BLG 354E Homework - 5

Due Date: 28.05.2017 22:00

Policy: Please do your homework on your own. The code and the report you submitted must be your own work. Cheating is highly discouraged for it could mean a zero or negative grade from the homework.

For your questions: albay@itu.edu.tr

1. **[MATLAB]** Read the page https://www.mathworks.com/help/images/fourier-transform.html carefully and explain each line of the code shown below:

```
f = zeros(30,30);
f(5:24,13:17) = 1;
imshow(f,'InitialMagnification','fit')
F = fft2(f);
F2 = log(abs(F));
imshow(F2,[-1 5],'InitialMagnification','fit');
colormap(jet); colorbar
F = fft2(f,256,256);
imshow(log(abs(F)),[-1 5]); colormap(jet); colorbar
F = fft2(f,256,256);
F2 = fftshift(F);
imshow(log(abs(F2)),[-1 5]); colormap(jet); colorbar
```

2. **[MATLAB]** Run the following code. Explain each line of the code and compare Figure 4 and Figure 6 that are created by the code. What are the reasons of difference between the two images?

```
I = imread('cameraman.jpg');
I = im2double(I);
fft_I = fft2(I);
fft_I_shifted = fftshift(fft_I);
fft_I_shifted_abs = abs(fft_I_shifted);
fft_I_shifted_abs_log = log(fft_I_shifted_abs + 1);
figure('Name', 'Figure 1')
imshow(mat2gray(fft_I_shifted_abs_log));
figure('Name', 'Figure 2')
fft_I_inv = ifft2(fft_I);
imshow(abs(fft_I_inv))

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fft_I_shifted_orig = fft_I_shifted;
fft_I_shifted(size(fft_I_shifted, 1)/2 - 25: size(fft_I_shifted, 1)/2 + 25,...
    size(fft_I_shifted, 2)/2 - 25: size(fft_I_shifted, 2)/2 + 25) = 0;
```

```
fft_I_shifted_abs = abs(fft_I_shifted);
fft_I_shifted_abs_log = log(fft_I_shifted_abs + 1);
figure('Name', 'Figure 3')
imshow(mat2gray(fft_I_shifted_abs_log))

fft_I_inv = ifft2(fftshift(fft_I_shifted));
figure('Name', 'Figure 4')
imshow(abs(fft_I_inv))

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

fft_I_shifted = fft_I_shifted_orig;
fft_I_shifted(1:size(fft_I_shifted, 1)/2-25, :) = 0;
fft_I_shifted(:, 1:size(fft_I_shifted, 2)/2 - 25) = 0;
fft_I_shifted(size(fft_I_shifted, 1)/2+25:size(fft_I_shifted, 1), :) = 0;
fft_I_shifted(:, size(fft_I_shifted, 2)/2 + 25:size(fft_I_shifted, 2)) = 0;
fft_I_shifted_abs = abs(fft_I_shifted);
fft_I_shifted_abs_log = log(fft_I_shifted_abs + 1);
figure('Name', 'Figure 5')
imshow(mat2gray(fft_I_shifted_abs_log))

fft_I_inv = ifft2(fftshift(fft_I_shifted));
figure('Name', 'Figure 6')
imshow(abs(fft_I_inv))
```

3. Consider the amplitude modulation system in Figure 2 with a bandlimited signal whose Fourier Transform is depicted in Figure 1.
   (a) Plot the spectrum $V(jw)$.
   (b) Design an ideal band-pass filter $H(jw)$ so the output $y(t)$ is single-banded in positive frequencies.
   (c) Draw a block diagram of system that will recover $x(t)$ from $y(t)$.

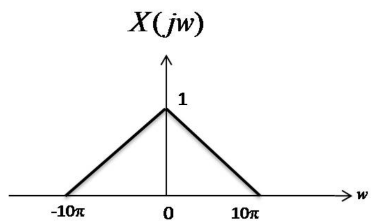

Figure 1: Input Signal

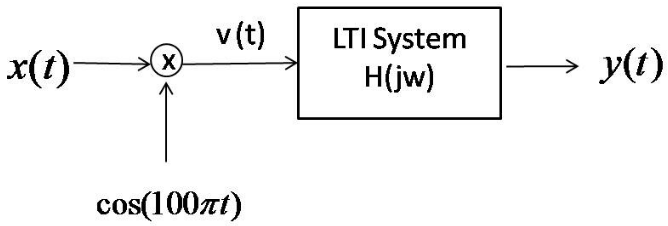

Figure 2: Modulation System

4. Refer to Figure 4 for impulse train sampling.

   (a) Use the sampling theorem to choose the sampling rate $w_s = \frac{2\pi}{T_s}$ so that no aliasing occurs for the input in Figure 3.

   (b) Plot the Fourier Transform of $x_s(t)$ given the sampling rate in part 4a.

   (c) Design ideal low-pass filter H_r such that $x_r(t) = x(t)$.

   (d) If the sampling period is $T_s = 0.2s$, what would the spectrum of the reconstructed signal be given the filter you found in part 4c.

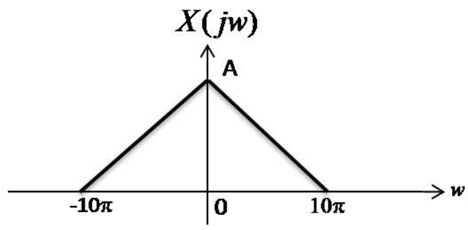

Figure 3: Input Signal

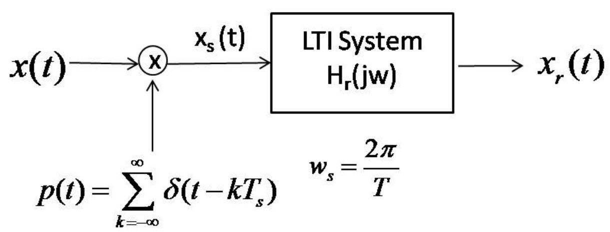

Figure 4: Impulse Train Sampling