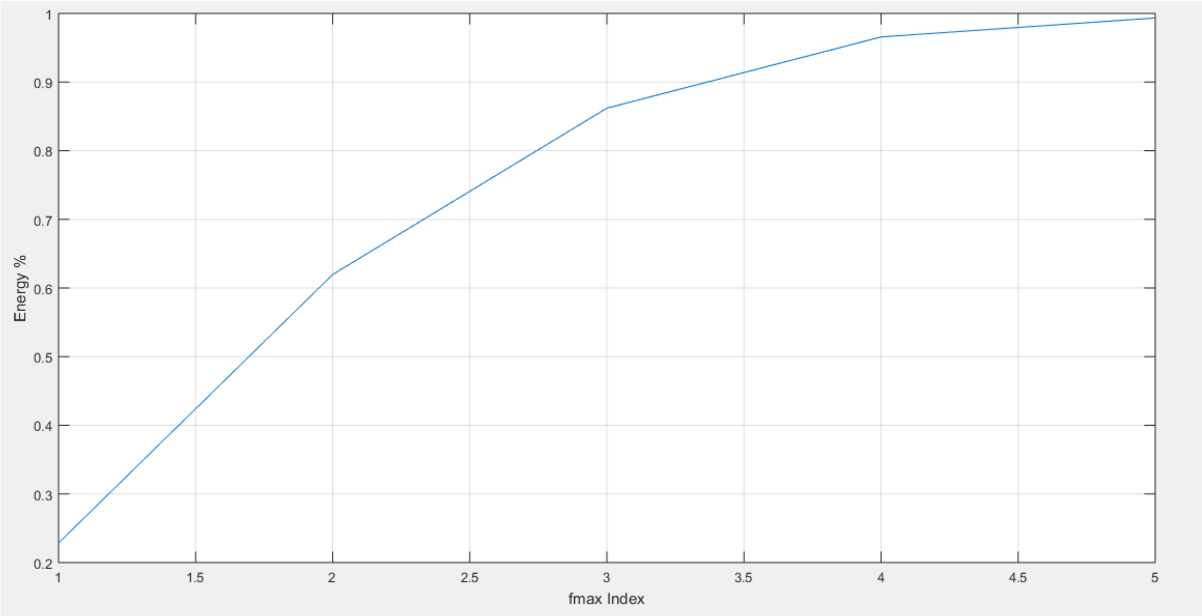
3. Figure 3:Fourier transform of the figure by theoretical method.



