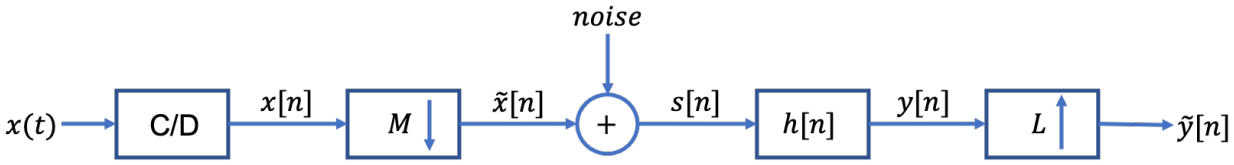
Assignment-2 (Matlab)
BEE-10CD
Due Date: 18th December 2020

Problem: You have studied sampling of the continuous-time signal to get discrete-time signal, downsampling and upsampling. Your task is to implement the following given processing pipeline.



1. Record an audio signal using Matlab in your own voice. The duration should be 2s with sampling frequency Fs = 44100 Hz, Bits per sample = 8 and mono-channel. Explore "audiorecorder" function of Matlab.

2. Plot the signal and its spectrum. Label correctly the x-axis and y-axis of plots in time (t) and frequency Ω. Although every sequence in Matlab is stored in array, you should assume this as a continuous-time signal.

3. This signal should be passed through analogue low-pass filter before converting it into discrete-time signal. Filter the signal with cut-off frequency of 5 kHz. You can take 3rd order Butterworth analog filter. Discuss why we need such filtering and why it is safe to choose these parameters of frequency and order? Plot and label the filtered signal and its spectrum. Also plot the frequency response of the Butterworth filter. Hint: Useful Matlab commands are "**butter** and **freqz**". Although analogue Butterworth filter should be designed but we don't have actual analogue signal so applying analogue filtering may not give you right answer. So design digital Butterworth filter and assume it as analogue.

4. Now practically C/D step is done using zero-order hold/sample-hold filter followed by quantization as practically multiplication with the continuous-time impulse train is not possible. Therefore, study the zero-order hold filter and quantization process in detail and apply in Matlab for C/D conversion. You cannot use Matlab's built-in C2D conversion command. Is there any significance of

sampling period T in designing zero-order hold filter? Should we take care of any Nyquist Criteria in designing zero-order hold filter? Also design a wrong zero-order hold filter to depict aliasing in frequency domain. Attach all relevant plots of zero-order hold filter and quantizer. Plot the sampled discrete-time signal and its spectrum. Plotting discrete-time signal uses "**Stem**" command of Matlab and mind the frequency axis of the spectrum of discrete-time signal. If the plot gets too jumbled up, plot a portion of the discrete signal for clear visibility.

5. Once you get $x[n]$, downsample it with $M = 2$ factor to make it $\tilde{x}[n]$. You can use Matlab's built-in function **decimate**. Explain what this function does and how it can be compared to the one in the lectures? Draw the spectrum of the downsampled signal and compare it with the original spectrum of $x[n]$ using subplot. Do you see any difference?

6. Now add a high frequency noise (2s of noise provided) to the downsampled signal $\tilde{x}[n]$ to make it $s[n]$. Plot the spectrum of s$[n]$ and compare it with $\tilde{x}[n]$. Do you see any difference?

7. Once you get $s[n]$, apply $h[n]$, a low pass filter to cut high frequency noise as much as possible. Design your own low-pass filter, once again using **butter, ([B,A] = butter(N,Wn,'low')**) with appropriate normalized cut-off frequency **Wn** and order **N** to get $y[n]$. Plot and label this system $h[n]$ and output $y[n]$.

8. Now upsample the $y[n]$ with $L = 2$ to get $\tilde{y}[n]$. You can use Matlab's built-in function **interp**. Explain what this function does and how it can be compared to the one in the lectures? Plot and compare the spectrums of $y[n]$ and $\tilde{y}[n]$.

Deliverable: Short report in soft form with the printout of the source code and all relevant plots. All plots should be labeled. Explore the how to make .mlx files in Matlab with should contain your text descriptions and code section in a single file. Source code will also be uploaded to LMS as a single .mlx file as [firstname_lastname.mlx]. The file should be without any errors and should be run with any other dependency.

Warning: Any plagiarism will result in strict action and negative marking. Your source code should be able to generate exact plots as mentioned. You must give bibliography should you want to get some help from published paper or internet sources.