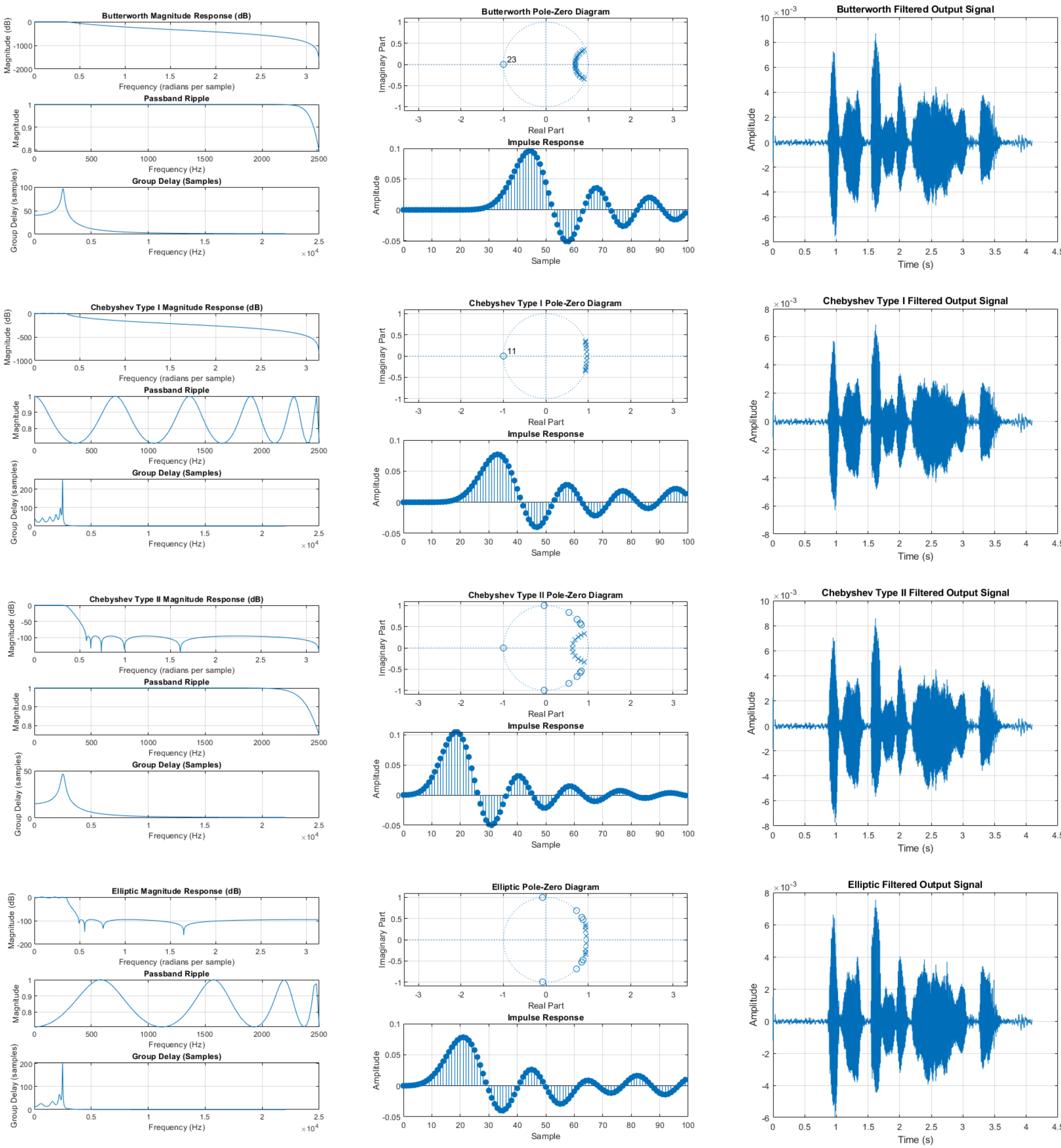
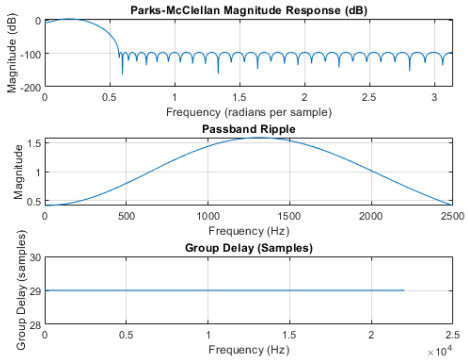
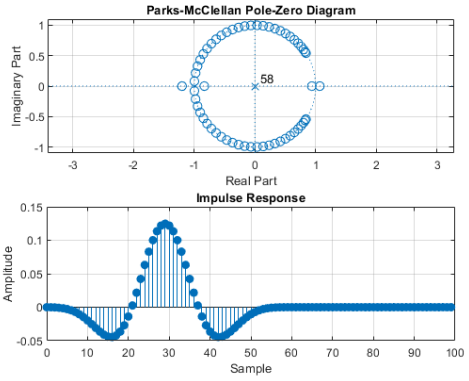
```
clear; clc; close all;
load projIB.mat;

% Filter specifications
Fs = 44100;           % Sampling frequency in Hz
Fp = 2500;            % Passband edge in Hz
Fs_stop = 4000;       % Stopband edge in Hz
Rp = 3;               % Passband ripple in dB (from 40 dB to 37 dB)
Rs = 95;              % Stopband attenuation in dB

filter_types = {'Butterworth', 'Chebyshev Type I', 'Chebyshev Type II', 'Elliptic', 'Parks-McClellan', 'Kaiser'};
filter_functions = {@butterworth_filter, @chebyshev1_filter, @chebyshev2_filter, @elliptic_filter, @pm_filter, @kaiser_filter};

x = noisy;
t = (0:length(x)-1) / Fs;

for i = 1:length(filter_types)
    filter_name = filter_types{i};
    filter_func = filter_functions{i};

    if contains(filter_name, 'Parks-McClellan') || contains(filter_name, 'Kaiser')
        [b, filter_order, num_multiplications] = filter_func(Fp, Fs_stop, Rp, Rs, Fs);
        % FIR filter response and group delay calculations
        [H, W] = freqz(b, 1, 1024, Fs);
        [gd, W_gd] = grpdelay(b, 1, 1024, Fs);
        y = filter(b, 1, x); % FIR filter
    else
        [sos, filter_order, num_multiplications, z, p] = filter_func(Fp, Fs_stop, Rp, Rs, Fs);
        % IIR filter response and group delay calculations
        [H, W] = freqz(sos, 1024, Fs);
        [gd, W_gd] = grpdelay(sos, 1024, Fs);
        y = sosfilt(sos, x); % IIR filter
    end

    % Display filter details
    fprintf('%s Filter:\n', filter_name);
    fprintf('  Filter Order: %d\n', filter_order);
    fprintf('  Multiplications per Sample: %d\n', num_multiplications);

    % Plot magnitude response, passband ripple, and group delay
    figure('Name', [filter_name ' Frequency Response Analysis']);

    % Magnitude Response Plot (dB vs radians)
    subplot(3, 1, 1);
    plot(2 * pi * W / Fs, 20*log10(abs(H)));
    title([filter_name ' Magnitude Response (dB)']);
    xlabel('Frequency (radians per sample)');
    ylabel('Magnitude (dB)');
    grid on;
    xlim([0, pi]);

    % Passband Ripple Plot
    subplot(3, 1, 2);
    plot(W, abs(H));
    title('Passband Ripple');
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');
    grid on;
    xlim([0 Fp]);

    % Group Delay Plot
    subplot(3, 1, 3);
    plot(W_gd, gd);
    title('Group Delay (Samples)');
    xlabel('Frequency (Hz)');
    ylabel('Group Delay (samples)');
    grid on;

    % Pole-Zero and Impulse Response
    figure('Name', [filter_name ' Pole-Zero and Impulse Response']);

    % Pole-Zero Plot
    subplot(2, 1, 1);
    if contains(filter_name, 'Parks-McClellan') || contains(filter_name, 'Kaiser')
        zplane(b, 1); % For FIR filters, plot only zeros
    else
        zplane(z, p); % For IIR filters, plot both poles and zeros
    end
    title([filter_name ' Pole-Zero Diagram']);
    grid on;

    % Impulse Response (100 samples)
    impulse = [1; zeros(99, 1)]; % 100-sample impulse input
    if contains(filter_name, 'Parks-McClellan') || contains(filter_name, 'Kaiser')
        imp_response = filter(b, 1, impulse); % FIR filter impulse response
    else
        imp_response = sosfilt(sos, impulse); % IIR filter impulse response
    end

    subplot(2, 1, 2);
    stem(0:99, imp_response, 'filled');
    title('Impulse Response');
    xlabel('Sample');
    ylabel('Amplitude');
    grid on;

    % Plot filtered signal
    figure('Name', [filter_name ' Filtered Signal']);
    plot(t, y);
    title([filter_name ' Filtered Output Signal']);
    xlabel('Time (s)');
    ylabel('Amplitude');
    grid on;

    % Play filtered signal
    disp(['Playing ', filter_name, ' filtered output signal...']);
    soundsc(y, Fs);
    pause(length(y) / Fs + 1);
end
```

