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Course Project Assignment Report

on

Simulation of FIR Low Pass Filter and High Pass Filter with Noise Input using Falstad.com Digital Filter Simulator

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Course title : Digital Signal Processing

Course code : BEC502

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2025-26

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1. Introduction

Digital filters play a major role in signal processing applications such as audio processing, communication systems, biomedical electronics, and noise removal. Finite Impulse Response (FIR) filters are widely preferred because of their inherent stability and linear phase characteristics.
This project aims to simulate FIR Low Pass and FIR High Pass filters using the Falstad.com Digital Filter Simulator, a browser-based interactive tool. The primary goal is to observe how each filter responds to an input signal corrupted by noise.

2. Objective

- To design and simulate an FIR Low Pass Filter and High Pass Filter.
- To apply a noisy input signal and study the filtering behavior.
- To visualize time-domain and frequency-domain responses using the Falstad simulator.

3. Tools Used

- Falstad Digital Filter Simulation Tool (browser-based)
    - Provides real-time signal visualization
    - Allows user-defined filter coefficients
    - Supports noise generation and waveform analysis

4. Methodology

4.1 FIR Low Pass Filter Simulation

1. Open the Falstad Digital Filter Simulator.
2. Select the **FIR Filter** option.
3. Choose or manually enter FIR low-pass coefficients (equally weighted or window-based coefficients).
4. Generate a noisy input by adding white noise to a sine wave.
5. Observe:
    - The low-frequency components pass through the filter.
    - The high-frequency noise is attenuated.
    - The output waveform appears smoother and less distorted.

4.2 FIR High Pass Filter Simulation

1. Configure the FIR filter with high-pass coefficients (differentiator-like or window-based HPF coefficients).
2. Apply the same noisy input signal.
3. Observe:
    - High-frequency components are retained.
    - Low-frequency portions of the input signal are suppressed.
    - Noise (mostly high-frequency) may still appear, depending on cutoff.

5. Observations

- The **Low Pass Filter (LPF)** effectively removed high-frequency noise from the input signal, resulting in a cleaner output.
- The **High Pass Filter (HPF)** allowed high-frequency components and filtered out low frequencies, demonstrating clear differences in frequency selectivity.
- Falstad's real-time visualization clearly showed:
    - Input vs. Output waveforms
    - Filter impulse response
    - Spectrum changes before and after filtering

6. Results

- FIR LPF successfully smoothed the noisy signal, demonstrating strong attenuation of frequencies above the cutoff.
- FIR HPF highlighted the noise and high-frequency elements while removing low-frequency parts of the signal.
- The simulation validated the theoretical behavior of FIR filters.

7. Conclusion

This project demonstrates the successful simulation of FIR Low Pass and High Pass Filters using Falstad.com. The browser-based simulator provided an intuitive environment to visualize filter characteristics and signal behaviour. The experiment clearly shows how FIR filters operate in noise reduction (LPF) and frequency isolation (HPF), supporting their use in digital signal processing applications.

8. Future Scope

- Design FIR filters using different window techniques (Hamming, Blackman, Kaiser).
- Compare FIR and IIR filter performance.
- Implement the same filters using MATLAB or Python.