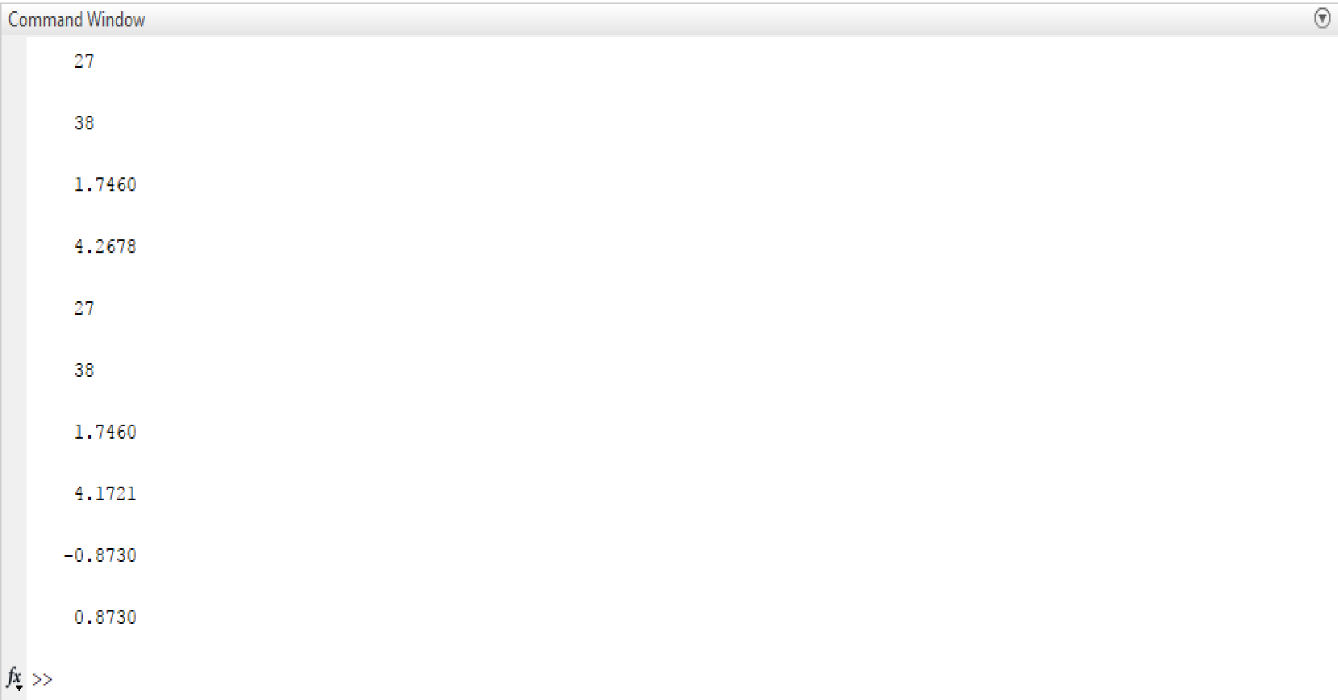
4. Figure 4: Rise of Energy in % against Index



5. **Figure 5: Energy rise through theoretical method**



6. **Figure 6: Final results in the command window**



```
Command Window
    27

    38

    1.7460

    4.2678

    27

    38

    1.7460

    4.1721

   -0.8730

    0.8730

fx >>
```

DISCUSSION & ANALYSIS:

1. **We design the given signal with T = 0.5 as assumption, thereby creating a triangular wave signal and the same can be seen in the first figure.**
2. **We find the Fourier transform of the signal by using fft function and plot it against the frequency.**
3. **The Fourier transform as generated by the fft function in Matlab can be seen in the figure 2.**
4. **The Fourier transform using $sinc^2(\omega t)$, which is obtained theoretically for a triangular wave signal can be seen in the third figure.**
5. **We can find that the graphs obtained in second and third figures are almost equal, which proves that the Matlab fft function works the same as the theoretical integral function.**

6. **We conclude from the Fourier transform graphs that the signal is not band limited as it never becomes constant as 0. So we obtain the bandwidth where 99% of the energy resides.**
7. **We use Parseval's Energy Relation to find out the spectrum where almost 99% of the Energy is obtained.**
8. **The Parseval's Energy Relation's implementation is evident from the 2 while loops implemented in the Matlab Code for each of the methods.**
9. **From the values displayed in the command window, the start and stop indices for both the methods implemented are equal.**
10. **So the frequencies at the points constitute the bandwidth, which we have got to be $-\mathbf{0.8730}$ and $\mathbf{0.8730}$.**
11. **So the bandwidth is $\mathbf{1.7460}$ in both the cases as seen through the command window.**
12. **We also notice that the Energies obtained are almost equal i.e. $\mathbf{4.2678}$ and $\mathbf{4.1721}$.**
13. **Therefore, we obtain maximum frequency at 0.8730.**
14. **So sampling rate should be twice of it i.e. $\boldsymbol{sampling\ rate = 2 * f_{max} = 1.7460}$.**

CONCLUSION:

1. **Sampling rate = 1.7460Hz**
2. **Bandwidth = 1.7460Hz**
3. **We get equal bandwidths in each case, through direct fft or through theoretical method of integration.**
4. **Energy is almost similar in both cases.**
5. **Parseval's Energy Relation is applied and the bandwidth in which 99% of the Energy resides is found.**

*******Thanks for reading*******