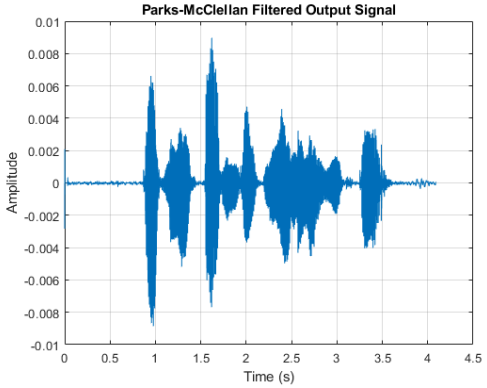
```
Butterworth Filter:
  Filter Order: 24
  Multiplications per Sample: 60
Playing Butterworth filtered output signal...
Chebyshev Type I Filter:
  Filter Order: 12
  Multiplications per Sample: 30
Playing Chebyshev Type I filtered output signal...
Chebyshev Type II Filter:
  Filter Order: 12
  Multiplications per Sample: 30
Playing Chebyshev Type II filtered output signal...
Elliptic Filter:
  Filter Order: 8
  Multiplications per Sample: 20
Playing Elliptic filtered output signal...
Parks-McClellan Filter:
  Filter Order: 58
  Multiplications per Sample: 59
Playing Parks-McClellan filtered output signal...
```

