10.Matlab Graphical User Interface (GUI). Write a Matlab GUI that allows the user to control the cut-off frequency of a low-pass filter. The GUI should have a slider for the cut-off frequency.

The GUI should display the

 • impulse response

 • frequency response (magnitude)

These plots should update as the user adjusts the slider.

**Matlab code: filter\_gui\_question10.m**

function filter\_gui\_question10

N = 500;

n = 0:N;

x = ( n==0 );% impulse response

Fs = 8000;

fc = 0.1;

[b, a] = butter(2, 2\*fc);

y = filtfilt(b, a, double(x));

% y = filter(b, a, x);

% frequency

[H, om] = freqz(b, a);

f\_freqz = om\*Fs/(2\*pi); %?Fs?fc

f1 = figure(1);

clf

subplot(2,1,1)

line1 = plot(n,y,'color','blue','linewidth',2)

legend('impulse response')

xlim([0 N])

ylim([-1 1])

subplot(2,1,2)

line2 = plot(f\_freqz,abs(H),'color','red','linewidth',2)

legend('frequency response')

title( sprintf('Output of LPF. Cut-off frequency = %.3f (normalized)', fc) )

xlabel('Time')

box off

% xlim([0, N]);

% ylim([-3 3])

drawnow;

slider\_handle = uicontrol(f1, ...

'Style', 'slider', ...

'Min', 0, 'Max', 0.2, ...

'Value', fc, ...

'SliderStep', [0.02 0.05], ...

'units', 'normalized', ...

'Position', [0.2 0.0 0.6 0.2], ...

'Callback', {@fun1, line1, line2 });

end

% callback function fun1

function fun1(hObject, eventdata, line1, line2)

fc = get(hObject, 'Value'); % cut-off frequency

fc = max(0.001, fc); % minimum value

fc = min(0.499, fc); % maximum value

N = 500;

n = 0:N;

x = ( n==0 );% Input signal

Fs = 8000;

[b, a] = butter(2, 2\*fc);

y = filtfilt(b, a, double(x));

% y = filter(b, a, x);

[H, om] = freqz(b, a);

f\_freqz = om\*Fs/(2\*pi); %?Fs

set(line1, 'ydata', y);

set(line2, 'ydata', abs(H), 'xdata', f\_freqz);

title( sprintf('Output of LPF. Cut-off frequency = %.3f (normalized)', fc) )

end

**Comment:**

When the slider came to the right side, fc became a large number which make the impulse response decrease rapidly, the band-pass frequency have a larger range. When the slider came to the left side, fc became a small number which make the impulse response decrease gradually, the band-pass frequency have a small range.

I first used n = 1:N, and x = ( n==0 ), then came no signal on the screen, for a long time I confused what is wrong with my code. Then came out this version, I still not sure.

1. When I used % y = filter(b, a, x); the wave in the figure begin with 0.5 instead of 1. When I used y = filtfilt(b, a, double(x)); the initiate number is exactly 1. What make it different?
2. When I refer to filter\_cat.m for how to make the frequency response, it show me that f\_freqz = om\*Fs/(2\*pi), and in this question, I am not sure if it is Fs or fc. fc means cut-off frequency, it should be set from 0-1, [b, a] = butter(2, 2\*fc); if 2\*fc in this equation be set to ensure the rank of fc?