Signals and Systems Laboratory
Indian Institute of Technology Jammu
Experiment No.-7 and 8

Objective-
(a) Take x(n) on your own voice. Compute energy of overall speech signal and segment wise of speech signal, respectively. Plot energy vs segment.
(b) Generate a synthetic signal by adding two signals sin(2π50t)+ sin(2π120t). Add noise of 50 Hz and 2000 Hz, amplitude of 0.25 to the signal. Plot it both signal and signal+noise in time-domain. Plot the magnitude response of the synthetic signal, noisy signal of 50 Hz, and noisy signal of 2000 Hz.
(c) Design a low pass filter to remove 2000 Hz noise. Use the knowledge of low pass IIR where choose α accordingly.
(i) using convolution, (ii) using inbuilt function.
(d) Design a high pass filter to remove 50 Hz noise. Use the knowledge of high pass IIR where choose α accordingly.
(i) using convolution, (ii) using inbuilt function.
Apparatus- python+matplotlib, Matlab.
Theory-
Energy of Speech Signal:
The energy of a speech signal refers to the overall magnitude or strength of the signal. The energy E of a discrete-time signal x[n] can be computed by,

$$E = \sum_{n=0}^{N-1} |x[n]|^2$$

Where E = energy of the signal, x[n] = signal amplitude at time index n, N = total number of samples in the signal.
Low Pass Filter (LPF) with Infinite Impulse Response (IIR):
An ideal Low pass filter is the one that allows to pass all frequency components of a signal below a designated cutoff frequency ω_c, and rejects to pass all frequency components of a signal above ω_c.
Its frequency response satisfies:

$$H_{LP}(e^{jw}) = \begin{cases} 1, & 0 \leq \omega \leq \omega_c \\ 0, & \omega_c \leq \omega \leq \pi \end{cases}$$

The transfer function of LPF IIR is:

$$H(z) = (\frac{1-\alpha}{2})\frac{1-z^{-1}}{1-\alpha z^{-1}}$$

where α is,

$$\alpha = \frac{1-sin(\omega_c)}{cos(\omega_c)}$$

High Pass Filter (HPF) with Infinite Impulse Response (IIR):
An ideal Highpass filter is the one that allows to pass all frequency components of a signal above a designated cutoff frequency ω_c, and rejects to pass all frequency components of a signal below ω_c.
Its frequency response satisfies:

$$H_{HP}(e^{jw}) = \begin{cases} 0, & 0 \leq \omega \leq \omega_c \\ 1, & \omega_c \leq \omega \leq \pi \end{cases}$$

The transfer function of HPF IIR is:

$$H(z) = (\frac{1-\alpha}{2})\frac{1-z^{-1}}{1+\alpha z^{-1}}$$

where α is,

$$\alpha = \frac{1 - sin(\omega_c)}{cos(\omega_c)}$$

HPF filter transfer function can be obtain from LPF filter transfer function by replacing 'z' with '-z'. Replacing 'z' by '-z' means frequency shifting by $\pm\pi$.

Observations-

Result- Computed energy on overall speech signal and segment wise of speech signal, respectively. Generated a synthetic signal by adding two signals. Added noise to the signal. Also plotted both signal and signal+noise. Designed low pass and high pass filter to remove 2000 Hz and 50 Hz noise respectively.

Precautions:-

- Program must be written carefully to avoid errors.
- Programs can never be saved as standard function name.
- Commands must be written in proper format.