Department of Electrical and Electronics

Lab Assignment 5

Devansh Tanna
Roll: *2019A3PS0158P*
Email: *f20190158@pilani.bits-pilani.ac.in*

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Contents

Python Task 1

Code

```
[x, fs] = audioread("si1188.wav");
x = x';
N = length(x);
% N-point DFT
n = N;
x_f = (fft(x, N));
% freq = [linspace(0,fs/2, n/2) linspace(-fs/2, -1, n/2)];
freq = 0:n-1;
t = (0:n-1)/fs;
figure;
subplot(3, 1, 1);
plot(t, x);
xlabel('n', 'Interpreter', 'latex');
ylabel('$x[n]$', 'Interpreter', 'latex');
title('Audio Signal($N$-point DFT)', 'Interpreter', 'latex');
grid on;

subplot(3,1,2);
plot(freq, abs(x_f));
xlabel('k', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title('$|X[k]|$', 'Interpreter', 'latex');
grid on;

subplot(3,1,3);
plot(freq, wrapTo2Pi(angle(x_f)));
xlabel('k', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title('$\angle X[k]$', 'Interpreter', 'latex');
ylim([-1 7]);
grid on;


figure;
x_f2 = (fft(x, 2*N));
freq = 0:2*N-1;
subplot(3, 1, 1);
plot(t, x);
xlabel('n', 'Interpreter', 'latex');
ylabel('$x[n]$', 'Interpreter', 'latex');
title('Audio Signal($2N$-point DFT)', 'Interpreter', 'latex');
grid on;

subplot(3,1,2);
plot(freq, abs(x_f2));
xlabel('k', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title('$|X[k]|$', 'Interpreter', 'latex');
grid on;

subplot(3,1,3);
plot(freq, wrapTo2Pi(angle(x_f2)));
xlabel('k', 'Interpreter', 'latex');
```

```
ylabel('Amplitude', 'Interpreter', 'latex');
title('$\angle X[k]$', 'Interpreter', 'latex');
ylim([-1 7]);
grid on;

disp("As we can see by increasing the N, we get more frequency resolution,");
disp("but in cost of more number of spikes in spectrum. We can prove this");
disp("by considering rectangular windows whose fourier transform is sinc");
disp("function which has many sidelobs");
```

Results

Python Task 2

Code

```
f1 = 170;
f2 = 390;
fs = 6630;

xn = @(n) cos(2*pi*f1/fs*n) + cos(2*pi*f2/fs*n);

N = [170, 390, 663, 200];

h = 1;
for k=N
    n = (0:k-1);
    x = xn(n);
    xf = abs(fft(x, k));
    subplot(4, 2, 2*h-1);
    plot(n, x);
    xlabel('n', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    title(sprintf('$x[n]$ for N = %d', k), 'Interpreter', 'latex');
    grid on;

    freq = linspace(0, fs-1, k);
    subplot(4, 2, 2*h);
    plot(freq, xf);
    xlabel('k', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    title(sprintf('$|X[k]|$ for N = %d', k), 'Interpreter', 'latex');
    grid on;
    h = h+1;
end

k = 170;
n = (0:k-1);
x = xn(n);
xf = abs(fft(x, k));

fprintf("-----------------------------------------------\n");
fprintf("For N = %d the f1 (170 Hz) is %spresent in the spectrum and f2 (390) is %sprese
fprintf("For N = %d the f1 (170 Hz) is %spresent in the spectrum and f2 (390) is %sprese
fprintf("For N = %d the f1 (170 Hz) is %spresent in the spectrum and f2 (390) is %sprese
fprintf("For N = %d the f1 (170 Hz) is %spresent in the spectrum and f2 (390) is %sprese
fprintf("-----------------------------------------------\n");

figure;
subplot(3, 1, 1);
plot(n, x);
xlabel('n', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title(sprintf('$x[n]$ for N = %d', k), 'Interpreter', 'latex');
grid on;

freq = linspace(0, fs-1, k);
subplot(3, 1, 2);
plot(freq, xf);
```

```
xlabel('k', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title(sprintf('$|X[k]|$ for N = %d', k), 'Interpreter', 'latex');
grid on;

freq = linspace(-fs/2, fs/2, k);
subplot(3, 1, 3);
plot(freq, fftshift(xf));
xlabel('k', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');
title(sprintf('Shifted $|X[k]|$ for N = %d', k), 'Interpreter', 'latex');
grid on;
```

Results