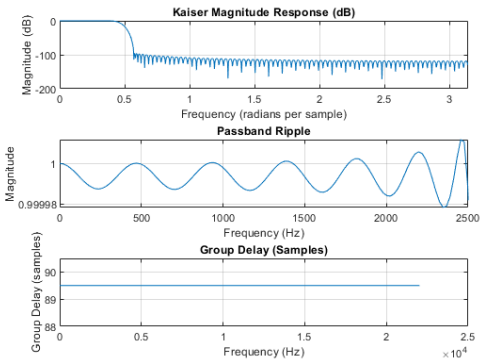
```
Kaiser Filter:
  Filter Order: 179
  Multiplications per Sample: 180
Playing Kaiser filtered output signal...
```

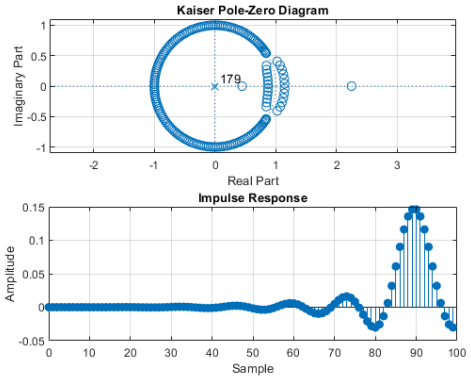


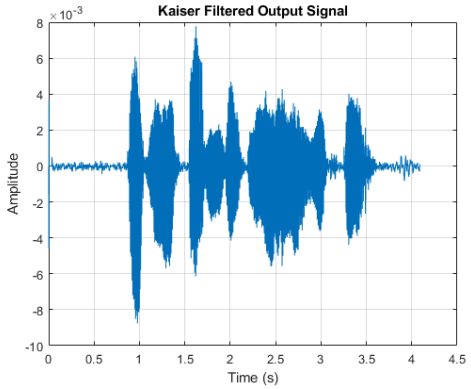












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