Assignment 2

1. Time domain – Frequency domain

- Which fundamental relationship exists between the two domains?
- Take a look at figure 1 and try to explain the illustrations.
  - Red dashed line: Range of sampled values
  - Blue lines: Signal
- Draw a basic discrete frequency domain scheme of figure 1 within the range [-3Fs 3Fs].
  - Fs… Sampling frequency
- Why does the discrete frequency domain scheme look like this? What causes the effect?
- The second row shows the filtered signal within the frequency domain using and ideal low pass filter.
- Why is the complete second half of the spectrum not weighted with zeros for the filter operation? (See red dashed line)
- Which cut-off frequency was used?
- Why does the matching time domain look distorted? Which effects are causing this distortion?

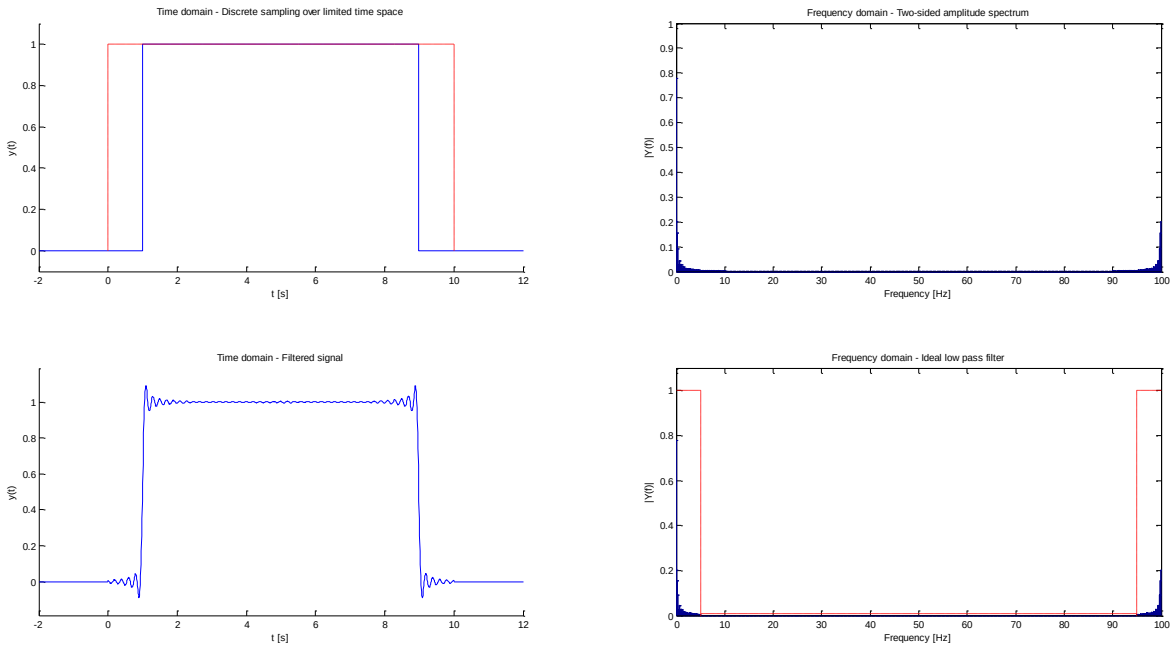

Figure 1: Impulse in time and frequency domain (1st row). Filtered impulse signal in frequency and time domain (2nd row).

2. Discrete Convolution

- What is the convolution function?
  - Write down the formula of the discrete one dimensional convolution.
  - Implement a one dimensional convolution function in MATLAB.
    - Function signature `[w]=myconv(u,v)`
  - Write a MATLAB test script `testconv.m` which compares your implementation with the MATLAB reference implementation `conv` in a 1x2 plot.
    (1st plot: reference `conv`; 2nd plot: `myconv`)
- What is the fast discrete convolution?
  - Illustrate the basic concept. State the benefits and drawbacks of the fast discrete convolution.
  - Implement your own fast discrete convolution function in MATLAB.
    - Function signature `[w]=myfastconv(u,v)`
  - Extend your test script `testconv.m` by adding a third row, plotting the result of your implementation `myfastconv`.

3. Discrete Cross Correlation

- Revise the fundamental mathematics towards the discrete cross correlation.
  - Which analogies can be seen towards the discrete convolution?
  - Create a MATLAB test script which uses the functions `myconv` and `myfastconv` from section 2 to serve as cross correlation functions. Again use a 1x3 plot to compare to the reference MATLAB function `xcorr`.

4. Applications

Discrete convolution and cross correlation can be used in a variety of applications. The following two applications should give a brief example, what purposes can be fulfilled.

a. Convolution: Reverb effect

- Create a MATLAB program which allows mixing real space models with an arbitrary audio signal.
  - Use your own MATLAB function you implemented in section 2.

b. Correlation: Audio delay estimation

- Extract the left and right channel of a given audio sample and determine the delay between the channels by using cross correlation.
- Determine the distance between the microphone channels.

Home Assignment: Discrete Autocorrelation

- Create a MATLAB demo script `demoautocorr.m` which generates the variable Fourier series for a square wave signal and a uniformly distributed noise signal.
  - Fourier series – 1 sec period
    - $f(x) = \frac{4\mathrm{h}}{\pi} \sum_{k=1,3,5,\ldots}^{n} \frac{1}{k} \sin(2\pi k x)$
    - Be careful: step size is 2 for sum
  - Common parameters for both signals
    - Sampling frequency; [1 1000]Hz; default: 1kHz
    - Signal length (Number of periods); [1 10]sec; default: 1 sec.
  - Fourier series specific parameters
    - Amplitude (h); [0 10]; default: 1
    - Fourier series length (k); [1 21]
  - Noise signal specific parameters
    - Amplitude (h); [0 10]; default: 1
  - Design a MATLAB GUI within the test script. Requirements:
    - 2x1 plots for generated signal and ACF.
    - Parameters variation in the defined range (sliders).
    - Option to select ACF function from section 3 (radio button).
    - Plots should be updated automatically on parameter change.
- Analyze the ACF spectrum for different parameter settings.
  - Name the influences of the single parameters on the ACF.
  - Write a technical paper stating your results with the following limitations:
    - One single A4 page two column style (IEEE manuscript style[1])
    - PDF document
    - Maximum of four figures (comprehensively explained in text)
- MATLAB M files must have a header. Plots should be labeled and must have axis labeling.
- Required upload
  - `demoautocorr.m`
  - `autocorr.pdf`

[1] http://www.ieee.org/conferences_events/conferences/publishing/templates.html