# Lab - 2

***Instructions:***

1. Please plot so that we are able to understand, i.e., with legends, axis labels, titles etc.
2. Observations pertaining to each plot is expected below the same.
3. Kindly number your answers correctly.
4. **NO PLAGIARISM.**
5. **Put all the code in the Appendix at the end of the report.**
6. Ask any questions in class or via LMS so that it will be beneficial to all (us and you).
7. The plot should have valid titles (titles like question-1 or plot-1 etc won't be accepted)

***Questions:***

1.

**(a)** Consider the signal $u(t) = 2I_{[1,3]}(t) - 3I_{[2,4]}(t)$. Plot u(t) and its matched filter $u_{mf}(t) = u(-t)$ on the same plot. **(Plot -1)** (These plot numbers are given just for reference of how many plots are required. Don't use it as plot titles).

**(b)** Use the function "contconv" to convolve u(t) and $u_{mf}(t)$. Plot the result of the convolution. Where is the peak of the signal? **(Plot -2)**

**(c)** Now, consider a complex-valued signal $s(t) = u(t) + j\,v(t)$, where $v(t) = I_{[-1,2]}(t) + 2I_{[0,1]}(t)$. The matched filter is given by $s_{mf}(t) = s^{*}(-t)$. Plot the real parts of s(t) and $s_{mf}(t)$ on one plot **(Plot - 3)**, and the imaginary parts on another **(Plot - 4)**.

**(d)** Use the function "contconv" to convolve s(t) and $s_{mf}(t)$. Plot the real part **(Plot -5)**, the imaginary part **(Plot - 6)**, and the magnitude of the output **(Plot-7)**. Do you see a peak?

**(e)** Now, use the function contconv to convolve $s_1(t) = s(t - t_0)e^{j\theta}$ and $s_{mf}(t)$, for $t_0 = 2$ and $\theta = \pi/4$. Plot the real part **(Plot-8)**, the imaginary part **(Plot-9**), and the magnitude of the output **(Plot-10)**. Do you see a peak?

**(f)** If you did not know t and θ, could you estimate it from the output of the convolution in (e)? Try out some ideas and report on the results.

**Fourier transform**

The following Matlab function is a modification of Code Fragment 2.5.1.

```
function [X,f,df] = contFT(x,tstart,dt,df_desired)
%Use Matlab DFT for approximate computation of continuous time
Fourier %transform
%INPUTS
%x = vector of time domain samples, assumed uniformly spaced %tstart=
time at which first sample is taken
%dt = spacing between samples
%df_desired = desired frequency resolution
%OUTPUTS
%X=vector of samples of Fourier transform
%f=corresponding vector of frequencies at which samples are obtained
%df=freq resolution attained (redundant--already available from
%difference of consecutive entries of f)
%%%%%%%%%
%minimum FFT size determined by desired freq res or length of x
Nmin=max(ceil(1/(df_desired*dt)),length(x));
%choose FFT size to be the next power of 2
Nfft = 2^(nextpow2(Nmin));
%compute Fourier transform, centering around DC
X=dt*fftshift(fft(x,Nfft));
%achieved frequency resolution
df=1/(Nfft*dt);
%range of frequencies covered
f = ((0:Nfft-1)-Nfft/2)*df; %same as f=-1/(2*dt):df:1/(2*dt) - df
%phase shift associated with start time
X=X.*exp(-j*2*pi*f*tstart);
end
```

2.

(a) Use the function contFT to compute the Fourier transform of s(t) = 3sinc(2t − 3), where the unit of time is a microsecond, the signal is sampled at the rate of 16 MHz, and truncated to the range [−8, 8] microseconds. We wish to attain a frequency resolution of 1 KHz or better. Plot the magnitude of the Fourier transform versus frequency **(Plot-11)**, making sure you specify the units on the frequency axis. Check that the plot conforms to your expectations.

(b) Plot the phase of the Fourier transform obtained in (a) versus frequency **(Plot-12)** (again, make sure the units on the frequency axis are specified). What is the range of frequencies over which the phase plot has meaning?

[you can use this link for reference: https://www.gaussianwaves.com/2015/11/interpreting-fft-results-obtaining-magnitude-and-phase-information/]

**Matched filter in the frequency domain**

3.

(a) Consider the signal s(t) in 1(c). Assuming that the unit of time is a millisecond and the desired frequency resolution is 1 Hz, use the function contFT to compute and plot $|S(f)|$. **(Plot -13)**

(b) Use the function contFT to compute and plot the magnitude of the Fourier transform of the convolution $s * s_{mf}$ numerically computed in 1(d) **(Plot-14)**. Also plot for comparison $|S(f)|^2$ , using the output of 3(a). The two plots should match.

(c) Plot the phase of the Fourier transform of $s * s_{mf}$ obtained in 3(b). Comment on whether the plot matches your expectations. **(Plot - 15).**

**Lab Report :**

**• Discuss the results you obtain, answer any specific questions that are asked, and print out the plots to support your answers.**

**• Append your programs to the report. Make sure you comment them in enough detail so they are easy to understand. In addition to the functions you are asked to write, label the code fragments used for each assigned segment (1 through 5) separately.**

**• Write a paragraph about any questions or confusions that you may have experienced with this lab**