

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, f_c 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, f_c 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 F_s 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?